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Debt, Taxes, and Banks

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Abstract

Understanding the impact of the asymmetric tax treatment of debt and equity on the capital structures of financial institutions is critical to shaping and assessing responses to the problem of excessive leverage that underlay the 2009 financial crisis—but there is no empirical evidence to draw on. Guided by a simple model of banks' financing decisions in the presence of both regulatory constraints and tax asymmetries, this paper explores the impact of corporate tax bias on bank leverage, the use of hybrid instruments and regulatory capital ratios for a panel of over 14,000 commercial banks in 82 countries over nine years. On average, the sensitivity of banks' debt choices proves very similar to that of non-financial firms, consistent with rough offsetting of two opposing effects suggested by the theory. As the model predicts, somewhat counter-intuitively, the impact of tax on hybrids is generally weak or insignificant. Responsiveness to taxation varies significantly across banks, however: those holding smaller equity buffers, and larger banks, are noticeably less sensitive to tax.

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I. INTRODUCTION

Socially excessive levels of leverage in the financial sector are widely seen as having played a central role in triggering and deepening the financial crisis of 2009,[2] and reforms to reduce the likelihood of similar occurrences have been at the core of the post-crisis policy agenda. These efforts have been very much focused on regulatory change, with the emerging Basel III standards increasing both the level and quality of the equity buffers required. There is though now increased (albeit still limited) recognition, at least qualitative, that tax distortions to financial institutions' capital structures are also problematic:[3] the deductibility against the corporate income tax (CIT) of interest payments but not, in general, of payments to equity implies a tax incentive to use debt rather than equity finance that, at a minimum, sits oddly with regulatory measures intended to do exactly the opposite. And some have gone even further, making the case not merely for eliminating the tax preference for debt but for corrective taxes that would establish some tax preference for equity. Several European countries have indeed now adopted new bank taxes[4] which, while intended partly to finance fiscal interventions prompted by financial crises and not usually rationalized in these terms, go some (small) way to offsetting the effects of this asymmetric tax treatment of debt and equity.

What has been missing from the debate, however, is any empirical evidence on how significant these tax distortions to banks' financing decisions actually are.[5] There is plenty of evidence on how taxes affect the capital structures of *non*-financial firms: see, for example, the review of theory and evidence in Auerbach (2002) and Graham (2006) and the meta-analyses of Feld and others (2011) and De Mooij (2011a). But it is standard procedure in these analyses to simply discard observations on financial institutions, presumably because their capital structure decisions are expected to be in some important way different. On the other hand, there are also many studies of the capital structure of banks (including Berger and others (2008) and Gropp and Heider (2010))—but none of these analyzes the impact of taxation. The aim of this paper is to thus to bring empirical evidence, guided by some simple theory, to bear on the central question of fact: Are banks'[6] capital structures materially affected by the differentially favorable tax treatment of debt?

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[2] See for instance Reinhart and Rogoff (2009) and Sinn (2010).

[3] This point is made, for instance, by IMF (2009), Lloyd (2009), and Slemrod (2009).

[4] The most common form of these is as a tax on liabilities other than Tier 1 capital and insured deposits: the intended target is thus wholesale debt finance.

[5] The only exception of which we are aware is an unpublished paper by Henderson (2005). Using Compustat data for 87 U.S. banks between 1987 and 1993, she finds that higher tax rates raise bank leverage. We exploit a larger, multi-country dataset, use a dynamic specification that allows for sluggish adjustment, look at interactions with regulatory variables, and consider differences in bank size.

[6] While the core issue applies to all financial institutions, the analysis here focuses on banks.

Although exactly the same tax asymmetry applies to them as to non-financial companies, banks' capital structure decisions may indeed be very different. One view is that tax is likely to be less important for them than it is for non-financial firms—perhaps entirely unimportant—because regulatory requirements effectively drive their financing decisions. But it is well-known that banks aim to hold buffers of equity beyond regulatory requirements: in the data used here, for example, banks on average hold over 60 percent more equity than they are required to for regulatory purposes.[7] This leaves clear scope for tax effects on leverage and capital ratios. Indeed, an alternative view is that, to the contrary, financial institutions' capital structures may well be *more* tax-sensitive than are those of non-financials: the nature of their business gives them more opportunities for and adeptness at tax avoidance strategies exploiting the tax asymmetry. The availability of 'hybrid' instruments—debt for tax purposes but equity for regulatory—blunts the impact of regulatory requirements. Moreover, the benefit to those that lend to banks from explicit deposit insurance and perhaps implicit 'too big to fail' insurance further enhances their ability to exploit this tax differential, suggesting that they could actually be more sensitive to tax considerations. Where the truth lies between these possibilities—and hence the answer to a range of core policy issues in the tax treatment of financial institutions—is ultimately an empirical issue, on which this paper aims to shed some light.

While the main focus here is on the use of leverage and hybrids (relative to total assets), we look too at the impact of taxation on regulatory capital ratios. EEAG (2011) and Devereux (2011) argue, for instance, that even if tax asymmetries increase the use of debt finance,[8] this may be accompanied by such a reduction in the riskiness of the assets they hold (as measured for regulatory purposes) as to leave the ratio of equity to risk-weighted assets unchanged. This would be identically true if the regulatory constraint always exactly bites, but the holding of buffers over the requirements in practice leaves room for a tax sensitivity that is also characterized and tested for below.

Section II sets out a simple model of a bank's capital structure decisions in the presence of both tax incentives to use debt and regulatory requirements of the type in Basel II and III that penalize both shortfalls of equity relative to risk-weighted assets and the use of hybrids above an upper bound. Particular attention is paid to the significance in this context of hybrid instruments, widely used by financial institutions prior to the crisis. The analysis generates some sharp predictions, which guide the empirics that follow. Section III describes the empirical methodology and data used: a panel of 14,377 commercial banks in 82 countries from 2001 to 2009. Empirical results are in Section IV, and Section V concludes.

[7] Similarly, Flannery and Rangan (2008) report that the mean large bank in their sample for the earlier period 1986 to 2001 held book capital, 75 percent above the regulatory minimum.

[8] While their argument is couched in terms of 'bank taxes' on the stock of debt issued, the same point applies to the corporate tax asymmetries considered here.

II. Modeling the Determinants of Banks' Leverage

This section develops a simple model to identify and explore the distinctive implications for banks' leverage decisions of the regulatory capital requirements they face. [9] [10]

A. A Stylized Model of Taxes and Bank Leverage

The focus is on the leverage decisions of a single bank, and the action occurs over three periods. Decisions are taken in period 1, uncertainty is resolved in period 2 and the payoff received in period 3.

In period 1, the bank's assets A are financed by debt in amount L and equity E:

$$A = L + E\,. \tag{1}$$

Interest payments on all debt L are tax deductible, but there is no deduction for the cost of equity finance. Some debt, however—issued in amount H—is the form of 'hybrids' that pay tax-deductible interest but are treated as equity in meeting the overall capital requirement,[11] though their use is itself subject to a subsidiary constraint. To focus on financing decisions, $A > 0$ is taken as fixed: the bank's choice variables in period 1 are total borrowing L (referred to as 'leverage') and hybrid use H. A proportion α of the bank's assets are held in risky form, the rest in safe. Since the focus here is on leverage decisions rather than those on riskiness of asset positions, α is taken as fixed in developing the theory (but treated as endogenous in the empirics).

In period 2, risky assets realize a proportionate capital gain (or loss) of $\theta - 1$, so the banks' risky assets are then worth $\theta\alpha A$; the random variable θ is distributed with twice-differentiable distribution function $\Phi(\theta)$ on support $(0, \infty)$, the density being denoted $\phi(\theta)$ and the expectation $\bar{\theta} \equiv E[\theta] > 1$. It is after the realization of θ that the regulatory requirements are applied. Mimicking the (evolving) Basel accords, there are two. The first requires that the capital ratio K—the ratio of equity plus hybrids to risk-weighted assets—not fall short of some capital requirement $\bar{K}$: Basel II, for instance, requires that Tier 1 assets be at least 4 percent of risk weighted assets, and the sum of Tier 1 and Tier 2 capital be at least

[9] Aspects of banks' capital decisions are discussed in Myres and Rajan (1998), Diamond and Rajan (2000), Gropp (2004) and Allen and others (2009). None considers the tax aspects that are the focus here.

[10] For non-financial companies, thin capitalization rules have somewhat similar effect (the penalty to too high a leverage ratio being the loss or deferral of interest deductions on the excess).

[11] Such as convertible bonds (which give the holder the option to convert to equity, and sometimes the issuer the option to call the bond) and preferred securities (which pay distributions at a fixed rate but allow the issuer to defer payment).

8 percent.[12] With the capital gain (or loss) on risky assets taken into equity, a constraint of this kind is imposed here as the requirement that

$$K \equiv \frac{E + H + (\theta - 1)\alpha A}{\theta \alpha A} \geq \bar{K}\,, \tag{2}$$

the assumption in the denominator being that the regulator attaches a weight of unity to the risky asset, and of zero to the safe. Note too the implication that the regulatory requirement accurately captures the true riskiness of assets held; a natural simplification for present purposes, but one at some odds with reality.

It is sufficient for the bank's regulatory capital ratio K to be strictly increasing in θ (so that, as one would expect, the capital requirement is more likely to be met the higher is the return on risky assets) that

$$L - H > (1 - \alpha)A\,. \tag{3}$$

meaning that debt which is not treated as equity exceeds safe assets. It will be assumed in what follows that this is the case, and moreover that L¸ E, and H are all strictly positive at the bank's optimum. The capital requirement (2) then translates into a condition that the capital gain on the risky asset not fall below a critical value θ^* defined by

$$\theta^*(L, H, \alpha) \equiv \frac{L - H - (1 - \alpha)A}{\alpha A(1 - \bar{K})}\ . \tag{4}$$

This critical value, it will be useful to note, can also be written as

$$\theta^* = 1 - \frac{\Omega}{1 - \bar{K}} \tag{5}$$

where

$$\Omega \equiv \frac{E + H}{\alpha A} - \bar{K} \tag{6}$$

is the ex ante capital 'buffer' held by the bank: the excess of regulatory capital (prior to the realization of θ) over the minimum required. The probability of violating the capital constraint is thus determined simply by the buffer that the bank chooses to hold.

The bank is assumed to be penalized whenever (2) is violated, the penalty being greater the larger is the capital shortfall. This penalty—which may be in the form, for instance, of the

[12] Under Basel III, the minimum ratio of common stock to risk-weighted assets (around 2 percent in most Basel II standards) is to rise to 4.5 percent (supplemented by a 2.5 percent capital conservation buffer) and the minimum ratio of Tier 1 capital to risk-weighted assets to 6 percent. A minimum leverage ratio (relative to non-risk weighted assets) of 3 percent is also proposed.

requirement to inject costly equity, or a loss of discretion in its operations—is not modeled explicitly but is taken to be an amount C (paid in period 3)[13] for each unit by which equity falls short of the amount required to meet the capital requirement. Thus, using (2), the penalty in the event that $\theta < \theta^*$ is

$$C.(\theta\alpha A\bar{K} - E - H - (\theta - 1)\alpha A) = C\alpha A(1 - \bar{K})(\theta^* - \theta) \quad . \tag{7}$$

The second regulatory requirement (referred to here as the *hybrid constraint*) is an upper limit on the use of hybrids relative to risk-weighted assets: Basel II guidelines, for instance, allow up to 15 percent of Tier 1 capital to be in the form of hybrids. Such a limit is modeled as the requirement that $H/\theta\alpha A \leq \bar{h},$ which defines another critical value of the random return,

$$\theta^h \geq \theta^{*h} \equiv \frac{H}{\bar{h}\alpha A} \ , \tag{8}$$

below which the condition is violated, with corresponding penalty assumed proportional to the excess of hybrid use over the maximum allowed:

$$C^h\big(H - \bar{h}\theta\alpha A\big) = C^h\alpha A\bar{h}(\theta^{*h} - \theta) \ . \tag{9}$$

In period 3 (after which the world ends), all assets (including the post-capital gain risky asset) pay the safe pre-tax rate of return R; the same rate is paid on both debt and equity, but is tax deductible only in the former case. Combining these elements to construct the bank's net payoff,[14] taking expectations, ignoring terms that depend only on the fixed level of assets and/or risk α, and normalizing the safe rate of return to unity, the risk-neutral bank's maximand is[15]

$$\Pi(L, H) = TL - S(L, H) - S^h(H) - AB(L/A, H/A) \tag{10}$$

where $B(L/A, H/A)$ denotes agency costs associated with the use of both debt in general and hybrids in particular (per unit of assets[16]), while

$$S(L, H) \equiv C\alpha A(1 - \bar{K}) \int_0^{\theta^*(L,H,\alpha)} (\theta^* - \theta)\, \phi(\theta) d\phi \tag{11}$$

[13] This is simply to ensure that all payoffs occur at the same time and so avoid the extra notation of discounting.

[14] This is $(1 - T)R\theta\alpha A + (1 - T)R(1 - \alpha)A\ - C\alpha A(1 - \bar{K}).max\big((\theta^* - \theta), 0\big) - C^h\alpha A\bar{h}.ma\,x(\theta^{*h} - \theta,0-1-TRL-RE$.

[15] For simplicity, it is assumed that the earnings and equity are always sufficient to pay creditors, so that the bank cannot fail; this point is returned to below.

[16] This preserves scale invariance of the bank's problem.

$$S^h(H) \equiv C^h \alpha A \bar{h} \int_0^{\theta^{*h}(L,H,\alpha)} (\theta^{*h} - \theta)\phi(\theta) d\phi \qquad (12)$$

denote the expected costs from violating, respectively, the capital and hybrid requirements. Agency costs in the spirit of *B* are a common feature in modeling the capital structures of non-financial firms (recent examples being discussed by Gordon (2010) and Weichenrieder and Klautke (2008)), reflecting for instance the restrictions imposed by creditors in order to prevent the firm taking subsequent actions shifting value away from them. While the same considerations will be present for banks, they may take a quite different form; deposit insurance and, for larger institutions, the expectation of bail out by the state will reduce creditors' exposure to these problems. The lower agency costs implied are indeed often suggested as one explanation of the higher leverage of banks relative to financial institutions. In capturing these considerations, the inclusion of agency costs here—not needed, as will be seen, to generate internal solutions for the bank's leverage decisions—is largely to facilitate comparison with work on the debt choices of non-financial companies. These agency costs are assumed to be strictly increasing and convex in L and *H*: $B_L, B_H, B_{LL}, B_{HH} > 0$.[17]

B. Leverage, Hybrids, and Taxes

Consider first the bank's choice of L, the total amount of debt. From (10), the necessary condition[18] on this is

$$\Pi_L(L,H) = T + S_L(L,H) - B_L(L/A, H/A) = 0\,. \qquad (13)$$

Using (9) and noting from (4) that

$$\theta_L^* = \frac{1}{\alpha A(1-\bar{K})} \quad ; \quad \theta_L^{*h} = 0\,, \qquad (14)$$

this becomes

$$\Pi_L = T - C\Phi(\theta^*) - B_L(L/A, H/A) = 0\,. \qquad (15)$$

The necessary condition is thus a simple modification of the idea that non-financial companies borrow up to the point at which the marginal agency costs of borrowing just offset the tax advantage of doing so: for the bank, the expected costs of violating the capital requirement also act to limit borrowing. Indeed, unlike the simple non-financial company of the corresponding stylized models, the bank could reach an internal solution for its financial structure even in the absence of agency costs, equating the tax advantage to the last dollar of debt issued to the expected additional costs this would imply in the event of violating the capital requirement. That banks nonetheless have higher leverage than non-financial

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[17] Derivatives are denoted by subscripts for functions of many variables, and by primes for functions of just one, and B_i denotes the derivative of *B* with respect to *i/A*.

[18] The assumptions above ensure that the second order conditions here and in relation to *H* are satisfied.

companies can be rationalized in this model as reflecting their facing relatively low marginal agency costs of borrowing, for the reasons noted above.

Of particular interest in the present context is how the bank's leverage responds to changes in the corporate tax rate. Starting with the simplest case, holding *H* constant, differentiating in (15) and using (14) gives:

<u>PROPOSITION 1:</u> *For a given level of hybrid use, the effect on the bank's total borrowing L of an increase in the corporate tax rate is given by:*

$$\left.\frac{dL}{dT}\right|_{H} = -\left(\frac{1}{\Pi_{LL}}\right) = \frac{1}{B_{LL} + \phi(\theta^{*})\left(\frac{C}{\alpha A(1-\bar{K})}\right)} > 0 \qquad (16)$$

This captures the two effects raised informally in the introduction. Through the second term in the denominator, the capital requirement itself unambiguously makes debt less responsive to the tax rate than it would be if only agency costs (in the first term) were at work. This does not mean, however, that banks' leverage decisions will be less sensitive to taxation than those of nonfinancial: to the extent that banks' marginal agency costs rise less rapidly with leverage, this will tend to make their leverage more responsive to taxation than is that of non-financial companies not benefiting from similar explicit or implicit insurance of creditors.

Turning to the use of hybrids, using the implications of (4) and (8) that

$$\theta_{H}^{*} = \frac{-1}{\alpha A(1-K)} \quad ; \qquad\qquad \theta_{H}^{*h} = \frac{1}{\bar{h}\alpha A} \quad , \qquad (17)$$

the necessary condition on their use is:

$$\Pi_{H} = C\Phi(\theta^{*}) - C^{h}\Phi(\theta^{*h}) - B_{H}(L/A, H/A, \alpha) = 0\,. \qquad (18)$$

The bank thus balances the distinctive gain from using hybrids (rather than other debt) in reducing the likelihood of violating the capital requirements against the potential cost of violating the upper limit on the use of hybrids and the agency costs that their use involves. This has the striking implication that, conditional on the total amount of borrowing, the use of hybrids is independent of the tax rate:

<u>PROPOSITION 2</u>: *For a given level of total leverage L, the use of hybrids is independent of the tax rate:*

$$\left.\frac{dH}{dT}\right|_{L} = 0 \qquad (19)$$

This stark result is at odds with a simple intuition which might suggest that hybrids are essentially an instrument of tax avoidance, so that their use should be strongly sensitive to taxation. What Proposition 2 stresses is that it is debt in general that is the tax planning instrument: hybrids serve rather to arbitrage the regulatory requirements. In effect, there is a 'pecking order' effect at work: since hybrids carry the same tax advantage as debt but have the additional appeal of helping to meet the regulatory constraint, it is optimal to issue them before non-hybrid debt, up to the point dictated by the regulatory limit on their use.

While instructive, Propositions 1 and 2 capture only the partial effects of tax changes on L and H (in each case holding the other constant), not the full effects through the solutions $L(T), H(T)$ to the government's optimization characterized in (13) and (15). To simplify the more cumbersome analysis this calls for, agency costs—which the analysis above shows are not needed to ensure an interior solution of financial policy for the bank's financial policy—are from now assumed to be identically zero.[19] The full effects of the tax rate are then characterized in:

PROPOSITION 3: *In the absence of agency costs, with L and H jointly determined:*

$$(a) \quad \frac{dL}{dT} > \left.\frac{dL}{dT}\right|_H \tag{20}$$

$$(b) \quad \frac{dL}{dT} > \frac{dH}{dT} > 0 \tag{21}$$

Proof: Appendix A.

The implication of part (a), comparing with Proposition 1, is that the ability also to adjust hybrid use makes overall leverage more sensitive to taxation: intuitively, the bank can increase leverage by a larger amount in response to a higher tax rate, for instance, because issuing at least part of this in the form of hybrids dampens the unwelcome effect that this has on the capital ratio. Part (b) indicates that—consistent with the same intuition—overall leverage is more responsive to taxation than is hybrid use. Nonetheless, hybrid use does increase with the tax rate.[20]

We do not explore here how tax affects the bank's decisions as to the riskiness of its asset position, our focus being on leverage decisions. But clearly the riskiness of its position may affect those leverage decisions, and so is a natural control for the empirics that follow. For this, the model points to entirely opposite impacts of risk on total borrowing and on hybrid use:

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[19] Some but not all of the results below continue to hold under natural assumptions on agency costs: no restriction is required, for instance, for the conclusion in part (a) of Proposition 3, but that part (b) requires B_{HL} not to be 'too large' positive.

[20] A sharp link between hybrid use and the tax rate emerges on noting that the two first order conditions imply (with agency costs identically zero) that $T = C^h \Phi(\theta^{*h})$. That is, just as the use of leverage is set to balance the tax benefit against the risk of the capital requirement being violated, so hybrid use is set to balance the tax benefit against the risk of the regulatory constraint on hybrid use being violated.

PROPOSITION 4: *In the absence of agency costs, the partial and total effects of an increase in risk are such that*

$$(a) \qquad \left.\frac{dL}{d\alpha}\right|_{H} < 0 \ ; \qquad \left.\frac{dH}{d\alpha}\right|_{L} > 0 \tag{22}$$

$$(b) \qquad \frac{d(L-H)}{d\alpha} < 0. \tag{23}$$

Proof: Appendix B.

The partial effects in part (a), acting in opposite directions, reflect the mechanics of the capital and hybrid constraints. Higher risk lowers the capital ratio in (4), which encourages a reduction in total borrowing L in order to reduce the likelihood of violating the capital requirement. For the same reason, higher risk also encourages greater use of hybrids—this being another way to moderate the impact on the capital ratio K—while at the same time reducing the hybrid ratio in (8) and so providing more space to do so. The contrast is less stark, however, when both margins of choice are available: it could be for instance that L increases with the level of risk. Part (b) shows though that non-hybrid debt should decrease with the riskiness of assets.

As noted in the introduction, the impact of taxation on regulatory capital ratios when risk can be adjusted is also of interest. In the absence of agency costs, the necessary condition on total borrowing, equation (15), can be written, using (5), as

$$0 = T - C\phi\left(\frac{\Omega}{1-\overline{K}}\right) \tag{24}$$

and so simply defines the buffer Ω held by the bank as a function of the tax rate; and this relation would continue to hold if riskiness α were taken as choice variable (since (15) would remain a necessary condition of that wider problem). Trivially, one then has:

PROPOSITION 5: *In the absence of agency costs,*

$$\frac{d\Omega}{dT} = -\left(\frac{1-\overline{K}}{C\phi(\theta^{*})}\right) < 0 \tag{25}$$

so that a higher tax rate leads the bank to hold a smaller ex ante regulatory buffer.

This is as of course as one would expect. So too is the further implication of (25) that, assuming $\phi'(\theta^{*}) > 0$—plausibly, since one would expect the capital requirement to apply in 'bad' outcomes in the lower tail of the return distribution—and all else equal, banks with large buffers will adjust them more in response to an increased tax incentive to borrow than will those holding small buffers.

One last implication of this model will be useful. Although the choice of asset riskiness α is not explored in the empirics below and so, for brevity, is not analyzed in detail here, it can be shown that in the setting above—in the absence of hybrids and agency costs—an increase in the tax rate leads to a reduction in α. The intuition is as in the introduction: reducing risk-taking helps offset the impact on the regulatory capital ratio of the increased leverage induced by a higher tax rate.[21] This point proves helpful in interpreting the empirical results below.

III. Empirical Strategy and Data

The analysis above generates several testable hypotheses. This section describes how we set about exploring them; a full description of the data used is in Appendix C.

A. Methodology

The strategy is to estimate a series of panel regressions of the general form:

$$lev_{it} = \alpha + \beta_1 lev_{it-1} + \beta_2 \tau_{it} + \beta_3' \boldsymbol{X}_{it} + \alpha_i + u_t + \epsilon_{it} \qquad (26)$$

where lev_{it} is a debt-related variable—we consider three possibilities—for bank i in year t, τ is the statutory corporate income tax (CIT) rate it faces, $\boldsymbol{X}$ a vector of controls that varies across specifications, and α_i and u_t are respectively bank- and time-fixed effects. The inclusion of the lagged dependent variable, to allow for sluggish response, is standard in capital structure regressions for banks:[22] static regressions yield essentially the same long-run tax effects. Attention focuses on the parameter β_2, which reflects the marginal short-run impact of the CIT rate on the banks' choice of the debt variable on the left of the regression, and on the long-run impact of the tax as given by $\beta_2/(1-\beta_1)$.

These estimating equations can be thought of as linearizations of the solutions[23] that emerge from the framework above for three debt ratios:

a) The leverage ratio (corresponding to *L*/A), calculated from the Bankscope data described in the data Appendix C as the ratio of total liabilities to total assets: for this, β_2 is expected to be strictly positive (Proposition 1), but smaller when conditioned on hybrid use than when not (Proposition 3a);

[21] Since the bank is risk-neutral, the effect of higher taxation in inducing greater private risk-taking by reducing the variability of returns is not at work in this model.

[22] As for example, in Flannery and Rangan (2008), Lemmon and others (2008), Huang and Ritter (2009) and Gropp and Heider (2010))

[23] In alternative representations, depending for instance on whether or not the choice of *L* is treated as conditional upon that of *H*.

b) The ratio of 'non-hybrid debt' to assets (*(L-H)/A)*, calculated as unity minus the ratio of the sum of Tier 1 and Tier 2 capital to total assets; β_2 is again expected to be positive, but smaller than for the leverage ratio.

c) The ratio of 'hybrids' to assets (*H/*A), proxied—in the absence of explicit data on hybrid instruments—as the excess of leverage over non-hybrid debt; β_2 is in this case expected to be insignificant when controlling for leverage (Proposition 2), positive (but presumably small) when not (Proposition 3);

As noted, we also explore tax effects on the equity buffer, replacing *lev* in (26) by Ω, expecting in this case to find $\beta_2 < 0$, so that a higher tax rate is associated with smaller buffers (Proposition 5).

The controls in $\boldsymbol{X}$ are those usually included in capital structure regressions (as for example Rajan and Zingales (1995) and Frank and Goyal (2009)). First, we include the book value of a bank's assets and its square to allow for size effects: our data confirm the well-known regularity that larger banks have higher leverage ratios, perhaps because of a too-big-to-fail effect (see, for example, De Haan and Poghosyan, 2011). Second, we include the average return on assets as a measure of profitability: higher profits add to equity when retained within the firm, directly reducing the leverage ratio. Third, we include as a (doubtless imperfect) measure of the riskiness of bank assets (α) the ratio of risk-weighted assets (as computed for regulatory purposes) to unweighted assets: we expect a negative coefficient on risk in (22) for total debt, but a positive coefficient for hybrids (Proposition 4). Fourth, we include the growth rate of GDP and the rate of inflation to allow for country-specific variation over time. Finally, we experiment with an indicator of deposit insurance coverage, the expectation being that more generous deposit insurance would positively impact leverage(by lowering agency costs (depositors then being more willing to place their funds in a bank without monitoring its activities). However, the coverage of the available data on this (deposits insured per individual in percent of GDP, from Demirguc-Kunt and others (2008)) is much less complete than for other variables, so the sample size drops considerably when it is included. We therefore, simply illustrate its impact in one regression, providing some reassurance that any bias from its omission from regressions using the much larger data set is insubstantial. .

These basic results are reported in Table 1 in the next section. A separate set of regressions, reported in Table 2, use information on capital requirements ($\bar{K}$): a higher capital requirement is expected to reduce leverage ratios—this is readily verified from (15)—especially (recalling the definition of θ^*) when the bank has a risky asset portfolio. We also explore at this point the impact of taxes on the buffer Ω. To allow for the possibility that tax effects may depend on the size of the buffers, we also run separate regressions with the sample partitioned, according to the size of the buffer, into 'capital-abundant' and 'capital-tight' banks: the expectation, recalling the discussion after Proposition 5, is that taxation will have less of an impact for capital-tight banks, since they are more constrained by the minimum capital requirement.

A final set of results (Table 3) instead partitions observations by asset size, to allow for the possibility of significant differences in tax-sensitivity between large and small banks.

Further results are reported in Appendix D, allowing for a wider range of interaction effects and nonlinearities. The implied marginal coefficients for the tax variable evaluated at sample means of the independent variables are very similar to those from the linear specifications now reported.

Dealing with the inconsistency arising from correlation of the lagged dependent variable with the fixed effects requires some such estimation method as the Arellano-Bond GMM estimator. But since tax rates are highly persistent over time, the lagged values used in the Arellano-Bond estimator might be poor instruments for the endogenous change variables in the dynamic specification. Estimation is therefore by the system GMM estimator of Arellano and Bover (1995) and Blundell and Bond (1998), which estimates a system consisting of the first-differenced equation and the model in levels. Bank- and time-fixed effects are included, and standard errors are clustered by country, in all results reported.

IV. RESULTS

A. Taxes, Leverage, and Hybrids

The first set of results is reported in Table 1. In the system GMM regressions, the maximum number of lags is two and (as throughout) the risk variable is treated as endogenous. The total number of instruments is 20; and the reported standard errors are heteroskedasticity-robust, clustered across countries. The diagnostics are in all cases satisfactory: the Hansen test on the over identifying restrictions does not reject the null that the instruments are valid, and the Arellano-Bond test suggests no second-order serial correlation.

In columns (1)-(4), the dependent variable is the leverage ratio.[24] Column (1) is the simplest form; columns (2)–(4) subsequently add the risk variable, hybrid use (treated as endogenous, and included to explore the conditional response of leverage as in Proposition 1) and the indicator for deposit insurance. In columns (5), the dependent variable is non-hybrid debt; the risk variable is included, but not hybrid use, so this is best compared to column (2). Columns (6) and (7) consider hybrid use, in turn unconditionally and conditional on leverage (as in Proposition 2).

[24] Other indicators of leverage, such as the complement of ordinary stock or of the equity-asset ratio yield results that are very close to those reported below.

Table 1. Bank Leverage, Non-hybrid Debt, Hybrids, and Taxation 1/

	Leverage				Non-hybrid debt	Hybrids	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lagged value	.30***	.33***	.33***	.22***	.34***	.65***	.65***
	(.05)	(.06)	(.07)	(.01)	(.06)	(.07)	(.05)
CIT rate	.18***	.18***	.14***	.16***	.18***	−.000	.001
	(.03)	(.04)	(.03)	(.03)	(.03)	(.002)	(.003)
Log assets	.07***	.07***	.07***	.11***	.07***	−.002***	−.001
	(.01)	(.02)	(.02)	(.01)	(.02)	(.000)	(.001)
Log assets sq	−.27***	−.26***	−.24***	−.39***	−.26***	.010***	.007
(x100)	(.06)	(.07)	(.07)	(.03)	(.06)	(.000)	(.007)
Profit	−.31***	−.28***	−.28***	−.58***	−.29***	−.001**	−.005
	(.01)	(.01)	(.01)	(.01)	(.01)	(.001)	(.004)
GDP growth	.12	.12	.21***	.05***	.22***	−.001	.002
	(.08)	(.08)	(.08)	(.01)	(.07)	(.012)	(.012)
Inflation	−.11	−.13	−.17***	−.14***	−.31***	.019***	.017**
	(.08)	(.09)	(.04)	(.03)	(.06)	(.007)	(.007)
Risk		.01	.02	.06	.00	.011***	.010***
		(.02)	(.02)	(.02)	(.01)	(.001)	(.002)
Hybrids			−.61**				
			(.26)				
Deposit insurance				.005***			
				(.001)			
Leverage							−.010
							(.002)
No. of obs	49187	50201	50048	18647	48851	49122	48916
AB-AR(1)	.00	.00	.00	.08	.00	.00	.00
AB-AR(2)	.26	.30	.35	n.a.	.37	.49	.28
Hansen-p	.33	.42	.32	.70	.19	.43	.67
Long-run impact	.26***	.27***	.21***	.20***	.28***	−.001	.004
	(.04)	(.05)	(.05)	(.04)	(.05)	(.001)	(.009)

1/ Two-step system GMM estimator with the lagged dependent variable and risk instrumented (and, in columns (3) and (7), hybrids and leverage, respectively). The maximum number of lags is two. Standard errors (between brackets) are heteroskedasticity robust and clustered within countries. *, **, *** denotes significance at the 10, 5, and 1 percent level.

Beginning with columns (1)–(4), what stands out is that the tax effect on the leverage ratios is in all specifications positive and highly significant, with little variation in magnitude. The effect is marked, if not dramatic: the marginal coefficient on the tax rate in columns (1) and (2) of 0.18, for instance, implies that a 10 percentage point increase in the corporate tax rate increases the leverage ratio, in the short run, by 1.8 percentage points. The long-run marginal impact of an increase in the corporate tax rate, also significant in all cases, at 1 percent, is around 0.27 in the first two columns. This is strikingly close to the average marginal response of 0.28 found for non-financial firms in the meta-analysis of De Mooij (2011a).

Capital requirements thus do not seem, on average, to make banks less responsive to tax than non-financial firms; broadly speaking, the two distinct effects on the financing decisions of banks identified in Proposition 1—capital requirements making them more responsive to tax, the agency cost structure less so—cancel out.

Notable too is that the adjustment appears to be rapid, and faster than for non-financial companies. With a coefficient on the lagged dependent variable of around 0.3, the implied half life is around 0.6 years: this compares with the half-life of 3.7 years for non-financial companies found by Huang and Ritter (2009). Banks' financing decisions thus seem to respond about as much to tax biases as do those of non-financial companies, but to do so noticeably more quickly.

Turning to the controls, bank assets and profits enter with the expected signs. Comparing columns (1) and (2), including risk does not greatly change the size or significance of the tax effect. The impact of risk is positive but insignificant: consistent with the apparent ambiguity of effect noted after Proposition 4, thought part (a) of the result might have led one to expect a negative effect.

Column (3) controls for hybrids. While Proposition 3a implies a coefficient on the tax rate in column (3) smaller than that in column (2), there emerges no significant difference between the two. Risk also remains insignificant, contrary to the implication of Proposition 4(a) of a negative impact. This perhaps suggesting that the links between risk and leverage are shaped by considerations other than the links with regulatory capital requirements stressed in the model above. The estimates may, for instance, be picking up a 'gambling for resurrection' effect, as banks with high leverage take on more risk in the recognition that doing so cannot worsen the downside outcome for them of outright failure but will improve the upside outcome when their assets yield a strong return.[25]

Column (4) adds the indicator for deposit insurance–and the sample size consequently drops by two-thirds. That more extensive deposit insurance is associated with higher bank leverage is as one would expect. It contrasts, however, with Gropp and Heider (2010), who find—for a smaller sample of large banks in the U.S. and Europe—that deposit insurance has no

[25] The implication of limited liability is structurally different from that of the penalty on low capital ratios captured in the model above, since (unlike that penalty) the (private) costs of bankruptcy would not naturally be expected to increase with its depth.

significant effect on capital structures. But the key point for present purposes is that the tax effect remains highly significant; that in the long run becomes somewhat smaller, though short-run tax impacts are essentially unchanged.

Column (5) takes non-hybrid debt as the dependent variable. Comparing with column (2), which uses the same specification and sample, the tax effect for non-hybrid debt is the same as that for leverage.

Taking hybrid use as the independent variable, column (7) tends to confirm the strong and perhaps counter-intuitive prediction of Proposition 2 that hybrid use be insensitive to taxation: the estimated marginal effect is tiny and very far from significance. Less consistent with the theory (Proposition 3b) is the lack of a significant effect unconditionally on leverage found in column (6). One other theoretical implication that is now verified, however, is Proposition 4: there is a significant positive association between the riskiness of banks' asset positions and their use of hybrids.

B. Taxes, Capital Requirements, Risk, and Buffers

Table 2 reports results including minimum capital requirements, and also explores tax effects on regulatory capital.

The first four columns consider the sample of all bank-year observations; the others look in turn at (equal-sized) subsamples of capital-abundant and capital-tight banks. The capital-abundant banks in columns (5) to (7) are those with a ratio of equity to risk-weighted assets of at least 1.8 times the minimum capital requirement; the capital-tight have a regulatory capital ratio less than 1.8 times the minimum capital requirement.

In columns (1), (2), (5), and (8) the dependent variable is the ratio of leverage to total (non-risk-weighted) assets. Columns (3), (6), and (9) look at leverage relative to risk-weighted assets, to see if banks adjust their risk profile along with leverage; since the left-hand side variable is corrected for risk, the risk variable is omitted from these regressions. In columns (4), (7), and (10) the dependent variable is the buffer Ω, with both risk and the minimum capital requirement in this case omitted.

As expected, more stringent capital requirements significantly reduce leverage ratios. Column (2) adds the interaction of the capital requirement with the riskiness of assets: recalling (4), it is an implication of the necessary condition (15) that the capital requirement affects leverage only in this way. (Intuitively, the impact of the regulatory requirement on permissible leverage depends solely on the riskiness of assets held.) And it is indeed only this interaction that proves significant, with the negative coefficient for this interaction implying (as the theory predicts) that capital requirements decrease leverage more the riskier are bank assets. Comparing columns (1) and (2) with the results in Table 1, the tax effect is reduced by the inclusion of the minimum capital requirements: the long-run marginal impact is 0.15, compared to 0.27 for the same regression in Table 1. This reflects a negative correlation in the data (for which there seems to be no obvious theoretical rationale) between capital requirements and statutory corporate tax rates, implying that regressions in Table 1 suffer from omitted variable bias.

Table 2. Taxes, Bank Capital Structure, Risk and Capital Requirements 1/

	All banks /2				Capital-abundant banks /2			Capital-tight banks /2		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	L/A	L/A	L/RWA	Buffer	L/A	L/RWA	Buffer	L/A	L/RWA	Buffer
Lagged value	.34***	.32***	.38***	.25***	.51***	.44***	.28***	.28***	−.09***	.19***
	(.06)	(.06)	(.04)	(.02)	(.09)	(.05)	(.03)	(.01)	(.03)	(.00)
CIT rate	.10**	.10*	.20***	−.24***	.13***	.11	−.22*	−.02	.06*	−.00
	(.04)	(.06)	(.06)	(.05)	(.05)	(.07)	(.12)	(.02)	(.03)	(.01)
Log assets	.07**	.07***	.33***	−.40***	.06*	.37***	−.64***	.01**	.02***	−.01***
	(.02)	(.02)	(.02)	(.03)	(.03)	(.04)	(.06)	(.00)	(.00)	(.00)
Log assets sq	−.25**	−.26***	−1.18***	1.47***	−.23*	−1.33***	2.48***	−.04**	−.06***	.03***
(x100)	(.08)	(.07)	(.08)	(.13)	(.13)	(.16)	(.24)	(.02)	(.01)	(.01)
Profit	−.28***	−.28***	−.73***	1.14***	−.22***	−.67***	1.07***	−.36***	−.25***	.44**
	(.01)	(.01)	(.04)	(.02)	(.01)	(.04)	(.02)	(.02)	(.04)	(.02)
GDP growth	.16*	.22	.21*	−.07	.16	.22	.26	.10**	.04	−.02
	(.10)	(.14)	(0.12)	(.26)	(.11)	(.14)	(.42)	(.05)	(.09)	(.02)
Inflation	−.05	−.03	.02	.00	−.19*	.03	.11	.02	.00	−.01
	(.08)	(.07)	(.06)	(.06)	(.09)	(.07)	(.26)	(.02)	(.02)	(.01)
Risk	.01	.44***			.13***			−.015**		
	(.02)	(.17)			(.02)			(.006)		
Capital	−.98**	2.66	−1.58**		−.67	−1.65**		−.74***	−.80***	
requirement	(.48)	(1.81)	(.70)		(.39)	(.66)		(.13)	(.23)	
Risk x Capital		−5.15**								
requirement		(2.04)								
No. of obs	50128	50128	58568	49128	26299	34813	25747	23829	23755	23381
AB-AR(1)	.00	.00	.00	.00	.00	.00	.00	.00	.09	.26
AB-AR(2)	.28	.31	.86	.65	.05	.96	.78	.17	.67	.83
Hansen-p	.57	.42	.40	.37	.62	.34	.40	.53	.05	.47
Long-run impact	.15**	.15*	.33***	−.33***	.26**	.19	−.31*	−.03	.05*	−.003
	(.06)	(.08)	(.09)	(.07)	(.11)	(.12)	(.18)	(.03)	(.03)	(.012)

1/ Two-step system GMM estimator with the lagged dependent variable and risk instrumented. The maximum number of lags is two. Standard errors (between brackets) are heteroskedasticity robust and clustered within countries. *, **, *** denotes significance at the 10, 5, and 1 percent level.

2/ L/A denotes the leverage-asset ratio, and L/RWA the ratio of leverage to risk-weighted assets. Capital-abundant (resp., tight) banks at each date are those with a ratio of equity/risk-weighted assets exceeding (less than) 1.8 times the capital requirement.

Column (4) shows that a higher CIT rate is associated with smaller buffers, as in Proposition 5. So while column (3) suggests that banks may reduce the riskiness of their asset position in response to a higher tax rate, they do not do so by enough to prevent a reduction in the buffer. Banks accept a smaller buffer, and a higher expected cost of violating the capital requirement, in return for the greater tax benefit from borrowing.

Measuring leverage relative to risk-weighted assets rather than total assets, column (3) in Table 2 shows a larger impact of the statutory tax rate. This is consistent with the theoretical prediction noted above that banks will respond to higher corporate tax rates not only by increasing their leverage but also by reducing the riskiness of their positions. The latter will partly or fully offset the impact that higher leverage ratio has on the buffer and, therefore, on the expected cost of violating the capital requirement.

Columns (5) to (7) show that the tax responsiveness of capital-abundant banks is similar to that for the full sample of all banks. Column (5) indicates that capital requirement itself has no significant impact on their leverage decisions: other considerations seem to determine the capital structure choice of these banks. Other studies, such as Gropp and Heider (2010) also find that the capital structure choice of banks is governed by the same factors as for non-financial firms and that bank regulation seems to have little effect. Capital-abundant banks also show a significant positive impact of risk on leverage, contrary to Proposition 4; the 'gambling for resurrection'-effect discussed in the previous section might indeed matter for the capital-abundant banks.

Columns (8) to (10) show that banks with small buffers respond very differently. In columns (8) and (10) respectively, there is no significant impact of taxation on leverage or on buffers. Relative to risk-weighted assets, column (9) shows a weakly significant effect of taxation, again suggesting that banks might reduce their risk exposure at higher tax rates. In contrast to earlier results, column (8) also shows risk having a significantly negative effect on the leverage of capital-tight banks, as in Proposition 4. The central conclusion, however, is that taxation appears to have only a limited impact on the financial decisions of capital-tight banks, which are driven rather by regulatory capital requirements.

Table 3 reports results when banks are partitioned by the size of their asset holdings rather than that of their buffer. Column (1) repeats the result for all banks in column (1) of Table 2. Column (2) then restricts the sample to the 50 percent of bank-year observations with the largest asset holdings: a cutoff asset level of $118 million; column (3) focuses on the largest 5 percent, with asset holdings above $1.2 billion. Columns (4)–(6) do the same, but for the buffer. Comparing columns (1) and (2) and columns (4) and (5), the results for the largest 50 percent of banks are similar to those for the full sample. The results in columns (3) and (6), however, suggest that the capital structures of the very largest banks are not sensitive to taxation or, in case of the buffer, are much less so;[26] nor, perhaps surprisingly, are large banks responsive to the capital requirement (see column (3)).

[26] This is consistent with results in Appendix D, where the interaction of the tax rate and assets is shown to be significantly negative.

This low (or lack of) responsiveness of the largest banks is consistent with the similar finding in Table 2 for capital-tight banks, since larger banks tend to hold smaller buffers: of the 5 percent bank-year observations with the largest assets, 25 percent are capital-abundant and 75 percent capital-tight. (Not all smaller banks are capital abundant, however: of the 95 percent with the lowest assets, 54 percent are capital-abundant and 46 percent capital-tight.) These largest banks are, of course, a very important group: the largest 5 percent of banks in the sample together hold 58 percent of total bank assets. The implication that neither taxation nor capital requirements significantly affect the leverage ratios of the largest banks poses a challenge for policy design. It perhaps provides support for the adoption, as in Basle III, of explicit constraints on leverage ratios.

Table 3. Response in Leverage and Buffer, the Impact of Bank Size 1/

	Effects on Leverage-asset Ratio			Effects on Buffer		
	All banks	50 percent largest/2	5 percent largest /2	All banks	50 percent largest/2	5 percent largest /2
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged value	.34***	.38***	.98***	.25***	.23***	.60***
	(.06)	(.08)	(.07)	(.02)	(.05)	(.10)
Tax	.10**	.09**	.02	−.24***	−.18***	−.06*
	(.04)	(.04)	(.03)	(.05)	(.04)	(.04)
Log assets	.07***	.02***	.09***	−.40***	−.09***	−.59***
	(.02)	(.01)	(.01)	(.03)	(.01)	(.13)
Log assets sq	−.25***	−.08***	−.28***	1.47***	0.27***	1.82***
(x100)	(.07)	(.02)	(.04)	(.13)	(.03)	(.41)
Profit	−.28***	−.50***	−.18*	1.14***	1.37***	.60***
	(.01)	(.04)	(.10)	(.02)	(.09)	(.19)
Growth	.16	.16	.07	−.07	−.01	.03
	(.10)	(.10)	(.08)	(.26)	(.22)	(.11)
Inflation	−.05	−.03	−.02	.00	−.04	.01
	(.07)	(.07)	(.02)	(.06)	(.06)	(.02)
Risk	.01	−.02	−.01			
	(.02)	(.02)	(.04)			
Capital	−.98**	−.71*	.03			
requirement	(.48)	(.40)	(.33)			
No. of obs	50128	25775	3015	49128	44870	2813
AB-AR(1)	0.00	0.00	0.00	.00	.06	.06
AB-AR(2)	0.28	0.16	0.62	.65	.33	.39
Hansen-p	0.57	0.28	0.32	.37	.45	.33
Long-run	.15**	.15***	.86	−.33***	−.23***	−.16
impact	(.06)	(.06)	(3.33)	(.07)	(.05)	(.10)

1/ Dependent variable is the leverage ratio. Two-step system-GMM estimator with the lagged dependent variable and risk instrumented. The maximum number of lags is two. Standard errors (between brackets) are heteroskedasticity robust and clustered within countries. *, **, *** denotes significance at the 10, 5, and 1 percent level.

2/ The 50 percent largest bank-year observations have an asset value exceeding US$118 million; The 5 percent largest bank-year observations have an asset value exceeding US$1.2 billion.

V. Conclusions

The results reported here suggest that the differentially favorable corporate tax treatment of debt finance does lead banks to be more highly leveraged than they otherwise would be, notwithstanding the regulatory capital requirements they face. Indeed, banks' capital structures are in general about as responsive to tax asymmetries as are those of non-financial firms. The size of the buffers they hold over regulatory requirements also emerges as sensitive to tax. Nor is all this simply a matter of response through exotic hybrid instruments, and hence addressed by Basel III measures limiting their use. To the contrary, the model developed here suggests, and the empirics tend to confirm, that these are rather unresponsive to tax incentives: intuitively, there is in effect a 'pecking order' in which their treatment as regulatory capital means that hybrids are the preferred source of debt finance and, so long as there is any tax advantage to debt, are issued up to the point at which regulatory limits on their use start to bite.

It also emerges, however, that there are important differences across banks. Whereas those with large buffers show significant responses to tax but not to capital requirements, capital-tight banks show the opposite response: they are insensitive to taxes but sensitive to changes in capital requirements. Moreover, the largest 5 percent of banks—holding almost 60 percent of all bank assets—are considerably less responsive to taxation and are unresponsive to minimum capital requirements.

These results pose challenges for policy design. The issues at stake—of whether, for instance, to restrict interest deductibility or, conversely, extend deductibility to a notional return on equity; and of whether to impose special 'bank taxes' on wholesale borrowing of banks, as several European countries have done—are not addressed here.[27] What does emerge from the empirics is a need to recognize some subtleties in the potential implications of such measures. For most banks, like non-financial institutions, taxes do matter for their financing decisions, and tax reform could significantly affect their capital structures. The results here imply, for instance, that eliminating the bias to debt finance created by a 25 percent CIT rate might increase banks' capital in the long run by, on average 3.75 percent of their assets: an increase of more than 30 percent over their current levels.[28] But the very largest banks—which dominate the sector and give rise to the systemic externalities that have been the key concern since the crisis of 2008—are different. They emerge as very unresponsive to taxation. This does not mean that taxation can have no effect on their capital structures, but does suggest that large reforms would be needed to have a marked effect. Nor does it imply that regulation is the socially optimal way to address these systemic externalities. It does though suggest that, at the margin, regulatory reforms targeted to the aspect of capital structure most closely associated with those externalities is likely to be the more effective strategy.

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[27] See for instance De Mooij (2011b) and Kocherlakota (2011).

[28] This is based on the marginal impact coefficient of 0.15 in column (1) of Table 2. Taking instead the marginal impact coefficient of 0.27 in column (2) of Table 1, bank capital would increase by 6.75 percent of total assets, or 50 percent of current capital.

Appendix 1. Proof of Proposition 3

Perturbing (12) and (16) for a small change in dT gives

$$\begin{bmatrix} \Pi_{LL} & \Pi_{LH} \\ \Pi_{HL} & \Pi_{HH} \end{bmatrix} \begin{bmatrix} dL \\ dH \end{bmatrix} = -dT \begin{bmatrix} 1 \\ 0 \end{bmatrix} \quad , \tag{A.1}$$

and hence

$$\frac{dL}{dT} = \frac{-\Pi_{HH}}{\Delta} \ ; \quad \frac{dH}{dT} = \frac{-\Pi_{HL}}{\Delta} \tag{A.2}$$

where, by the second order conditions, $\Delta \equiv \Pi_{LL}\Pi_{EE} - (\Pi_{HL)}{}^2 > 0$. Part (a) follows on writing

$$\frac{dL}{dT} = -\left(\Pi_{LL} - \left(\frac{(\Pi_{LH})^2}{\Pi_{HH}}\right)\right)^{-1} > -\left(\frac{1}{\Pi_{LL}}\right) \tag{A.3}$$

and recalling (14). That $dH/dT > 0$ follows on noting that with zero agency costs

$$\Pi_{HL} = -C\phi(\theta^*)\theta_H^* \tag{A.4}$$

and recalling from (15) that $\theta_H^* < 0$. For the rest of part (b), differentiating in (16) gives

$$\Pi_{HH} = C\phi(\theta^*)\theta_H^* - C^h\phi(\theta^{*h})\theta_H^{*h} = -\Pi_{HL} - C^h\phi(\theta^{*h})\theta_H^{*h} \ , \tag{A.6}$$

where the second equality is from (A.4); hence, from (A.2),

$$\frac{dL}{dT} - \frac{dH}{dT} = \frac{\Pi_{HL} - \Pi_{HH}}{\Delta} = \frac{C^h\phi(\theta^{*h})\theta_H^{*h}}{\Delta} > 0 \tag{A.7}$$

the inequality being from (14).

Appendix 2. Proof of Proposition 4

Part (a) follows on applying the implicit function theorem to each of (12) and (16), noting in turn that

$$\Pi_{L\alpha} = -C\phi(\theta^*)\theta^*_\alpha < 0 \tag{B.1}$$

$$\Pi_{H\alpha} = C\phi(\theta^*)\theta^*_\alpha - C^h\phi(\theta^{*h})\theta^{*h}_\alpha > 0\,, \tag{B.2}$$

the signs following from the implications of (4) and (7) that

$$\theta^*_\alpha = \frac{E+H}{\alpha^2(1-\bar{K})} > 0\,;\ \theta^{*h}_\alpha = -\left(\frac{1}{\alpha^2}\right)\frac{H}{\bar{h}A} < 0\,. \tag{B.3}$$

For part (b), solving the system (12) and (16) for a change $d\alpha$ gives

$$\begin{bmatrix}\Pi_{\mathrm{LL}} & \Pi_{\mathrm{LH}}\\ \Pi_{\mathrm{HL}} & \Pi_{\mathrm{HH}}\end{bmatrix}\begin{bmatrix}dL\\ dH\end{bmatrix} = -d\alpha\begin{bmatrix}\Pi_{\mathrm{L\alpha}}\\ \Pi_{\mathrm{H\alpha}}\end{bmatrix} \tag{B.4}$$

and hence

$$\frac{dH}{d\alpha} - \frac{dL}{d\alpha} = \left(\frac{1}{\Delta}\right)[(\Pi_{HH} + \Pi_{HL})\Pi_{L\alpha} - (\Pi_{LL} + \Pi_{HL})\Pi_{H\alpha}]. \tag{B.5}$$

Noting from (A.6) that $\Pi_{HH} + \Pi_{HL} = -C^h\phi(\theta^{*h})\theta^{*h}_H$ and from (14) that (since $\theta^*_L = -\theta^*_H$ from (4)) $\Pi_{LL} = -\Pi_{LH}$, this gives

$$\frac{dH}{d\alpha} - \frac{dL}{d\alpha} = -\left(\frac{1}{\Delta}\right)C^h\phi(\theta^{*h})\theta^{*h}_H\Pi_{L\alpha} > 0 \quad , \tag{B.6}$$

the sign following from (15) and (B.1).

Appendix 3. Data

We use the Bankscope data of Bureau van Dijk, containing balance sheet and income statements for banks on the basis of annual reports. In selecting the data, we focus on commercial banks, saving banks, and cooperative banks and exclude other financial institutions, such as investment banks, holding companies, or mortgage banks. We also eliminate from the sample inactive banks, which often means banks in the process of liquidation, takeover, or merger (and showing exceptional financial ratios). Bankscope further distinguishes between consolidated and unconsolidated accounts. For our purposes, we are interested in unconsolidated accounts, which terminate at the border and to which national tax rates and regulations apply; observations on consolidated accounts are removed. Finally, we use banks in 82 countries across Europe, Asia, and the Americas for which we have tax data, eliminating those showing a negative equity value or a negative capital ratio. The remaining sample consists of 14,377 banks. We use data for nine years between 2001 and 2009. But we only use observations for which the main explanatory variables are available. This reduces the sample, yielding 65,575 bank-year observations that can be used. The panel is unbalanced as not all variables are reported for all years and all banks.

Table 4. Summary Statistics

	No. of obs	Mean	St. dev.	Min	Max
Leverage	65228	.88	.082	.09	1
'Non-hybrid debt'	65043	.87	.081	0	1
'Hybrids'	65367	.01	.005	0	.24
Tax rate	65575	.38	.025	0	.41
Log assets	65575	11.81	1.367	6.83	21.28
Profitability	65574	.012	.140	-1.66	33.872
Risk Weight	65575	.68	.152	0	4.216
GDP growth	51849	.02	.022	-.179	.142
Price index	58930	.03	.018	-.03	1.07
Deposit insurance	21749	2.74	.414	0	12.59
Capital requirement	65485	.08	.002	0.08	.14
Buffer	65389	.13	.350	-.08	9.74

Sources: Bankscope, IMF Finance Statistics, KPMG, ZEW and OUCBT, Demirguc-Kunt and others.

Table 4 summarizes the dataset, including constructed variables. Leverage is measured as total liabilities as a share of total assets; liabilities here include all interest-bearing liabilities, reserves, tax liabilities, insurance, non-interest bearing liabilities and other deferred liabilities. 'Non-hybrid' debt is measured as unity minus the sum of tier 1 and tier 2 capital, expressed as a percentage of total assets. In the absence of data explicitly identifying hybrid instruments, 'hybrids' are computed as the difference between leverage and non-hybrid debt.

The average leverage ratio of sample banks is 88 percent, slightly higher than that for non-hybrid debt. These rates are high compared to non-financial firms, which generally have ratios between 40 and 60 percent. The standard deviation in leverage ratios is around 8 percent.

Tax data are collected from two main sources. The most important is KPMG's corporate and indirect tax survey 2010, which reports statutory corporate tax rates for most countries between 2000 and 2010. These rates generally include local taxes and surcharges.[29] The average tax rate is 0.36: this may seem rather high in light of much lower rates in many countries, but many observations refer to the U.S., Japan, and Germany, which have higher rates during most of the sample period.

For profitability, we use the average return on assets. The average value is 1.1 percent, with a standard deviation of 11.5 percent. Risk weighted assets average 68 percent of total unweighted assets, with 95 percent of the observations between 40 and 100 percent.

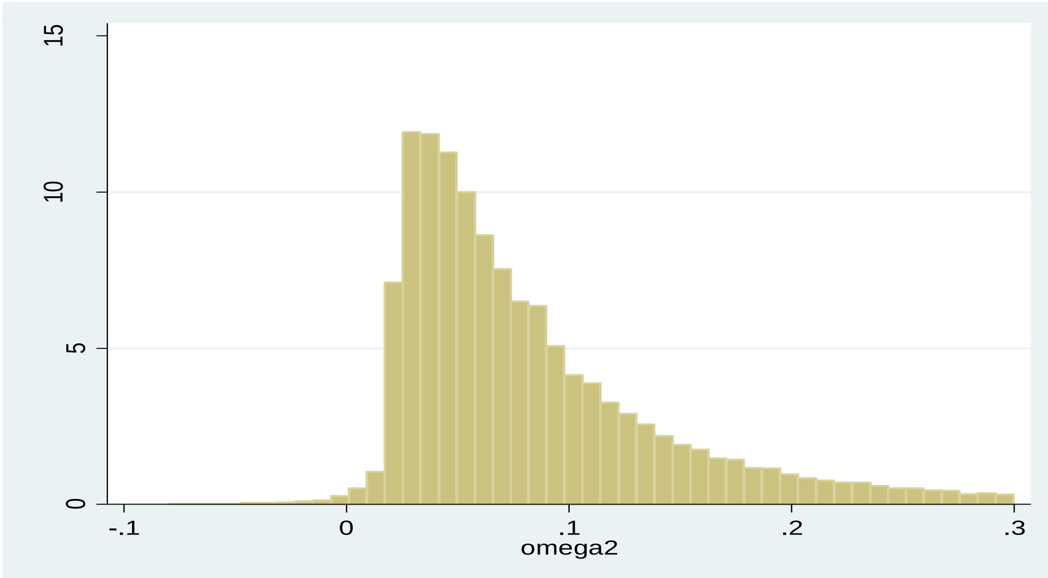
Macroeconomic data, such as inflation and economic growth, are obtained from the *IMF Financial Statistics*. Deposit insurance coverage is measured by the indicator of Demirguc-Kunt and others (2008): the amount of deposit insurance coverage per individual, in percent of per capita GDP. The coverage of this variable is limited, however, as there are only three years available and a number of countries are not included. The sample size is thus reduced significantly in regressions with this variable.

Data on minimum capital-asset requirements are taken from the World Bank database on Bank regulation and supervision (Barth and others 2001). This contains data on capital requirements for 2003 and 2007 only; we assume that the 2003 series applies to all years between 2001 and 2004, and the 2007 series to all years between 2005 and 2009. The ratio for most countries is adjusted for risk. Table 5 shows that the mean value of the minimum capital ratio is 8 percent, but varies up to 14 percent.

The buffer, Ω, is defined, following (6), as the excess of equity capital relative to risk-weighted assets over the minimum capital requirement. Figure 1 shows its distribution for the 95 percent of bank-year observations with a buffer below 30 percent. The mean is 13 percent; for 68 percent of observations, the buffer lies between 0 and 10 percent.

[29] For some European countries, we modify rates on the basis of an extensive review by ZEW and OUCBT (2008). This study is more explicit on how it has calculated tax rates. For the U.S., we take the average local rate across U.S. states and apply this rate to all U.S. banks.

Figure 1. Distribution of the Buffer



Appendix 4. Second-order Approximation

Table 5 reports the estimation of a second-order approximation, including both squared independent variables and interactions between independent variables with the tax rate on the right-hand side of the regression equation. The interaction between the tax rate and growth and the direct effect of the capital requirement is omitted to avoid multicollinearity problems.

Table 5. Second-order Approximation 1/

Lagged value	.29*** (.04)
Tax	1.45** (.43)
Tax sq	−.09 (.49)
Log assets	.11*** (.01)
Log assets sq (x100)	−.27*** (.04)
Tax * Log assets	−.085*** (.02)
Profit	−.21*** (.07)
Profit sq	.10*** (.03)
Tax * Profit	−.44*** (.07)
Risk	.07 (.05)
Risk sq	−.04 (.03)
Tax * Risk	.03** (.01)
Inflation	−.18 (.27)
Tax * Inflation	.58 (.87)
Tax * capital requirement	−1.88* (1.06)
No. of obs	48882
AB-AR(1)	0.00
AB-AR(2)	0.70
Hansen-p	0.56
Long-run impact	
Bank with 118 million assets (median bank)	.24** (.07)
Bank with 1.2 bln assets (top 5%)	0.04 (.08)

1/ Dependent variable is the leverage ratio. Two-step system-GMM estimator with the lagged dependent variable and risk instrumented. The maximum number of lags is two. Standard errors (between brackets) are heteroskedasticity robust and clustered within countries. *, **, *** denotes significance at the 10, 5, and 1 percent level.

There is no sign of non-linearity in the tax effects: the squared tax rate enters with an insignificant coefficient. Three tax interaction variables do matter, however: those with size, profitability, and risk. First—and as discussed in the text—larger banks respond less to taxation than do smaller banks. This is illustrated at the bottom of the table for two values of asset holding (and with other independent variables set at their respective sample means): those of the median bank and of the bank whose asset value just places it in the largest 5 percent. Whereas the marginal tax coefficient for the median bank is 0.24, that for the large bank is close to zero and insignificant. Second, the interaction of profits and the tax rate is significantly negative. This is unexpected since profits generally increase the value of the tax allowance for debt. Indeed, the literature on capital structure regressions usually emphasizes that non-debt tax shields, in the form of losses or losses carried forward, significantly reduce responsiveness to tax. We do not find support for this claim, also when we take past profits as a proxy for non-debt tax shields. Third, there is a negative effect from the interaction of the risk variable and the tax rate. With more risky portfolios, banks become less responsive to tax. This might be expected as more risky assets reduce the buffer, which makes banks less responsive to tax.

Other interactions are insignificant, or close to. For instance, banks do not seem more responsive to taxation when inflation is higher. This contrasts to the expectation that inflation increases the benefit of debt finance since nominal, rather than real, interest is deductible for the CIT. The interaction with the capital requirement shows a weakly significant effect, as the model predicts.

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