The Shadow Cost of Bank Capital Requirements

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Abstract

How much would an increase in regulatory capital requirements cost banks? We estimate the shadow cost of capital requirements for banks using data on their participation in a costly regulatory loophole. We show theoretically that the extent to which banks bypassed capital requirements, by providing liquidity guarantees to asset-backed commercial paper conduits, reveals their private compliance costs. We estimate that a one percentage point increase in capital requirements would cost $220 million a year for all banks that exploited the loophole combined, and no more than $370 million for all US banks. The average cost per bank is $14.3 million, or 0.4 percent of annual profits.

JEL classification: G21, G28, L51

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1 Introduction

Capital requirements are an important tool in the regulation of financial intermediaries. Leverage amplifies shocks to the value of an intermediary's assets, increasing the chance of distress, insolvency, and costly bailouts. Following the recent financial crisis, prominent economists and policy-makers have called for a substantial increase in capital requirements for financial intermediaries, as a way to rein in their leverage. Nevertheless, proposals to increase capital requirements face fierce and successful opposition from financial intermediaries, apparently driven by their *private costs* of capital requirements. Despite the central role of these costs in shaping the regulation, they have not been measured empirically.[1]

We use banks' own actions to infer their perceived compliance costs. Prior to the financial crisis of 2007-2010, banks had access to a costly loophole that helped them bypass capital requirements. Since, according to the banking industry, higher regulatory ratios decrease profitability, a profit maximizing bank would trade off the cost of the loophole against the benefit of reduced capital. Therefore, data on loophole use, together with information on its costs, reveal the shadow costs of capital requirements. This approach, first used by Anderson and Sallee (2011) to study fuel-economy standards, allows estimating the shadow costs of regulation without the need to estimate demand elasticities and other unobservables.

To examine this intuition empirically, we set up a simple banking model and take it to data on banks' provision of liquidity guarantees to asset-backed commercial paper (ABCP) conduits. As documented by Acharya, Schnabl, and Suarez (2013), banks that provided liquidity guarantees to ABCP conduits effectively held the risks of the underlying assets. However, instead of treating such guarantees as risky assets, banks were allowed to include only ten percent (zero before 2004) of these guarantees in the calculation of regulatory capital ratios. Therefore, this loophole allowed banks to decrease their economic capital ratios while keeping their regulatory ratios within the guidelines.

While the loophole benefited banks by relaxing their regulatory constraints, using it was costly, as banks had to pay an incremental cost for using ABCP conduits. Therefore, for constrained banks that use the loophole, the ratio of the marginal cost of using the loophole to the marginal benefit reveals the shadow cost of the regulatory capital constraint. The shadow cost for unconstrained banks is zero.

We derive the marginal benefit of exploiting the loophole for each regulatory capital

[1] The costs of capital requirements are high according to banks (see, e.g., American Bankers Association, 2012). For an opposing view see Admati, DeMarzo, Hellwig, and Pfleiderer (2011) and Admati and Hellwig (2013). In 2010, many leading researchers signed an open letter in the Financial Times that called for an increase capital requirements, and stated that while this may reduce profits, the cost would be mostly borne by banks. Similar proposals have appeared following past crises (Simons, 1948; Bryan, 1988). The latest revision of US bank regulation increases capital requirements by at most two percentage points.

ratio (tier 1 risk-based, total risk-based, and tier 1 leverage ratio). The benefits can be calculated using our data; they are higher for banks that could achieve a higher reduction in the reported ratios by using the loophole. The marginal cost—an incremental increase in the cost of capital due to the loophole—is harder to quantify. For our baseline estimates, we use the 30 day ABCP spread over financial commercial paper, which is positive and stable during the pre-crisis period. In addition, since the spread may not capture the full cost of the loophole, we derive an upper bound for the marginal costs of the loophole (and hence for the shadow costs) that allows for arbitrary measurement error in the marginal cost of the loophole.

Our approach allows us to estimate the shadow costs of capital regulation for constrained banks that used the ABCP loophole, and provides an upper bound for other banks. We identify 18 US bank holding companies that sponsored and provided liquidity guarantees to ABCP conduits in the pre-crisis period, using detailed data on ABCP conduits from Moody's Investor Service and banks' quarterly reports.[2] Although few in numbers, these institutions account for about half of all US bank assets. Consistent with the model, we show that they tend to be much more constrained by capital regulations than the rest of the banking universe. These large, heavily levered banks were at the epicenter of the recent financial crisis, and are still the subjects of (and active participants in) the policy debate on capital requirements.

We find that the shadow costs of capital requirements during the pre-crisis period were modest. According to our baseline estimates, which rely on a direct measurement of the marginal cost of the loophole, a one percentage point increase in required tier 1 capital ratios would cost all participating banks *combined* about \$220 million a year (\$160 million for the total risk based ratio). The cost to an average bank is about \$14 million for tier 1 ratios (\$10 million for the total risk-based ratio), which corresponds to 0.4 percent of its annual profits. The upper bounds on the shadow cost, which allow for measurement error in the marginal cost of the loophole, are \$63 million for tier 1 ratios and \$45 million for the leverage ratio (1.4–2 percent of annual profits). These estimates confirm the baseline results and imply rather modest shadow cost of capital requirements, since they were calculated using an inflated upper bound for the effect of equity on the cost of capital.

To get a point estimate of the shadow cost we need constrained banks that use, but do not finance their entire asset portfolio through the loophole. We verify these conditions in Section 4. For the rest of the industry's 2,500 bank-holding companies, we calculate an

[2]For brevity, we use the terms "ABCP sponsors" and "Liquidity providers to ABCP conduits" interchangeably. We explain the distinction between the two terms below. Also, while our analysis is done at the bank holding company level, we use the terms "Bank" and "Bank Holding Company" interchangeably.

upper bound for the costs, under the assumption that all of them were constrained by the capital requirements and faced similar marginal cost of the loophole. We find that adding the rest of the industry does strikingly little to the magnitude of the aggregate costs. For example, under the baseline measure of the marginal cost, for *all* US banks combined, a 1 percentage point increase in the capital requirements would cost no more than $370 million for tier 1 ratios and $270 million for the total risk-based ratio. Such small change in the aggregate costs stems from the fact that banks that participated in the loophole were about 100 times larger than an average non-participating bank.

The modest shadow cost may appear puzzling given banks' resistance to higher capital requirements. Note, however, that this is the shadow cost for banking profits, rather than the cost of issuing equity (Kashyap, Stein, and Hanson, 2010; Baker and Wurgler, 2013) or deleveraging due to distress (Peek and Rosengren, 1997). We capture the effect of regulation during an economic expansion after banks utilized all available tools to mitigate the impact of the constraints. Therefore, our estimates imply that banks either significantly overstate the effect on the cost of capital, or that they are able to neutralize the effects of the cost increase on profits.[3] Furthermore, our calculations show that the effects on lending quantities and interest rates, are also likely to be small, which alleviates the concern that higher capital requirements would force banks to restrict or bias their provision of credit.[4]

Our study is most closely related to the literature on the impact of increased capital requirements on lending and the cost of loans. Kashyap, Stein, and Hanson (2010) estimate that a 10 percentage point increase in capital ratios would raise banks' weighted average cost of capital by 25-45 basis points, while Baker and Wurgler (2013) estimate the same policy change would result in a 60-90 basis points higher cost of capital. Other papers focus on the benefits of higher capital requirements by examining the performance and survival of banks during banking crises (e.g., Berger and Bouwman, 2013). Van den Heuvel (2008) measures the welfare loss from increasing bank capital requirements beyond their socially optimal level in a competitive banking environment. Our approach differs from the rest of the literature in that we focus on the effect of the regulation on the net *producer surplus*, which includes the parts of expected costs and benefits internalized by banks.

[3]Banks could, for example, tilt their loan portfolio towards assets with lower risk weights or pass the increase in costs to borrowers. Under both interpretations, our results show that increasing capital requirements while holding other rules constant would not significantly affect banking profitability, while achieving the benefits of increased equity. Brun, Fraisse, and Thesmar (2013) report a large effect on corporate lending in France following Basel II changes in risk-weighting rules. We leave the treatment of the effect risk-weighting schemes for future research, but note that even if new regulations result in changes in risk-weighting schemes, our methodology would still be applicable.

[4]While banks' lobbying efforts may appear surprising given the low estimated costs, we note that lobbying expenses are not paid every year, whereas the costs we estimate are incurred annually. See Mian, Sufi, and Trebbi (2010) and Thakor (forthcoming) on the political economy of bank regulation.

Our approach adds to this literature in several ways. First, we do not impose a particular model of the effect of capital structure, such as Modigliani and Miller (1958); banks in our framework may perceive equity to be arbitrarily costly. Therefore, we do not dismiss at the outset any view on the costs of capital requirements.[5] Instead, we use revealed preference, and let the data tell us how costly banks perceive the requirements to be. In fact, we find that imposing the Modigliani-Miller framework with taxes further decreases the estimates of the shadow costs.

Second, we are able to estimate the cost of capital requirements during an economic expansion (2002-2007), without relying on negative economic shocks for identification.[6] This increases the relevance of our estimates for policy, since the tightening of capital requirements is rarely done in a crisis period, allowing banks a sufficient transition period and access to well-functioning capital markets. Related, our estimates can help regulators assess the potential effects of macroprudential regulation, which relies on increasing required capital ratios during expansions (Rochet, 2010; Shleifer and Vishny, 2010).

Third, both consumer and producer surpluses are obviously important in quantifying the social costs of higher capital requirements. While the effect of capital requirements on producer surplus plays a central role in the regulatory debates, to the best of our knowledge ours is the first paper to provide a direct estimate. Our estimates can directly inform policy and academic work on the preferences of the banking sector towards leverage and help us better understand the forces opposing regulatory capital reform.

More broadly, our paper is related to a literature in microeconomics that studies the effect of regulation on industry participants and market outcomes. Most closely related is Anderson and Sallee (2011), who study the effect of regulatory fuel-economy standards on automakers. Their approach greatly influenced the development of our model and estimation. To apply this framework in our setting, we extend it in two important respects. First, we relate the static model to a fully dynamic model that accounts, among other things, for adjustment costs in loophole use and regulatory uncertainty. Second, we relax the assumption that the incremental costs of using the loophole are perfectly observable to an econometrician. We derive and estimate bounds on these costs (and hence on shadow costs of regulation) using firms' actions that reveal their reservation prices.

We also contribute to a burgeoning macro-finance literature studying the costs of finan-

[5]Theoretically, the costs could be large if the fragile capital structure is necessary for bank operation (Calomiris and Kahn, 1991; Diamond and Rajan, 2001). For opposing arguments see Admati, DeMarzo, Hellwig, and Pfleiderer (2011) and Admati and Hellwig (2013). Other recent theories suggest that higher equity may increase bank value by improving incentives (e.g., Holmstrom and Tirole, 1997; Allen, Carletti, and Marquez, 2009; Mehran and Thakor, 2011).

[6]Much of the related literature study periods of economic downturns (see, e.g., Peek and Rosengren, 1997; Brun, Fraisse, and Thesmar, 2013).

cial constraints for financial intermediaries. Most related is Koijen and Yogo (2013), which estimates the shadow cost of statutory reserve regulation for life insurers. The main advantage in adapting the Anderson and Sallee (2011) loophole approach to banking is that it avoids fully specifying the competitive equilibrium, as well as estimating demand elasticities, markups, and other unobservables. Due to the complexity of the banking industry this would involve multiple limiting assumptions and significantly increase the data requirements. Our estimates could be used to calibrate macroeconomic models with financial frictions (He and Krishnamurthy, 2013, 2012; Brunnermeier and Sannikov, forthcoming).[7]

The paper proceeds as follows. Section 2 describes the institutional setting and the model. Section 3 describes our data. Section 4 verifies necessary conditions for estimation. Section 5 reports the main results. Section 6 verifies the robustness of our estimates to alternative assumptions. Section 7 presents extensions (dynamics, effects on lending and interest rates, and the costs of capital requirements in Europe). Section 8 concludes.

2 Institutional Setting and Model

We begin by describing the regulatory environment in which banks operate and the regulatory treatment of ABCP liquidity guarantees. Given this context, we then model a bank maximizing its profits subject to a regulatory capital constraint and derive the marginal benefit from using the ABCP loophole to relax the capital constraint. We then derive the optimal use of the loophole and provide a simple expression for the shadow costs of the regulatory capital constraints in terms of observable variables.

Of course, the shadow cost is equalized across different margins and could potentially be revealed by other optimal choices. The main advantage of the present approach is that it avoids estimation of a large number of demand elasticities, markups, and production cost parameters. At an interior solution (that is, when the fraction of assets in the ABCP conduits is strictly between 0 and 1), the ratio of the marginal cost to the marginal benefit of exploiting the loophole reveals the shadow cost of regulatory capital requirements, and we can remain agnostic about the details of the equilibrium and key parameters that we do not observe (Anderson and Sallee, 2011).

[7] See Gertler and Kiyotaki (2010) and Brunnermeier, Eisenbach, and Sannikov (2013) for recent surveys.

2.1 Regulatory Environment

2.1.1 Capital Ratios and Risk-Weighted Assets

A bank holding company in the United States reports three separate capital ratios to its regulator. Upon observing the ratios and other banking characteristics, regulators decide whether the bank is well-capitalized, adequately capitalized, or under-capitalized. A bank is considered *well-capitalized* if all of the following are true:[8]

1. Core capital (leverage) ratio $\equiv$ Tier 1 (core) capital as a percent of average total assets - ineligible intangibles $\geq$ 3% to 5% depending on its composite CAMELS rating;

2. Tier 1 risk-based capital ratio $\equiv$ Tier 1 (core) capital as a percent of risk-weighted assets $\geq$ 6%; and

3. Total risk-based capital ratio $\equiv$ Total risk-based capital as a percent of risk-weighted assets $\geq$ 10%.

Banks that are not well-capitalized face greater regulatory scrutiny, are less likely to get regulatory approval for acquisitions, and cannot accept brokered deposits without an explicit approval from the regulator. If a bank fails to be *adequately-capitalized*,[9] it faces stronger regulatory sanctions, such as the need to submit a plan to the regulator detailing the ways the bank would increase its capital. Failure to submit, receive an approval, and execute such a plan would trigger further sanctions. Further deterioration in the ratios can change the status of the bank to *significantly under-capitalized* or *critically under-capitalized*, and may eventually result in a takeover by the federal deposit insurance corporation.

A central feature of bank capital regulation that plays an important role in our analysis is the risk-weighting of banks' assets for the purposes of calculating capital ratios. To calculate risk-weighted assets, the bank applies a risk weight w_j to each asset of a risk group j on its balance sheet. There are four major risk weights: 0%, 20%, 50%, and 100%.[10] For example, cash holdings get a risk-weight of zero, claims conditionally guaranteed by OECD central governments 20 percent, residential mortgages 50 percent, and standard assets 100 percent. Off-balance sheet items are converted into balance sheet equivalents by further multiplying their risk-weighted value by a conversion factor β smaller than 1.[11]

[8] See 12 CFR Part 225.

[9] Tier 1 risk-based ratio falls below 4%, total risk-based ratio below 8%, or tier 1 leverage ratio below 4%.

[10] Some assets, such as securitized assets get weights between 20% and 200% depending on credit ratings.

[11] To simplify notation, we omit the asset-specific subscript on β except when we describe the conversion factor for ABCP assets.

2.1.2 Regulatory Treatment of Liquidity Guarantees to ABCP Conduits

Here, we briefly describe the structure of ABCP conduits and the regulatory treatment of their liquidity guarantees, highlighting the issues most relevant for our analysis. We refer interested readers to Acharya, Schnabl, and Suarez (2013) and the follow-up literature, as well as industry publications (e.g., Bate, Bushweller, and Rutan, 2003) for a detailed discussion of conduit structure and relevant regulation.

Liquidity guarantees to ABCP programs were given a special regulatory treatment. In particular, for such guarantees, the conversion factor was $\beta_{ABCP} = 0\%$ until September 2004, and 10% until January 2010 when this loophole was closed. In other words, before September 2004 banks could completely ignore these guarantees when calculating their risk-based capital ratios. After June 2004, the risk-weights were applied to 10% of these assets.[12]

The equity tranche of such "special purpose vehicles" could potentially require banks to hold extra capital. However, in practice, ABCP conduits were almost entirely financed with commercial paper and with very little equity. According to Bate et al. (2003), "ABCP conduits issue high levels of debt with virtually no equity." Moreover, "the party that owns the equity of an ABCP conduit [...] will vary by the corporate form of the conduit and the jurisdiction. In the U.S. it is typically a subsidiary of a specialized management company; in European transactions it is often a charitable trust." This description is consistent with a case study analyzed by Acharya and Schnabl (2010) of an ABCP conduit, which "only had a sliver of equity, around $36 million, or 30 basis points of its asset value."

Acharya, Schnabl, and Suarez (2013) show that this special treatment of liquidity guarantees to ABCP conduits is equivalent to securitization without risk transfer. That is, the bank providing the guarantee (usually 102% of asset value) effectively assumes all of the risk in the loans made by the conduit, even though the guarantees are conditioned on the assets performing well.[13] The reason is that investors in the short term ABCP (e.g. money-market mutual funds) provide only short-term financing to the conduit and would stop rolling over the debt long before the assets stop performing. At this point the liquidity provider would be required to step in, repay the maturing debt and take possession of the assets. Therefore, for all practical purposes, conduit assets were equivalent to on-balance sheet loans. In fact, the role of ABCP conduits in bypassing the regulation was widely recognized at the time.[14]

[12] See Final Rule issued July 20, 2004 by the federal banking and thrift regulatory agencies on Capital Requirements for Asset-Backed Commercial Paper Programs, which became effective September 30, 2004. For the 2010 revision, see Federal Register Vol. 75 No. 18 dated January 28, 2010.

[13] On top of liquidity guarantees, some conduits have "credit enhancements" designed to protect investors from default of the underlying assets. As we discuss in Section 4, however, credit enhancements have little relevance for our analysis; they cover a small part of the assets, and tend to be provided by the sponsors.

[14] Consider these quotes from Moody's (Bate, Bushweller, and Rutan, 2003): *"The programs are typically structured and accounted for by the banks as an off-balance sheet activity. If the bank were to provide a direct*

Had the regulation recognized this fact, the conversion factor for ABCP liquidity guarantees would have been $\beta_{ABCP} = 100\%$, as it has been since 2010. We next turn to modeling the bank's behavior given the regulatory requirements and the presence of the ABCP loophole.

2.2 Banks

We assume that banks operate in an oligopolistic environment and maximize profits by choosing the interest rate r_j they charge on loans of risk class j, capital ratio k, and share of assets they move off the books using liquidity guarantees to ABCP conduits $\theta \in [0, 1]$

$$\max_{\mathbf{r},k,\theta} \Pi = \sum_j [r_j - c(k) - \alpha\theta] \, q_j(\boldsymbol{r}) - I(\theta > 0) \times F, \tag{1}$$

subject to a regulatory capital constraint

$$K(\boldsymbol{q}, k, \theta) \geq \sigma. \tag{2}$$

Banks are constrained to have a regulatory capital ratio K at least as large as the capital requirement(s) σ.[15] The bank must pay a fixed cost F to set-up an off-balance sheet ABCP conduit before it can exploit the loophole. Once set-up, an ABCP conduit can contain assets of any kind, thus fixed-costs are shared among assets of different risk classes. We therefore assume the fraction of loaned capital used to fund ABCP conduits θ is constant across risk classes (we relax this assumption in the robustness section).

The bank faces a residual demand function $q_j(\mathbf{r})$, and its total assets are denoted by $Q = \sum_j q_j$. Total assets of each risk class, q_j, include on and off balance sheet assets, as well as the liquidity guarantees:

$$q_j = a_j + \beta_j b_j + l_j$$

where a_j are on-balance sheet assets, b_j are off-balance sheet assets (other than ABCP

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corporate loan, even one secured by the same assets, it would appear on the bank's balance sheet as an asset and the bank would be obligated to maintain regulatory capital for it. An ABCP program permits the Sponsor (i.e., the commercial bank) to offer receivable financing services to its customers without using the Sponsor's balance sheet or holding incremental regulatory capital."

"The rise of bank risk-based capital standards around the world in 1988 imposed significant costs on Support Providers in fully-supported ABCP programs. Risk-based capital standards required Support Providers to hold regulatory capital for the entire face amount of ABCP outstanding under certain ABCP programs because the support facility has been viewed as a "direct credit substitute" and not merely as a loan commitment. The increased costs associated with providing direct credit substitutes motivated banks to find a more cost effective way to structure ABCP programs. The result was the creation of partially-supported ABCP programs, which were eligible for more advantageous treatment under the risk-based capital standards, and could continue to offer funding at attractive rates to Sellers."

[15] Here, for clarity of exposition, we ignore the fact that there are three different capital ratios, and address them in detail below.

liquidity facilities) converted into credit equivalent amounts by the conversion factors β_j (not to be confused with risk-weights w_j).[16] Liquidity guarantees for ABCP conduits l_j are assumed to be a fixed proportion of total actual assets, i.e. $l_j = \theta q_j$ for all j.

The marginal cost of bank capital $c(k)$ is increasing in its capital ratio k. This assumption is consistent with bankers beliefs, and captures frictions that make equity capital costly relative to debt financing from the bank's perspective, such as taxes, underpriced deposit insurance, a demand for money-like securities, or market segmentation (Gorton and Pennacchi, 1990; Dang, Gorton, and Holmstrom, 2012; Stein, 2012; DeAngelo and Stulz, 2013).

The capital ratio k is the economic capital ratio of the bank, which is potentially different from the regulatory ratio K. The wedge between k and K is meant to capture ways banks can change their risk profiles while holding constant their regulatory ratios. The exact ways in which k and K differ plays no role in most of our analysis, since, as we show below, k does not enter our shadow cost expressions. We find it useful, however, to think of k as the ratio that matters for bank investors and other market participants (as opposed to regulators). A difference between k and K, then, means that the market is not misled by the different regulatory loopholes that the bank may be using.

The incremental cost per dollar of assets financed through the ABCP loophole is α. It is positive, reflecting the assumption the banks would face a lower marginal cost of financing were they to absorb these assets on their balance sheets. In other words, while ABCP conduits do not change the bank's economic capital ratio k, moving assets into shadow banking is costly. Measuring α empirically requires an estimate of the bank's marginal cost of capital. In the empirical section, we validate the assumption that α is positive and examine the sensitivity of our results to various alternatives assumptions about α.

Summing over risk classes, we get total balance-sheet assets $A = \sum_j a_j$, off-balance sheet converted assets $B = \sum_j \beta_j b_j$, and total liquidity guarantees $L = \sum_j l_j$. Differently from total actual bank assets Q, risk-weighted assets are

$$Q^r = \sum_j w_j \left(a_j + \beta_j b_j + \beta_{ABCP} l_j\right) = \left[1 - \left(1 - \beta_{ABCP}\right)\theta\right] \sum_j w_j q_j, \tag{3}$$

where the second equality holds only under the assumption that θ is constant across risk classes. Denoting by $E1(k)$, $E2(k)$, and $E3(k)$ the tier 1, tier 2, and tier 3 capital raised

[16] To calculate total economic assets q_j one must make off-balance sheet notional amounts comparable to loans on the balance sheet. We rely on regulatory conversion factors, which are perhaps imperfect, but also the best we can do with reported data (banks report only credit equivalent amounts $\beta_j b_j$ rather than notional amounts b_j for derivatives). An extreme conversion factor of $\beta = 0$ would ignore such exposures, while a conversion factor of 1 would clearly overstate out-of-the-money derivative exposures.

by the bank, the leverage ratio is

$$K^{T1Lev}(\mathbf{q}, k, \theta) = \frac{E1(k)}{A} = \frac{E1(k)}{Q(1-\theta) - B}, \tag{4}$$

tier 1 risk-based capital ratio is

$$K^{T1RB}(\boldsymbol{q}, k, \theta) = \frac{E1(k)}{Q^r} = \frac{E1(k)}{\left[1 - (1 - \beta_{ABCP})\theta\right]\sum_j w_j q_j}, \tag{5}$$

and total risk-based capital ratio is

$$K^{TotRB}(\boldsymbol{q}, k, \theta) = \frac{E1(k) + E2(k) + E3(k)}{\left[1 - (1 - \beta_{ABCP})\theta\right]\sum_j w_j q_j}. \tag{6}$$

Equations (4), (5), and (6), substituted into equation (2), provide expressions for the regulatory capital constraints faced by banks. These expressions determine the marginal benefit of exploiting the loophole to relax the constraint.

Having defined the competitive and regulatory environment for banks, we can now solve for optimal usage of the ABCP loophole and derive the shadow costs of banking regulation.

2.3 Optimal ABCP Shares Reveal the Shadow Cost

Banks choose the share of assets to hold in ABCP conduits. Focusing only on this decision, the Lagrangian for the maximization problem is

$$\mathcal{L} = \sum_j \left[r_j - c(k) - \alpha\theta\right] q_j(\boldsymbol{r}) - I(\theta > 0) \times F + \lambda Q\left[K(\boldsymbol{q}, k, \theta) - \sigma\right] \tag{7}$$

where λ is the shadow price per dollar of the capital constraint. By the envelope theorem, the effect of a marginal increase in σ on profits is simply this Lagrangian multiplier. The first-order condition for banks with an interior ABCP share of assets $\theta \in (0, 1)$ can be solved for the Lagrangian multiplier. Therefore the shadow cost per dollar of the regulatory capital constraint as revealed by optimal use of the loophole is simply

$$-\frac{\partial \mathcal{L}^*}{\partial \sigma}\frac{1}{Q} = \lambda = \frac{\alpha}{K_\theta} \text{ if } \theta \in (0, 1). \tag{8}$$

Intuitively, given a bank's optimal capital structure, interest rates and the use of the loophole, a higher marginal cost of exploiting the loophole (α) or a smaller marginal benefit (K_θ) imply the bank faces a higher cost of complying with the capital constraint.

Note that our analysis for each constraint is valid only if it binds. Expression (8) still holds, however, even if banks' capital ratios are not exactly equal to the constraint, but rather they keep a constant buffer from σ, which, as we show below, is supported by the data. If a bank does not use the loophole to relax the constraint ($\theta = 0$), then α/K_θ is an upper bound on the shadow cost faced by the bank.

For each binding constraint, we can calculate its shadow cost from (8). Specifically, from the leverage ratio constraint our estimate of the shadow cost per dollar of assets is

$$\lambda^{T1Lev} = \frac{\alpha}{K^{T1Lev}} \times \frac{A}{Q}, \tag{9}$$

from the tier 1 risk-based capital ratio constraint it is

$$\lambda^{T1RB} = \frac{\alpha}{K^{T1RB}} \times \frac{Q^r}{(1-\beta_{ABCP})\sum_j w_j q_j}, \tag{10}$$

and similarly the shadow cost implied by the bank's total risk-based capital ratio is

$$\lambda^{TotRB} = \frac{\alpha}{K^{TotRB}} \times \frac{Q^r}{(1-\beta_{ABCP})\sum_j w_j q_j}. \tag{11}$$

The shadow costs of binding constraints are positive, and zero for non-binding constraints. The expressions below are exact when only one constraint binds for each bank, and provide upper bounds if more than one constraint binds.[17]

All else equal, the shadow cost is larger for banks with smaller ratios K, and smaller discounts from loophole usage applied to its asset base in each regulatory ratio. To gain some intuition, consider two hypothetical banks with the same leverage ratio K^{T1Lev} and the same marginal cost α: a "simple" bank with all its assets on the balance sheet, and a "complex" bank with only a small fraction of its economic assets on the books. The marginal benefit that increasing θ has on the leverage ratio is just $K^{T1Lev} \times 1$ for the simple bank, while, for the complex bank, the marginal benefit would be the larger $K^{T1Lev} \times \frac{Q}{A}$. Since the simple bank pays the same incremental cost α, *despite* the fact that its marginal benefit at the optimum is small, its perceived shadow cost of the capital constraint must be larger.

2.4 Discussion

Before proceeding to the empirical implementation, we discuss two features of our approach not explicitly mentioned above. First, λ measures each bank's marginal compliance costs in equilibrium. This may appear limiting, since regulatory changes are likely to apply to

[17] The multiple constraints version of (8) is $\sum_s \lambda^s K^s_\theta \leq \alpha$, giving an upper bound for the shadow cost of constraint j, $\lambda^j \leq \frac{\alpha - \sum_{s \neq j} \lambda^s K^s_\theta}{K^j_\theta} \leq \frac{\alpha}{K^j_\theta}$ since for each constraint s, $\lambda^s \geq 0$ and in our setting $K^s_\theta \geq 0$.

the whole industry. We note, however, that if regulatory tightening of capital requirements substantially change the interest rates or capital structure for competing banks, then the marginal loss in profits the bank would suffer would likely be *smaller* than we estimate. Intuitively, it would harm competitors and weaken the effect on the individual bank.[18]

Second, the envelope theorem argument holds constant the endogenous choice variables (interest rates, capital structure, ABCP share), to estimate the first-order effect on profits of a small increase in capital requirements. In this sense, our estimates share the limitation of studies that use linear regressions to estimate treatment effects—we cannot directly analyze very large changes in capital requirements. Such analysis would require a structural estimation, and is outside of the scope of this paper.

This limitation, however, is mitigated by the following considerations. First, perhaps the biggest advantage of our methodology is to avoid the assumptions needed for a full structural estimation, and, as we discuss in the introduction, our work can be used to inform structural models, rather than replace them. Second, the changes to capital requirements currently contemplated and implemented by policy-makers are small, and our framework is directly informative about the costs of such reforms. Third, the effect of a substantial tightening would include second-order effects from choice variable adjustments. Since these choices would be made to mitigate the loss in profits, our estimates, again, would likely overstate the total effect.

3 Data

3.1 ABCP Conduits

Our data on ABCP programs was provided to us by Moody's Investor Service. It includes information on the asset composition, ratings, and liquidity guarantees of most programs from 2002 to 2012. The data consists of distinct datasets. The first dataset contains monthly data on bank-sponsored multi-seller, security arbitrage, and hybrid programs. It includes information on the total amount of assets in the conduit and the composition of assets over time, such as industry, credit rating, and deal size (but not the identity of the seller). It also provides information about the sponsoring institution and the list of entities that provide liquidity guarantees to the conduit, as well as their relative share in the provision of the guarantees. Finally, the data covers other contractual features of the conduit, such as credit enhancements and the limit on the size of conduit assets.

The second dataset provided to us by Moody's has quarterly coverage of the ABCP

[18]See Anderson and Sallee (2011) for an extensive discussion of this issue.

universe, and includes (in addition to the conduits described above) single-seller conduits, Structured Investment Vehicles (SIV), and loan-backed conduits. While this dataset covers a larger part of the ABCP universe and has complementary information, such as the type of support given to the conduit (full vs. partial), it does not provide an asset-level breakdown or the list of liquidity providers.[19] We match these datasets by conduit name and date to create an exhaustive database of ABCP conduits, their sponsors, and liquidity providers.

Figure 1 tracks the size of the ABCP market and compares the coverage of our data with the aggregate numbers provided by the Federal Reserve. The figure shows that our conduit-level data tracks well and exceeds in coverage the publicly-available aggregate numbers. Also, as has been well-documented elsewhere (e.g., Covitz, Liang, and Suarez, forthcoming), the figure shows the increase of the ABCP market prior to the crisis, as well as its eventual collapse. The decline is likely due to both the recession and the diminished incentive to use ABCP financing after the liquidity guarantees loophole was closed in the aftermath of the financial crisis. We focus on the pre-crisis period to estimate the shadow cost of capital regulation in normal times.

Table 1 provides summary statistics on ABCP sponsors and the underlying conduit assets. Panel (a) shows the number of sponsors, liquidity providers, total assets and total liquidity provisions. The entries "Liquidity Providers" and "Total Liquidity Provisions" focus on conduits relevant for the loophole—ABCP programs covered by liquidity guarantees. This category excludes conduits whose paper was covered by weaker guarantees, such as SIVs, CDOs, and ABCP with extendible guarantees. The table shows these statistics separately for three categories of sponsors: US Banks, Non-US Banks, and Non-banks ("Other").

Consistent with the predominant use of liquidity guarantees to bypass capital requirements, the table shows that while non-banks were active participants in the ABCP market as a whole, they provided only about five percent of the total dollar value of liquidity guarantees.

Panel (b) of Table 1 takes a closer look at the quality of assets held by the conduits covered by liquidity guarantees. ABCP conduits held securitized and unsecuritized assets. For unsecuritized assets, our data includes the credit ratings of the sellers of these assets. For securitized assets, the table shows the credit ratings of these assets. The table shows that ABCP conduits were comprised predominantly of assets that would be considered high quality at the time.

While liquidity guarantees covered, on average, 102% of assets, some conduits also had conduit-level "credit enhancements." We find (untabulated) that these credit enhancements covered 6.8% of the assets on average. Moreover, for an average (median) conduit 71%

[19] See Acharya, Schnabl, and Suarez (2013) for a detailed description of this second dataset.

(100%) of these credit enhancements were letters of credit provided by the *sponsor itself.*[20] This supports the premise that for the conduits in our analysis banks that provided liquidity guarantees to ABCP conduits bore the risks of conduit assets.

3.2 Bank Holding Companies

After correcting Moody's identification of sponsoring banks for mergers, owner-subsidiary links, name changes, and other such issues, we merge Moody's data with the financial information on bank holding companies from the Consolidated Financial Statements (FR Y-9C) filed quarterly with the Fed.

We find 18 bank holding companies that provided liquidity guarantees to ABCP programs during our sample period (2002Q4 - 2007Q2). While few in numbers, as we discuss in detail below, these institutions hold about half of aggregate US bank assets in our sample. Table 2 compares these bank holding companies with the rest of the banking universe. ABCP sponsoring banks are on average much larger than non-sponsors, and all three of their regulatory capital ratios are smaller.

3.3 Economic Significance of ABCP-sponsoring Banks

Since there are relatively few banks that choose to exploit the ABCP loophole, it is important to examine the relevance of these banks for the banking sector, and, in particular, for the debate on tightening the capital constraints regulation. Figures 2a and 2b examine the relevance of the banks captured by our methodology to the economy and the capital regulation debate. Figure 2a shows the fraction of the total banking assets held by these banks.[21] Domestic sponsors held on average 50 percent of all banking assets in the United States. Adding the assets of banks owned by foreign ABCP-sponsoring banks (and thus also provide liquidity to conduits) increases this number to 63 percent. Therefore, while relatively few in number, ABCP sponsors appear to be a significant part of the banking sector.

Further evidence that ABCP sponsors are central to the current regulatory debate is provided in Figure 2b, which takes a closer look at the differences in the distribution of bank size between the ABCP sponsors and other banks. The difference in the size distributions is striking. There appears to be little overlap in the size distribution between domestic

[20] See Bate, Bushweller, and Rutan (2003) for a detailed discussion of these arrangements. Major categories of credit enhancements are: Credit Asset Purchase Agreements, Cash Collateral Account, Letter of Credit, and Surety Bond.

[21] This number is calculated each quarter for banks that actively provided liquidity guarantees to ABCP conduits (a bank that participated in the ABCP market, but had not provided liquidity guarantees would not be included in the calculation).

ABCP sponsors and other banks.[22] As policy-makers focus their attention to the correlation between the size of assets of individual banks and the risks they pose, it appears that our sample of liquidity guarantors represents well the banks currently at the epicenter of the regulatory debate: large banks that capture a significant share of the industry.

4 Preliminary Analysis: Conditions for the Empirical Applicability of the Model

Empirical applicability of the model in section 2 relies on two important conditions. First, we have derived the shadow costs of capital requirements from the first-order condition for the share of ABCP assets of a profit-maximizing bank. For these first-order conditions to hold with equality, the bank cannot be in a corner solution—that is, we cannot identify the shadow costs using our methodology for banks that do not exploit the loophole, or for banks that shift all of their portfolio of assets to ABCP conduits. For banks that do not exploit the loophole, the ratio of the marginal cost of reducing capital ratios using the loophole to its marginal benefit α/K_θ gives an upper bound on the compliance costs for such banks (see (8)). Second, we assume that the quantities demanded $q_j(\boldsymbol{r})$ do not depend directly on the share of assets placed in conduits. That is, borrowers care about the interest rates charged by the bank, but do not care about the way banks finance their loans.

This suggests that in order to use equations (9), (10), and (11) to calculate the shadow costs of capital requirements, we need to verify that the following sufficient conditions are satisfied in our data:

C1 Constrained banks must exploit the liquidity guarantee loophole to comply with capital regulation (i.e. $K \approx \sigma$ implies $\theta > 0$).

C2 Constrained banks must not finance their entire operation with ABCP conduits (i.e. $\theta \in (0, 1)$).

C3 Marginal borrowers must not value loans financed with traditional deposits differently from those financed with ABCP conduits.

We verify C1 and C2 empirically below. Although our data does not allow us to verify C3 directly, the assumption seems plausible since the value of a dollar to the borrower is the same regardless of whether the loan is held by an ABCP conduit or by the bank itself. In Section 6.1 we show that if conduits created value in addition to their regulation-avoidance

[22] While the sample of US banks that do not sponsor ABCP conduits includes some extremely large banks, we find that most of them are banks owned by foreign ABCP sponsors.

role, our results *overestimate* the the shadow cost of regulation. Our results would still hold if in practice, for whatever reason, some borrowers prefer that their loan would be held by the bank itself, or, alternatively by an ABCP conduit, as long as many marginal borrowers are indifferent between the source of financing.

4.1 Constrained Banks Exploit but Do Not Exhaust the Loophole

Figure 3 contrasts the distribution of capital ratios for banks that use the loophole with the distribution for banks that do not. The distribution in the whole banking sector is consistent with Berger, DeYoung, Flannery, Lee, and Oztekin (2008) who show that banks hold capital buffers on top of what is required by law, as a protection in volatile environments. The behavior of ABCP sponsors, however, exhibit additional interesting patterns. Consistent with condition C1, ABCP sponsors are bunched up much closer to the regulatory "well-capitalized" threshold. While they appear more constrained than the rest, these banks seem to keep a buffer of about 2% from the threshold. This is most apparent in the case of the tier 1 risk-based capital—a constraint usually considered the most binding of the three.

A closer look into individual cases clarifies the evidence from the aggregate distributions. Figure 4 shows the regulatory ratios for the participating banks as they were reported to the regulators, and the adjusted ratios that would be reported if the ABCP assets were held on the books. This figure reveals several interesting facts. First, the buffers appear to be remarkably stable over time.[23] Second, while some banks kept larger buffers in some ratios, they were constrained by other ratios, in which they keep stable buffers. For example, State Street held a larger buffer relative to risk-based constraints, but it has been constrained by the leverage ratio and its usage of the ABCP loophole appears to have allowed it to relax that constraint. Overall, we find that banks appear to have targeted the minimum requirement for being "well-capitalized," plus a stable buffer of 2 percentage points.[24]

Why do banks keep stable buffers on top of the requirements, and what does this mean for our estimation? While we are not aware of a written rule that requires a specific buffer, it appears that regulators—explicitly or implicitly—require banks to hold a certain amount of capital in excess of the minimum ratios.[25] This interpretation is complementary to the

[23] While few banks (e.g., Fifth-Third) had sharp adjustment to their capital ratios, they kept the ratios at a stable level before and after the adjustment. Mellon appears to be the only exception to the rule of the stable buffer, as its capital ratios grew throughout the sample period. Interestingly, this bank held the smallest fraction of its assets in the ABCP conduits.

[24] Other papers have found evidence that commercial banks target a fixed leverage ratio. See, e.g., Adrian and Shin (2010), who find that leverage growth is insensitive to asset growth.

[25] Consider the following excerpt from the comments made in response to a multi-agency proposed rule to increase capital requirements: "Some commenters stated that they manage their capital so that they operate with a buffer over the minimum and that examiners expect such a buffer. These commenters expressed

precautionary motives studied in the prior findings (e.g., Berger, DeYoung, Flannery, Lee, and Oztekin, 2008), but it appears to be especially important in our sample of the largest banks. In terms of our estimation, as we discussed above, fixed buffers do not alter the shadow cost expression (8), because the level of required ratios (σ) does not play a role in our analysis, and as long as it is stable, our methodology goes through.[26]

Finally, condition C2 requires that banks would not exhaust the loophole. In line with this condition, Figure 5 shows that the average ratio of total assets financed with ABCP with liquidity guarantees θ is about 2.5 percent, and a median is 2 percent . This fraction is quite stable over the pre-crisis period and across banks with a standard deviation of 0.26 percentage points. To preserve space we do not report shares of individual banks here, but we find that the maximum share over the whole sample was 13 percent (Zions).

To further verify condition C2, we study the composition of assets in the ABCP conduits. Moody's data includes detailed information about the types (and industry affiliation) of assets held in the conduits. This allows comparing dollar amounts of various types of assets held in the conduits with the amounts reported in FR-Y9C forms. If the fraction of assets of each type held in the ABCP conduits is between zero and one, this would imply that condition C2 holds both on the bank and the asset type level.

We aggregate Moody's data to broad asset type categories in order to compare ABCP assets to the bank data in the FR-Y9C forms. These categories (and their percent of total ABCP assets) are: Consumer Loans (18.9%), Commercial Loans (18.8%), Residential Mortgages (14.2%), Trade Receivables (11.2%), CBO&CLO (11.7%), Credit Card Receivables (10.7%), Other (14%).[27]

Panel (b) of Figure 5 shows the average and the median shares of ABCP assets for the asset types that we could match to the numbers in the FR-Y9C forms: credit cards, consumer loans, commercial loans, and residential mortgages. Consistent with C2, the shares are well below one. In unreported tests, we verified that with the exception of State Street, this holds for each individual bank throughout our sample.

concern that examiners will expect even higher capital levels, such as a buffer in addition to the new higher minimums and capital conservation buffer (and countercyclical capital buffer, if applicable)." (page 95 of Final Rule issued July 2, 2013 by the federal banking regulatory agencies on Regulatory Capital.)

[26] One could interpret the buffers as evidence that banks are unconstrained by capital requirements. We find this implausible, given the bunching of these banks at a fixed distance from the constraint, and given the background of the regulatory debate. Of course, in this case the shadow cost of a non-binding constraint is zero. Therefore, under that explanation we are overestimating the shadow cost of regulatory capital requirements for banks.

[27] Commercial Loans include the following Moody's asset type classifications (with the percentage of the total in the parentheses): Commercial Loans (47.5%), Equipment Loans and Leases (24%) and Commercial Mortgage Loans (20%), Floorplan Finance (6.1%) and Commercial Paper (1.9%). Within Consumer Loans, the subcategories are Auto Loans and Leases (56%), General Consumer Loans (26%), and Student Loans (17%).

A potential concern is that unobserved features, uncaptured by these tests, could make some loans incompatible with ABCP conduits. If banks exhausted the loophole by financing all compatible assets through ABCP, Condition C2 would be violated. While we cannot directly rule this out, we find this highly unlikely given the large size of the banks in our sample, and the small size of ABCP conduits relative to the rest of the bank. Moreover, ABCP conduit assets have close substitutes. The underlying assets of many commercial bank-sponsored ABCP programs come from the same master trusts as existing term asset-backed securities (ABS) deals and are identically structured (Bate, Bushweller, and Rutan, 2003, p.6 and p.20). Pre-crisis, many banks securitized loans, and then turned around and reinvested in AAA-rated tranches of the very same securities. This alternative means of regulatory arbitrage was advantages because much like ABCP, highly rated ABS received preferential regulatory capital treatment (Acharya and Richardson, 2009). Since such securitizable assets were simultaneously financed through both ABCP and term-ABS transactions, banks could increase their use of the loophole by issuing less term-ABS and holding the assets in their ABCP program, or by purchasing rated ABS securities indirectly through the ABCP conduit.

Table 1 shows that 22 percent of ABCP conduit assets in our sample are securitized and rated assets, suggesting the scope for these large banks to increase their loophole use is nontrivial. Figure 6 shows that the amount of ABS outstanding is larger than ABCP outstanding reported in Figure 1, and that even the $250 billion of ABS issued annually pre-crisis is large enough that substituting assets from ABS to ABCP conduits could make for a large difference in loophole use. Banks might not find it optimal to do so if ABS provides a superior marginal source of financing, but such behavior is consistent with an interior optimal input mix, as opposed to a strict quantity restriction.

A remaining potential concern is that investors and rating agencies may have been worried that liquidity guarantees have not provided full insurance against poor performance of conduit assets. Since, in this scenario, banks would not completely bear all the risks of ABCP assets, they would have less of an incentive to properly screen and monitor these assets. Such concerns of investors and rating agencies could limit the fraction of assets bank could place in ABCP conduits.

In hindsight, liquidity guarantees performed ”as advertized” during the crisis and sponsoring banks ended up absorbing the assets. Acharya, Schnabl, and Suarez (2013) find that not a single conduit using credit or liquidity guarantees defaulted by December 2008. In order to gauge the ex ante attitudes of market participants toward this arrangement, we examined Fitch, Moody's, and S&P ABCP ratings criteria, and interviewed Moody's representatives.[28] We found that bank-sponsored multi-seller conduits typically had over 100% liquidity guarantees. Reading Moody's documentation, we found that analysis of a fully-supported program was based on the financial strength of the support provider, rather than on the quality of the assets. This information was confirmed by Moody's representatives. Fitch states that it "*may not require a review of transactions entered into by conduits that are fully supported or 'wrapped' by program-wide credit enhancement or liquidity providers. Under such circumstances, the risk characteristics of the underlying transactions become less critical to the rating process because the fully supporting credit enhancement or liquidity facility is ultimately relied upon for the full repayment of CP.*" We conclude that liquidity guarantees provided by banks were considered full insurance against poor performance of the underlying conduit assets.

To summarize the evidence presented thus far, US banks that provided liquidity to ABCP conduits represent a significant part of the banking universe. Since these banks are also constrained by regulatory capital requirements (more so than the rest of the banking industry), and exploit the ABCP loophole to relax the constraints, they represent a tenable sample for measurement of the shadow costs of capital regulation.

5 Estimating the Shadow Cost of Capital Requirements

5.1 Estimating Expressions

We use expressions (9), (10), and (11), to estimate the shadow costs of regulatory capital requirements. For risk-based ratios, which take a similar form, the empirical counterpart for the shadow cost of bank i in quarter t is

$$\lambda_{it} = \frac{\alpha_t}{K_{it}} \times \frac{Q_{it}^r}{(1-\beta_{ABCP})\sum_j w_j q_{ijt}}, \tag{12}$$

where K_{it} can be replaced by either the tier 1 or the total risk-based ratio. The shadow cost implied by the bank's leverage ratio when this constraint binds is

$$\lambda_{it} = \frac{\alpha_t}{K_{it}^{T1Lev}} \times \frac{A_{it}}{Q_{it}}. \tag{13}$$

To get a better idea of the economic magnitude of these costs, we can use each bank's total actual assets to compute its shadow cost of a $d\sigma$ increase in each regulatory capital

[28] See Fitch criteria report "Asset-Backed Commercial Paper Explained" dated Nov. 8, 2001, Moody's "The Fundamentals of Asset-Backed Commercial Paper," dated Feb. 3, 2003, and S&P's "Global Asset-Backed Commercial Paper Criteria," dated Sep. 29, 2005.

requirement $s \in \{Tier1\, RB,\, Tier1\, Lev,\, Tot\, RB\}$ as

$$d\Pi_{it} = -\lambda_{it}^{s} \times Q_{it} \times d\sigma. \tag{14}$$

5.2 Measuring the Marginal Benefit of the Loophole

Most inputs into these expressions are publicly reported by banks in their Consolidated Financial Statements. We take regulatory risk-weighted assets Q_{it}^{r} and capital ratio K_{it} as reported by the banks. The conversion factor β_{ABCP} applied to off-balance sheet guarantees to provide liquidity to ABCP facilities is zero prior to September 2004. After 2004 it is 10 percent until this loophole was closed in January 2010.

In order to construct the summation $\sum_j w_j q_{ijt}$ we need to apply risk weights to balance sheet and off-balance sheet assets, as well as to the liquidity guarantees. The first two are reported in schedule HC-R of the quarterly reports. Assigning risk weights to the ABCP assets is less straightforward because this information is not reported. We calculate our main estimates under the assumption that the distribution of risk weights in the conduits mirrors the distribution of risk weights of the rest of the assets, as reported by the bank. We show in the robustness section that our benchmark estimates are not sensitive to this assumption.

5.3 Measuring the Incremental Cost of the Loophole

An important component of the expression for the shadow cost of capital requirements is α. In the theoretical model, it has a straightforward interpretation: the incremental marginal cost of financing assets through ABCP conduits. Empirical measurement of α, however, is not trivial, as it involves both the cost of ABCP financing, and the cost a bank would incur if the ABCP assets were held on the books. Since neither of these quantities is observable, a direct measure of α has to rely on simplifying assumptions.

For this reason, we use two distinct approaches. First, we use a direct measure of α to estimate the shadow cost of capital requirements. We verify that while our results are robust to the possibility of an upward bias in α, they are sensitive to a downward bias. In other words, if significant costs of ABCP financing are not captured in our proxy for α, our estimates of shadow costs would be too small.

Our second approach eliminates the need to estimate α directly, and instead places bounds on this cost. The advantage of using bounds is that the estimates of the shadow cost are fully robust to measurement error in α. The downside, is that this precludes us from having a point estimate of the shadow costs. Therefore, it is important to verify that the bounds are informative, in that they produce a relatively narrow range of estimates, and we return to this issue below.

5.3.1 Direct Measures of α

As a starting point for our measurement of α we take the tax-adjusted difference between the 30 day AA ABCP rate and the 30 day AA financial commercial paper (CP) rate as reported by the Fed:

$$\alpha_t = \left(r_t^{ABCP,30d} - r_t^{CP,30d}\right)(1-\tau), \tag{15}$$

where the corporate tax rate is assumed to be $\tau = 35\%$.

The ABCP rate is an obvious measure of the direct financing costs for assets placed in ABCP conduits. Using this measure, we implicitly assume that additional nonfinancial *marginal* costs, such as legal and management expenses, would be similar if the assets were held on the books.

The assumption that financial CP represents the closest alternative source of capital for ABCP assets if they were placed on the books is perhaps less intuitive. We choose this rate as a starting point following conversations with industry participants, who indicated that bank-issued (financial) commercial paper rate is commonly considered an alternative cost of financing for similar assets. Therefore, this assumption is in line with our goal of estimating the cost of compliance as perceived by the banks. Obviously, it is hard to assign specific financing costs to individual assets on the bank's balance sheet. But, given that ABCP programs in our sample have liquidity guarantees by their sponsoring banks in excess of 100%, the "asset-backing" of ABCP is irrelevant. Economically, both CP and ABCP are forms of short-term debt issued directly by banks, which expose similar money market investors to similar risks.

In the robustness section, we vary our measure of α by replacing $r_t^{CP,30d}$ with alternative rates. Note that assuming higher alternative costs would *decrease* α, and therefore decrease the estimate of shadow cost. Therefore, to get a conservatively high estimate of α, we replace $r_t^{CP,30d}$ with a lower overnight Fed Funds rate.

Since we do not observe individual bank-level ABCP rates, we take the average spread between 30 day AA ABCP and 30 day AA financial CP as reported by the Fed. Regulators, and researchers at the Fed, have access to detailed bank-level data, and could therefore use our methodology to obtain more accurate bank-level shadow cost estimates. Using equations (12) and (13), this can be done by simply replacing our measure of alpha with a different number, without the need to replicate the rest of the analysis. Note, however, that since much of our empirical analysis deals with averages and aggregate estimates, much of this heterogeneity is averaged out.

Figure 1 shows that this spread was quite stable before the crisis. Until the second quarter of 2007, the spread was 4 basis points on average with a standard deviation of 0.9bp, after which it widened substantially.

5.3.2 Bounds for α

Potential additional costs of ABCP financing could include legal, management and accounting expenses, rating agencies fees, and other transaction costs. Moreover, in a multi-period setting, dynamic considerations such as adjustment costs in loophole usage could add to these unobservable costs. In Section A.2 we derive an upper bound for α in a general dynamic model. However, the simple static framework delivers an identical result while making it easier to see the intuition.

At first glance, the possibility of unobserved incremental costs of the loophole implies that the true shadow cost of capital requirements could be arbitrarily high. To get a better idea of a potential magnitude of these costs, we rewrite the first-order condition of the constrained bank as

$$\alpha_{it} = \frac{K_{\theta,it}}{K_{k,it}} c'\left(k_{it}\right), \tag{16}$$

Equation (16) shows the link between α_{it} and the marginal effect of the equity ratio on the cost of capital ($c'\left(k_{it}\right)$), through the data on loophole usage (θ_{it}). Importantly, this relationship holds for any incremental cost of the loophole α_{it}. Next, note that $\frac{K_{\theta,it}}{K_{k,it}}$ is a number below 1, which in the data ranges from 0.007 to 0.084, with a mean of 0.048. Therefore α falls between $0.007\underline{c}'$ and $0.084\overline{c}'$, where $\underline{c}'$ and $\overline{c}'$ are the smallest and the largest $c'\left(k\right)$. This is reassuring, because we learn that α is bounded by the sensitivity of the cost of capital to equity ratios.

While this exercise shows that α cannot be arbitrarily high, it highlights an identification challenge: both sides of equation (16) are unobserved. The equation merely shows that *given* a measure of $c'\left(k_{it}\right)$, our data allow identifying α_{it}. But in practice, $c'\left(k_{it}\right)$ is hard to estimate, as manifested by widespread disputes about this quantity. In fact, an important advantage of our revealed preferences approach is that it does not rely on the estimation of $c'\left(k\right)$. Therefore, we need to find a bound for α without estimating $c'\left(k\right)$, and using $r_t^{ABCP,30d} - r_t^{CP,30d}$, or any other spread.

Using the definition of the weighted average cost of capital we get

$$c'\left(k\right) = r_d\tau + \left(r_e - r_d\right) + k\frac{\partial r_e}{\partial k} + \left(1-\tau\right)\left(1-k\right)\frac{\partial r_d}{\partial k} \tag{17}$$

This expression is familiar from the cost of capital accounting. Imposing a weak assumption that $k\frac{\partial r_e}{\partial k} + (1-\tau)(1-k)\frac{\partial r_d}{\partial k} \leq 0$, gives us an extreme upper bound for α:[29]

$$\alpha_t \leq \frac{K_{\theta,it}}{K_{k,it}}\left[r_{e,it} - (1-\tau)\, r_{d,it}\right]. \tag{18}$$

Importantly, we do not suggest that $[r_e - (1-\tau)\, r_d]$ should be taken seriously as an estimate of $c'(k)$, as it ignores the effect of leverage on the cost of equity. Recent discussion of this issue can be found in Admati et al. (2011), who explain why this is an inflated estimate, and document that it is often used as a basis for the opposition to higher capital requirements. In our setting this bound is useful precisely because it is inflated. Since we are interested in the shadow costs as perceived by the banks, we do not want to rule out, a priori, any opinions on the cost of capital, as extreme as they may be. Therefore, it is important that our estimates do not rely on models that preclude a large impact of equity on the cost of capital (e.g., Modigliani and Miller, 1958). Instead, our estimates rely on revealed preferences and the features of the ABCP loophole, allowing us to to accommodate wide ranges of $c'(k)$ (and, hence, α).

While bounds resolve the issue of the measurement error in α, this approach does not provide a point estimate of the shadow cost. Therefore, an important characteristic of bounds is their informativeness—i.e., whether they provide a relatively narrow range of alternative estimates. To enhance the informativeness of the bound in (18), we use the fact that our sample consists of a relatively homogenous group of the largest banks during the period before the recent financial crisis. This homogeneity implies that they likely faced similar borrowing costs. Assuming that banks in our sample faced uniform incremental costs of the loophole, the revealed preferences argument implies that the cost was equal to the willingness to pay of the bank with the lowest reservation price.[30]

$$\alpha_t \leq \min_i \left\{\frac{K_{\theta,it}}{K_{k,it}}\left[r_{e,it} - (1-\tau)\, r_{d,it}\right]\right\} \tag{19}$$

Note that the bound still uses an extreme estimate of $c'(k)$, and therefore even under some heterogeneity in spreads it would likely overestimate the shadow cost.

[29] For $k\frac{\partial r_e}{\partial k} + (1-\tau)(1-k)\frac{\partial r_d}{\partial k} \leq 0$ to hold, it suffices that the costs of equity and debt are non-increasing in the capital ratio. See, e.g., Berger and Bouwman (2013) and Mehran and Thakor (2011) for recent evidence.

[30] The uniform spreads assumption holds, for example, if banks face an elastic supply of ABCP financing at a single market price. In Table 8 in the Appendix we verify that borrowing rates, as measured in the LIBOR survey, are remarkably homogeneous across banks, and virtually all variation is explained by time effects. Our main analysis above is consistent with this assumption since we only observe the aggregate spread reported by the Fed each period. As we mentioned above, regulatory agencies have access to bank-level data on the ABCP rates. This data can be used to gauge the importance of such heterogeneity and further sharpen the bound estimates.

An additional advantage of looking at the problem through equation (16) is that it clarifies the connection between our approach and the existing literature on the effect of capital regulation on the bank cost of capital. For example, in section (5.4.1) we compare our estimates to the special case of Modigliani and Miller (1958) model with taxes (see, e.g., Kashyap et al., 2010), where $c'(k) \approx r_d \tau$, which implies that $\alpha_{it} = \frac{K_{\theta,it}}{K_{k,it}} r_{d,it} \tau$.

5.4 Results

Table 3 presents the results of the benchmark estimation, where the marginal cost of the loophole is measured directly by the spread in equation (15). Columns (1) through (3) of Table 3 report time-series averages for each of the ABCP sponsoring banks in our pre-crisis sample for each of the three regulatory capital ratios. The average shadow costs per dollar assets across all banks and over time are precisely estimated at $\lambda^{T1RB} = 0.003$, $\lambda^{TotRB} = 0.0022$, and $\lambda^{T1Lev} = 0.0025$.

Columns (3) to (6) of Table 3 report the time-series averages of $d\Pi_{it}$ from equation 14—the dollar cost of a 1 percentage point increase in capital requirements. We find that such an increase in the tier 1 capital ratio would cost an average bank in our sample about \$14 million, or 0.4 percent of its annual profits. A similar increase in the other two ratios would cost about 0.3 percent of annual profits.

Table 4 presents the upper bounds of shadow costs (columns 1 through 3) and changes in profits (columns 4 through 6), calculated using bounds on the marginal cost of the loophole (equation (19)).[31] The upper bound on α from equation (19), used here was 12bp, compared to 2.5bp of the average ABCP spread used in Table 3. As a result, the upper bound of the effects on profits of a one percentage point increase in the ratios are \$63.2 million (tier 1 risk based ratio), \$45.2 million (total risk-based ratio), and \$63.4 million (tier 1 leverage ratio).

These estimates support the robustness of our baseline results to measurement issues with α. Although the upper bound for the shadow cost is 4.5 times higher than the baseline estimate in Table 3, it relies on an unrealistically high estimate of $c'(k)$ (8.7% on average). It is high not just because it ignores the endogeneity of r_e, but also because we take r_d to be equal to the 30-day financial commercial paper rate (with a mean of 2.7%). We choose this rate to get as high an estimate of shadow cost as logically possible. For example, we estimate (unreported) that using $r_d = 7\%$ as in Kashyap et al. (2010), results in an average

[31] To estimate $r_{e,it}$, we apply a CAPM regression to each bank's monthly returns using CRSP database for the period 1989-2012. The average beta is 1.099, consistent with previous literature. For FNB Omaha and Marshall-Ilsley which do not have CRSP data, we use the average estimate. For r_d, we use the financial commercial paper rate described above. The results are practically identical if we use the ratio of interest expense to liabilities (item BHCK4073 over quarterly average of BHCK2948).

decrease in profits of \$23.7 million.[32]

Figure 7 plots the aggregate effects on profits from Tables 3 and 53 over time. Panel (a) of Figure 7 plots the aggregate annualized cost of a 1 percentage point increase in each capital ratio for all ABCP sponsoring bank holding companies combined. These quarterly estimates are rather stable over the pre-crisis sample, ranging from \$83 million and \$334 million, across all ratios.[33] An average aggregate effect is \$220 million for tier 1 ratios, and \$160 million for the total risk-based ratio. Panel (b) of Figure 7 constructs a time series aggregate for the upper bound of the aggregate effect, from Table 4. The quarterly aggregates range between \$540 million and \$1.3 billion over time, across three ratios.

Since our methodology provides a point estimate of shadow costs only for banks that participate in the loophole, estimates in Tables 3, 4, and Figure 7 are calculated using only these banks. While the focus of this paper is the population of the largest banks in the economy, rather than the whole banking universe, it is useful to examine a possible extrapolation of our estimates for the whole banking sector.

Assuming that non-participating banks faced similar marginal costs of the loophole as the participating banks, we can recover an upper bound for the shadow cost of non-participating banks from equation (8), which implies that $\lambda \leq \frac{\alpha}{K_\theta}$. While the assumption that non-participating banks faced similar ABCP rates is strong—non-participating banks could face higher costs of ABCP financing—note that this extrapolation also assumes that all banks were constrained by regulation, regardless of how far they were from the constraint. As we saw in Figure 3 and Table 2, most non-participating banks had significantly more capital than required by law, which makes this an over-estimation of the true costs of regulatory constraints for the majority of the sector.

Figure 8 presents the result of this extrapolation. Panel (a) shows the aggregates for the entire banking sector over time, calculated using the direct measure of α. According to this extrapolation, a 1 percentage point increase in the capital ratios would decrease the aggregate profit of the sector by about \$370 million on average for tier 1 risk-based ratio. For the leverage ratio and total risk-based ratio the upper bounds are, on average, \$357 million and \$268 million. The estimates range between \$150 and \$550 million, across all ratios. Panel (b) of Figure 8 repeats the exercise using the upper bound for α. The quarterly aggregates are between \$1 and \$2.4 billion. The time series averages are \$1.6 billion (tier 1 risk-based and leverage ratios), and \$1.2 billion (total risk-based ratio).

Interestingly, comparing the aggregate results in Figure 8 to Figure 7, we find a relatively modest increase in the aggregate costs. For example, the average effect for the tier 1 risk-

[32] Such r_d assumes that ABCP financing replaces long-term debt on the bank's balance sheet.

[33] The "spikes" in the figure are due to variation in the ABCP spread (α).

based ratio increased from \$200 million to about \$370 million (Panel (a) in each figure). This is despite the fact that Figure 7 is based on more than 2,500 banks, compared to 18 banks in Figure 7. This may appear surprising, even in light of the modest shadow cost estimates for the participating banks. Recall, however, that an average participating bank was about a hundred times larger than an average non-participating bank. As a result, adding non-participating banks does not add as much to the aggregate estimates of the shadow costs, as would be implied by their numbers.

We focus on the pre-crisis period because it reveals the shadow cost of capital regulation during normal times when adjustment costs play a minor role. During the crisis, banks would probably reduce their exposure to ABCP conduits quickly, if they could do so cheaply. Mid-crisis, adjustment costs play a larger role, which could be interesting to study, but beyond the scope of the current paper. With this qualification in mind, at the height of the crisis (fourth quarter of 2007), the aggregate shadow cost of a ten percentage point increase in the tier 1 risk based ratio was around \$58 billion. Intuitively, relaxing capital constraints in times of stress is valuable because the shadow costs are relatively large.

5.4.1 Comparison with Prior Estimates

Prior literature provides estimates of the increase in the cost of capital (dc) due to an increase in regulatory capital ratios. Most closely related is Kashyap, Stein, and Hanson (2010) who derive their estimates under the assumptions of the Modigliani-Miller model with taxes (M&M). They estimate that a 10 percentage point increase in capital ratios would raise banks' cost of capital by 25-45 basis points.[34] These estimates are much larger than our upper bound of 3 basis points, and it is useful to understand the sources of the difference.

In our setting, we can impose M&M assumptions by replacing $r_{e,it} - r_{d,it}(1-\tau)$ with $r_d \tau$ in equation (19). Table (5) estimates the shadow cost and the corresponding effects on profits under this restriction for the three capital ratios. These resulting estimates are smaller than our benchmark numbers in Tables (3) and (4). Under M&M, a 1 percentage point increase in required ratios decreases profits by \$6.2 million, \$4.4 million, and \$5.92 million for tier 1 risk-based, total risk-based, and leverage ratios.

Applications based on M&M rely on several important assumptions. In particular, two assumptions that are most relevant for our setting are: (i) the only reason for the increase in the cost of capital is the loss of the debt tax shield, and (ii) banks have to comply by increasing the equity ratio (i.e., they cannot avoid the capital charge). The major difference

[34] Other estimates are available in the literature. Baker and Wurgler (2013) estimate the same policy change would increase the cost of capital by 60-90 basis points. See also a recent contribution by Gornall and Strebulaev (2013), who calibrate a supply chain model of banking and find that such policy change would increase the cost of credit by 15 basis points.

in our approach is that we avoid making these assumptions and infer the costs from banks' actions. While we view this as an important advantage, we do not examine which one of these assumptions fails. It could be the case that higher capital ratios would have a positive effect, mitigating the effect of the lost tax shield, as implied by some banking theories.[35] Alternatively, as we mentioned in the introduction, banks could diminish the effect of regulation using other tools, such as shifting their assets toward lower regulatory risk weights or using other loopholes.

While estimates based on M&M provide an important benchmark of what would be the increase in the cost of capital if assumptions (i) and (ii) held in practice, our estimates show how much of this increase would persist once banks act to mitigate the costs and realize some additional benefits of equity financing.

6 Robustness

6.1 Unobservable Benefits of ABCP Financing

So far in our analysis, regulatory constraints were the only reason for the use of ABCP conduits: the loophole allowed banks to decrease their costs by increasing leverage. It could be the case, however, that the ABCP arrangement created some additional value for banks and borrowers. Access to ABCP market could potentially have changed the supply curve as well as the demand curve. The supply-side effect could happen if banks could reduce their costs by using ABCP to finance loans. The demand could change if marginal borrowers valued the fact that their loans were warehoused in ABCP conduits.

Our conversations with the market participants revealed that, if anything, the supply-side effect was in play. While all market participants—including bankers—agreed that ABCP conduits were a way to circumvent the regulation, some have indicated that ABCP was sometimes viewed as a way to reduce banks' cost of lending.[36]

To model this, we assume that the ABCP financing reduces the banks' marginal cost by γ, and rewrite the Lagrangian as:

$$\mathcal{L} = \sum_j \left[r_j - \left(c\left(k\right) - \gamma\theta_j\right) - \alpha\theta_j\right] q_j\left(\mathbf{r}\right) - I\left(\theta_j > 0 \text{ for any } j\right) \times F + \lambda Q\left[K\left(\boldsymbol{q}, k, \theta\right) - \sigma\right],$$

[35] See, e.g., Allen, Carletti, and Marquez (2009); Mehran and Thakor (2011).

[36] See, also Bate, Bushweller, and Rutan (2003, p. 15)—Moody's description of the ABCP market—for a similar argument. In our interviews we learned that a potential source of these cost savings was that ABCP provided money market mutual funds with an opportunity to circumvent diversification requirements, which may have contributed to their willingness to accept a lower rate of return on their ABCP investments.

which leads to the following expression for the shadow costs of capital requirements:

$$\lambda = \frac{\alpha}{K_{\theta_j}} - \frac{\gamma}{K_{\theta_j}} \tag{20}$$

where the first term on the right is our benchmark estimate. Equation (20) shows that as long as $\gamma > 0$, our benchmark estimates *overestimate* the shadow costs of capital constraints.[37]

6.2 Alternative Definitions of a "Binding Constraint"

Thus far, our estimates of the shadow costs have not distinguished between banks with different proximity to the regulatory threshold. Essentially, we have treated all banks that provided liquidity guarantees to ABCP conduits as constrained by the capital regulation. The evidence provided in Section 4 suggests that this is not a restrictive assumption. There is, however, some heterogeneity in the proximity of banks to the regulatory thresholds (Figure 3 and Table 2). Therefore, we would like to examine the behavior of our estimates as we limit our sample to bank-quarter observations that are closer to the constraint. That is, we are interested in the stability of our estimates when we omit observations that are further away from the constraint.

The estimates of shadow costs remain quite stable when we change the definition of the binding constraint. In Figure 9 we plot the mean, median, and the confidence intervals around the mean of the shadow costs for different subsamples, defined based on the proximity to the constraint. The estimates increase slightly as we shrink the sample, but overall remain stable and robust to alternative definitions of a constrained bank.

6.3 Risk Weighting of Conduit Assets

We do not observe the true risk weights of conduit assets, and our derivation of the shadow costs assumed, for simplicity, that the share of assets placed in the ABCP conduits is constant across risk weights. This assumption allows us to average out some uncertainty regarding the risk weights of conduit assets. We now examine the sensitivity of our results to alternative assumptions about risk weights.

The basic intuition on the potential importance of risk-weighting assumptions can be seen already in the benchmark model (equation 12). Smaller risk weights of ABCP assets in the denominator of the shadow cost expression would increase the estimated cost. Intuitively, if a bank places assets with low risk weights in the conduit, the constraint must be costly for

[37]It has to be the case that $\gamma < \alpha$, otherwise banks would opt for a corner solution of $\theta = 1$.

it, since these assets contribute less to relaxing the constraint.[38]

To properly explore the issue, we relax the assumption that all risk weights have the same fraction of assets placed in ABCP and derive the shadow cost equations for a model where each risk weight can get its own share. The Lagrangian for the bank's maximization problem in this extended model becomes:

$$\mathcal{L} = \sum_j \left[r_j - c\left(k\right) - \alpha\theta_j\right] q_j\left(\boldsymbol{r}\right) - I\left(\theta_j > 0 \,\text{for any } j\right) \times F + \lambda Q\left[K\left(\boldsymbol{q}, k, \theta\right) - \sigma\right] \tag{21}$$

where ABCP shares can vary across risk-weight classes j, and the rest of the model assumptions follow those in Section 2. The shadow cost becomes $\lambda = \frac{\alpha q_j}{QK_{\theta_j}}$ when $\theta_j \in (0, 1)$. With this adjustment, the shadow cost estimated from loophole use of risk weight j assets is:

$$\lambda_j^{T1Lev} = \frac{\alpha}{K^{T1Lev}} \times \frac{A}{Q} \tag{22}$$

$$\lambda_j^{T1RB} = \frac{\alpha}{K^{T1RB}} \times \frac{Q^r}{\left(1 - \beta_{ABCP}\right) w_j Q} \tag{23}$$

$$\lambda_j^{TotRB} = \frac{\alpha}{K^{TotRB}} \times \frac{Q^r}{\left(1 - \beta_{ABCP}\right) w_j Q}. \tag{24}$$

Assuming that the fixed costs of an ABCP conduit are shared among j's (i.e. the bank only pays to set up a conduit once), the only reason to have assets of more than one type j in the conduit is if their incremental cost α_j is different. If banks use the same α for all j (as our empirical implementation effectively assumes), the model implies that banks would prefer to use ABCP conduits for asset classes that relax the constraint the most (highest K_{θ_j}). An asset class that provides the largest net benefit in terms of relaxing the constraint would be exhausted ($\theta_j = 1$), before the next most beneficial asset class is used, and so on. In this scenario, there is only one valid first-order condition per constraint, the one for an interior $\theta_j \in (0, 1)$. To take this extended model to data, we make a conservative assumption that all conduit assets get a particular weight, and then examine what happens to our estimates when we change this risk weight.

Figure 10 presents the results for tier 1 risk-based ratio (Panel a) and total risk-based ratio (Panel b). The shadow costs estimates for the leverage ratio remain the same as in the benchmark model, since its expression is identical. The solid black line in each panel is the estimated effect on profits from the extended model for a range of risk weighing assumptions.

[38] The estimates from the benchmark model (unreported) remain virtually identical even when we make an extreme assumption that all ABCP assets carried the risk weight of 20%. This is not surprising since the fraction of assets in ABCP conduits relative to the rest of the bank's assets (θ) was about 3%, which mitigates the effect of risk weighting assumptions.

Adjacent to the line, for comparison, is the benchmark estimate from Table 3. Relative to the benchmark estimates, these estimates range between 50% smaller if most assets have high risk-weights to 150% larger for the lowest risk-weight. Since the truth likely rests somewhere in between these extremes, we find it reassuring that our benchmark estimates do as well. In practice, the actual risk-weights are known to bank regulators, who could use our methodology to calculate the shadow costs more accurately.

7 Extensions

In this section we examine several extensions to our framework. In section 7.1 we discuss the effect of capital requirements on lending and interest rates. Section 7.2, we set up a multiperiod model to study how dynamic considerations, such as adjustment costs and expectations of the financial crisis, may affect our inference. Section (7.3) replicates our baseline results for European banks.

7.1 Effects on Lending and Interest Rates

We can use our estimates to make a back-of-the-envelope calculation of the impact of increasing regulatory capital ratios on lending and interest rates faced by borrowers. For simplicity, focus on a special case of our model with a single asset class $q = Q$. We can see from the total derivative of profits with respect to σ,

$$\frac{d\Pi}{d\sigma} = -\lambda Q_0 = \frac{\partial \Pi}{\partial \theta}\frac{d\theta}{d\sigma} + \frac{\partial \Pi}{\partial Q}\frac{dQ}{d\sigma} + \frac{\partial \Pi}{\partial r}\frac{dr}{d\sigma} + \frac{\partial \Pi}{\partial c}\frac{dc}{d\sigma}, \tag{25}$$

that the effect of tighter capital requirements on profits emanates from four potential sources: a change in loophole use θ, credit demand Q, lending interest rates r, or funding costs c.

7.1.1 Interest Rates and Cost of Capital

To get an estimate of the effect of an increase in regulatory ratios on the cost of capital (c) and interest rates (r), we first examine the last term on the right-hand side of (25). Expanding the last term, we get $\frac{dc}{d\sigma} = c'(k)\frac{dk}{d\sigma}$. From the first-order condition with respect to k, we have $c'(k) = \lambda \frac{\partial K}{\partial k}$. We assume that the bank remains constrained under the new regulation, so that $\frac{dK}{d\sigma} = 1 = \frac{\partial K}{\partial k}\frac{dk}{d\sigma} + \frac{\partial K}{\partial r}\frac{dr}{d\sigma} + \frac{\partial K}{\partial \theta}\frac{d\theta}{d\sigma}$, where the last two terms are likely nonnegative.[39] Therefore, $1 \geq c'(k)\frac{1}{\lambda}\frac{dk}{d\sigma}$ and hence

$$\frac{dc}{d\sigma} \leq \lambda, \tag{26}$$

which implies that the effects on the cost of bank capital are bounded by the shadow cost. Intuitively, this upper bound would be reached if the bank was forced to raise equity to comply with tighter regulation, without changing its lending or loophole use.

Focusing, for brevity, on the tier 1 risk-based capital ratio, let $\lambda = 0.003$ as in Table 3. This implies that a ten percentage point increase in the regulatory ratio would increase the cost of capital for an average bank by at most 3 basis points. This calculation also places an upper bound on the increase in r, which is likely bounded from above by the increase in the cost of capital, i.e., $dr \leq dc \leq 3$ basis points.

7.1.2 Lending

Turning to the effect on the quantity of lending (dQ), we rearrange (25) to express the effect of increased capital requirements as a fraction of assets

$$\frac{dQ}{Q} = \frac{-\lambda - \left(\frac{dr}{d\sigma} - \frac{dc}{d\sigma}\right)}{r - c} \times d\sigma, \tag{27}$$

where we omit the effect of loophole use on the markup. As a rough proxy for the markup $r - c$ we can use the bank's annualized interest income minus interest expense divided by its assets, which, in our sample is on average around 0.02. Therefore, in order to calculate the total effect of increased regulatory ratios on lending, we need dc (for which we now have an upper bound), and dr, which captures the total increase in interest rates.

While estimation of demand elasticity is beyond the scope of this paper, we can estimate the change in lending dQ's implied by different assumptions about dr, for different estimates of dc. For example, given $dc \geq 0$, assuming that $dr = 0$ could underestimate the effect on lending, while assuming $dr = dc$ could overestimate the effect, since it would imply that the bank passed all of the increase in costs to borrowers. If we make the latter extreme assumption, equation (27) simplifies to $\frac{dQ}{Q} = -\frac{\lambda}{r-c} \times d\sigma$, which implies that a ten percentage point increase in the tier 1 risk-based regulatory capital ratio would lead to a decline of about $-\frac{0.003}{0.02} \times 0.1 = -1.5\%$ of bank assets.

[39] From (4), (5), and (6), we expect that holding k constant, and specializing to $E1(k) = kQ(r)$, the effect of higher interest rates on the numerator in percentage terms is similar to the effect on the denominator so that the second term is quite small ($\frac{\partial K}{\partial r} \approx 0$). Furthermore, the loophole works to increase capital ratios ($\frac{\partial K}{\partial \theta} > 0$), and we expect its usage to increase in response to an increase in capital requirements ($\frac{d\theta}{d\sigma} > 0$).

7.2 Loophole Use in a Dynamic Model

A potential concern thus far not addressed, is that the loophole could have dynamic consequences for the bank. Estimates derived from the static model could be biased if the bank's choice of θ_{it} affects its future profits, which influences the bank's current decisions. To fix ideas, consider a scenario where the bank anticipates that in the future it can be costly to wind down the ABCP conduit. Such adjustment costs could lead to lower loophole usage in a manner similar to unobservable costs analyzed in section (5.3.2). An econometrician, who does not observe these costs, might erroneously attribute the low usage of the loophole to small shadow costs of capital requirements.

To understand these concerns, we develop a dynamic extension of our model. Here we discuss the main results of this extension and the intuition behind them, and leave the full presentation of the model for the Appendix. We show that in a dynamic setting the shadow costs expression would have additional unobservable terms, which were not present in the static formulas. To assess the quantitative importance of these terms, we derive upper bounds on the shadow costs.

The notation of our dynamic model closely follows the static framework. Compared to the static framework, in the dynamic model, the Lagrangian multiplier on the period t regulatory capital constraint, λ_t, captures the per-period shadow cost of complying with capital requirements. Therefore, in the dynamic model, the shadow cost has exactly the same interpretation as in the static framework.

The effect of a permanent increase in σ on the bank's *present value* of profits discounted at rate $\delta \in (0, 1)$ is

$$-\frac{\partial V_t}{\partial \sigma}\frac{1}{Q_t} = E_t\left[\sum_{s=0}^{\infty}\delta^s \lambda_{t+s}\frac{Q_{t+s}}{Q_t}\right] = \frac{\lambda_t}{1-\delta\left(1+g\right)}, \tag{28}$$

where the first equality holds generally, and the second equality holds assuming a constant shadow cost per-dollar and a constant expected growth rate $g < \frac{1}{\delta} - 1$ of bank assets (i.e. $E_t Q_{t+s} = Q_t\left(1+g\right)^s$). Intuitively, (28) shows that if $\delta\left(1+g\right)$ is close to 1 then banks would strongly resist an increase in capital requirements. Indeed, the costs of a permanent increase in capital requirements accrue long after the rules are revised.

7.2.1 Adjustment Costs

Our dynamic model allows analyzing adjustment costs in loophole use. Under fairly weak assumptions we show that the first-order condition for loophole use θ_{t+1} chosen at time t

and held at start of time $t+1$ is

$$\lambda_t \leq \frac{\alpha_t + \kappa \left\{L_t - L_{t-1} - \delta E_t \left[L_{t+1} - L_t\right]\right\}}{\frac{\partial K_t}{\partial \theta_{t+1}}}, \tag{29}$$

where λ_t is the shadow cost per dollar, K_t is regulatory capital, $L_t \equiv \theta_{t+1} Q_t$ is the dollar amount of assets financed through the loophole, α_t is the incremental cost of capital raised at t and paid at $t+1$, and κ is the marginal cost of adjusting loophole use.

The difference between (29) and our benchmark estimator of shadow costs is in the second additive term in the numerator, which comes from the adjustment costs in the loophole use. As before, the shadow cost increases in $\alpha_t / \frac{\partial K_t}{\partial \theta_{t+1}}$, but now it is also larger if the adjustment cost κ is large and if current growth in loophole use is expected to revert next period.

Even before we examine the empirical importance of this friction, we can gain some intuition about its magnitude. Note that for a bank operating in normal times (steady state), adjustment costs would hardly affect its use of the loophole. This is because close to a steady state $L_t - L_{t-1} \approx \delta E_t \left[L_{t+1} - L_t\right]$. Figure (2a) shows that during our sample period (2002-2007) the fraction of assets held in the ABCP conduits was, on average, quite stable. Taking this as a suggestive evidence that banks were close to a steady state with respect to their loophole use, we find it unlikely that adjustment costs could have introduced a significant bias to our benchmark estimates.[40]

7.2.2 Loophole Use and the Expectation of a Financial Crisis

Another potential explanation for low use of the loophole, is that banks may have feared that the loophole would be closed by future regulation. In this case, they would have to bring the assets back onto their books. Another related issue is that banks could have been concerned that in the event of the market downturn they would incur additional costs due to their use of the loophole. Note that this is not about the need to issue equity during bad times. The reason is that banks bore the risks and enjoyed the benefits of the ABCP-financed assets, regardless of whether they were held in the conduits or on the books. The need to issue additional equity in a bad state of the world has to do with the banks' choice of leverage rather than with their choice of θ. Therefore, here we focus on the possibility that banks feared that θ could expose them to additional adjustment costs during the crisis.

Suppose that banks had expected a financial crisis to occur with a certain probability.

[40] We therefore find our benchmark estimates to be most accurate during normal times rather than crisis periods that could change substantially the bank's desire to exploit the loophole. This is one of the reasons for our focus on the pre-crisis period. As mentioned above, in our empirical work we examine the robustness of our estimates to general measurement errors in the numerator of expressions like (29).

Moreover, assume that they foresaw that in the event of the crisis, there would be a sharp rise in ABCP spreads (α_t), which would force banks to bring the ABCP assets on their books by purchasing the maturing commercial paper. We also allow the loophole to vanish at that time. Ex-post these expectations may seem plausible, since ABCP spreads were 30 times higher in 2008, though the loophole was officially closed only later in January 2010.

To analyze the the effects of such expectations, we introduce a state variable z_t, equal to one if a crisis occurs in period t. Conditional on normal times ($z_t = 0$), a bank expects the crisis to happen in the next period with the probability $\pi_t = Pr_t\{z_{t+1} = 1\}$, in which case the loophole closes. We maintain the assumption of a relatively constant growth in normal times ($L_t - L_{t-1} \approx \delta E_t[L_{t+1} - L_t | z_{t+1} = 0]$). We show in the Appendix that in this case the shadow costs revealed by loophole use during normal times becomes

$$\lambda_t = \frac{\alpha_t + \pi_t \kappa \delta E_t[L_{t+1} | z_{t+1} = 0]}{\frac{\partial K_t}{\partial \theta_{t+1}}}. \tag{30}$$

Therefore we could be underestimating the shadow cost of capital requirements if over our pre-crisis sample banks perceived a high probability of an impending crisis (π_t), they expected large adjustment costs associated with bringing existing conduit assets back on their balance sheets (κ), their discount rate of future cashflows was low (δ is high), and in addition they expected to finance a large amount of assets through ABCP in future normal times ($E_t[L_{t+1} | z_{t+1} = 0]$).

While ex-post, having witnessed the events of the recent financial crisis, one might find such a scenario plausible, we would like to gauge how important were these considerations for banks during our sample period.[41]

In the Appendix we derive upper bounds for the incremental loophole cost and, therefore, the shadow costs, using the bank's first-order condition with respect to its economic capital ratio k_{t+1}. It turns out the upper bound for the effective cost in the dynamic version,

$$\tilde{\alpha}_t \equiv \alpha_t + \kappa\{L_t - L_{t-1} - \delta \mathbb{E}_t[L_{t+1} - L_t | z_{t+1} = 0]\} + \kappa \delta \pi_t \mathbb{E}_t[L_{t+1} | z_{t+1} = 0], \tag{31}$$

is identical to the static one. Therefore the estimates of the following robustness section also place upper bounds on the shadow costs in a more general dynamic setting.

[41] Recent literature argues, to the contrary, that prior to the recent crisis market participants underestimated the likelihood of the market downturn (Gennaioli, Shleifer, and Vishny, 2012; Gerardi, Sherlund, Lehnert, and Willen, 2008; Coval, Jurek, and Stafford, 2009), suggesting that π_t was small. Gandhi and Lustig (2013) estimate that the unconditional probability of a banking crisis is 13%, and that it decreases during economic expansions.

7.3 European Banks

Since the first Basel accord, the regulatory treatment of banks in different participating countries has been roughly comparable, making our methodology applicable to non-US banks as well. Of particular interest are European banks who have been active in the ABCP market prior to the crisis (Acharya, Schnabl, and Suarez, 2013). Unfortunately, due to the low quality of the available international data, we excluded European banks from our main analysis. We find it instructive, however, to apply our methodology to the international data for two reasons. First, we would like to compare the magnitudes of our estimates using data from countries with a comparable regulatory regimes. Second, as shown in Figure 2, these banks have a significant US presence.

We obtain annual data on European banks from Bankscope. After identifying bank holding companies in Bankscope, and tracing owner-subsidiary relationships, we match the Bankscope data with the liquidity guarantors dataset from Moody's by bank holding company names. After dropping bank-year observations with missing or non-reconstructible capital ratios, we are left with 27 European bank holding companies (131 bank-year observations) that provided liquidity guarantees between 2002 and 2007.

Table 6 presents summary statistics for ABCP sponsoring European banks. Compared to US ABCP sponsors described in Table 2, European ABCP Sponsors are larger and more levered, as measured by the debt-to-assets ratio. The tier 1 leverage ratio requirement does not apply to European banks in this period. They do, however, maintain a roughly comparable regulatory tier 1 risk-based capital ratio.

Table 7 reports estimates of shadow costs and changes in profits for each of the 27 banks in this sample. The average shadow cost estimate for the tier 1 risk-based ratio is 0.0038 (compared to 0.003 for the US). This, and the fact that these banks are larger in size, results in a higher average effect on profits of $35 million (compared to $14.3 million for the US). Overall, the results for the foreign sample are similar to the results for the United States and show a modest effect of capital constraints on bank profits.

8 Conclusion

We estimate the shadow cost of capital requirements for banks' profitability using data on their participation in a costly loophole that helped them bypass the requirements by providing liquidity guarantees to asset-backed commercial paper conduits. We find that an increase in regulatory capital ratios would have modest effects.

The latest revision of US bank regulation increased capital requirements by small amounts.

Effective January 1, 2015, to be well-capitalized, a bank needs the same total risk-based capital ratio (10%) it needed during our sample; a 2 percentage point higher tier 1 risk-based capital ratio (8%); a 2 percentage point higher leverage ratio (5%); and a new requirement that common equity tier 1 capital ratio be 6.5 percent or more. Our estimates suggest its effect on bank profitability would be hardly noticeable. That said, several changes were made to the calculation of risk-weighted assets, and a counter-cyclical capital buffer was introduced.[42] Furthermore, regulators now require banks to satisfy capital requirements under stress scenarios, effectively increasing them in normal times. Our model is quite general and could incorporate such changes. Since bank regulation provides multiple ways for relaxing capital constraints, it would be interesting to compare our estimates to those implied by other loopholes, such as structured investment vehicles and letters of credit.

Our approach builds on recent advances in the industrial organization literature, and could be applied more broadly to study the effects of regulation in banking, and financial intermediation in general. Moreover, our estimates could be used to calibrate structural macroeconomic models with financial frictions.

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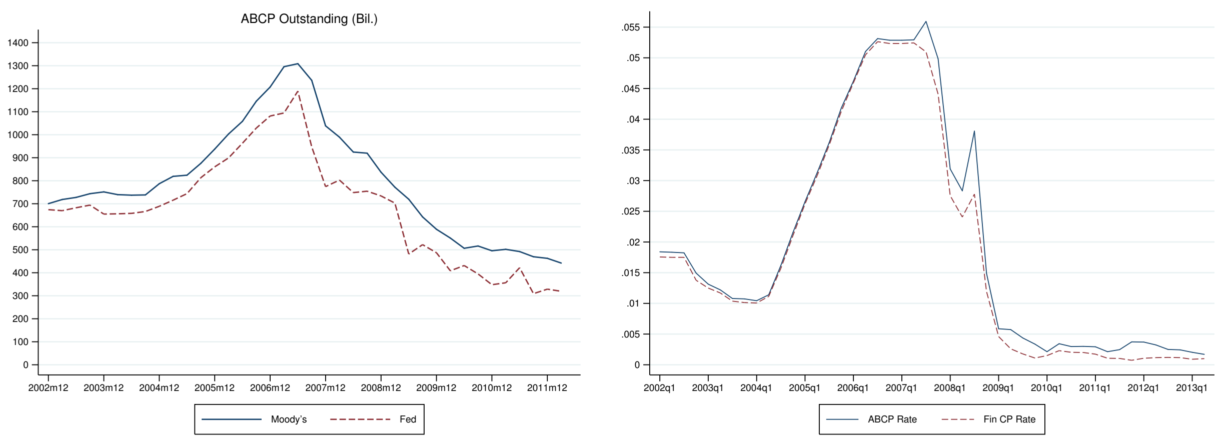
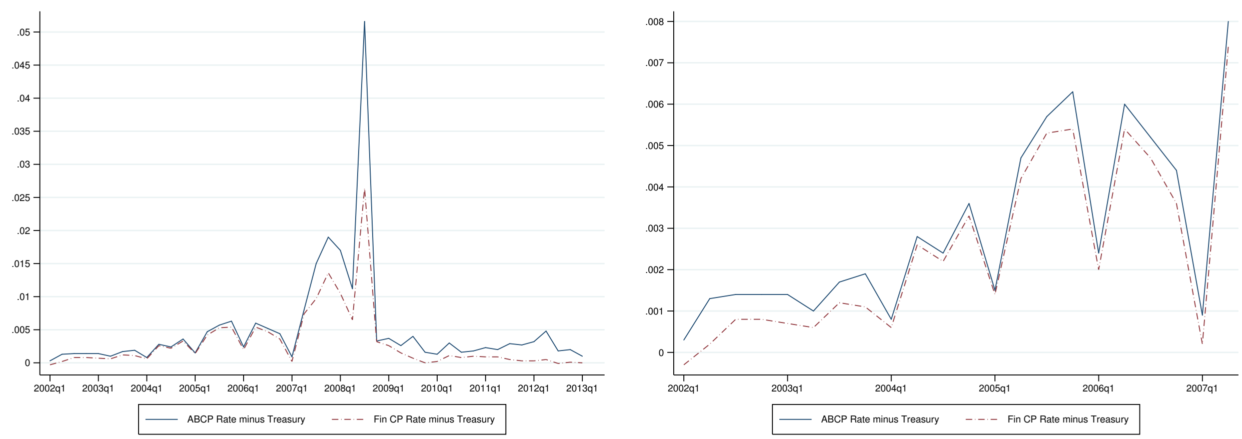
Figure 1: ABCP Market Over Time



(a) Market Size and Rates Over Time

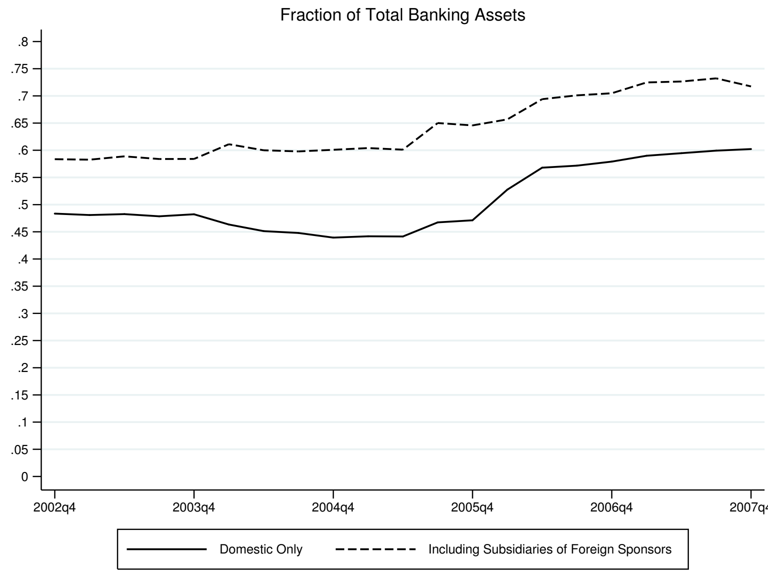


(b) ABCP and Financial CP Rates Net of Treasury

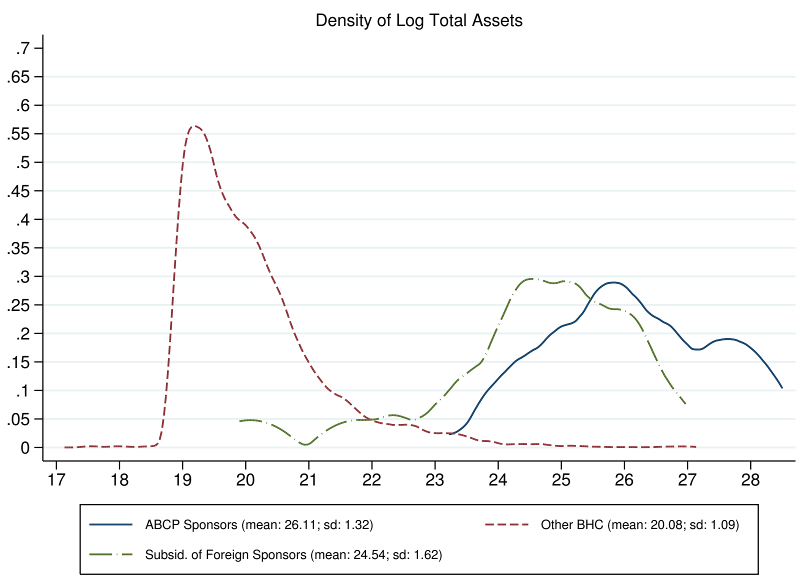
Notes: Left hand-side figure of Panel (a) shows total asset-backed commercial paper outstanding (excluding SIV) from quarterly and monthly reports by Moody's Investor Service (solid line) and reported weekly by the Fed (dashed line). Right hand-side figure pf Panel (a) shows the quarterly averages of top rated 30-day ABCP rates compared to the 30-day top-rated financial commercial paper rates. Panel (b) shows same ABCP and financial commercial paper rates spread over same maturity treasuries for the period 2002-2013 (on the left) and for the sample period studied in this paper (2002-2007Q2) (on the right).

Figure 2: Total Assets Held by ABCP Sponsors vs. Other Banks

(a) Fraction of Total Banking Assets Held by Participating Banks

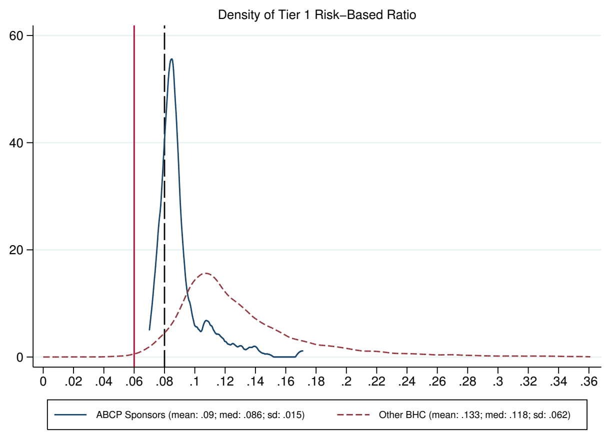


(b) Distribution of Log Total Assets

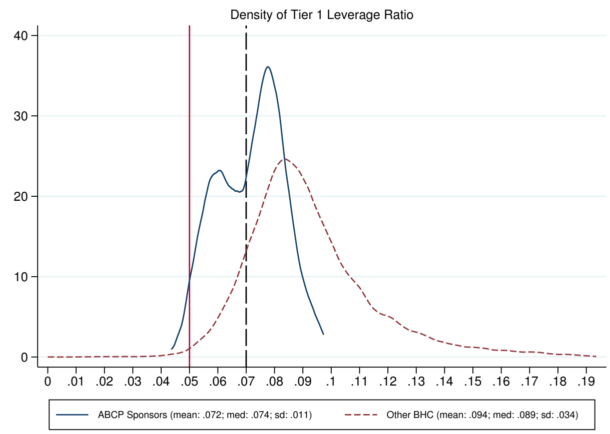


Notes: Figure 2a shows the fraction of total banking assets in the US held by bank holding companies ("BHC") that provided liquidity guarantees to ABCP conduits with (dashed line) and without (solid line) subsidiaries of foreign ABCP sponsors. Figure 2b reports kernel density estimates of the log assets for bank holding companies that provided liquidity guarantees to ABCP conduits (solid line), BHCs that were subsidiaries of foreign banks that provided such guarantees (long dashed line), and BHCs that did not participate in the ABCP market (dashed line). Only bank-quarters with non-zero liquidity guarantees were included in the sample of BHCs that provided liquidity guarantees. That is, observations for banks that participated in the ABCP market, but did not provide liquidity guarantees in a particular quarters were designated as "Other BHC." Sample period: 2002Q4-2007Q4. Kernel: Epanechnikov.

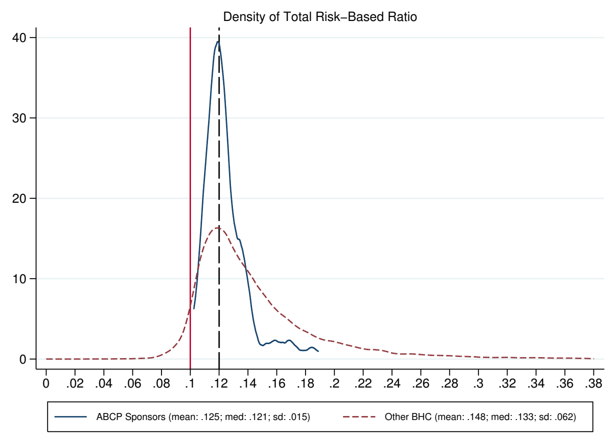
Figure 3: Distribution of Capital Ratios: ABCP Sponsors vs. Other Banks



(a) Tier 1 Risk-Based Ratio



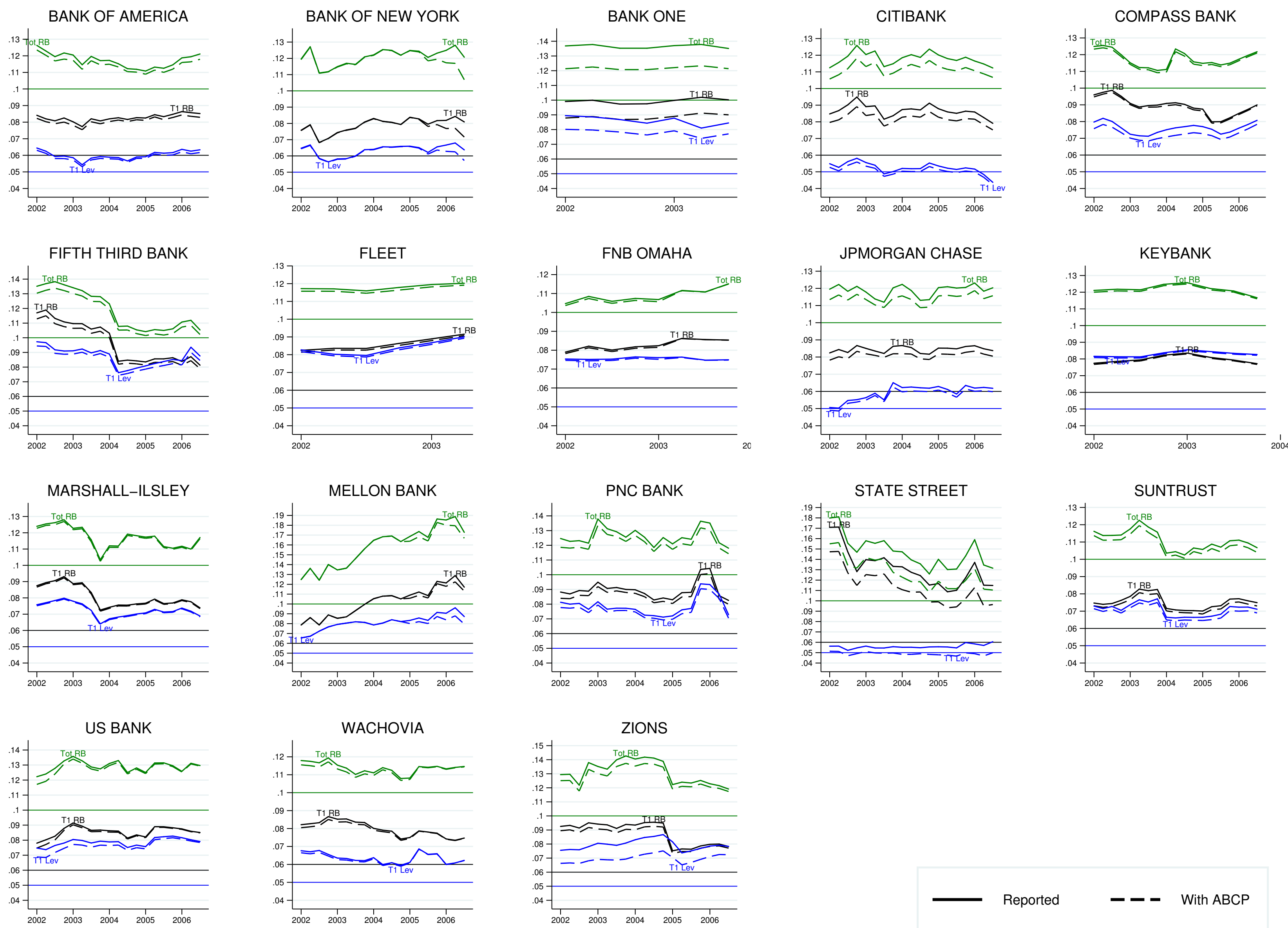
(b) Tier 1 Leverage Ratio



(c) Total Risk-Based Ratio

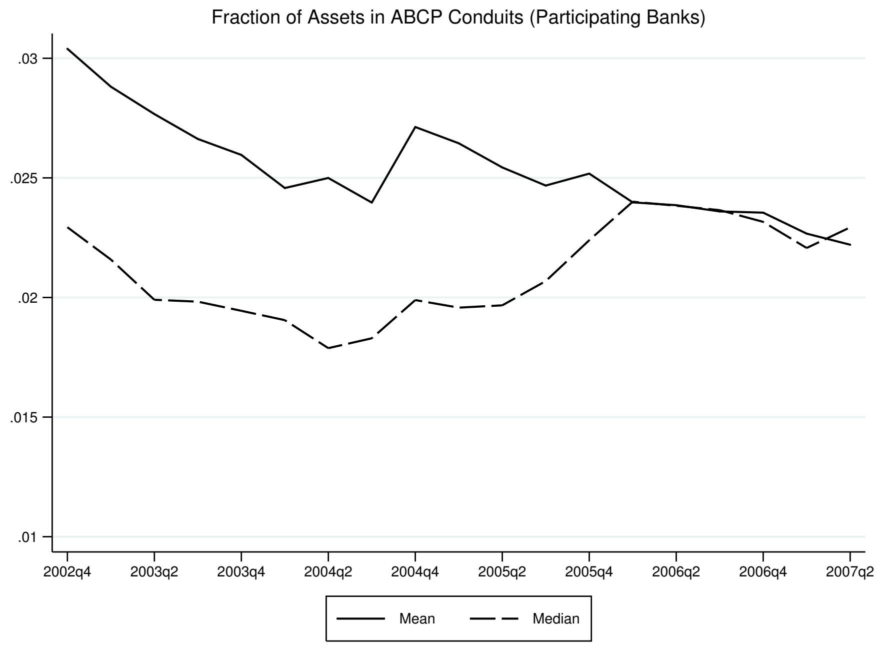
Notes: All figures report kernel density estimates of the corresponding capital ratios. "ABCP Sponsors" (solid line) are bank holding companies that provide liquidity guarantees to ABCP conduits. For each ratio, the solid vertical line denotes the well-capitalized regulatory threshold, and the dashed vertical line shows the well-capitalized threshold plus a 2% buffer. Sample period: 2002Q4-2007Q2. Kernel: Epanechnikov.

Figure 4: Reported and Adjusted Capital Ratios Relative to the Constraint

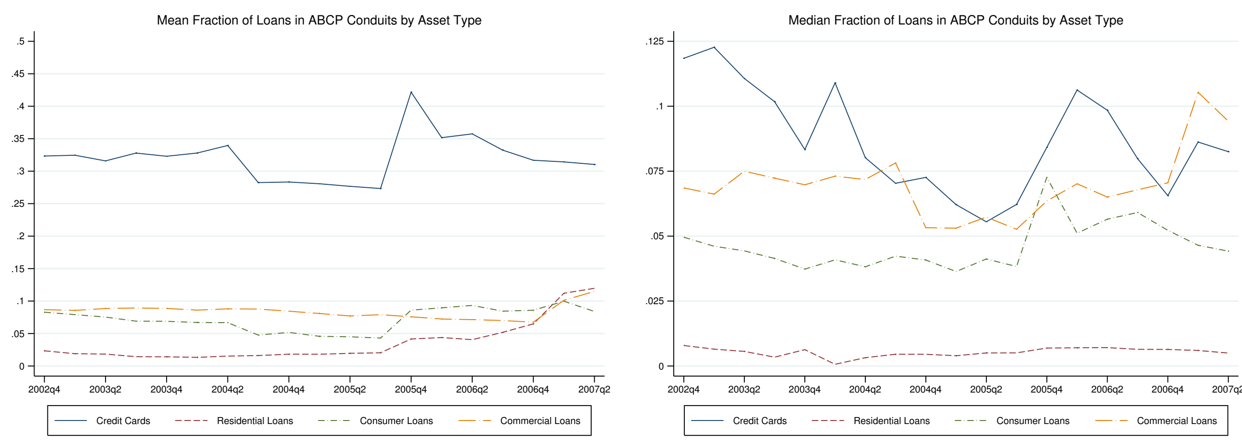


Notes: Solid lines are reported capital ratios. Dashed lines are ratios that would be reported if ABCP assets were held on the books. Horizontal lines show the regulatory requirement for each of the three capital constraints: total risk-based ratio (green); tier 1 risk-based ratio (black); tier 1 leverage ratio (blue). Sample: US banks that provided liquidity guarantees to ABCP conduits during 2002Q4-2007Q2.

Figure 5: Constrained Banks Did Not Exhaust the ABCP Loophole



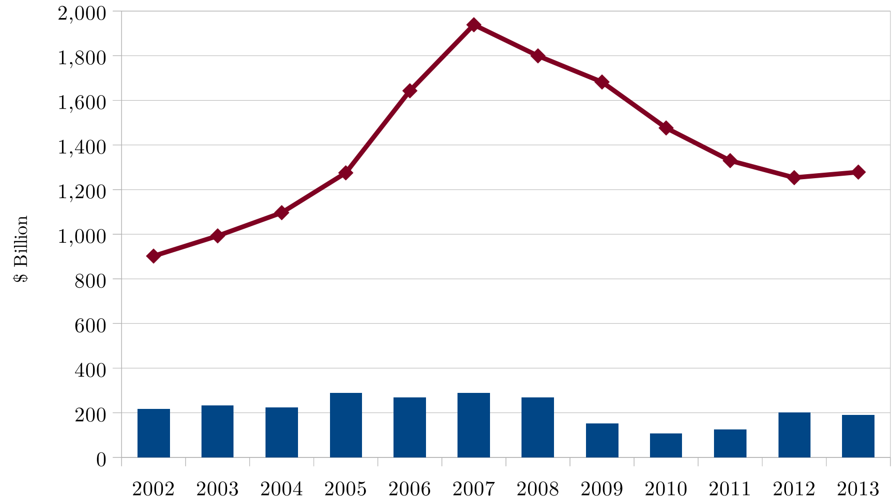
(a) Fraction of Assets in ABCP Conduits



(b) Fraction of Assets in ABCP Conduits by Asset Type

Notes: Panel (a) shows the aggregate fraction of assets in ABCP conduits over time. The mean (solid line) and the median (dashed line) of the fraction of total assets financed via ABCP conduits with liquidity guarantees (θ in the model) by US bank holding companies that provided liquidity guarantees to ABCP conduits in the period 2002Q4-2007Q2. Panel (b) shows the mean (left) and the median (right) of the fraction of assets in ABCP conduits for major asset types over time. Each point is the fraction of assets of the particular type that were financed through ABCP out of all assets of that type financed by the bank.

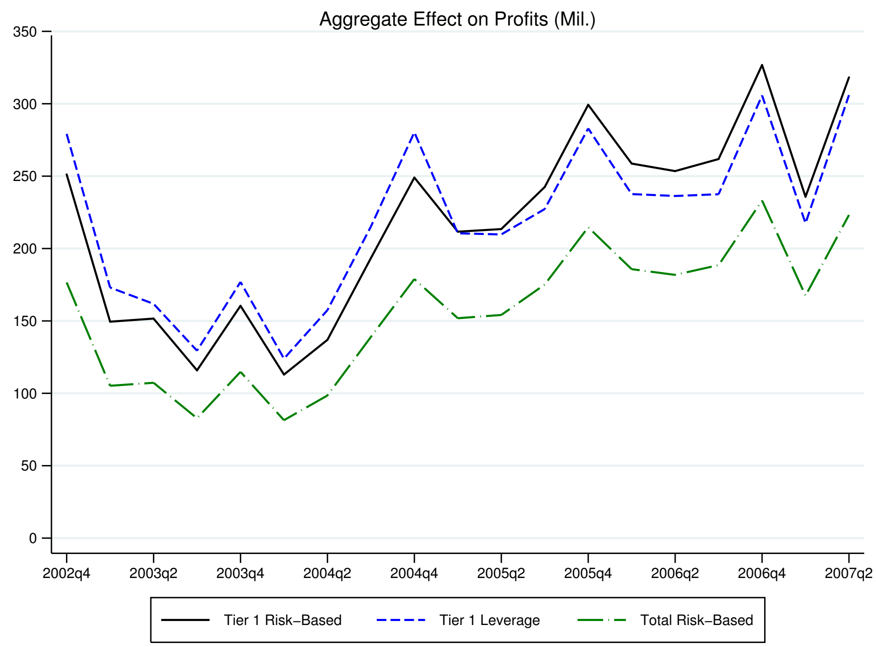
Figure 6: US Asset-Backed Securities: a Close Substitute to ABCP financing



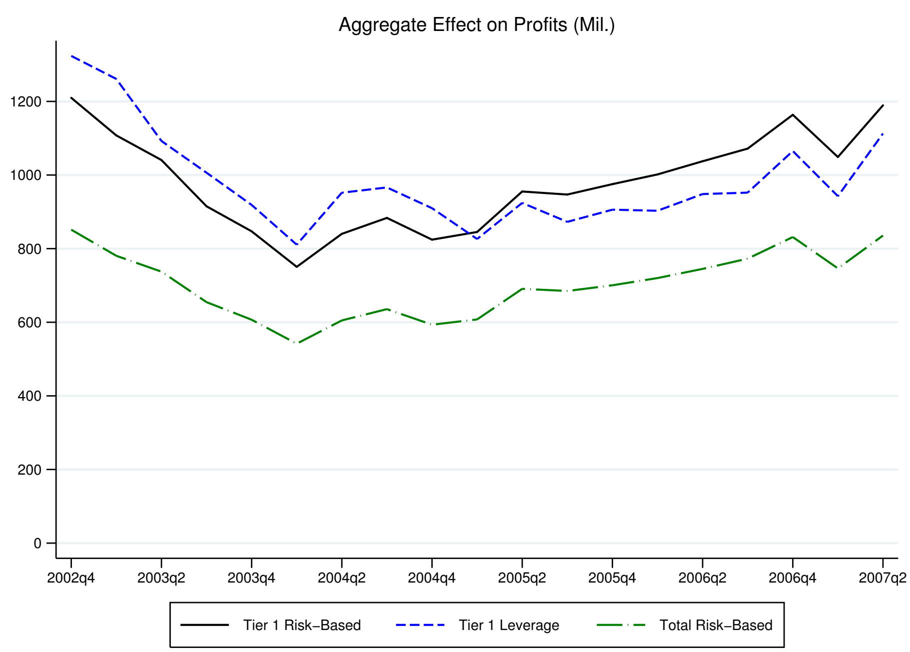
Notes: Total US asset-backed securities (ABS) issuance (bars) and amount outstanding (line). Source: SIFMA

Figure 7: Aggregate Cost of a One Percentage Point Increase in Regulatory Ratios for Banks that Used the Loophole

(a) Point Estimates



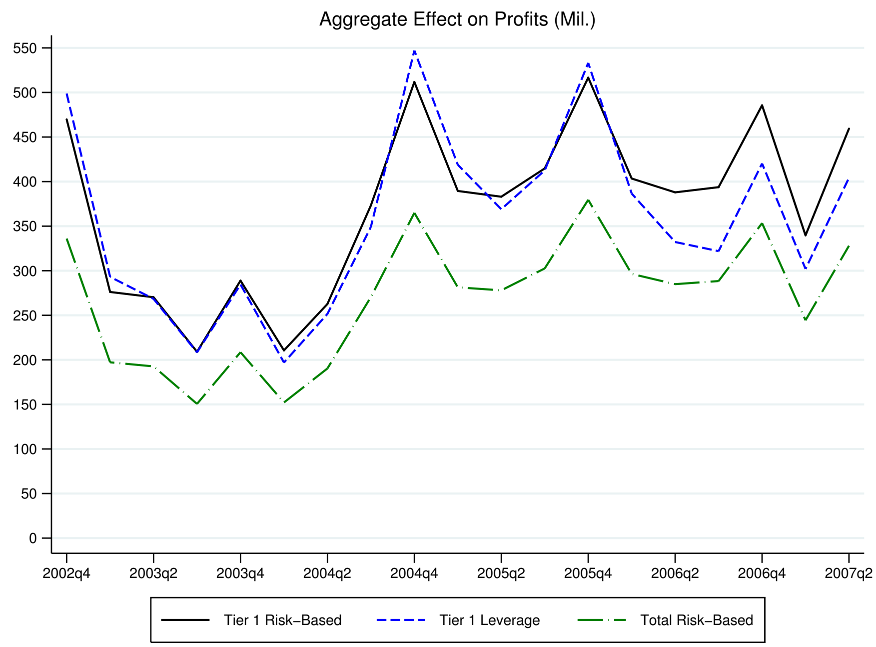
(b) Upper Bound Estimates



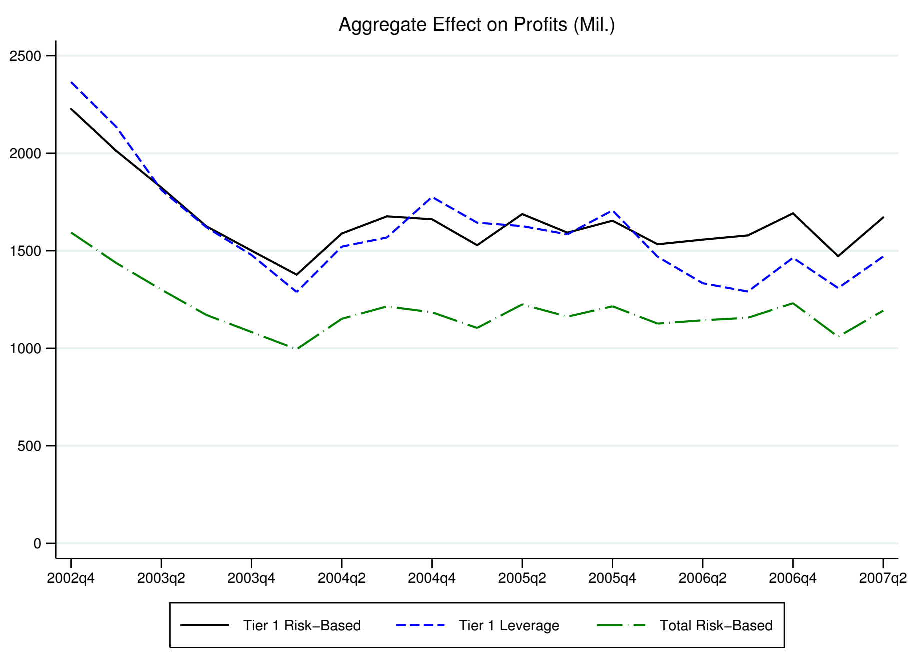
Notes: Aggregate cost for bank profits (in millions of dollars) of a 1 percentage point increase in each regulatory ratio for US banks that participated in the ABCP loophole (listed in Table 3). Panel (a): Point estimates calculated using the marginal cost of the loophole from equation 15. Panel (b): the upper bound on the costs from equation 19. The aggregate change in profit is calculated as $\Sigma_i d\Pi_{ist} = \lambda^s_{it} \times Q_{it} \times d\sigma_s$, where λ^s_{it} is the shadow cost of constraint s for bank i, $s \in \{Tier1\,RB,\, Tier1\,Lev,\, Tot\,RB\}$, $d\sigma_s = 1\%$ and Q_{it} is the total assets of bank i in quarter t.

Figure 8: Aggregate Cost of a One Percentage Point Increase in Regulatory Ratios: Extrapolation for All US Banks

(a) Extrapolation Using Point Estimate of the Marginal Cost

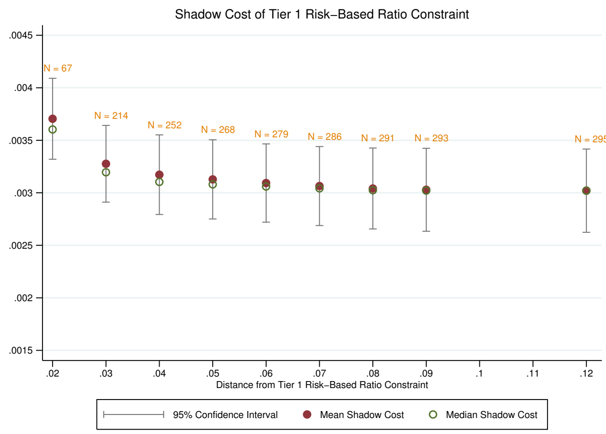


(b) Extrapolation Using Upper Bound for the Marginal Cost

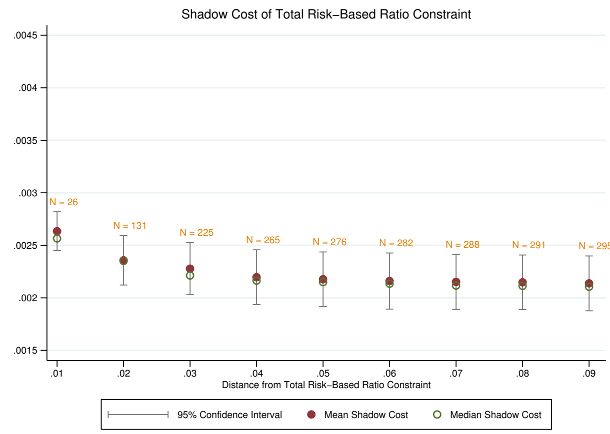


Notes: Upper bound extrapolation of the aggregate cost for bank profits (in millions of dollars) of a 1 percentage point increase in each regulatory ratio for all US banks. Panel (a): extrapolation using the marginal cost of the loophole from equation 15. Panel (b): extrapolation using the upper bound on the costs from equation 19. The aggregate change in profit is calculated as $\Sigma_i d\Pi_{ist} = \lambda^s_{it} \times Q_{it} \times d\sigma_s$, where λ^s_{it} is the shadow cost of constraint s for bank i, $s \in \{Tier1\,RB, Tier1\,Lev, Tot\,RB\}$, $d\sigma_s = 1\%$ and Q_{it} is the total assets of bank i in quarter t.

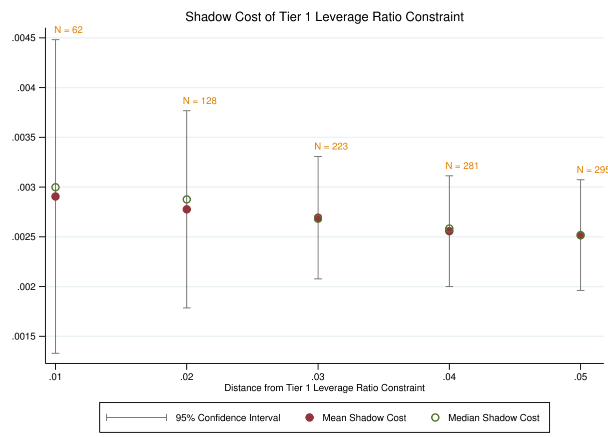
Figure 9: Shadow Cost Estimates vs. the Distance from the Constraint



(a) Tier 1 Risk-Based Ratio



(b) Total Risk-Based Ratio

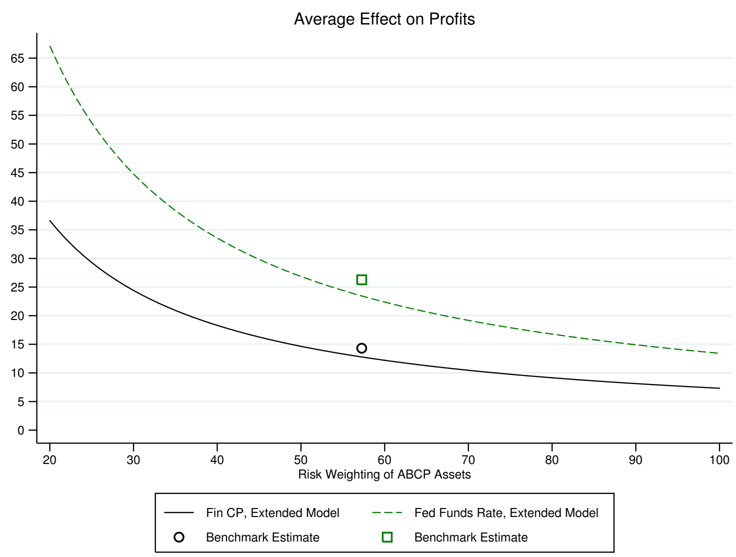


(c) Tier 1 Leverage Ratio

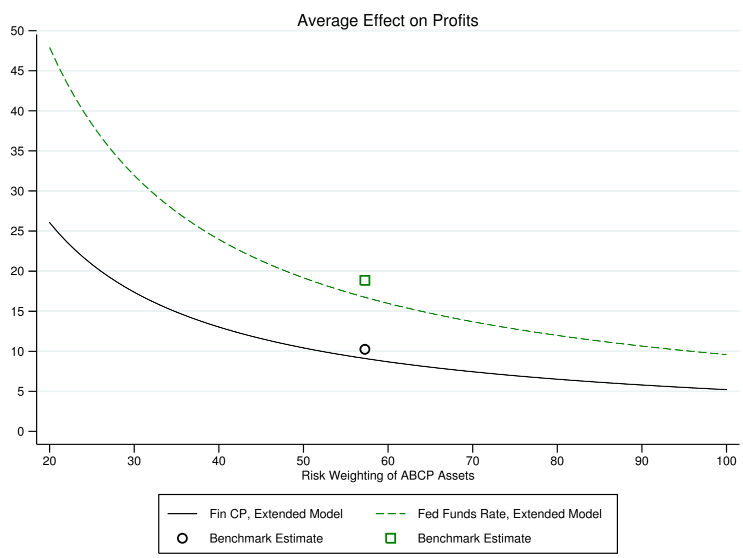
Notes: On the horizontal axis is the distance from the constraint. Each dot represents the mean or the median shadow cost of all bank-quarters whose reported ratio is at or below the distance on the horizontal axis. The estimates for the rightmost group on each plot include the full sample. N is the number of bank-quarters in each group. Standard errors for confidence intervals are adjusted for two-way clustering on a bank and year-quarter level. Sample: US bank holding companies that provided liquidity guarantees to ABCP conduits in the period 2002Q4-2007Q2.

Figure 10: Sensitivity of the Estimated Average Cost ($ Mil.) to Risk-Weighting and Cost of Capital Assumptions

(a) Cost of a 1 Percentage Point Increase in Tier 1 Risk-Based Ratio



(b) Cost of a 1 Percentage Point Increase in Total Risk-Based Ratio



Notes: Average cost (in terms of banks' profits) of a one percentage point increase in each regulatory ratio. For each bank i, the change in profit is $d\Pi_{ist} = \lambda_{it}^{s} \times Q_{it} \times d\sigma_s$, where λ_{it}^{s} is the shadow cost of constraint s for bank i, σ is the required ratio, Q_{it} is the total assets. Lines represent estimates from the extended model (equations 23 and 24) that allows for differential risk weighting of ABCP assets, for a range of risk weighting assumptions. Solid black lines use the benchmark incremental cost of ABCP financing, calculated as the difference between the ABCP rate and financial commercial paper rate. Dashed green lines use the upper bound incremental cost for ABCP financing, calculated as the difference between the ABCP rate and the overnight Fed Funds rate. Adjacent to each line is the estimate from the benchmark model given the corresponding assumption about the incremental cost (black circle is the estimate in table 3 and green square is the estimate from the same model, using Fed Funds rate as an alternative cost of capital).

Table 1: Summary Statistics, ABCP Sponsors and Assets

(a) ABCP Sponsors and Liquidity Providers

	U.S. BHC	Non-U.S. BHC	Non-Banks
N of Sponsors	22	59	124
N of Liquidity Providers	18	52	33
Total ABCP (bil.)	236	524	197
Total Liquidity Guarantees (bil.)	150	431	32

(b) Assets in ABCP Conduits Covered by Liquidity Guarantees

	Percent of Deals	Percent of Assets
Seller Rating		
AAA – A3	24.49	33.97
BAA1 – BAA3	18.51	15.80
BA1 – BA3	7.75	4.89
B1 – B3	2.74	1.41
CAA1 – CA	0.37	0.13
Not Rated	20.87	21.56
Security Rating		
AAA – A3	21.44	20.86
BAA1 – BAA3	1.45	0.64
BA1 – BA3	0.31	0.06
B1 – B3	0.17	0.02
CAA1 – CA	0.01	0.00
Not Rated	1.88	0.65

Notes: First two rows of Panel (a) show the number of sponsors and the number of liquidity providers, for each category described in the column header. Total ABCP is the total monthly amount (in billion of US dollars) of ABCP outstanding for each category, averaged over time. Total Liquidity Provisions is the total monthly amount of liquidity provisions for each category, averaged over time.

Panel (b) shows the breakdown of assets by credit ratings in conduits that had liquidity guarantees from US banks. The first part, under *"Seller Rating,"* shows the breakdown by the credit rating of the sellers behind the unsecuritized underlying assets. The category *Not Rated* refers to sellers for which Moody's did not provide credit ratings. The second part, under *"Security Rating,"* provides a similar breakdown for securitized assets held by these conduits.

Table 2: Summary Statistics: ABCP Sponsors and the Rest of the Banking System

	ABCP Sponsors	Other BHC	Diff in Means	All
Total Balance Sheet Assets (bil.)	331.8	3.40	328.4***	6.31
	(475.44)	(27.15)	[3.01]	(60.67)
Total Assets, Including Off-BS (bil.)	444.8	3.75	441.0***	7.67
	(545.07)	(30.55)	[3.43]	(72.57)
Total Risk-Weighted Assets (bil.)	230.2	2.33	227.9***	4.36
	(302.28)	(18.62)	[1.95]	(40.12)
Quarterly Net Income (bil.)	1.06	0.0096	1.05***	0.019
	(1.55)	(0.10)	[0.01]	(0.20)
Tier 1 Risk-Based Ratio (%)	8.90	13.1	-4.23***	13.1
	(1.51)	(4.95)	[0.28]	(4.95)
Tier 1 Leverage Ratio (%)	7.14	9.27	-2.12***	9.25
	(1.13)	(2.48)	[0.14]	(2.48)
Total Risk-Based Ratio (%)	12.4	14.6	-2.22***	14.6
	(1.52)	(4.87)	[0.28]	(4.86)
Balance Sheet Debt to Assets (%)	90.7	90.7	0.064	90.7
	(1.52)	(2.84)	[0.16]	(2.83)
Observations	305	34039		34344
Banks	18	2537		2553

Notes: Column "ABCP Sponsors" shows the means and standard deviations of variables for bank holding companies ("BHC") that provided liquidity guarantees to ABCP conduits. Column "Other BHC" shows the means and standard deviations for the rest of the sample. Column "All" shows the statistics for the whole sample. Column "Diff in Means" shows the differences in means between the subsamples and the corresponding standard errors. Standard deviations are in parentheses and standard errors are in brackets. Statistical significance of the differences in means: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. Sample period: 2002Q4-2007Q2. Variable Definitions: Total assets BHCK2170. Total risk-weighted assets BHCKA223. Total assets by risk-weight BHCKB696-BHCKB699. Net Income BHCK4340. Tier 1 capital BHCK8274. Tier 2 capital BHCK5311. Tier 3 capital BHCK1395. Total risk-based capital BHCK3792. Tier 1 risk-based ratio BHCK7206. Tier 1 leverage ratio BHCK7204. Total risk-based ratio BHCK7205. Total debt BHCK2948. Balance sheet debt to assets BHCK2948/BHCK2170.

Table 3: Shadow Costs of Regulatory Ratios and Change in Profits due to a One Percentage Point Increase in Required Ratios

	Shadow Cost			Change in Profit (Mil.)			Change in Profit/Profit			N
	T1 RB	Tot RB	T1 Lev	T1 RB	Tot RB	T1 Lev	T1 RB	Tot RB	T1 Lev	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
BANK OF AMERICA	0.0032	0.0023	0.0038	-40.9	-29.2	-47.6	-0.0025	-0.0018	-0.0030	19
BANK OF NEW YORK	0.0034	0.0022	0.0010	-13.4	-8.81	-3.83	-0.0097	-0.0063	-0.0030	19
BANK ONE	0.0023	0.0016	0.0021	-8.66	-6.30	-7.87	-0.0024	-0.0017	-0.0021	7
CITIBANK	0.0031	0.0023	0.0044	-50.7	-37.1	-71.9	-0.0028	-0.0021	-0.0041	19
COMPASS BANK	0.0030	0.0022	0.0029	-1.01	-0.76	-0.97	-0.0025	-0.0019	-0.0024	19
FIFTH THIRD BANK	0.0028	0.0023	0.0024	-3.36	-2.71	-2.83	-0.0031	-0.0025	-0.0025	19
FLEET	0.0029	0.0021	0.0023	-7.11	-5.15	-5.68	-0.0039	-0.0028	-0.0031	6
FNB OMAHA	0.0030	0.0023	0.0028	-0.39	-0.30	-0.36	-0.0037	-0.0028	-0.0035	8
JPMORGAN CHASE	0.0032	0.0022	0.0031	-48.1	-34.2	-45.2	-0.0067	-0.0047	-0.0068	19
KEYBANK	0.0031	0.0020	0.0021	-3.63	-2.37	-2.47	-0.0038	-0.0025	-0.0026	8
MARSHALL-ILSLEY	0.0034	0.0023	0.0029	-1.78	-1.21	-1.46	-0.0025	-0.0017	-0.0021	19
MELLON BANK	0.0027	0.0017	0.00071	-4.66	-3.02	-1.10	-0.0058	-0.0037	-0.0014	19
PNC BANK	0.0030	0.0021	0.0024	-3.41	-2.42	-2.65	-0.0026	-0.0018	-0.0020	19
STATE STREET	0.0021	0.0018	0.0010	-10.4	-9.10	-4.39	-0.011	-0.0096	-0.0048	19
SUNTRUST	0.0036	0.0024	0.0029	-6.62	-4.49	-5.36	-0.0037	-0.0025	-0.0030	19
US BANK	0.0031	0.0021	0.0025	-7.97	-5.28	-6.29	-0.0019	-0.0012	-0.0015	19
WACHOVIA	0.0034	0.0024	0.0031	-21.4	-14.8	-18.9	-0.0034	-0.0024	-0.0031	19
ZIONS	0.0028	0.0019	0.0024	-1.36	-0.90	-1.11	-0.0028	-0.0019	-0.0024	19
Mean	0.0030	0.0022	0.0025	-14.3	-10.2	-14.1	-0.0043	-0.0031	-0.0030	
Std. Error	[0.00020]	[0.00013]	[0.00028]	[4.39]	[3.16]	[5.42]	[0.00073]	[0.00058]	[0.00041]	

Notes: Time-series averages for ABCP sponsoring US bank holding companies, 2002Q4-2007Q2. The shadow costs (λ) per dollar of a unit change in the regulatory capital requirement for tier 1 risk-based ("T1 RB") and for the total risk-based capital ratio ("Tot RB") are calculated using equation (12). The shadow cost for the tier 1 Leverage ratio ("T1 Lev") is calculated using equation (13). Change in Profit is calculated as $d\Pi_{is} = -\lambda_s \times Q_i \times d\sigma_s$, where $d\sigma_s$ is a one percentage point increase in the regulatory ratio $s \in \{Tier1\ RB,\ Tier1\ Lev,\ Tot\ RB\}$ and λ_s is a corresponding shadow cost, and Q_i is the total assets of bank i. The column "Change in Profit/Profit" scales the change in profits by the annualized quarterly net income. "N" is the number of quarterly observations of each bank with non-zero liquidity guarantees. Standard errors are adjusted for two-way clustering on a bank and year-quarter level.

Table 4: Upper Bound Estimates: Shadow Costs and Change in Profits due to a One Percentage Point Increase in Required Ratios

	Shadow Cost			Change in Profit (Mil.)			N
	(1) T1 RB	(2) Tot RB	(3) T1 Lev	(4) T1 RB	(5) Tot RB	(6) T1 Lev	(7)
BANK OF AMERICA	0.015	0.010	0.018	-177.3	-125.7	-208.8	19
BANK OF NEW YORK	0.016	0.010	0.0050	-59.1	-38.6	-17.6	19
BANK ONE	0.014	0.010	0.013	-53.0	-38.5	-48.3	7
CITIBANK	0.014	0.010	0.020	-223.1	-163.7	-319.4	19
COMPASS BANK	0.013	0.010	0.013	-4.44	-3.36	-4.36	19
FIFTH THIRD BANK	0.013	0.010	0.011	-14.7	-11.9	-12.7	19
FLEET	0.018	0.013	0.014	-43.5	-31.6	-34.9	6
FNB OMAHA	0.018	0.013	0.016	-2.29	-1.74	-2.13	8
JPMORGAN CHASE	0.015	0.010	0.014	-209.8	-149.0	-201.6	19
KEYBANK	0.018	0.012	0.012	-21.3	-14.0	-14.5	8
MARSHALL-ILSLEY	0.015	0.011	0.013	-7.66	-5.25	-6.45	19
MELLON BANK	0.013	0.0082	0.0035	-20.6	-13.3	-5.06	19
PNC BANK	0.014	0.0097	0.011	-15.1	-10.7	-11.8	19
STATE STREET	0.0092	0.0082	0.0049	-44.0	-38.8	-19.9	19
SUNTRUST	0.016	0.011	0.013	-29.2	-19.7	-23.7	19
US BANK	0.014	0.0094	0.011	-36.0	-23.8	-28.8	19
WACHOVIA	0.015	0.011	0.014	-91.9	-63.8	-83.0	19
ZIONS	0.013	0.0086	0.011	-5.85	-3.88	-4.96	19
Mean	0.014	0.010	0.012	-63.2	-45.2	-63.4	
Std. Error	[0.00087]	[0.00058]	[0.0014]	[18.5]	[13.3]	[23.6]	

Notes: Time-series averages for ABCP sponsoring US bank holding companies, 2002Q4-2007Q2. The estimates are calculated using an upper bound for the the marginal cost of ABCP financing from equation (19). The shadow costs (λ) per dollar of a unit change in the regulatory capital requirement for tier 1 risk-based ("T1 RB") and for the total risk-based capital ratio ("Tot RB") are calculated using equation (12). The shadow cost for the tier 1 Leverage ratio ("T1 Lev") is calculated using equation (13). Change in Profit is calculated as $d\Pi_{is} = -\lambda_s \times Q_i \times d\sigma_s$, where $d\sigma_s$ is a one percentage point increase in the regulatory ratio $s \in \{Tier1\ RB,\ Tier1\ Lev,\ Tot\ RB\}$ and λ_s is a corresponding shadow cost, and Q_i is the total assets of bank i. "N" is the number of quarterly observations of each bank with non-zero liquidity guarantees. Standard errors are adjusted for two-way clustering on a bank and year-quarter level.

Table 5: Shadow Costs and Change in Profits Under Modigliani-Miller with Taxes

	Shadow Cost			Change in Profit (Mil.)			N
	(1) T1 RB	(2) Tot RB	(3) T1 Lev	(4) T1 RB	(5) Tot RB	(6) T1 Lev	(7)
BANK OF AMERICA	0.0013	0.00093	0.0015	-17.9	-12.9	-20.4	19
BANK OF NEW YORK	0.0014	0.00090	0.00038	-5.88	-3.87	-1.54	19
BANK ONE	0.00058	0.00042	0.00053	-2.23	-1.62	-2.02	7
CITIBANK	0.0012	0.00091	0.0017	-22.0	-16.1	-30.5	19
COMPASS BANK	0.0012	0.00091	0.0011	-0.43	-0.32	-0.40	19
FIFTH THIRD BANK	0.0012	0.00096	0.00096	-1.46	-1.17	-1.16	19
FLEET	0.00077	0.00056	0.00062	-1.87	-1.35	-1.49	6
FNB OMAHA	0.00076	0.00058	0.00071	-0.099	-0.075	-0.093	8
JPMORGAN CHASE	0.0013	0.00091	0.0012	-21.0	-14.9	-19.0	19
KEYBANK	0.00079	0.00052	0.00054	-0.93	-0.61	-0.63	8
MARSHALL-ILSLEY	0.0014	0.00095	0.0011	-0.80	-0.54	-0.62	19
MELLON BANK	0.0010	0.00068	0.00025	-2.03	-1.32	-0.44	19
PNC BANK	0.0012	0.00086	0.00093	-1.47	-1.05	-1.11	19
STATE STREET	0.00086	0.00075	0.00037	-4.74	-4.13	-1.79	19
SUNTRUST	0.0015	0.00099	0.0012	-2.82	-1.92	-2.26	19
US BANK	0.0013	0.00084	0.00098	-3.31	-2.20	-2.55	19
WACHOVIA	0.0014	0.00097	0.0012	-9.58	-6.53	-8.09	19
ZIONS	0.0012	0.00078	0.00095	-0.62	-0.41	-0.47	19
Mean	0.0012	0.00085	0.00096	-6.17	-4.42	-5.92	
Std. Error	[0.00014]	[0.000096]	[0.00013]	[2.06]	[1.49]	[2.40]	

Notes: Time-series averages for ABCP sponsoring US bank holding companies, 2002Q4-2007Q2. The estimates are calculated using an upper bound for the the marginal cost of ABCP financing from equation (19), under the restriction of Modigliani-Miller model with taxes: $c'(k) = r_d\tau$, where $c(k)$ is the weighted average cost of capital, k is the equity ratio, and τ is the corporate tax rate. The shadow costs (λ) per dollar of a unit change in the regulatory capital requirement for tier 1 risk-based ("T1 RB") and for the total risk-based capital ratio ("Tot RB") are calculated using equation (12). The shadow cost for the tier 1 Leverage ratio ("T1 Lev") is calculated using equation (13). Change in Profit is calculated as $d\Pi_{is} = -\lambda_s \times Q_i \times d\sigma_s$, where $d\sigma_s$ is a one percentage point increase in the regulatory ratio $s \in \{Tier1\ RB,\ Tier1\ Lev,\ Tot\ RB\}$ and λ_s is a corresponding shadow cost, and Q_i is the total assets of bank i. "N" is the number of quarterly observations of each bank with non-zero liquidity guarantees. Standard errors are adjusted for two-way clustering on a bank and year-quarter level.

Table 6: Summary Statistics: European Bank Holding Companies Providing Liquidity Guarantees to ABCP Conduits

	Mean	St. Dev.
Total Balance Sheet Assets (bil.)	802.2	558.5
Total Assets, Including Off-BS (bil.)	969.9	678.9
Total Risk-Weighted Assets (bil.)	311.8	211.6
Quarterly Net Income (bil).	3.80	4.27
Tier 1 Risk-Based Ratio (%)	8.15	1.47
Total Risk-Based Ratio (%)	15.2	3.87
Balance Sheet Debt to Assets (%)	96.1	1.48
Observations	131	
Banks	27	

Notes: Sample: Annual data on European bank holding companies available in Bankscope database that provided liquidity guarantees to ABCP conduits in the period 2002Q4-2007Q2. Variable Definitions: Total assets DATA2025. Net Income DATA2115. Off-Balance Sheet Items DATA2065. Tier 1 capital DATA2140. Total risk-based capital DATA2055+DATA2160+DATA2165. Total debt DATA2060-DATA2055. Tier 1 risk-based ratio DATA2130. Balance sheet debt to assets (DATA2060-DATA2055)/DATA2025.

Table 7: Shadow Costs of Regulatory Ratios and Change in Profits due to a One Percentage Point Increase in Ratios (European Banks)

	Shadow Cost		Change in Profit (Mil.)		N
	T1 RB	Tot RB	T1 RB	Tot RB	
	(1)	(2)	(3)	(4)	(5)
ABN AMRO	0.0033	0.0019	-40.3	-23.4	6
BARCLAYS	0.0040	0.0021	-69.4	-37.1	6
BAYERISCHE L-B	0.0038	0.0021	-22.3	-12.0	3
BNP	0.0039	0.0019	-80.9	-39.0	3
CALYON	0.0038	0.0019	-68.4	-33.8	3
COMMERZBANK AG	0.0043	0.0025	-30.3	-17.8	6
CREDIT SUISSE	0.0024	0.00099	-24.2	-10.1	5
DANSKE BANK	0.0041	0.0025	-18.7	-11.2	6
DEUTSCHE BANK	0.0033	0.0016	-54.3	-26.5	6
DRESDNER BANK	0.0037	0.0016	-25.9	-11.2	6
DZ BANK	0.0036	0.0022	-21.0	-12.7	3
HBOS	0.0039	0.0022	-41.0	-23.0	6
HSBC	0.0035	0.0018	-57.0	-30.7	6
HSH NORDBANK	0.0047	0.0028	-12.7	-7.58	6
ING BANK	0.0041	0.0025	-40.9	-25.3	6
INTESA	0.0043	0.0022	-63.8	-34.3	4
KBC	0.0037	0.0021	-13.2	-7.48	4
LLOYDS BANK	0.0036	0.0019	-23.3	-12.4	6
NATIONWIDE	0.0026	0.0020	-5.76	-4.47	4
NATIXIS	0.0033	0.0013	-23.1	-9.30	3
NORDDEUTSCHE L-B	0.0048	0.0027	-13.2	-7.54	3
RABOBANK	0.0027	0.0023	-17.8	-14.9	6
RBS	0.0042	0.0018	-80.2	-31.9	6
SOCIETE GENERALE	0.0038	0.0019	-62.5	-30.9	3
STANDARD CHARTERED	0.0040	0.0019	-7.79	-3.63	4
UNICREDIT	0.0050	0.0022	-43.3	-18.7	6
WESTLB AG	0.0041	0.0023	-17.0	-9.78	6
Mean	0.0038	0.0021	-36.3	-18.9	
Std. Error	[0.00033]	[0.00020]	[4.97]	[2.31]	

Notes: Time-series averages for each ABCP-sponsoring European bank holding company. The shadow costs (λ) per dollar of a unit change in the regulatory capital requirement for tier 1 risk-based capital ratio in columns "T1 RB" and for the total risk-based capital ratio ("Tot RB") are calculated using equation (12). Change in Profit is calculated (in millions of dollars) as $d\Pi_{is} = -\lambda_s \times Q_i \times d\sigma_s$, where $d\sigma_s$ is a one percentage point increase in the regulatory requirements a ratio $s \in \{Tier1\ RB,\ Tier1\ Lev,\ Tot\ RB\}$ and λ_s is a corresponding shadow cost, and Q_i is the total assets of bank i. "N" is the number of annual observations of each bank with non-zero liquidity guarantees and nonmissing data. Standard errors are adjusted for two-way clustering on a bank and year-quarter level. Sample: European bank holding companies that provided liquidity guarantees to ABCP conduits in the period 2002Q4-2007Q2.

Appendix

A Dynamic Loophole Model

We provide an analysis of optimal loophole use in a dynamic banking model and relate the results to our benchmark model estimates. The model is admittedly more general than necessary, but we find it instructive to see which features omitted from the benchmark model could actually result in a meaningful change in our estimates of the shadow cost of bank capital requirements.

Consider the value maximization problem of a bank with an infinite horizon which chooses each period t, a vector of controls $u_t = [\mathbf{r}_{t+1}, k_{t+1}, \theta_{t+1}]$ consisting of beginning of period $t+1$ interest rates $\mathbf{r}_{t+1}$, economic capital ratio k_{t+1}, and loophole use θ_{t+1}, given a state vector $x_t = [\mathbf{r}_t, k_t, \theta_t, z_t, \ell_t, \mathbf{p}_t, \alpha_t, \sigma_t]$ consisting of choices of the controls made in the previous period, in addition to a crisis indicator z_t, and an indicator for the availability of the loophole ℓ_t for purposes of complying at the end of period t with the required capital ratio σ_t. We can write the bank's Bellman equation as

$$V(x_t) = \max_{u_t} \Pi(x_t, u_t) + \delta E_t [V(x_{t+1})], \tag{32}$$

subject to the per period regulatory capital constraint

$$K(x_t, u_t) = K(\mathbf{r}_{t+1}, k_{t+1}, \theta_{t+1} \times \ell_t) \geq \sigma_t. \tag{33}$$

The period t profit function

$$\Pi(x_t, u_t) = \sum_j q_{j,t-1} r_{j,t} p_{j,t} - [c(k_{t+1}, z_t) + \alpha_t \theta_{t+1}] Q(\boldsymbol{r}_{t+1}) - \frac{\kappa}{2}(L_t - L_{t-1})^2 - I(\theta_{t+1} > 0) \times F,$$

is the sum of previous period promised interest rates revenue $r_{j,t} q_{j,t}$ multiplied by an class specific shock $p_{j,t} \in [0,1]$ denoting the fraction of performing loans, and less bank wide cost of capital per dollar of assets, $c(k_{t+1}, z_t)$ that depends on economic capital structure of this period and potentially the previous one, and less the incremental cost of using the loophole $\alpha_t \theta_{t+1}$. Here $Q_t = Q(\boldsymbol{r}_{t+1})$ denotes total actual demand for the bank's loans, which depend on its chosen interest rates. We denote by $L_t \equiv \theta_{t+1} Q_t$ the dollar amount of assets financed through the loophole at time t. The problem is dynamic because of adjustment costs $\kappa > 0$ payed for changing ABCP assets. We can summarize the random shocks vector as $\epsilon_t = [z_t, \mathbf{p}_t, \alpha_t]$. We allow both cost of capital terms c and f to depend change in a crisis, and give banks the foresight that the loophole would close in a crisis. Specifically,

$\ell_t = \ell_{t-1}(1 - z_t)$, so that the loophole is initially available, but once it goes $z_t = 1$, it goes for good and $\ell_{t+s} = 0$ for all $s \geq 0$.

Assigning a Lagrangian multiplier $\lambda_t Q_t$ to the period t regulatory constraint we rewrite (32) the Bellman equation as

$$V(x_t) = \max_{u_t, \lambda_t} \Pi(x_t, u_t) + \lambda_t Q_t [K(x_t, u_t) - \sigma_t] + \delta E_t [V(x_{t+1})]. \tag{34}$$

A.1 Temporary and Permanent Increases in Capital Requirements

Considering the effect of a small increase in period t minimum required capital ratio σ_t on the banks value, and applying the Benveniste-Scheinkman envelope theorem we get

$$-\frac{\partial V(x_t)}{\partial \sigma_t} \frac{1}{Q_t} = \lambda_t, \tag{35}$$

just like in the static model, showing that the shadow costs we measure are per period costs. Alternatively, if we consider a permanent increase in $\sigma = \sigma_{t+s}$ for all $s \geq 0$, we get

$$-\frac{\partial V(x_t)}{\partial \sigma} = E_t \left[\sum_{s=0}^{\infty} \delta^s \lambda_{t+s} Q_{t+s} \right], \tag{36}$$

which shows that the loss of value is the expected present value of all future Lagrangian multipliers. If we assume a constant shadow cost per dollar and a constant expected growth rate of bank assets ($E_t Q_{t+s} = Q_t (1+g)^s$), then the shadow cost per dollar of expected assets is

$$-\frac{\partial V(x_t)}{\partial \sigma} \frac{1}{Q_t} = \lambda \sum_{s=0}^{\infty} (\delta (1+g))^s = \frac{\lambda}{1 - \delta(1+g)}, \tag{37}$$

which for $\delta(1+g)$ close to 1 is substantial and can rationalize easily why banks lobby so hard against increased capital requirements. The costs of a permanent increase in capital requirements accrue every period.

The first-order condition for loophole usage θ_{t+1} chosen at time t is

$$\lambda_t \frac{\partial K(x_t, u_t)}{\partial \theta_{t+1}} \leq \alpha_t + \kappa \{ L_t - L_{t-1} - \delta \mathbb{E}_t [L_{t+1} - L_t] \}. \tag{38}$$

If the marginal benefit of the loophole is zero ($\frac{\partial K(x_t, u_t)}{\partial \theta_{t+1}} = 0$) as is the case when the loophole vanishes, or if the bank is unconstrained ($\lambda_t = 0$), a bank might still find an interior loophole share optimal if adjustment costs of eliminating loophole paid today, $\kappa(L_{t-1} - L_t)$, are large enough relative to the marginal costs, $\alpha_t - \kappa \delta E_t [L_{t+1} - L_t]$, which are effectively smaller if it expects to use the loophole in the near future.

Finally, we can decompose the expectation by normal and crisis states:

$$\lambda_t \frac{\partial K(x_t, u_t)}{\partial \theta_{t+1}} \leq \alpha_t + \kappa \{L_t - L_{t-1} - \delta \mathbb{E}_t [L_{t+1} - L_t | z_{t+1} = 0]\} + \kappa \delta \pi_t \mathbb{E}_t [L_{t+1} | z_{t+1} = 0]. \quad (39)$$

where $\pi_t \equiv E_t[z_{t+1}] = Pr\{z_{t+1} = 1 | x_t\}$ is the probability of a crisis next period. In Section 7.2, we use this last expression to provide intuition for several model extensions and examine their effects on our conclusions.

A.2 Bounds on Loophole Costs

The first-order condition for economic capital ratio k_{t+1} chosen at time t is

$$\lambda_t \frac{\partial K(x_t, u_t)}{\partial k_{t+1}} \leq \frac{\partial c(k_{t+1}, z_t)}{\partial k_{t+1}}. \quad (40)$$

The bank's weighted-average cost of capital (WACC) is

$$c(k_{t+1}, z_t) = k_{t+1} r_{e,t+1}(k_{t+1}, z_t) + (1-\tau)(1-k_{t+1}) r_{d,t+1}(k_{t+1}, z_t), \quad (41)$$

where $r_{e,t+1}(k_{t+1}, z_t)$ and $r_{d,t+1}(k_{t+1}, z_t)$ are respectively its costs of equity and debt, and τ its tax rate. Differentiating w.r.t to k_{t+1} we get

$$\frac{\partial c(k_{t+1}, z_t)}{\partial k_{t+1}} = r_{e,t+1}(k_{t+1}, z_t) - (1-\tau) r_{d,t+1}(k_{t+1}, z_t) + k_{t+1} \frac{\partial r_{e,t+1}}{\partial k_{t+1}} + (1-\tau)(1-k_{t+1}) \frac{\partial r_{d,t+1}}{\partial k_{t+1}}.$$

Since a higher capital ratio would lower the required return on both equity and debt (see the discussion in section , we get an upper bound

$$\frac{\partial c(k_{t+1}, z_t)}{\partial k_{t+1}} \leq r_{e,t+1}(k_{t+1}, z_t) - (1-\tau) r_{d,t+1}(k_{t+1}, z_t) \quad (42)$$

Combining the FOC for θ (38) with the FOC for k (40) for a bank interior in both gives

$$\lambda_t = \frac{\tilde{\alpha}_t}{\frac{\partial K(x_t, u_t)}{\partial \theta_{t+1}}} = \frac{\frac{\partial c(k_{t+1}, z_t)}{\partial k_{t+1}}}{\frac{\partial K(x_t, u_t)}{\partial k_{t+1}}} \quad (43)$$

Let $\tilde{\alpha}_t \equiv \alpha_t + \kappa \{L_t - L_{t-1} - \delta \mathbb{E}_t [L_{t+1} - L_t | z_{t+1} = 0]\} + \kappa \delta \pi_t \mathbb{E}_t [L_{t+1} | z_{t+1} = 0]$ denote the effective incremental cost of using the loophole that includes both α_t and the adjustment costs. Then from (42) and (43) we get a useful upper bound on the effective loophole costs

$$\tilde{\alpha}_t \leq \frac{\frac{\partial K(x_t,u_t)}{\partial \theta_{t+1}}}{\frac{\partial K(x_t,u_t)}{\partial k_{t+1}}} \left[r_{e,t+1}\left(k_{t+1}, z_t\right) - (1-\tau)\, r_{d,t+1}\left(k_{t+1}, z_t\right) \right]. \tag{44}$$

Specializing to Tier 1 risk-based capital ratio, $K = \frac{kQ}{Q^r}$, $K_k = \frac{Q}{Q^r}$, $K_\theta = \frac{K}{Q^r}\left(1-\beta_{ABCP}\right)\sum_j w_j q_j$,

$$\tilde{\alpha}_t \leq K_t^{T1RB}\left(1-\beta_{ABCP}\right)\frac{\sum_j w_j q_{j,t}}{\sum_j q_{j,t}}\left[r_{e,t+1} - (1-\tau)\, r_{d,t+1} \right], \tag{45}$$

Specializing to the Leverage Ratio, $K = \frac{kQ}{(1-\theta)Q-B}$, $K_k = \frac{Q}{A}$, $K_\theta = K\frac{Q}{A}$,

$$\tilde{\alpha}_t \leq K_t^{LR}\left[r_{e,t+1} - (1-\tau)\, r_{d,t+1} \right]. \tag{46}$$

B Homogeneity of Bank-Level Borrowing Costs

Table 8: Intraday LIBOR In a Panel of Banks

	Oct2002–Jun2007			Jan1995–Aug2014		
	(1)	(2)	(3)	(4)	(5)	(6)
US Bank		-0.00209***			-0.0160***	
		(-14.56)			(-25.33)	
Date Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effects	No	No	Yes	No	No	Yes
Root Mean Squared Error	0.00780	0.00776	0.00708	0.0667	0.0664	0.0630
Adjusted R^2	1.000	1.000	1.000	0.999	0.999	0.999
Observations	19199	19199	19199	75551	75551	75551

Notes: Reported are panel regressions explaining the one month LIBOR percent interest rate submitted by each of the survey participating banks at the daily frequency. The statistic of interest is the root mean squared error after controlling for time fixed effects. US Bank is an indicator variable. The first three columns use the sample period used for our shadow costs estimates, whereas the last three columns use the entire sample. LIBOR rates are from Bloomberg.