The Shadow Cost of Bank Capital Requirements

Roni Kisin Asaf Manela*

First draft: June 2013

This draft: February 2016

Abstract

We estimate the shadow cost of capital requirements using data on a costly loophole that allowed banks to relax these constraints. This loophole—liquidity guarantees to asset-backed commercial paper conduits—was exploited by the largest banks before the crisis of 2008. We show theoretically that a bank's use of the loophole reveals its private compliance cost, which takes into account both the costs of issuing equity and the effectiveness of capital regulation. We find that increasing capital requirements would impose a modest cost—$220 million a year for all participating banks combined per 1pp increase, and $14 million on average.

JEL classification: G21, G28, L51

Keywords: Financial Intermediation, Bank Capital Requirements, Leverage, Regulatory Arbitrage, Regulatory Loopholes

*Both authors are at Washington University in St. Louis. Email: rkisin@wustl.edu or amanela@wustl.edu. We thank Philip Strahan (the editor) and anonymous referees whose comments and suggestions have substantially improved the paper. We are grateful to Christa Bouwman (discussant), Allen Berger, Doug Diamond, Jennifer Dlugosz, Phil Dybvig, Mark Flannery (discussant), Michael Gofman, Stuart Greenbaum, Bart Hamilton, Robert Hauswald (discussant), Zhiguo He, Christopher Hrdlicka, Alan Moreira, Justin Murfin (discussant), Ajay Palvia, George Pennacchi (discussant), Everett Rutan, Anjan Thakor, executives at a large national bank, seminar participants at UCLA, UNC, and Wash U, and participants of the AFA Meetings, Wharton Conference on Liquidity and Financial Crises, the FDIC-JFSR Banking Research Conference, the Financial Research Association (FRA) conference, and the GSU Symposium on Liquidity Risk and Capital Requirements for helpful comments. We thank Moody's for providing us with ABCP programs data.

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. 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 bank's own actions to infer their perceived compliance costs. Prior to the financial crisis of 2007–2009, 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 model and take it to data on bank's provision of liquidity guarantees to asset-backed commercial paper conduits (ABCP). As documented by Acharya, Schnabl, and Suarez (2013), banks that provided liquidity guarantees to ABCP conduits effectively held the risks of the underlying assets. Instead of treating such guarantees as risky assets, however, 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,

[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 U.S. bank regulation increased capital requirements by at most two percentage points.

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 its marginal capital relief reveals the shadow cost of the regulatory capital constraint.

Our approach allows us to estimate the shadow costs of capital regulation for constrained banks that used the loophole. 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 were 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 derive the marginal capital relief from exploiting the loophole for each regulatory capital 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 achieve a higher reduction in regulatory ratios using the loophole. The marginal cost—an incremental cost of exploiting 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, because this spread may not capture the full marginal cost of exploiting the loophole, we derive an upper bound for it (and hence for the shadow costs) that allows for arbitrary measurement error.

We find that the shadow costs of capital requirements during the pre-crisis period were modest. According to our baseline estimates, 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 \$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 are about \$140 million for tier 1 ratios and \$100 million for the total risk-based ratio (2–3 percent of annual profits). These bounds, calculated using an intentionally inflated measure of the incremental cost of equity, confirm the baseline results and imply modest shadow cost of capital requirements.

[2] We use the terms "sponsors" and "liquidity providers" interchangeably. We explain the distinction below. Also, while our analysis is at the bank holding company level, we use the term "bank" throughout the paper, for brevity.

The modest shadow cost may appear puzzling given banks' resistance to higher capital requirements. Note, however, that we estimate the costs of complying with regulation, rather than the cost of issuing additional equity. We show that modest shadow costs could be due to ineffective regulation, when regulatory ratios do not map into true economic capital ratios. Indeed, a large literature documents that banks avoid regulation by exploiting weaknesses of risk-weighting rules, shifting activities into softer regulatory environments, and using other loopholes.[3]

This suggests a way to use our estimates (combined with information on marginal costs) to gauge the effectiveness of regulation. If equity is costly, a small shadow cost implies that banks can avoid an increase in the economic capital ratios. We find that even under Modigliani and Miller (1958) (henceforth "M&M") with taxes, regulators would have to increase regulatory requirements by 10 percentage points to achieve a 1 percentage point increase in economic capital ratios. Our estimates imply that the recent modest increase in capital requirements will have a negligible effect on bank profits as well as on banks' economic capital, as banks appear to neutralize the increase in regulatory requirements.

Our study is most closely related to the literature on the impact of increased capital requirements on the cost of capital and lending. The most closely related contribution in this literature is Kashyap, Stein, and Hanson (2010), who estimate that a 10 percentage point increase in capital ratios would raise bank's weighted average cost of capital by 25–45 basis points. Their estimates are derived under the M&M model with taxes, and assuming that an increase in regulatory capital requirements leads to a comparable change in actual capital ratios. Our shadow cost estimates can be interpreted as the effect on a bank's cost of capital, if the bank is forced to raise equity in response, without changing the quantity of its risky assets and the rates it charges to borrowers. For the sake of comparison, our partial equilibrium estimates imply that a ten percentage point increase in capital requirements would lead to a 3 basis point increase in banks' cost of capital. In

[3]See, e.g., Hellwig (2010), Demirguc-Kunt, Detragiache, and Merrouche (2013), Houston, Lin, and Ma (2012), Karolyi and Taboada (2014), Duchin and Sosyura (2014), Kane (1981; 2012)), Basel Committee on Banking Supervision (2009). Regulation can be further weakened if banks shift to riskier assets (Harris, Opp, and Opp, 2014). The industry's approach is exemplified by the quote from Deutsche Bank CEO Anshu Jain: "*The bank aims to apply all capital levers at its disposal before considering raising equity from investors*" (Wall Street Journal, April 30, 2013). The article goes on to describe how "*Instead, the bank managed to strengthen its capital by reducing risk-weighted assets by about €80 billion through the end of the year.*"

practice, however, banks have more leeway and general equilibrium effects could be different.[4]

Our paper adds to this literature in several ways. First, we do not assume that regulation is fully effective. Rather we derive our estimates taking as given the imperfections of the system. This feature increases the relevance of our approach for the analysis of currently-implemented policies.

Second, we do not impose a particular capital structure model, such as M&M. Banks in our framework may perceive equity to be arbitrarily costly.[5] Instead, we use revealed preference, and let the data tell us how costly do banks perceive the requirements to be. In fact, imposing the M&M model with taxes decreases our estimates of the shadow costs.

Third, we estimate the cost of capital requirements during an economic expansion, without relying on negative economic shocks for identification. Much of the literature studies periods of economic downturns (e.g. Peek and Rosengren, 1997; Brun, Fraisse, and Thesmar, 2013). This increases the relevance of our estimates, since increases in capital requirements are done in "normal" times, allowing a transition period with access to well-functioning capital markets. Related, our estimates can be used to study the potential effects of macroprudential regulation, which relies on increasing capital ratios during expansions (Rochet, 2010; Shleifer and Vishny, 2010).

Fourth, both consumer and producer surpluses are important in quantifying the social costs of higher capital requirements. While the effect on producer surplus plays a central role in the regulatory debates, to the best of our knowledge ours is the first paper to provide an estimate. Our estimates can 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.

Our paper is related to a literature in microeconomics studying the effect of regulation on industry participants and market outcomes. Most closely related is Anderson and Sallee (2011),

[4] Baker and Wurgler (2013) estimate that such a change would increase cost of capital by 60–90 basis points. Other papers focus on the benefits of higher capital requirements by examining banking crises (e.g., Berger and Bouwman, 2013). Van den Heuvel (2008) studies the welfare loss from increasing capital requirements beyond the socially optimal level in a competitive banking model. Like much of the preceding literature, we use partial equilibrium analysis. Subsequent work on capital requirements in general equilibrium includes Nguyen (2014) and Corbae and D'Erasmo (2014), but abstracts from a distinction between economic and regulatory capital. Interestingly, Begenau (2014) shows that higher capital requirements can *reduce* bank funding costs in general equilibrium. See also 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.

[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 theories suggest that equity may increase bank value by improving incentives (e.g., Holmstrom and Tirole, 1997; Allen, Carletti, and Marquez, 2009; Mehran and Thakor, 2011).

who study the effect of fuel-economy rules on automakers. Their approach greatly influenced the development of our model and estimation. We extend this framework in several respects. First, 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). Second, we extend the model to a dynamic setting, which accounts, among other things, for adjustment costs in loophole use and regulatory uncertainty. Third, we relate the estimated marginal compliance cost to the total cost of a substantial policy change.

Finally, we contribute to a growing macro-finance literature on the costs of financial constraints for financial intermediaries. Most related is Koijen and Yogo (2014), who estimate the shadow cost of reserve regulation for life insurers. The main advantage of the current approach is that we avoid fully specifying the competitive equilibrium, and estimating demand elasticities and markups. 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.[6]

The paper proceeds as follows. Section 2 explains how loophole use reveals the shadow cost. Section 3 describes the ABCP loophole. Section 4 combines the model with the specifics of the institutional environment, and verifies necessary conditions for identification. Section 5 reports the main results. Section 6 discusses several extensions and robustness tests. Section 7 concludes.

2 Model

We start with a simple, yet fairly generic model of a bank that maximizes its profits subject to a regulatory capital constraint. We derive the optimal use of a loophole, and provide a simple expression for the shadow costs of regulatory capital constraints in terms of observable variables. We then discuss the intuition, advantages, and limitations of the loophole approach.

[6] See He and Krishnamurthy (2013, 2012); Brunnermeier and Sannikov (2014); Gertler and Kiyotaki (2010); Brunnermeier, Eisenbach, and Sannikov (2013). For recent surveys, see Gertler and Kiyotaki (2010) and Brunnermeier, Eisenbach, and Sannikov (2013).

2.1 Loophole Use Reveals the Shadow Cost of Bank Capital Requirements

The bank has total assets A, of which O are held off-balance sheet, and the remaining $A-O$ are financed by a mix of equity E and debt D. Bank profits (revenues R net of costs C) are maximized subject to the constraint that its regulatory capital ratio K exceeds the required ratio σ.

To fix ideas, a simple form of capital regulation could impose a minimum book capital ratio $K = \frac{E}{A-O} \geq \sigma$. In this case, and more generally, the bank can comply with an increase in σ by increasing its equity capital, reducing its total assets, or moving assets off-balance sheet.

The bank chooses $(A, E, D, O, \mathbf{z})$ to maximize profits

$$\begin{aligned} \max_{(A,E,D,O,\mathbf{z})} \Pi &\equiv R(A,E,D,O,\mathbf{z}) - C(A,E,D,O,\mathbf{z}) \\ \text{s.t. } E + D &= A - O \\ \sigma &\leq K(A,E,D,O,\mathbf{z}), \end{aligned}$$

where $\mathbf{z}$ is a vector of other possible policies for a bank.[7] Denote by λA the Lagrange multiplier on the regulatory capital constraint, so that λ is the shadow cost per dollar of assets. Differentiating the bank's Lagrangian at the optimum $\mathcal{L}^*$ with respect to the required capital ratio σ and dividing by total assets gives the marginal compliance cost in terms of lost profits per dollar of assets:

$$-\frac{d\mathcal{L}^*}{d\sigma}\frac{1}{A} = -\frac{\partial \mathcal{L}^*}{\partial \sigma}\frac{1}{A} = \lambda,$$

which uses the fact that by the envelope theorem indirect effects are zero around the optimum.[8]

Combining the first-order conditions for the profit-maximizing debt D and off-balance sheet assets O yields a tractable expression for the shadow cost of a bank that uses but does not exhaust the loophole $(0 < O < A)$

$$\lambda = \frac{C_O - C_D - (R_O - R_D)}{A(K_O - K_D)}, \tag{1}$$

where the subscripts denote partial derivatives. Intuitively, if we were to observe a bank that uses

[7]Since uncertainty about loan payoffs would play no role in our shadow cost expression, here we focus on a simpler riskless setup. Random outcomes are introduced in Appendix A.

[8]For example, banks may respond by increasing equity ($\frac{dE}{d\sigma} > 0$), but $\frac{\partial \mathcal{L}^*}{\partial E} = 0$, which nullifies the effect on profits.

the loophole, despite facing a high net marginal cost $(C_O - C_D - (R_O - R_D))$, or a low marginal capital relief $(K_O - K_D)$ of funding through the loophole, then we would infer that the bank faces a high cost of complying with the regulatory capital constraint.

Our goal is to construct an empirical measure of λ using data on banks that provide off-balance sheet liquidity guarantees to ABCP conduits during the pre-crisis sample. To do this, we will adapt the model to the specifics of the institutional environment. But before we turn to this task, we can already see the main drivers of our estimates and get a back-of-the-envelope estimate of the shadow cost. Take the after-tax spread between the yield on ABCP and a similar balance sheet debt as a proxy for $C_O - C_D$ (≈ 2.5 basis points). The capital relief (described in detail below) is $A(K_O - K_D) \approx 8\%$. Assuming that $R_O - R_D \approx 0$ (i.e., revenues are independent of loophole use), the average shadow cost is therefore 30 basis points per dollar of assets. Participating banks, with aggregate assets of about \$8 trillion, would suffer a $(8 \times 10^{12}) \times (30 \times 10^{-4}) \times 0.01 = \$240$ million reduction in annual profits from a one percentage point increase in the regulatory ratio. This rough estimate is close in magnitude to our main results.

The intuition behind this estimate can be summarized by a simple revealed preference argument: banks financed a relatively small fraction of their assets through the loophole, despite the fact that the loophole provided a relatively large capital relief, and using it was relatively cheap (the cost of ABCP financing was only slightly higher than the cost of on-balance sheet financing). Therefore, an optimizing bank must have had a low marginal cost of complying with capital requirements; otherwise, it would have financed more of its investments using ABCP.

2.2 Discussion of the Model

Several comments about the shadow cost expression are in order. First, our analysis is valid if the constraint binds, or if banks keep constant buffers above σ, which, as we show below, is supported by the data.[9] Moreover, as we discuss below, banks face multiple regulatory constraints. Expression (1) is exact when only one constraint binds for each bank, and provides an upper bound if more

[9] The shadow costs are zero for non-binding constraints. Also, the second-order conditions must hold at an interior loophole share of assets $(0 < O < A)$. These conditions will hold, for example, if the cost function is sufficiently convex in the bank's capital ratio. While participating banks do in fact use interior shares of about 3 percent of assets, we cannot verify the second-order conditions empirically.

than one constraint binds.[10]

Second, the envelope theorem provides a simple expression for the first-order effect on profits of a small increase in capital requirements. While such estimates are directly relevant for small policy changes implemented (so far) following the last crisis, without further structure we cannot directly analyze very large changes in capital requirements. In this sense, our estimates share the usual limitation of the estimates of treatment effects. Nevertheless, in Section 6.4 we discuss an extension of our framework to *substantial changes* in σ.

Third, the fact that λ measures each bank's marginal compliance costs in equilibrium may appear limiting, since regulatory changes are likely to apply to the whole industry, and may have general equilibrium effects. We note, however, that if regulatory tightening of capital requirements substantially change the interest rates or capital structure of 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. See Anderson and Sallee (2011) for a discussion of this issue.

Finally, it is instructive to see how the estimation of the shadow cost would proceed without using the loophole for identification. We can rewrite the shadow cost as:

$$\lambda = \frac{C_E - C_D}{A\,(K_E - K_D)}. \tag{2}$$

[10]The multiple constraints version of the Lagrangian is

$$\mathcal{L} = R - C + \sum_s \lambda^s A\,[K^s - \sigma^s] + \rho\,[E + D + O - A]\,.$$

Subtracting the first-order Kuhn–Tucker condition for on-balance sheet debt D, $R_D - C_D + \sum_s \lambda^s A K_D^s + \rho \leq 0$, from the condition for off-balance sheet debt O, $R_O - C_O + \sum_s \lambda^s A K_O^s + \rho \leq 0$, gives

$$\sum_s \lambda^s A\,(K_O^s - K_D^s) \leq C_O - C_D - (R_O - R_D)\,,$$

with equality at interior solutions. Isolating the shadow cost λ^s of a single constraint s, gives an upper bound

$$\lambda^s \leq \frac{C_O - C_D - (R_O - R_D) - \sum_{s' \neq s} \lambda^{s'} A \left(K_O^{s'} - K_D^{s'}\right)}{A\,(K_O^s - K_D^s)} \leq \frac{C_O - C_D - (R_O - R_D)}{A\,(K_O^s - K_D^s)},$$

where the second inequality follows from the fact that $\lambda^s \geq 0$ and $K_O^s - K_D^s \geq 0$, i.e., for each constraint s, the Lagrangian multipliers are nonnegative, and the loophole provides capital relief. Therefore, the single constraint expression (1) is exact when only one constraint binds ($\lambda^{s'} = 0$), and provides an upper bound otherwise.

This representation does not use the loophole, and instead focuses on substitution between debt and equity. The main difficulty with it, however, is the need to estimate $C_E - C_D$. Such estimation would have to rely on strong assumptions, which is, perhaps, why it remains a major stumbling block in the debate on capital requirements. For example, $C_E - C_D$ is simply the cost of debt multiplied by the tax rate in the M&M model with taxes. An important advantage of our approach is that we bypass the estimation of $C_E - C_D$.

3 Institutional Setting and Data

We describe the regulatory environment in which banks operate and the regulatory treatment of ABCP liquidity guarantees. We then describe our data and report descriptive statistics on participating banks that exploited this loophole.

3.1 Regulatory Environment and the Treatment of ABCP Liquidity Guarantees

Over the pre-crisis period (2002–2007), US bank holding companies reported three capital ratios to their regulator, who would then decide whether the bank was well-capitalized, adequately capitalized, or under-capitalized. A bank is considered *well-capitalized* under the following three conditions:[11] (i) its core capital (leverage) ratio ≡ Tier 1 (core) capital over average total assets less ineligible intangibles ≥ 3% to 5% depending on its composite regulatory rating (CAMELS); and (ii) its tier 1 risk-based capital ratio ≡ Tier 1 (core) capital over risk-weighted assets ≥ 6%; and (iii) its total risk-based capital ratio ≡ Total risk-based capital over risk-weighted assets ≥ 10%.

Non-well-capitalized banks face greater scrutiny, are less likely to get approval for acquisitions, and cannot accept brokered deposits without explicit regulatory approval. Non-*adequately-capitalized* banks (tier 1 risk-based ratio below 4%, total risk-based ratio below 8%, or tier 1 leverage ratio below 4%) face stronger sanctions, e.g. a requirement to submit a plan detailing the ways the bank would increase its capital. Failure to get this plan approved and executed would trigger further sanctions. Further deterioration can change the status of the bank to *significantly or critically under-capitalized*, and may eventually result in a takeover by the FDIC.

[11]See 12 CFR, Part 225.

An important feature of bank regulation is the risk-weighting of assets for the purposes of calculating capital ratios, in which a risk weight w_j is applied to each asset of a risk group j. There are four major risk weights: 0%, 20%, 50%, and 100%. For example, cash gets a weight of zero, claims guaranteed by OECD central governments 20%, residential mortgages 50%, and standard assets 100%. Off-balance sheet items are converted into balance sheet equivalents by multiplying their risk-weighted value by a conversion factor $\beta < 1$.

Liquidity guarantees to ABCP conduits were granted special treatment by capital regulation. ABCP conduits are pools of assets financed almost entirely with short-term debt. The conduits, however, were usually fully covered by a liquidity guarantee from the conduit-sponsoring bank. A "liquidity guarantee" means that if debt-holders (e.g. money-market mutual funds) stop rolling over the debt, while conduit assets are performing, the guaranteeing bank must step in, repay the maturing debt, and take possession of the assets. Acharya, Schnabl, and Suarez (2013) show that guaranteeing banks effectively assumed the risk in conduit assets, because the short-term debtholders would stop rolling over the debt long before the assets stop performing.

Despite the fact that guaranteeing bank shareholders were residual claimants on these assets, the guarantees were given a lax regulatory treatment. In particular, their conversion factor was zero ($\beta_{ABCP} = 0\%$) before September 2004, and 10% after. In other words, before September 2004 the guarantees were not counted towards assets, and were ignored when calculating regulatory capital ratios. After 2004, only 10% of the assets were accounted for in the capital ratio calculations. This loophole was closed in January 2010 when the conversion rate was set to $\beta_{ABCP} = 100\%$.[12]

[12] The role of ABCP in bypassing the regulation was widely recognized. Consider, for example, this quote from Moody's (Bate et al, 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 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."* And: *"The rise of bank risk-based capital standards around the world in 1988 imposed significant costs on Support Providers [...] 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."* See Acharya, Schnabl, and Suarez (2013) and industry publications (Bate et al.,2003), for a detailed discussion of this market. For official rulings on Capital Requirements for ABCP Programs see, e.g., the Final Rule (July 20, 2004) by the federal banking and thrift regulators, and the Federal Register Vol. 75 No. 18 from January 28, 2010.

3.2 Data

Our data on ABCP programs is from 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 two distinct datasets. The first is monthly data on bank-sponsored multi-seller, security arbitrage, and hybrid programs. It has 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 by Moody's was described in detail in Acharya, Schnabl, and Suarez (2013). It has quarterly coverage of the ABCP universe, including 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. 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 our data with the aggregate numbers from the Federal Reserve. We find that our conduit-level data tracks well and exceeds in coverage the publicly-available aggregate numbers. Also, consistent with existing evidence, (e.g., Covitz, Liang, and Suarez, 2013), the figure shows the growth of the ABCP market prior to the crisis, as well as its eventual collapse, which was likely driven by the crisis and the subsequent closure of the loophole. 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 ABCP programs covered by liquidity guarantees, which were relevant for the loophole. This category excludes conduits covered by weaker guarantees, such as SIVs, CDOs, and ABCP with extendible guarantees. The data is presented separately for 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.[13]

Panel (b) takes a closer look at the asset quality of conduits covered by liquidity guarantees. ABCP conduits held securitized and unsecuritized assets. Our data includes credit ratings of the sellers of unsecuritized assets, as well as the actual credit ratings of securitized assets. The descriptive evidence in the table suggests that ABCP conduits tended to hold assets that would be considered high quality at the time.

After correcting Moody's data for issues such as mergers, owner-subsidiary links and name changes, we merge it with the financial information on bank holding companies from the Consolidated Financial Statements (FR Y-9C) filed quarterly with the Fed. We find 18 US bank holding companies that provided liquidity guarantees to ABCP programs during our sample period (2002Q4–2007Q2). Table 2 compares these banks with the rest of the banking universe. ABCP sponsors are on average much larger, and have smaller regulatory capital ratios.

Figure 2a shows the fraction of total banking assets held by banks that provided liquidity guarantees to ABCP conduits. While relatively few in numbers, these banks held, on average, 50% of all banking assets in the US.[14] Adding the assets of banks owned by foreign ABCP-sponsoring banks (and thus also provide liquidity to conduits) increases this number to 63%.

Figure 2b further clarifies the significance of the ABCP sponsors for the regulatory debate, by taking 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 ABCP sponsors and other banks. While the

[13] While liquidity guarantees covered, on average, 102% of assets, some conduits also had conduit-level "credit enhancements," intended to provide further protection from asset defaults. These arrangements have little relevance for our analysis, as they covered, on average, only 6.8% of the assets. Moreover, for an average (median) conduit 71% (100%) of these enhancements were provided by the *sponsor itself.* Major categories of credit enhancements are: Credit Asset Purchase Agreements, Cash Collateral Account, Letter of Credit, and Surety Bond. See Bate et al. (2003) for a detailed discussion of these arrangements.

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

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. In Appendix C we replicate our main analysis using a sample of European banks.

To summarize, our sample captures banks that are currently at the epicenter of the regulatory debate: large, highly-levered institutions, controlling a significant share of the industry.

4 Measurement Approach and Conditions for Identification

In this section, we combine the basic model from Section 2.1 with the regulatory environment described in Section 3.1, discuss our measurement approach, and empirically verify sufficient conditions for the identification of the shadow costs.

4.1 Measuring the Capital Relief Provided by the Loophole

The marginal benefit of the loophole stems from its effect on the regulatory capital ratios. As discussed above, banks faced three regulatory capital constraints of the form

$$K^s = \frac{E^s}{A^s} \geq \sigma^s \text{ for } s = T1RB,\, TotRB,\, T1Lev, \tag{3}$$

where K^s is one of three regulatory capital ratios: tier-1 risk-based (T1RB), total risk-based (TotRB), and tier-1 leverage (T1Lev). E^s and A^s are regulatory measures of equity capital and bank assets. For the risk-based ratios, $A^s = \sum_j w_j \left(A_j - \sum_\ell (1-\beta_\ell)\, O_{j\ell}\right)$, where A_j are total assets with risk-weight w_j, and $O_{j\ell}$ are off-balance sheet assets, converted into balance-sheet equivalents by applying a conversion factor β_ℓ. For the leverage ratio, which uses book assets, $w_j = 1$ for all j and $\beta_\ell = 0$ for all ℓ. E^s is tier 1 capital for the tier 1-based ratios, while the total risk-based capital ratio allows a broader definition of capital. These features imply that banks can use both the size and the composition of their portfolios to manage capital ratios.

We can now rewrite the denominator of the shadow cost expression (1). The marginal capital relief attained by financing assets of risk class j with off-balance sheet ABCP is

$$A\left(K^s_{O_{j,ABCP}} - K^s_D\right) = (1-\beta_{ABCP})\, w_j K^s \frac{A}{A^s}, \tag{4}$$

The benefit is large when total assets $A \equiv \sum_j A_j$ are large relative to regulatory assets A^s, or if the conversion factor β_{ABCP} is small—a smaller fraction of loophole assets counts toward the regulatory ratios. Moreover, the benefit is larger for assets with a high risk-weight w_j or for banks with a high regulatory capital ratio K^s.

Most inputs for the marginal capital relief in (4) are available in the Consolidated Financial Statements. We take reported regulatory risk-weighted assets A^s and capital ratios K^s. The conversion factor β_{ABCP} applied to off-balance sheet liquidity guarantees to ABCP facilities is zero prior to September 2004, and 10 percent after, until this loophole was closed in January 2010.

We do not observe the risk weight applied to the marginal assets funded with ABCP w_j. We start by assuming that the distribution of conduit assets mirrors the one on-balance sheet, which is reported in schedule HC-R. In this case the marginal weight is replaced with the asset-weighted average risk weight $\bar{w} \equiv \sum_j w_j \frac{A_j}{A}$. We show in the robustness section that our conclusions are not sensitive to this assumption.

Consistent with this assumption, we calculate total on- and off-balance sheet assets, $A = A^s + (1-\beta_{ABCP})\, O_{ABCP}$, and assets that are assigned risk weight w_j, $A_j = \frac{A^s_j}{1-(1-\beta_{ABCP})\frac{O_{ABCP}}{A}}$, which adds back a constant fraction of reported assets to account for the fact that moving assets into ABCP does not change the riskiness of assets.[15]

4.2 Measuring the Incremental Cost of the Loophole

An important component of the shadow cost expression (1) is $C_O - C_D$. In the model, it has a straightforward interpretation: the incremental marginal cost of financing assets through ABCP conduits. Its empirical measurement, 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

[15] For all off-balance sheet assets other than ABCP, we rely on regulatory conversion factors (banks report credit equivalent amounts $\beta_\ell O_{j\ell}$). An extreme conversion factor of $\beta_\ell = 0$ would ignore such exposures, while a conversion factor of 1 would clearly overstate out-of-the-money derivative exposures.

neither of these quantities is observable, such a measure must rely on simplifying assumptions.

For this reason, we use two distinct approaches. First, we use a direct measure. This measure has many attractive features, but may miss some costs of ABCP financing, which would bias our estimates downward. Our second approach eliminates the need for a direct estimate, and instead places bounds on this cost. The advantage of using bounds is that the estimates of the shadow cost are robust to measurement error. 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, an issue we return to below.

4.2.1 Direct Measures of the Marginal Cost

A direct measure of the marginal cost follows from the expression for the cost of capital:

$$C\left(A,E,D,O\right) = r_e E + r_d D\left(1-\tau\right) + r_o O\left(1-\tau\right), \tag{5}$$

where r_e, r_d, and r_o are the yields on equity, balance-sheet debt, and off-balance sheet debt, and τ is the corporate tax rate.

To conserve notation, we denote by $\alpha \equiv C_O - C_D = \left(r_o - r_d\right)\left(1-\tau\right)$ the incremental cost of the loophole, which is the marginal cost of substituting between on- and off-balance sheet debt. The loophole helps identify the shadow cost by focusing on bank substitution between different types of debt, holding everything else including the economic equity capital ratio constant. Hence, on the margin, loophole use affects the bank's cost of capital only through the yield spread between the two types of debt.

We measure the time t marginal cost of ABCP financing, denoted α_t, as 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:

$$\alpha_t = \left(r_{ABCP,t} - r_{CP,t}\right)\left(1-\tau\right), \tag{6}$$

where we use the 30 day rates since they are closest to the average maturity of ABCP, and the corporate tax rate is $\tau = 35\%$.

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 a close alternative source of capital for ABCP assets if they were placed on the books is, perhaps, less intuitive. We chose 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 meets our goal of estimating the cost of compliance as perceived by banks. While it is hard to assign specific financing costs to individual assets on a bank's balance sheet, both CP and ABCP are forms of short-term debt issued directly by banks, which expose investors to similar risks.[16]

Figure 1 shows that the ABCP to financial CP 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 0.9 bp, after which it widened substantially.

In the robustness section, we vary our measure of α by replacing $r_{CP,t}$ 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 $r_{CP,t}$ with the lower overnight Fed Funds rate.

Since we do not observe individual bank-level ABCP rates, we take the spread between 30 day AA ABCP and 30 day AA financial CP as reported by the Fed. Regulators and researchers with access to detailed bank-level data on r_{ABCP}, can simply replace α in equation (6) to obtain more accurate bank-level shadow cost estimates, without the need to replicate the rest of the analysis. Note, however, that since much of our empirical analysis deals with averages and aggregates, much of this heterogeneity is averaged out.

[16]The fact that CP does not provide the "asset backing" feature is less relevant here given that ABCP programs in our sample have liquidity guarantees by their sponsoring banks in excess of 100%.

4.2.2 Bounds for the Marginal Cost

Potential additional costs of ABCP financing could include legal, management, accounting, rating fees, and other transaction costs. Moreover, in practice, equation (5) may not be linear and additive in loophole use. In a multi-period setting, dynamic considerations such as adjustment costs in loophole usage could add to these unobservable costs. In Appendix A 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.

We assume that the true (unobserved) marginal cost for each bank is $\alpha_{it} = \alpha_t + \varepsilon_i$, where ε_i is a time-invariant individual spread over α_t (equation 6). To remain conservative, we assume $\varepsilon_i \geq 0$. To develop a bound for α_{it}, we start by combining the shadow cost expressions (1) and (2). We maintain the assumption that $R_O - R_D = 0$, and note that in our setting $K_D = 0$, to get

$$\frac{\alpha}{AK_O} = \lambda = \frac{C_E - C_D}{AK_E}, \tag{7}$$

where we omit time and bank subscripts to simplify notation. This says that at the optimum the two margins are equalized. Therefore, the shadow cost λ could potentially be revealed either by loophole use O, or by the choice of equity versus debt.

As discussed in Section 2.2, a significant obstacle in implementing the right-hand-side version of the shadow cost is the need to estimate $C_E - C_D$. Equation (7) shows, however, that measurement error in α cannot be arbitrarily high—it is bounded by the sensitivity of the cost of capital to equity ratios since $\alpha = \frac{K_O}{K_E}(C_E - C_D)$. Since K_O and K_E can be directly measured, a bound on the incremental cost of equity $C_E - C_D$ would also bound the shadow cost.

Differentiating equation (5), we get:

$$C_E - C_D = r_e - (1-\tau)\, r_d + \frac{\partial r_e}{\partial k}\frac{E}{A} + (1-\tau)\left(\frac{\partial r_d}{\partial k}\frac{D}{A} + \frac{\partial r_o}{\partial k}\frac{O}{A}\right),$$

where $k \equiv \frac{E}{A}$. Assuming $\frac{\partial r_e}{\partial k}E + (1-\tau)\left(\frac{\partial r_d}{\partial k}D + \frac{\partial r_o}{\partial k}O\right) \leq 0$, i.e., the total pricing effect of a higher capital ratio is weakly negative, gives an inflated upper bound for the incremental cost of equity:

$$C_E - C_D = r_e - (1-\tau)\, r_d + \frac{\partial r_e}{\partial k}\frac{E}{A} + (1-\tau)\left(\frac{\partial r_d}{\partial k}\frac{D}{A} + \frac{\partial r_o}{\partial k}\frac{O}{A}\right) \leq r_e - (1-\tau)\, r_d, \tag{8}$$

Importantly, we do *not* suggest that $r_e - (1-\tau)\, r_d$ is a good estimate of $C_E - C_D$. Recent discussion of this issue can be found in Admati et al. (2011), who explain why it is inflated, and document its frequent erroneous use in the debate on capital requirements. In our setting this loose bound is useful precisely because it is inflated. Since we are interested in the highest bound that is logically possible, we do not impose models that preclude a large impact of the capital structure on the cost of capital (e.g., M&M).[17]

While bounds resolve the issue of measurement error in α, they do 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 estimates. A revealed preference condition provides a natural way to tighten the bounds: if the marginal cost α_{it} was too high, the bank would not participate in the loophole. Combined with the upper bound in equation (8), participation implies that

$$\alpha_t + \varepsilon_i \leq \frac{K_{O,it}}{K_{E,it}}\left[r_{e,it} - (1-\tau)\, r_{d,it}\right] \tag{9}$$

Since this revealed preference inequality holds for all i and t, and the bank-specific spread ε_i is assumed to be fixed, it is bounded by

$$\varepsilon_i \leq \min_t \left\{ \frac{K_{O,it}}{K_{E,it}}\left[r_{e,it} - (1-\tau)\, r_{d,it}\right] - \alpha_t \right\}, \tag{10}$$

where the minimum is taken over all periods when bank i participates in the loophole. Adding an estimate of the right-hand side of (10) to the ABCP spread α_t provides a bank-level bound on the incremental cost of the loophole, robust to potential unmeasured costs.[18]

[17] For comparison, in M&M with taxes, $C_E - C_D = r_d\tau - \frac{\partial r_d}{\partial k}\frac{D}{A}\tau - \frac{\partial r_o}{\partial k}\frac{O}{A}\tau$. Therefore (8) allows a substantial effect of capital ratios on the cost of capital on top of the M&M with taxes effect: $r_e - (1-\tau)\, r_d - \left(r_d\tau - \frac{\partial r_d}{\partial k}\frac{D}{A}\tau - \frac{\partial r_o}{\partial k}\frac{O}{A}\tau\right) \approx r_e - r_d$. Also, note that with this bound, the negative pricing effect of lower leverage on r_e is assumed to be stronger than any potential positive effects arising from a potential scarcity of equity capital.

[18] In the empirical implementation, we replace the minimum with the 10th percentile which is less sensitive to measurement error. Moreover, since the the constant ε_i restriction may be less suitable in a dynamic model, we also report estimates that do not impose it. We estimate $r_{e,it}$ using a CAPM regression of each bank's monthly returns

4.3 Conditions for Identification

A consistent estimate of the shadow cost equation relies on a first-order condition for optimal loophole use, and on the assumption that demand for loans does not directly depend on the share of assets in ABCP conduits. Therefore, before taking equation (1) to data, we need to verify the following sufficient conditions: (i) constrained banks exploit the loophole, (ii) banks do not finance their entire portfolio through the loophole, and (iii) marginal borrowers do not value differently loans financed via ABCP conduits ($R_O - R_D = 0$).

Conditions (i) and (ii) are required because we cannot point-identify λ for banks that do not exploit the loophole, or shift all assets to ABCP conduits. We verify these conditions below. Condition (iii) helps to isolate the loophole effect. While we cannot directly verify this condition, we find it quite reasonable, as it merely says that borrowers care about the terms of their loans and not about the way banks finance their operations.

Next, we verify that loophole participants were constrained by capital regulation (condition (i)). Note that if these banks were unconstrained by capital requirements, we would overestimate their shadow cost, as the true cost would be zero. Such conclusion appears implausible given the background of the regulatory debate, and, indeed it is rejected by the data. 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 et al. (2008) who show that banks hold capital buffers, as protection against volatility. The behavior of ABCP sponsors, however, shows additional interesting patterns. Consistent with condition (i), 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% above 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.

Figure 4 plots the regulatory ratios with and without the ABCP assets for individual banks. We find that while some banks kept larger buffers in some ratios, they were constrained by other

from CRSP over the period 1989-2007Q2. The average beta is 0.98, consistent with previous literature. For $r_{d,it}$ we use the 30 day AA financial CP rate, which is 2.7% on average. To reduce noise in the estimates of expected returns we use the average of estimated $r_{e,it} - (1 - \tau)\, r_{d,it}$ for banks in our sample (7.9%).

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 use of the ABCP loophole appears to have allowed it to relax that constraint. Moreover, the buffers are remarkably stable over time. While few banks made sharp adjustment to their capital ratios, they kept stable ratios before and after the change. 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. We conclude that banks were constrained by the regulatory ratios, and targeted the minimum requirement for being "well-capitalized."

Why do banks keep stable buffers on top of the requirements, and what does this mean for our estimation? As we discussed above, as long as the buffers are stable, they do not alter the shadow cost expression (1), because the level of required ratios (σ) does not play a role. 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. This interpretation is different from the precautionary motive (e.g., Berger et al., 2008), and it appears to be especially relevant in our sample of the largest banks.[19]

Finally, condition (ii) requires that banks do not exhaust the loophole. In line with this condition, Figure 5 shows that the average share of total assets financed through the loophole is about 2.5 percent, with a median of 2 percent. This fraction is quite stable over time and across banks with a standard deviation of 0.26 percentage points and a maximum of 13 percent (Zions).

Since it could be the case that banks exhausted their usage of the loophole in *some* types of assets, we reexamine condition (ii) at the asset level. Our data includes types and industry origin of conduit assets, which allows mapping these assets to the amounts reported in FR-Y9C forms, and calculating the share of assets held in the conduits. For condition (ii) to hold at the asset level, this share needs to be between zero and one.

We aggregate Moody's data to broad asset type categories in order to compare ABCP assets

[19]Consider the following comment 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 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. Emphasis added.)

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%).[20]

Panel (b) of Figure 5 shows the average and the median shares of ABCP assets, separated by asset types: credit cards, consumer loans, commercial loans, and residential mortgages. Consistent with condition (ii), 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.

5 Results

Combining the expressions for the marginal cost and the marginal benefit of ABCP financing gives the estimating equation for the shadow cost of capital requirement s for bank i at time t:

$$\lambda_{it}^{s} = \frac{\alpha_{it}}{\left(1 - \beta_{ABCP,t}\right) w_{it} K_{it}^{s} \frac{A_{it}}{A_{it}^{s}}}, \tag{11}$$

where α_{it} is measured either directly using equation (6) or bounded using equation (10). Equation (11) is an empirical counterpart of equation (1).

Table 3 presents our baseline estimation results, where the marginal cost of the loophole is measured directly by the spread in equation (6). 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 of 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 $d\Pi_{it} = -\lambda_{it} \times A_{it} \times d\sigma$ —the dollar cost of a 1 percentage point increase in capital requirements. In the case of the tier 1 capital ratio, this 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 upper bounds estimates of λ (columns 1–3) and $d\Pi$ (columns 4–6), calculated

[20] 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%).

using the bounds on the marginal cost of the loophole (10). The upper bound on α used here is 31bp, compared with the 2.5bp average ABCP spread used in Table 3. As a result, the upper bounds of the effects on profits of a one percentage point increase in the ratios are \$139 million (tier 1 risk based ratio), \$99 million (total risk-based ratio), and \$145 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 higher than the baseline estimate in Table 3, it relies on an unrealistically high estimate of $C_E - C_D$ (8% on average). It is high not only because it ignores the endogeneity of r_e, but also because of the relatively low r_d (financial CP rate that averaged 2.7%). We chose this rate to get a conservative estimate. For example, we estimate (untabulated) that using $r_d = 7\%$ as in Kashyap et al. (2010)—which amounts to assuming that ABCP replaces long-term debt on the bank's balance sheet—results in a much smaller average decrease in profits of \$75 to \$111 million across ratios.[21]

Figure 6 plots the aggregate effects on profits from Tables 3 and 4 over time. Panel (a) of Figure 6 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, ranging between \$83 and \$334 million, across all ratios.[22] The average aggregate effect is \$220 million for tier 1 ratios, and \$160 million for the total risk-based ratio. Panel (b) of Figure 6 shows a time series aggregate for the upper bound of the aggregate effect, from Table 4. The quarterly aggregates range between \$1.2 billion and \$3 billion over time, across ratios.

A different way to assess the magnitude is to compare the discounted value of the shadow cost to the present value of equity. With an expected return on equity of approximately 10%, the present value of the aggregate shadow cost becomes \$2.2 billion, or about 0.4% of the value of equity for banks in our sample (see Table 2). Coincidentally, it is similar to the \$2.07 billion aggregate underwriting expense of issuing additional equity equal to 1% of risk-weighted assets, taking an average secondary equity offering fee of 5%.[23]

[21] Without the assumption that the bank-specific spread ε_i in equation (10) is constant over time, we find that the average $d\Pi$ would be \$191, \$136, and \$200 million for tier 1 and total risk based, and tier 1 leverage ratios, respectively. As discussed above, such bounds are unrealistically high, but even in this case the average effect ranges between 3.2% and 4.7% of annual profits.

[22] The end-of-year "spikes" in the figure are mostly due to variation in the ABCP spread (α).

[23] We thank a referee for suggesting these benchmarks.

We focus on the pre-crisis period because it reveals the shadow cost of capital regulation during normal times when adjustment costs play a relatively 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 (2007Q4), the aggregate cost of a 1pp increase in the tier 1 risk-based ratio was around $5.8 billion. Intuitively, relaxing capital constraints in times of stress is valuable because the shadow costs are relatively large.

While the focus of this paper is the population of the largest banks in the economy, rather than the whole industry, in Appendix B we replicate the exercise using the whole banking universe. Doing so requires additional assumptions, since the identification relies on the interior solution with respect to the loophole use. Interestingly, adding non-participating banks does not significantly add to the aggregate estimates, mainly because an average participating bank was about a hundred times larger than an average non-participating bank.

Finally, our analysis focuses on US banks, but the methodology is applicable to non-US banks as well. In Appendix C we study European banks, who have been active in the ABCP market prior to the crisis (Acharya, Schnabl, and Suarez, 2013), and had a significant presence in the US (Figure 2). We find that European ABCP Sponsors were larger and more levered. The average shadow cost for the tier 1 risk-based ratio is 0.0038 (compared to 0.003 for the US). Their large size leads to a higher average effect on profits of $35 million (compared to $14.3 million for the US).

6 Discussion, Extensions, and Robustness

Here we discuss the implications of our results for the effectiveness of regulation (Section 6.1), show how to combine the loophole approach with specific capital structure models (Section 6.2), discuss the extension of our method to include limited liability (Section 6.3) and large changes in capital requirements (Section 6.4), and provide several robustness checks for our estimates (Section 6.5).

6.1 Implications for Bank Stability and the Effectiveness of Regulation

Regulatory capital ratios may not necessarily correspond to the economic ratios, and therefore may not reflect underlying default probabilities and bank safety. In this subsection, we use our shadow cost estimates to ask: how much would economic capital ratios rise if regulatory ratios increased by one percentage point?

A shadow cost estimate is a combination of the effect of equity on the cost of capital and the effectiveness of capital requirements. Denote by $k = E/A$ the economic capital ratio, which could be different from its regulatory counterpart $K^s = E^s/A^s$. We can rewrite equation (7) as follows

$$\lambda = \frac{C_E - C_D}{K^s_k}, \tag{12}$$

which shows that a modest shadow cost λ could be driven both by a small relative cost of equity $C_E - C_D$, or by a sizable wedge between economic and regulatory ratios $K^s_k \equiv \frac{\partial K^s}{\partial k} = AK^s_E = \frac{A}{A^s}\frac{\partial E^s}{\partial E}$.

Intuitively, the wedge K^s_k is large if actual assets are large relative to regulatory assets, or if a dollar increase in equity increases regulatory capital by more than a dollar. $K^s_k > 1$ means that the regulatory ratio K^s does not fully reflect the economic capital ratio k, and a desired increase in the economic ratio would require a larger increase in the regulatory one. The existence of such a wedge is evident from a large literature, cited in Section 1, that documents problems with regulatory risk measurements and "loophole-mining" as a pervasive feature of the system (Kane 1981; 2012). Such loopholes include but are not limited to the ABCP loophole studied in this paper.

Even under the conservative assumption that the wedge comes solely from the discrepancy between risk-weighted and economic assets, while regulatory and economic capital are essentially the same ($\frac{\partial E^s}{\partial E} = 1$), $\frac{A}{A^s} = 2.7$ for the mean bank in our sample. This implies that a 100 basis point increase in K achieves only a 37 basis point increase in the economic capital ratio. This wedge does not take into account other loopholes, which means that in practice regulation could be even less effective.[24]

[24] A recent controversial example of a potential loophole are trust preferred securities (TruPS), which are included in the tier-1 capital but not considered equity by capital markets. The Final Rule issued July 2, 2013 by the federal banking regulatory agencies states that even though they "continue to believe that TruPS do not absorb losses sufficiently to be included in tier 1 capital as a general matter," the final rule permanently grandfathers such non-qualifying capital instruments for banks with up to $15 billion in book assets, and for mortgage holding companies.

Further progress in quantifying K_k^s can be made by combining our estimates with models of capital structure. To illustrate, under the M&M model with taxes, and important benchmark, Hanson, Kashyap, and Stein (2011) estimate a lower bound for $C_E - C_D$ of 2.5% (25bp for 10pp increase). Taking this estimate as given, equation (12) implies that $K_k^s = \frac{0.025}{\hat{\lambda}} \approx 10$, which means that a policymaker aiming to increase economic capital ratios by one percentage point must raise regulatory ratios by ten percentage points. Higher estimates of $C_E - C_D$, such as those of Baker and Wurgler (2013) as well as our upper bounds from Section 4.2.2 imply larger wedges.

6.2 Implications for Bank Cost of Capital and Interest Rates

An alternative way to use equation (12) is to note that if we pin down the wedge K_k, we can recover the relative cost of equity. It is commonly assumed (e.g., Kashyap et al.) that banks comply with tighter requirements by increasing equity (as opposed to, say, changing the composition of assets), i.e. $K_k^s = 1$. With this assumption, the shadow cost reduces to $\lambda = C_E - C_D$, and can be directly interpreted as the effect of capital requirements on bank cost of capital and interest rates. Prior literature cited above focuses on this quantity, assuming specific capital structure models. While our exercise does not require such restrictions, we can combine specific models of capital structure with the loophole methodology to highlight some complementarities between the two approaches.

First, our shadow cost estimates can be directly used in calibration and estimation of capital structure models in banking and elsewhere. For example, in the M&M model with taxes, the capital ratio affects the cost of capital only through the tax shield, which implies that $C_E - C_D = r_d \tau$. Note, however, that the marginal cost of debt r_d—the key input under M&M—is unknown. Unfortunately, there is no clear guidance in the choice of empirical measures for it. This undermines the advantages of using the M&M model in estimation, since the estimates can be arbitrarily high or low depending on the researcher's assumption about the cost of debt. Our estimates can be used to impose an independent restriction on the shadow cost implied by the M&M framework. In particular, maintaining the assumption of a unit wedge, our estimates in Table 3 and the marginal tax rate of 35% imply that $r_d = \frac{\lambda}{\tau}$ is about 86 basis points.[25]

[25] Kashyap et al. (2010) assumed $r_d = 7\%$ to place an upper bound on the increase in bank cost of capital under M&M with taxes.

Specific capital structure models can be also used to provide sharper bounds for the marginal cost of the loophole—a key input to our estimates—by replacing $r_{e,it} - (1 - \tau)\, r_{d,it}$ in equation (10) with model-specific expressions. Such an exercise can be especially fruitful under richer models of capital structure which may place tighter bounds on α.

6.3 Limited Liability and Default Risk

Capital regulation is often motivated by the concern that limited liability leads shareholders to choose higher leverage than socially optimal. The effect of limited liability on our estimates depends on whether an increase in capital requirements (σ) has a direct and exogenous effect on expected bank profits, or only an indirect effect through a change in banks' endogenous choices (only the direct effect of a parameter change matters around the optimized value function).

To see this, suppose for simplicity that with probability p the bank defaults and its equity is wiped out. The Lagrangian becomes $\mathcal{L} = (1 - p) \times (R - C) + \lambda A\,(K - \sigma) + \rho\,(E + D + O - A)$. The scaled multiplier λ remains bounded from above by our baseline estimate since now

$$\lambda = \frac{(1 - p) \times (C_O - C_D) + (p_O - p_D) \times (R - C)}{A\,(K_O - K_D)} \leq \frac{C_O - C_D}{A\,(K_O - K_D)}, \tag{13}$$

where the inequality assumes that the effect on the default probability of borrowing on and off-balance sheet is economically identical ($p_O = p_D$). The shadow cost per dollar of assets, however, in this more general setup potentially has an additional term if σ directly affects the default probability

$$-\frac{d\mathcal{L}^*}{d\sigma}\frac{1}{A} = -\frac{\partial \mathcal{L}^*}{\partial \sigma}\frac{1}{A} = \lambda + \frac{\partial p}{\partial \sigma} \times \left(\frac{R - C}{A}\right). \tag{14}$$

If tighter capital requirements directly increase (decrease) the default probability, our baseline results would be underestimating (overestimating) the effect on profits (assuming the bank is profitable, $R > C$). For example, capital regulation may have a direct effect if for some reason it affects the threshold at which the bank is taken over by its regulator. By contrast, if tighter capital requirements only indirectly affect the default probability through a change in banks' choices (e.g. equity capital or asset risk), then limited liability has no first-order implications for bank value, and our baseline estimates are accurate.

6.4 Small vs. Substantial Policy Changes

The envelope theorem provides a simple expression for the first-order effect on profits of a small increase in capital requirements. While such estimates are directly relevant for small policy changes implemented (thus far) following the last crisis, this implies that without further structure, we cannot directly analyze very large changes in capital requirements. In this sense, our estimates share the limitation of studies that use linear regressions to estimate treatment effects. Nevertheless, we would like to examine the relevance of our estimates in analyzing *substantial changes* in σ.

If maximized profits are convex in σ, our marginal estimates provide an *upper bound* for the costs of substantial changes in capital requirements. Intuitively, if the initial increase in capital requirements is costlier than subsequent increases, then assigning the marginal cost of an infinitesimal increase to the entire increase, would overestimate the total cost of a substantial increase.

This raises the question whether profits are likely to be convex in our environment. While an empirical verification of this assumption is beyond the scope of this paper, the literature suggests that it may be plausible. One prominent feature of banking that implies convexity of the profit function in σ, is the existence of deposit insurance and government bailout guarantees. Merton (1977) shows that the value to a bank from such a guarantee is similar to a put option, whose value is increasing and convex in its strike price, which represents the face value of debt in our setting. Therefore, the value of the government put is a decreasing and convex function of the bank's capital ratio. Another theoretical rationale for convexity of the profit function in the capital ratio is the tax benefit of debt.[26]

Of course, the convexity condition may not hold in practice. For this reason, throughout the paper, we discuss effects of a 1 percentage point increase in capital requirements.

[26] For example, under M&M with taxes, the value of the levered firm $V_L = \sum_t \frac{CF_t}{(1+r_u-(1-k)r_d\tau)^t}$ (and the corresponding value of equity) is decreasing and convex in the capital ratio k, where r_u is the unlevered cost of capital.

6.5 Robustness

6.5.1 Unobservable Benefits of ABCP Financing

So far in our analysis, regulatory constraints are the only reason for the use of ABCP conduits: the loophole allows banks to decrease their costs by increasing leverage. It could be the case, however, that the ABCP arrangement creates some additional value for banks and borrowers. One direct source of such benefits is fees charged to the ABCP conduit by the liquidity guaranteeing bank, to its own ABCP program or to third-party programs. Moreover, access to the ABCP market could potentially change the supply curve as well as the demand curve. The supply-side effect could happen if banks can reduce their costs by using ABCP to finance loans (e.g. Greenbaum and Thakor, 1987). The demand can change if marginal borrowers value the fact that their loans are warehoused in ABCP conduits.

Our conversations with market participants revealed that, if anything, the supply-side effect was at 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 bank's cost of lending. A similar argument can be found in Moody's description of the ABCP market (Bate, Bushweller, and Rutan, 2003, p. 15). 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.

We can think of these demand effects using (1), by relaxing the assumption maintained thus far that revenue is independent of funding, and instead allow revenues from ABCP funded assets to exceed revenue from balance sheet loans, i.e. $R_O > R_D$. We can similarly think of the supply channel as measurement error in $\alpha = (r_o - r_d)(1 - \tau) - \gamma$ for some $\gamma > 0$. It is immediate from (1) that in both cases, our baseline estimates would *overestimate* the shadow costs of capital constraints. On the other hand, if ABCP-funded assets yield much lower revenues than balance-sheet funded ones ($R_O \ll R_D$), this conclusion could be reversed. We find that scenario unlikely.

6.5.2 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 4.3 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 7 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.

6.5.3 Risk Weighting of Conduit Assets

As discussed in Section 4.1, we do not observe the risk weight applied to the marginal assets funded with ABCP. Our baseline estimates assume that the distribution of risk weights is the same in the conduits as on the balance sheet. This allows us to average out some uncertainty about the risk weights of conduit assets. We now examine the sensitivity of our results to alternative assumptions.

Smaller risk weights of ABCP assets in the denominator of the shadow cost expression (11) would increase the estimated cost. Intuitively, lower risk weights in the conduit assets would be a sign of costlier constraints, since these assets contribute less to relaxing the constraint.[27]

Assuming that the fixed costs of a conduit are not asset-specific, banks would place multiple risk types j in the conduit only if their incremental costs α_j are different. If α is the same for all j (as our empirical implementation assumes), the model implies that banks would use the loophole for

[27]The estimates from the baseline model (unreported) remain virtually identical even when we assume 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 was about 3%, which mitigates the effect of risk weighting assumptions.

risk types that provide the largest net benefit, and use less beneficial types only after running out of more beneficial ones. In that scenario, only one first-order condition with an interior $O_{j\ell} \in (0, A_j)$ is valid per constraint. To take this extension to data, we make a conservative assumption that all conduit assets get a particular weight, and then calculate our estimates for each risk weight.

Figure 8 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 baseline model, since it implicitly assigns a risk weight of 1 to all assets. The solid black line in each panel is the estimated effect on profits from the extended model for a range of risk weighing assumptions. Adjacent to the line, for comparison, is the baseline estimate from Table 3. Relative to the baseline 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 baseline estimates do as well. In practice, the risk-weights are known to regulators, who could use our methodology to calculate the shadow costs more accurately. Figure 8 also shows that increasing α by using the overnight Fed Funds rate as the alternative cost of on-balance sheet financing increases our baseline estimates by about 80%.

7 Conclusion

We estimate the shadow cost of capital requirements for bank's 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 a marginal increase in regulatory capital ratios would have modest effects. According to our baseline estimates, a one percentage point increase in required capital ratios would cost all participating banks *combined* about $220 million a year. The cost to an average bank is $14 million, or 0.4 percent of its annual profits.

The modest shadow cost may appear puzzling given banks' resistance to higher capital requirements. Note, however, that this is the cost of complying with tighter *regulatory requirements* as opposed to the cost of actually raising equity capital. Our estimates capture the effect of regulation after banks use all available tools to mitigate its impact. This feature makes our estimates well-suited for a realistic analysis, which takes into account the existence of regulatory loopholes.

If equity capital is costly for banks, a modest shadow cost implies that banks can avoid an increase in their economic capital ratios using regulatory loopholes. An increase in capital requirements would have a minor effect on bank stability in that case. The need to create and preserve such loopholes could, potentially, explain the extensive lobbying effort of the banking industry.

The latest revision of US banking regulation (effective January 1, 2015) introduced relatively minor changes, such as the requirement for well-capitalized banks to have a common equity tier 1 capital ratio above 6.5 percent. Other ratios are increased by small amounts: the tier 1 risk-based and leverage ratios are increased by 2 percentage points each, and the total risk-based capital ratio requirement is left unchanged. Our estimates suggest that the effect of these changes 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. Regulators now require banks to satisfy capital requirements under stress scenarios, effectively increasing them in normal times, and banks deemed systemically important face higher capital requirements. Our model could be extended to study 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.

References

Acharya, Viral V., Philipp Schnabl, and Gustavo Suarez, 2013, Securitization without risk transfer, *Journal of Financial Economics* 107, 515–536.

Admati, Anat, and Martin Hellwig, 2013, *The Bankers' New Clothes* (Princeton University Press).

Admati, Anat R., Peter M. DeMarzo, Martin F. Hellwig, and Paul Pfleiderer, 2011, Fallacies, irrelevant facts, and myths in the discussion of capital regulation: Why bank equity is not expensive, Working paper Stanford.

Admati et al., 2010, Healthy banking system is the goal, not profitable banks, *Financial Times* Open Letter.

Allen, Franklin, Elena Carletti, and R. Marquez, 2009, Credit market competition and capital regulation, *Review of Financial Studies* 24, 983–1018.

American Bankers Association, 2012, Comment letter on proposals to comprehensively revise the regulatory capital framework for U.S. banking organizations, .

Anderson, Soren T., and James M. Sallee, 2011, Using loopholes to reveal the marginal cost of regulation: The case of fuel-economy standards, *American Economic Review* 101, 1375–1409.

Baker, Malcolm, and Jeffrey Wurgler, 2013, Would stricter capital requirements raise the cost of capital? bank capital regulation and the low risk anomaly, Working paper.

Basel Committee on Banking Supervision, 2009, Consultative proposals to strengthen the resilience of the banking sector., .

Bate, Swasi, Stephany Bushweller, and Everett Rutan, 2003, The fundamentals of asset-backed commercial paper, Special report by Moody's Investors Service.

Begenau, Juliane, 2014, Capital requirements, risk choice, and liquidity provision in a business cycle model, Working paper.

Berger, Allen N., and Christa H.S. Bouwman, 2013, How does capital affect bank performance during financial crises?, *Journal of Financial Economics* 109, 146–176.

Berger, Allen N., Robert DeYoung, Mark J. Flannery, David Lee, and Ozde Oztekin, 2008, How do large banking organizations manage their capital ratios?, *Journal of Financial Services Research* 34, 123–149.

Brun, Matthieu, Henri Fraisse, and David Thesmar, 2013, The real effects of bank capital requirements, Working paper.

Brunnermeier, Markus K., Thomas Eisenbach, and Yuliy Sannikov, 2013, *Macroeconomics with Financial Frictions: A Survey* (Cambridge University Press: New York).

Brunnermeier, Markus K., and Yuliy Sannikov, 2014, A macroeconomic model with a financial sector, *American Economic Review* 104, 379–421.

Bryan, Lowell L., 1988, *Breaking Up the Bank: Rethinking an Industry under Siege* (Dow Jones-Irwin: Homewood, IL).

Calomiris, Charles W., and Charles M. Kahn, 1991, The role of demandable debt in structuring optimal banking arrangements, *American Economic Review* 81, 497–513.

Corbae, Dean, and Pablo D'Erasmo, 2014, Capital requirements in a quantitative model of banking industry dynamics, Working paper.

Covitz, Daniel, Nellie Liang, and Gustavo A. Suarez, 2013, The evolution of a financial crisis: Collapse of the asset-backed commercial paper market, *Journal of Finance* 68, 815–848.

Demirguc-Kunt, Asli, Enrica Detragiache, and Ouarda Merrouche, 2013, Bank capital: lessons from the financial crisis, *Journal of Money, Credit and Banking* 45, 1147–1164.

Diamond, Douglas W., and Raghuram G. Rajan, 2001, Liquidity risk, liquidity creation, and financial fragility: A theory of banking, *Journal of Political Economy* 109, 287–327.

Duchin, Ran, and Denis Sosyura, 2014, Safer ratios, riskier portfolios: Banks' response to government aid, *Journal of Financial Economics* 113, 1–28.

French et al., 2010, *The Squam Lake Report: Fixing the Financial System* (Princeton and Oxford: Princeton University Press).

Gertler, Mark, and Nobuhiro Kiyotaki, 2010, Financial intermediation and credit policy in business cycle analysis, in Benjamin M. Friedman, and Michael Woodford, ed.: *Handbook of Monetary Economics*, vol. 3 . pp. 547–599 (Elsevier).

Gornall, William, and Ilya A Strebulaev, 2013, Financing as a supply chain: The capital structure of banks and borrowers, Working paper National Bureau of Economic Research.

Greenbaum, Stuart I, and Anjan V Thakor, 1987, Bank funding modes: Securitization versus deposits, *Journal of Banking & Finance* 11, 379–401.

Han, Joongho, Kwangwoo Park, and George Pennacchi, 2015, Corporate taxes and securitization, *Journal of Finance* 70, 1287–1321.

Hanson, Samuel, Anil K. Kashyap, and Jeremy C. Stein, 2011, A macroprudential approach to financial regulation, *Journal of Economic Perspectives* 25, 3–28.

Harris, Milton, Christian C Opp, and Marcus M Opp, 2014, Macroprudential bank capital regulation in a competitive financial system, Working paper.

He, Zhiguo, and Arvind Krishnamurthy, 2012, A model of capital and crises, *Review of Economic Studies* 79, 735–777.

——— , 2013, Intermediary asset pricing, *American Economic Review* 103, 732–70.

Hellwig, Martin F, 2010, Capital regulation after the crisis: business as usual?, *MPI Collective Goods Preprint*.

Holmstrom, B., and J. Tirole, 1997, Financial intermediation, loanable funds, and the real sector, *Quarterly Journal of Economics* 112, 663–91.

Houston, Joel F, Chen Lin, and Yue Ma, 2012, Regulatory arbitrage and international bank flows, *Journal of Finance* 67, 1845–1895.

Kane, Edward J, 1981, Accelerating inflation, technological innovation, and the decreasing effectiveness of banking regulation, *Journal of Finance* 36, 355–367.

——— , 2012, The inevitability of shadowy banking, Working paper Boston College.

Karolyi, George Andrew, and Alvaro G Taboada, 2014, Regulatory arbitrage and cross-border bank acquisitions, *Journal of Finance* 70, 2395–2450.

Kashyap, Anil K., Jeremy C. Stein, and Samuel Hanson, 2010, An analysis of the impact of "substantially heightened" capital requirements on large financial institutions, Discussion paper.

Koijen, Ralph S.J., and Motohiro Yogo, 2014, The cost of financial frictions for life insurers, *American Economic Review* 105, 445–475.

Mehran, Hamid, and Anjan Thakor, 2011, Bank capital and value in the cross-section, *Review of Financial Studies* 24, 1019–1067.

Merton, Robert C., 1977, An analytic derivation of the cost of deposit insurance and loan guarantees an application of modern option pricing theory, *Journal of Banking & Finance* 1, 3–11.

Modigliani, F., and M. H. Miller, 1958, The cost of capital, corporate finance and the theory of investment, *American Economic Review* 48, 261–97.

Nguyen, Thien Tung, 2014, Bank capital requirements: A quantitative analysis, Working paper.

Peek, Joe, and Eric S. Rosengren, 1997, The international transmission of financial shocks: The case of Japan, *American Economic Review* 87, 495–505.

Pennacchi, George, 1988, Loan sales and the cost of bank capital, *Journal of Finance* 43, 375–396.

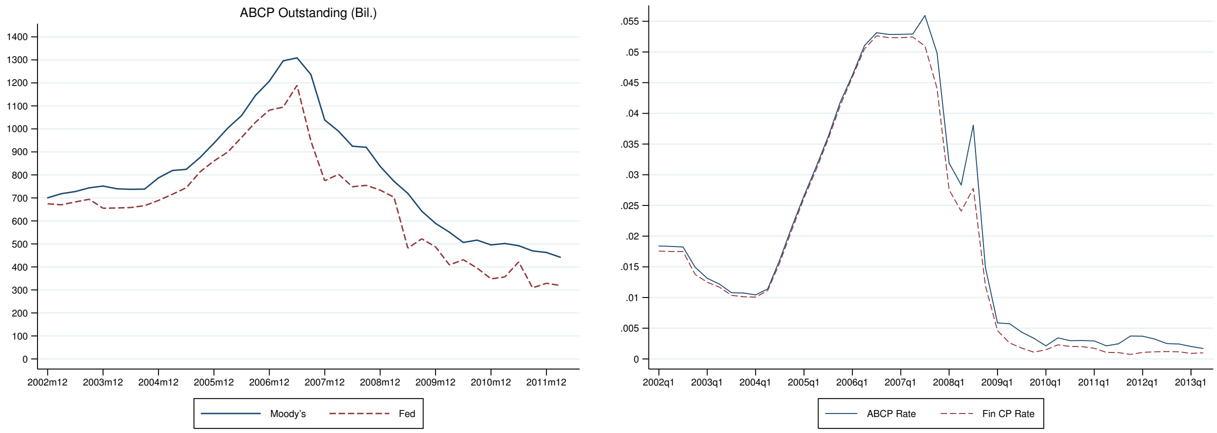
Rochet, JC, 2010, The future of banking regulation, in J.-C. Rochet by M. Dewatripont, and J. Tirole, ed.: *Balancing the Banks: Global Lessons from the Financial Crisis* . pp. 78–106 (Princeton University Press).

Shleifer, Andrei, and Robert W Vishny, 2010, Unstable banking, *Journal of financial economics* 97, 306–318.

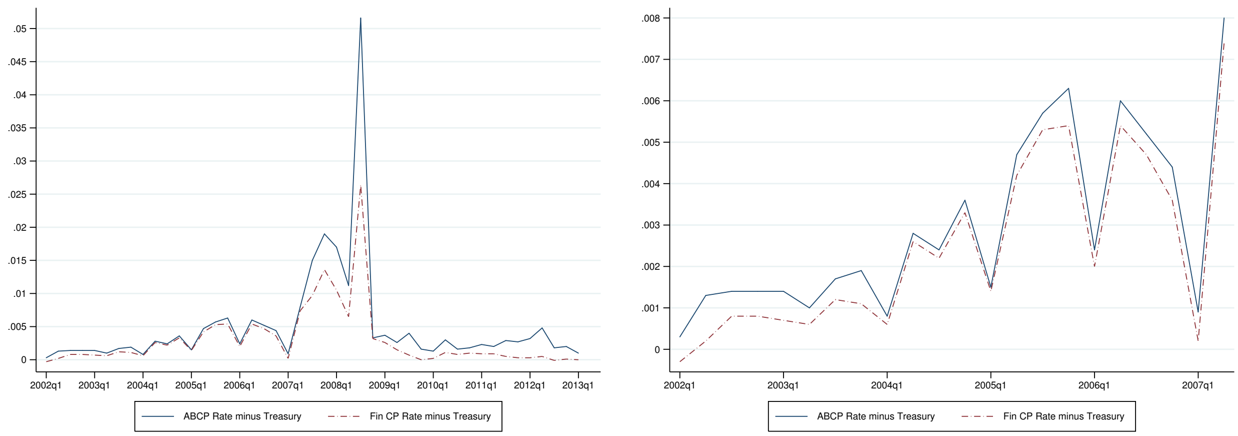
Simons, Henry C., 1948, *Economic Policy for a Free Society* (Univ. Chicago Press: Chicago, IL).

Van den Heuvel, Skander J., 2008, The welfare cost of bank capital requirements, *Journal of Monetary Economics* 55, 298–320.

Figure 1: ABCP Market Over Time



(a) Market Size and Rates Over Time

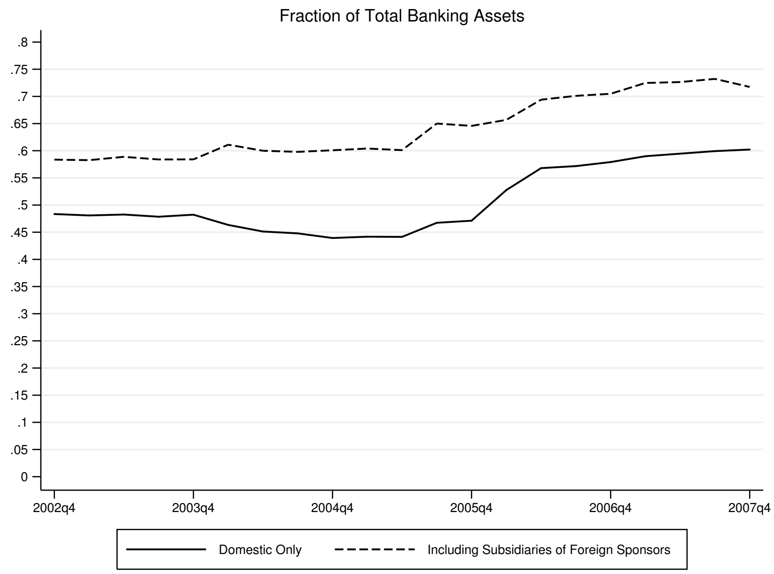


(b) ABCP and Financial CP Rates Net of Treasury

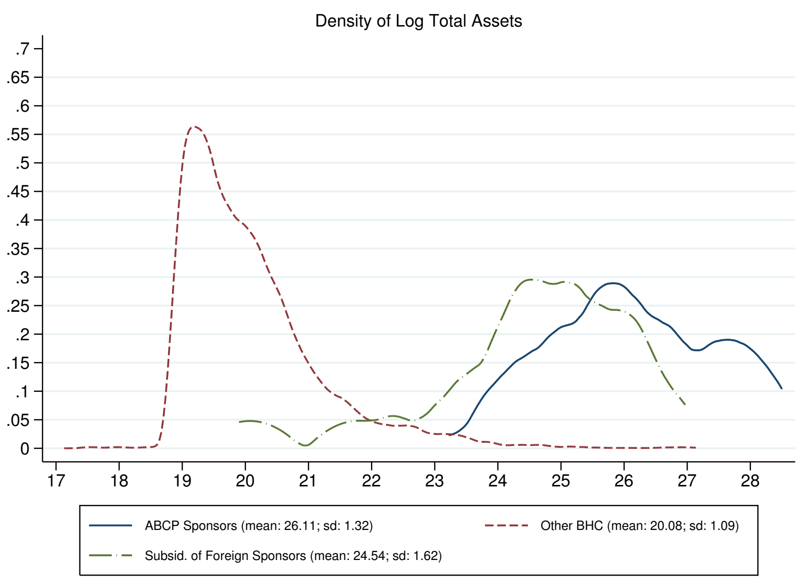
Notes: Left hand-side figure of Panel (a) shows total asset-backed commercial paper outstanding (excluding SIV) from quarterly and monthly reports by Moody's Investor Service (solid line) and reported weekly by the Fed (dashed line). Right hand-side figure pf Panel (a) shows the quarterly averages of 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

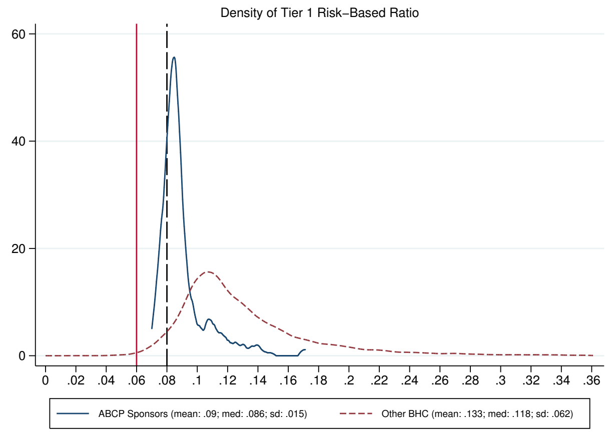


(b) Distribution of Log Total Assets

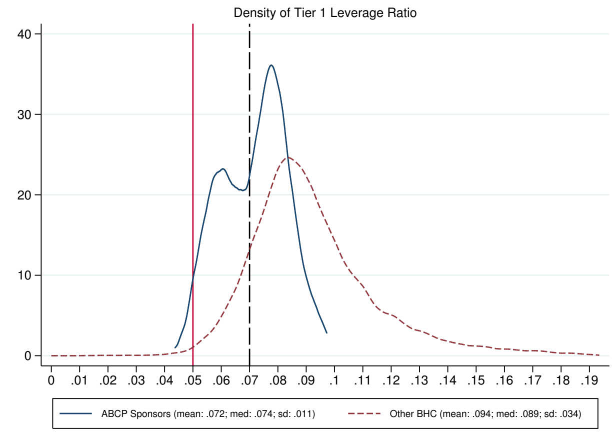


Notes: Figure 2a shows the fraction of total banking assets in the US held by bank holding companies ("BHC") that provided liquidity guarantees to ABCP conduits with (dashed line) and without (solid line) subsidiaries of foreign ABCP sponsors. Figure 2b reports kernel density estimates of the log assets 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.

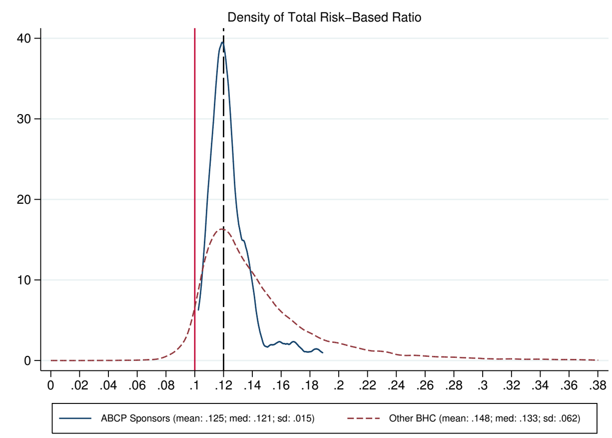
Figure 3: Distribution of Capital Ratios: ABCP Sponsors vs. Other Banks



(a) Tier 1 Risk-Based Ratio



(b) Tier 1 Leverage Ratio



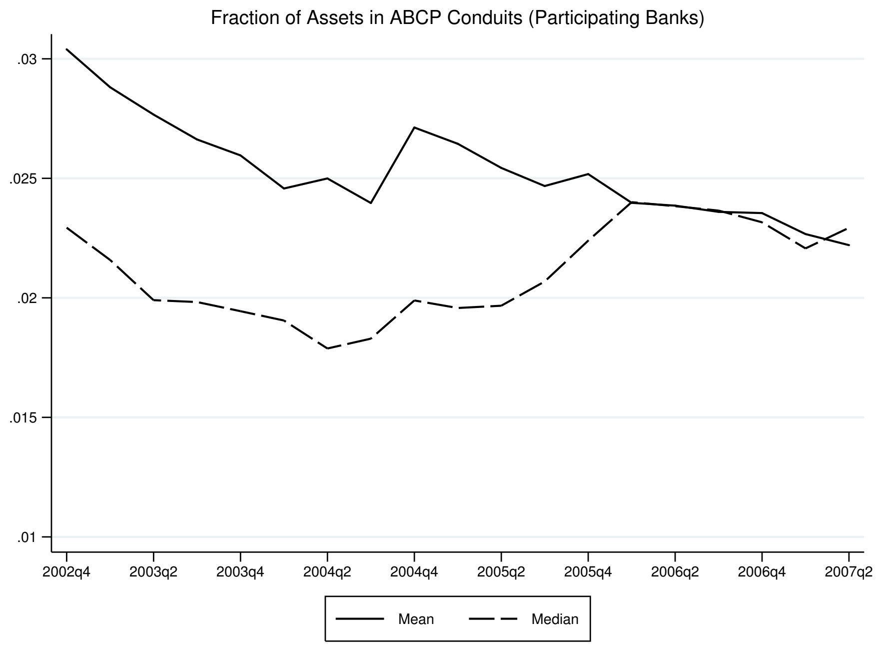
(c) Total Risk-Based Ratio

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.

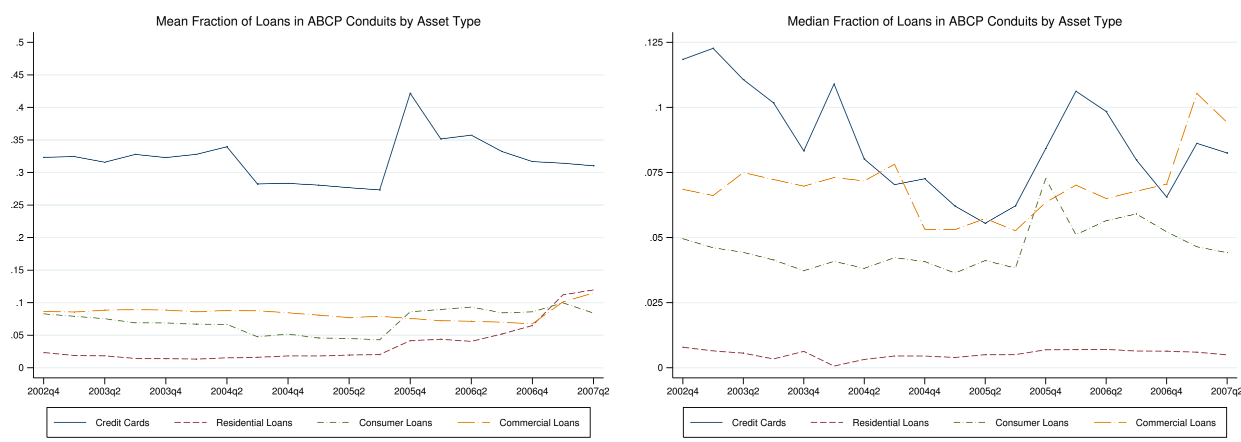
Figure 4: Individual Capital Ratios and Regulatory Constraints

Notes: Solid lines are reported regulatory capital ratios. Dashed lines are ratios that would be reported if ABCP assets were held on the books. Horizontal lines are the regulatory requirement for each ratio. Sample: US banks that provided liquidity guarantees to ABCP conduits.

Figure 5: Constrained Banks Did Not Exhaust the ABCP Loophole



(a) Fraction of Assets in ABCP Conduits

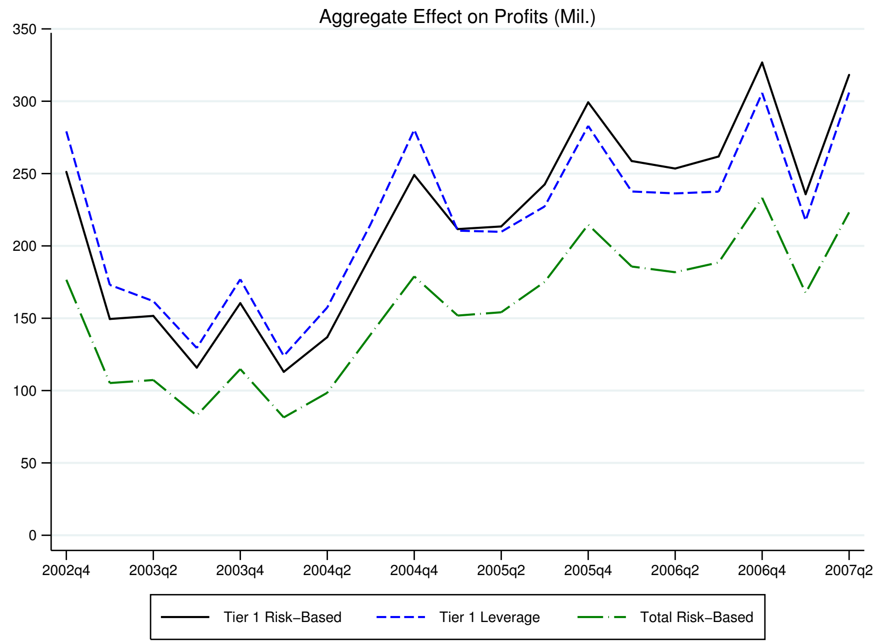


(b) Fraction of Assets in ABCP Conduits by Asset Type

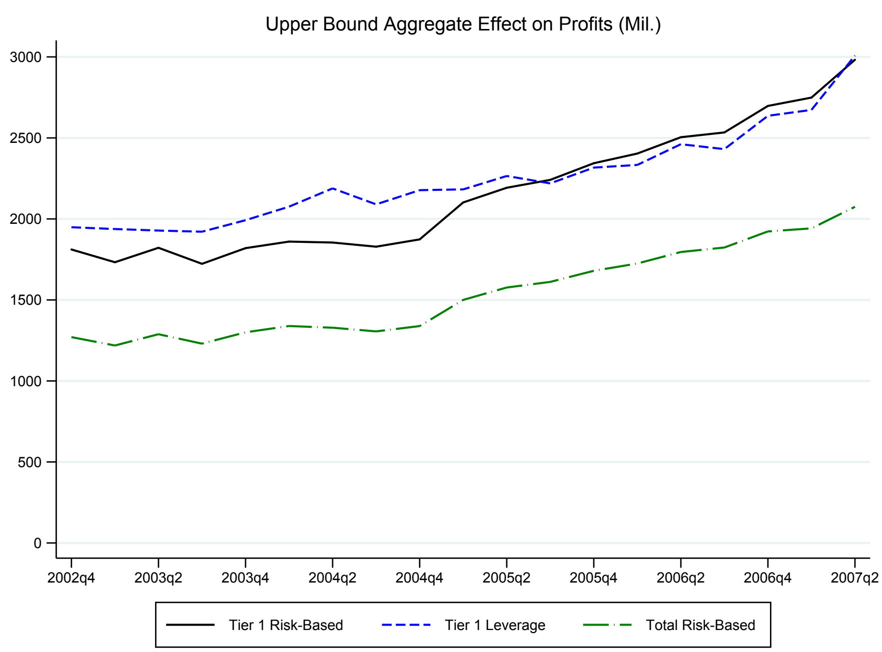
Notes: Panel (a) shows the aggregate fraction of assets in ABCP conduits over time. The mean (solid line) and the median (dashed line) of the fraction of total assets financed via ABCP conduits with liquidity guarantees (θ in the model) by US bank holding companies that provided liquidity guarantees 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: Aggregate Cost of a One Percentage Point Increase in Regulatory Ratios for Banks that Used the Loophole

(a) Point Estimates

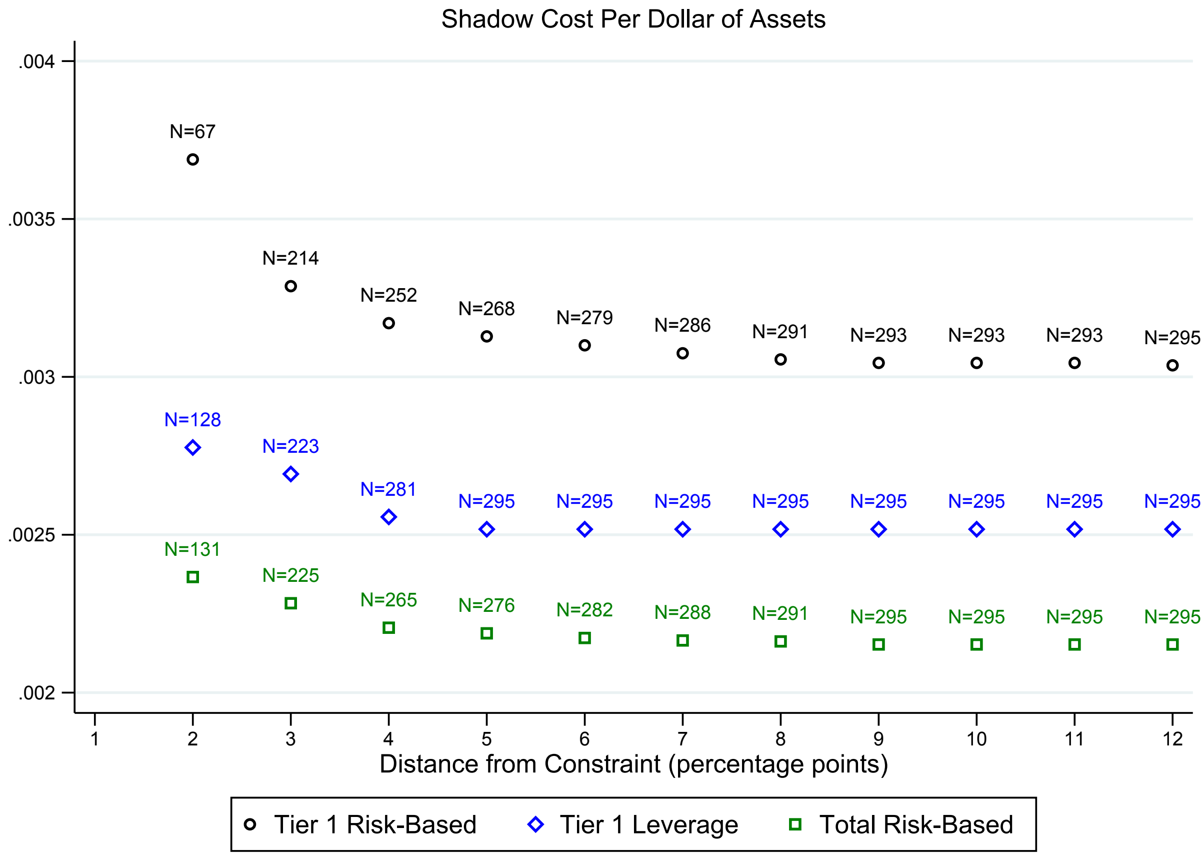


(b) Upper Bound Estimates



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 6. Panel (b): the upper bound on the costs from equation 10. The aggregate change in profit is calculated as $\Sigma_i d\Pi_{ist} = \lambda^s_{it} \times A_{it} \times d\sigma_s$, 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 A_{it} is the total assets of bank i in quarter t.

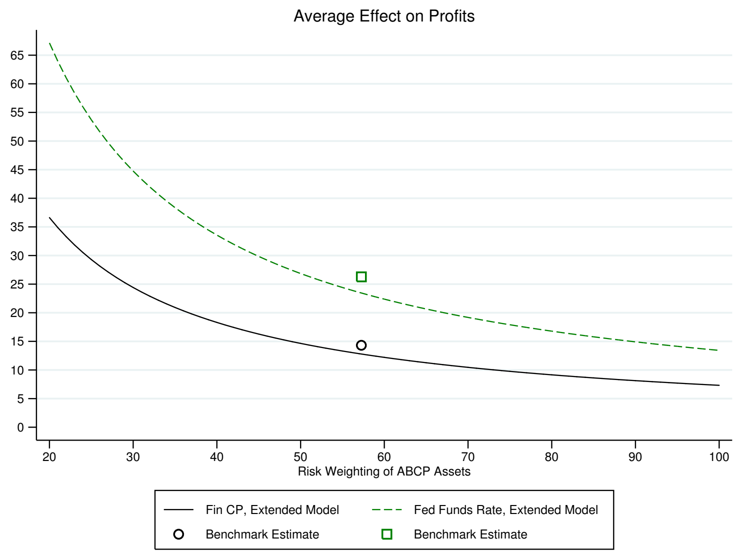
Figure 7: Shadow Cost Estimates vs. the Distance from the Constraint



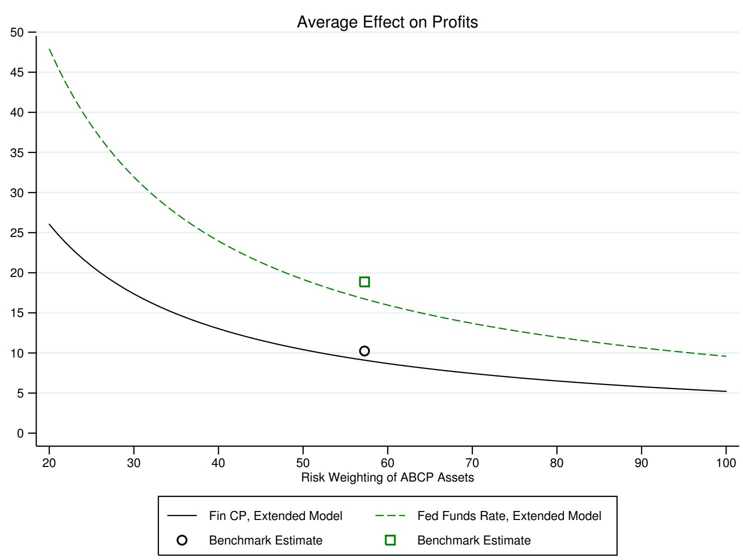
Notes: On the horizontal axis is the distance from the constraint in percentage points. Each marker represents the mean shadow cost per dollar of assets of all bank-quarters whose reported ratio is at or below the distance on the horizontal axis for the corresponding regulatory ratio. Circles (black) represent tier 1 risk-based ratio, diamonds (blue) tier 1 leverage ratio, and squares (green) total risk-based ratio. The estimates for the rightmost point for each ratio include the full sample. N is the number of bank-quarters in each group. Sample: US bank holding companies that provided liquidity guarantees to ABCP conduits in the period 2002Q4-2007Q2.

Figure 8: 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 bank's profits) of a one percentage point increase in each regulatory ratio. For each bank i, the change in profit is $d\Pi_{ist} = \lambda_{it}^{s} \times A_{it} \times d\sigma_{s}$, where λ_{it}^{s} is the shadow cost of constraint s for bank i, σ is the required ratio, A_{it} is the total assets. Lines represent estimates from the extended model that allows for differential risk weighting of ABCP assets, for a range of risk weighting assumptions. Solid black lines use the baseline 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 baseline 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 the tier 1 risk-based ("T1 RB"), the total risk-based capital ("Tot RB"), and the tier 1 Leverage ("T1 Lev") ratios are calculated using equation (11). Change in Profit is calculated as $d\Pi_{is} = -\lambda_s \times A_i \times d\sigma_s$, 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 A_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	0.039	0.028	0.046	-491.3	-350.4	-573.9	19
BANK OF NEW YORK	0.0094	0.0061	0.0029	-36.7	-24.1	-10.5	19
BANK ONE	0.053	0.039	0.049	-205.5	-149.7	-189.7	7
CITIBANK	0.028	0.020	0.040	-461.2	-337.4	-656.0	19
COMPASS BANK	0.042	0.032	0.041	-14.2	-10.7	-13.7	19
FIFTH THIRD BANK	0.042	0.034	0.036	-50.2	-40.5	-42.3	19
FLEET	0.064	0.047	0.052	-157.4	-114.8	-126.2	6
FNB OMAHA	0.067	0.051	0.063	-8.89	-6.76	-8.33	8
JPMORGAN CHASE	0.029	0.020	0.028	-432.6	-307.7	-405.3	19
KEYBANK	0.062	0.041	0.042	-73.1	-47.9	-49.6	8
MARSHALL-ILSLEY	0.040	0.027	0.034	-20.8	-14.2	-17.1	19
MELLON BANK	0.0072	0.0046	0.0019	-12.5	-8.11	-2.91	19
PNC BANK	0.036	0.026	0.029	-41.2	-29.2	-32.0	19
STATE STREET	0.0039	0.0035	0.0019	-19.9	-17.4	-8.35	19
SUNTRUST	0.046	0.031	0.037	-84.6	-57.4	-68.6	19
US BANK	0.042	0.028	0.033	-106.8	-70.8	-84.5	19
WACHOVIA	0.034	0.024	0.031	-212.7	-147.0	-188.6	19
ZIONS	0.036	0.024	0.031	-17.2	-11.3	-14.0	19
Mean	0.034	0.024	0.030	-139.2	-99.2	-145.0	
Std. Error	[0.0036]	[0.0026]	[0.0037]	[43.2]	[31.0]	[53.0]	

Notes: Time-series averages for ABCP sponsoring US bank holding companies, 2002Q4-2007Q2. The estimates are calculated using an upper bound for the marginal cost of ABCP financing from equation (10). The shadow costs (λ) per dollar of a unit change in the regulatory capital requirement for the tier 1 risk-based ("T1 RB"), the total risk-based capital ("Tot RB"), and the tier 1 Leverage ("T1 Lev") ratios are calculated using equation (11). Change in Profit is calculated as $d\Pi_{is} = -\lambda_s \times A_i \times d\sigma_s$, 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 A_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.

Appendix

A Loophole Use in a Dynamic and Uncertain and Environment

Our analysis above abstracts from the randomness of bank profits and from dynamic implications of loophole use. We relax these assumptions here and show that (i) randomness in operating profits does not change the shadow cost expression, which in a dynamic setting represents the marginal effect on expected cashflows to equity holders, and that (ii) adjustment costs in loophole use could bias the direct measure of the marginal cost (α) downward, however the bounds estimated in Section 4.2.2 are robust to this potential bias.

We allow the realized net return on loans r_a and operational costs $M(A, \mathbf{z})$ to be random. Assets are financed with equity E, debt D, and ABCP O. We denote time t variables as X, $t+1$ variables X', etc. Consider the free cashflows to equity at period t, with assets in place $A = E + D + O$, having chosen next period capital structure and assets, $FCFE = R - C$, where operational profits are $R = (1-\tau)(r_a A - M(A, \mathbf{z}))$, funding costs are $C = r_d(1-\tau) D + r_o (1-\tau) O + (A' - A) - (D' - D) - (O' - O) + \frac{\kappa}{2}(O' - O)^2$, and $\kappa \geq 0$ parametrizes the cost of adjusting loophole use.[28]

The Lagrangian at time t for a bank choosing end of period assets and liabilities to maximize the present value of equity cashflows V, discounted at the appropriate risky rate r_e is

$$\begin{aligned} \mathcal{L} &= FCFE + \frac{\mathbb{E}[V'] + \lambda' A' [K' - \sigma'] + \rho' [E' + D' - A' + O']}{1 + r_e} \qquad (15) \\ &= R - C + \frac{1}{1+r_e}\mathbb{E}[R' - C'] + \frac{1}{1+r_e}\mathbb{E}\left[\frac{V''}{1+r_e'}\right] + \frac{\lambda' A'}{1+r_e}[K' - \sigma'] + \frac{\rho}{1+r_e}[E' + D' - A' + O'], \end{aligned}$$

where we discount the multipliers λ and ρ by the equity rate so that they maintain the interpretation as the effect on next period (expected) cash flows, per dollar of assets, of tightening the current regulatory capital constraint. To see this, note that by the envelope theorem, $\frac{d\mathcal{L}^*}{d\sigma'} = -\frac{\lambda' A'}{1+r_e}$.

[28] Alternatively, loopholes could be incorporated into the setup of Pennacchi (1988) or Han, Park, and Pennacchi (2015).

The first order conditions for O', D' are respectively,

$$0 = -(1+r_e) C_{O'} - \mathbb{E}\left[C'_{O'}\right] + \lambda' A' K'_{O'} + \rho - \frac{\partial r_e}{\partial O'} \mathbb{E}\left[V'\right], \quad (16)$$

$$0 = -(1+r_e) C_{D'} - \mathbb{E}\left[C'_{D'}\right] + \lambda' A' K'_{D'} + \rho - \frac{\partial r_e}{\partial D'} \mathbb{E}\left[V'\right]. \quad (17)$$

The shadow cost in this more general environment is attained by subtracting (17) from (16), specializing C, and assuming as before that revenue is independent of this funding choice ($R_O = R_D$), and that both have the same effect on the discount rates ($\frac{\partial r_x}{\partial O'} = \frac{\partial r_x}{\partial D'}$ for $x \in \{e, d, o\}$):

$$\lambda' = \frac{(1-\tau)(r_o - r_d) + \kappa\left[(1+r_e)(O'-O) - \mathbb{E}\left[O''-O'\right]\right]}{A' K'_{O'}}, \quad (18)$$

which is identical to (1), with an additional term due to adjustment costs in loophole use (κ) that give rise to dynamic considerations. When these adjustment costs are small, or the growth in loophole use is steady ($(1+r_e)(O'-O) \approx \mathbb{E}\left[O''-O'\right]$), our estimates based on the static model are accurate.

Adjustment costs can be substantial, however, if current loophole use is expected to revert in the future. For example, 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, they expected large adjustment costs associated with bringing existing conduit assets back on their balance sheets, and in addition they expected to finance a large amount of assets through ABCP in future normal times relative to crisis times. 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.

We can derive upper bounds for the incremental loophole cost and, therefore, the shadow costs, by subtracting (17) from the following first order condition for E',

$$0 = -(1+r_e) C_{E'} - \mathbb{E}\left[C'_{E'}\right] + \lambda' A' K'_{E'} + \rho - \frac{\partial r_e}{\partial E'} \mathbb{E}\left[V'\right]. \quad (19)$$

The resulting upper bound on the incremental cost of ABCP α' in this more general setting (the numerator of (18)), is identical to the one from the static analysis in Section 4.2.2:

$$\alpha' = \frac{K'_{O'}}{K'_{E'}}\left[r_e - (1-\tau)\, r_d + (1-\tau)\left[\left(\frac{\partial r_d}{\partial E'} - \frac{\partial r_d}{\partial D'}\right) D' + \left(\frac{\partial r_o}{\partial E'} - \frac{\partial r_o}{\partial D'}\right) O'\right] + \left(\frac{\partial r_e}{\partial E'} - \frac{\partial r_e}{\partial D'}\right)\mathbb{E}V'\right]$$
$$\leq \frac{K'_{O'}}{K'_{E'}}\left[r_e - (1-\tau)\, r_d\right],$$

assuming debt increases the costs of equity and debt at least as much as equity does.

B Non-Participating Banks

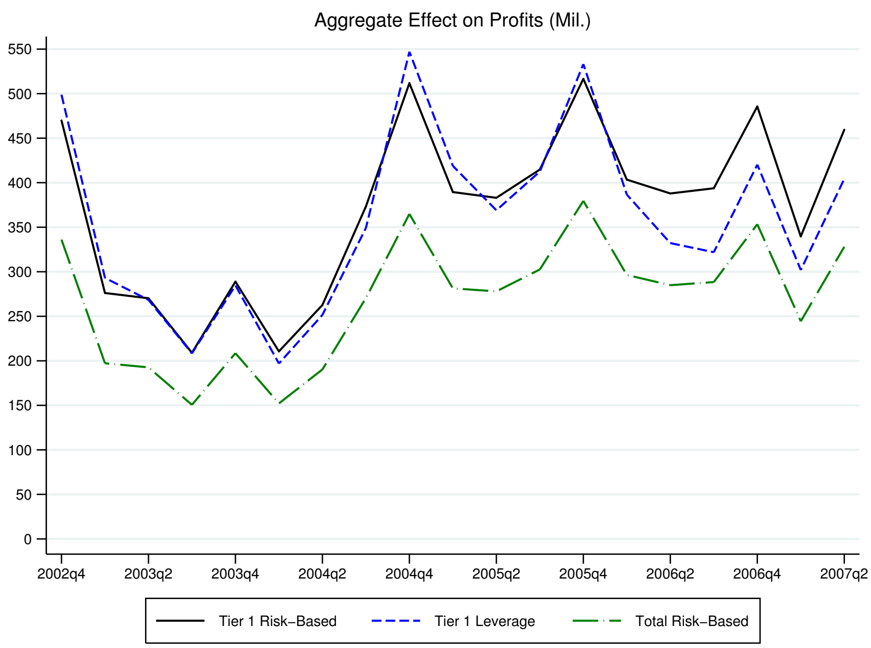
Since we can get a point estimate of λ only for banks that participate in the loophole, estimates in Tables 3, 4, and Figure 6 are calculated using only these banks. While the focus of this paper is the population of the largest banks in the economy, rather than the whole banking universe, it is useful 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 and their fixed costs of setting up an ABCP conduit are small, the right-hand-side of equation (1) provides an upper bound for the shadow cost of non-participating banks, $\lambda \leq \frac{\alpha}{AK_O}$. While the assumption that non-participating banks faced similar ABCP costs is strong—they could plausibly face a higher α and prohibitively high fixed costs—note that this exercise 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 A.1 presents the result of this extrapolation. The figure shows the aggregates for the entire 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.

Comparing Figures 6 and A.1, we find a relatively modest increase in the aggregate costs. For example, the average effect for the tier 1 risk-based ratio increased from \$200 million to about \$370 million. This is despite the fact that Figure A.1 is based on more than 2,500 banks, compared to 18 banks in Figure 6. 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 much to the aggregate estimates.

Figure A.1: Aggregate Cost of a One Percentage Point Increase in Regulatory Ratios: Extrapolation for All US Banks



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. Extrapolation using the marginal cost of the loophole from equation (6). The aggregate change in profit is calculated as $\Sigma_i d\Pi_{ist} = \lambda^s_{it} \times A_{it} \times d\sigma_s$, 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 A_{it} is the total assets of bank i in quarter t.

C 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 A.1 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 A.2 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.

Table A.1: 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 A.2: 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 (11). Change in Profit is calculated (in millions of dollars) as $d\Pi_{is} = -\lambda_s \times A_i \times d\sigma_s$, 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 A_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.