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Profit Taxation and Bank Risk Taking

Michael Kogler*

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Abstract

How can tax policy improve financial stability? Recent studies point to large potential stability gains from a reform that eliminates the debt bias in corporate taxation. Such a reform reduces bank leverage. This paper emphasizes a novel, complementary channel: bank risk taking. We model the portfolio choice of banks under moral hazard and thereby highlight the ‘incentive function’ of equity. The corporate income tax influences risk-taking incentives through the cost of equity relative to deposits, the after-tax returns on different portfolios, and future bank profits. The analysis yields two novel findings: A tax reform which eliminates the debt bias discourages risk taking and reduces bank failure risk. Raising the corporate tax rate can also reduce risk taking in the short run, but permanent tax hikes have destabilizing long-term effects.

JEL classification: G21, G28, H25

Keywords: Corporate taxation, tax reform, risk taking, financial stability

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1 Introduction

Taxes influence bank behavior and financial stability. In particular, corporate taxation is usually not neutral with respect to the capital structure because the interest expense on debt is tax-deductible in most countries, whereas the cost of equity is not. This well-known ‘debt bias’ creates an incentive for banks and non-financial firms to rely on debt instead of equity and may contribute to the build-up of excessive leverage. It runs counter to the primary goal of prudential regulation, namely, strengthening the resilience of banks. According to studies in the aftermath of the financial crisis (e.g., Langedijk et al., 2015), a tax reform that eliminates the debt bias like, for example, an allowance for corporate equity (ACE), promises large potential financial stability gains.

One can think of at least two sources of such stability gains at the individual bank level: If banks respond to a tax reform by reducing their leverage, they can better absorb losses because of larger capital buffers. They may also have more ‘skin in the game’ leading to stronger incentives for investing a safer, better diversified portfolio. While the implications for the capital structure are well understood despite some differences between banks and non-financial firms, little is known about how the corporate income tax affects bank risk taking and portfolio quality. The present paper studies this risk-taking channel of corporate taxation. Our analysis distinguishes between a *tax reform* with an allowance for equity (ACE) that alleviates the debt bias as well as simple changes in *tax rates*. The allowance grants a partial or full deduction of the notional cost of equity from the tax base. Our analysis aims at identifying the main channels through which taxes affect the risk-taking incentives of banks and at evaluating financial stability gains measured in terms of portfolio quality and the average probability of bank failure.

This paper develops a risk-taking model that pictures the bank’s choice between a

prudent or in a *gambling* portfolio. Gambling promises higher returns if successful but it is more likely to cause bank failure. Moral hazard emerges because financiers like depositors only observe the realized return but not the underlying portfolio choice. More indebted banks thus have an incentive for gambling (risk shifting). The use of equity is solely motivated by the ‘incentive function’: Equity raises a bank’s ‘skin in the game’, alleviates moral hazard, and ensures that it invests in the prudent portfolio.

With a discrete portfolio choice, the model emphasizes risk taking at the extensive margin: Charter values, which equal discounted profits in the future and are forgone once a bank fails, are heterogeneous reflecting differences in future bank profits. A large charter value mitigates risk shifting because such banks have a strong incentive to avoid failure. Equilibrium exhibits different risk-taking strategies: Banks with a large charter value invest in the prudent portfolio and may raise equity, while others gamble.

Banks have to pay a corporate income tax that discriminates between debt and equity (‘debt bias’). They cannot deduct the entire cost of the equity from the tax base. Corporate taxation influences risk taking through several channels such as (i) the cost of equity relative to deposits, (ii) after-tax portfolio returns and potential gains from gambling, and (iii), in an extension, future bank profits.

Our analysis yields two novel results: First, tax reforms like ACE reduce bank risk taking and improve financial stability. More banks find it profitable to raise equity buffers, which become less expensive as their costs are tax-deductible. The higher capital ratio makes investing in the ‘prudent’ portfolio with a low failure risk optimal.

Second, higher corporate tax rates offer stability gains at least in the short run. Taxing the high return of a successful gamble renders such a portfolio less attractive. This effect prevails although equity, which is necessary to set proper incentives, becomes

more expensive unless the capital ratio is very high. Consequently, a revenue-neutral tax reform that grants a full deduction of the cost of equity and raises tax rates to compensate for the shrinking tax base can substantially improve financial stability.

We evaluate these findings in two model extensions that (i) introduce capital requirements to explore the interaction of taxation and bank regulation and (ii) endogenize future bank profits and charter value to assess the risk-taking effects of taxation in the long run. With tight capital standards, an allowance becomes less effective in reducing portfolio risk, whereas the risk-taking effect of a higher tax rate is more negative. At the same time, tax reforms that favor equity make risk taking less sensitive to capital requirements as banks voluntarily attract more equity. If banks anticipate how taxes exactly influence their future profits, permanent tax hikes depress charter value and tend to have a destabilizing effect. A tax reform, in contrast, also lowers the cost of equity in the future, which boosts charter values and further reduces incentives to take risks.

The present paper connects to two strands of the literature in public economics and banking: A large literature has analyzed how corporate taxation influences the capital structure of non-financial firms and, more recently, of banks and identified the main distortions caused by the debt bias. Theoretical and empirical research suggests that the corporate income tax positively affects firm leverage (see surveys by Auerbach, 2002; Graham, 2003, 2008). These findings have motivated a number of reform proposals for a more neutral tax system such as the aforementioned allowance for corporate equity, which grants a deduction of the notional cost of equity.

Unlike non-financial firms, banks cannot freely choose their leverage as they must comply with capital regulation. Keen and de Mooij (2016) analyze the joint effects of regulatory constraints and the debt bias on the capital structure of banks. Their

theoretical analysis highlights heterogeneous effects: Leverage of capital-abundant banks with large voluntary equity buffers is considerably more responsive to taxation than leverage of banks with small buffers. The latter often face binding capital requirements. Using a sample of banks from 82 countries, Keen and de Mooij (2016) estimate tax elasticities of bank leverage between 0.14 in the short and 0.25 in the long run. These estimates are driven by the behavior of capital-abundant banks. Their results suggest that abolishing the debt bias could significantly increase bank capital by more than 50% given a corporate income tax rate of 25%. Comparable tax elasticities of leverage are found by Horvath (2014), Hemmelgarn and Teichmann (2014), and Gu et al. (2015), who stress debt bias and international debt shifting as determinants of leverage of multinational banks. Bond et al. (2016) consider the Italian tax on productive activities, which like the typical corporate income tax does not allow deducting the cost of equity. They show that banks symmetrically react to tax hikes and cuts and highlight the role of regulatory constraints that considerably weaken the tax sensitivity of bank leverage.

These studies generally exploit cross-country or regional variations in corporate tax rates. In the presence of the debt bias, the latter determine the size of the tax advantage of debt. An alternative approach exploits tax reforms: Schepens (2016) studies the introduction of a tax allowance (ACE) in Belgium 2006. He estimates an increase in bank capital ratios of 13.5 percent, which is mainly driven by a larger volume of equity. Similarly, C el erier et al. (2017) and Martin-Flores and Moussu (2018) analyze a tax allowance on marginal equity that existed in Italy between 1997 and 2002. They estimate that the allowance led to larger bank equity, whereas its phase-out contributed to rising leverage. Such findings suggest that eliminating the debt bias can substantially improve financial stability by reducing bank leverage: Using a conservative tax elasticity, Langedijk et al.

(2015) estimate that the public finance costs of financial crises (e.g., for the recapitalization of distressed banks) strongly decrease in the range of 40 to 77 percent. In countries with many capital-abundant banks that are more responsive to taxation, such gains may even exceed 80 percent.

A complementary source of such stability gains are safer (loan) portfolios. So far, little is known about how corporate taxation affects bank risk taking. A few empirical studies shed light on this issue but the evidence is mixed: Schepens (2016) finds that abolishing the debt bias in Belgium reduced portfolio risk represented by different measures like non-performing loans (NPL) ratio and the Z-score. Martin-Flores and Moussu (2018) show that introducing a notional interest deduction in Italy was associated with a lower NPL ratio. In contrast, Horvath (2014) uses cross-country data and estimates that a high corporate tax rate reduces portfolio risk represented by the average regulatory risk weight and the NPL ratio. He emphasizes the role of risk-sensitive capital requirements, which give rise to a trade-off between leverage and portfolio risk. Overall, the evidence suggests that tax reforms, which specifically address the debt bias, and tax cuts affect risk taking differently although they both lead to smaller costs bank equity.

The present paper addresses this issue and provides the first theoretical model of corporate taxation and bank risk taking. While the well-understood effects of taxation on bank leverage play an important role in our analysis, it takes an entirely different route: We emphasize the ‘incentive function’ of bank equity in alleviating moral hazard and reducing portfolio risk as a novel channel through which tax policy can enhance financial stability. We abstract from the more conventional role of equity as a buffer that enhances the loss-absorbing capacity of banks analyzed in previous literature (e.g. Keen and de Mooij, 2016). Consistent with the two main paths pursued in related empirical

research, we distinguish between changes in the corporate tax rate and a tax reform with an allowance for equity. This helps us rationalize the seemingly contrasting empirical results in this context.

Moreover, our work builds on the theoretical banking literature, which provides a comprehensive analysis of risk taking typically modeled as the portfolio or asset choice of banks. Risk taking is usually not contractible giving rise to moral hazard and risk shifting, an agency problem that induces indebted banks to take excessive risks. Hence, a high capital ratio and large future profits of banks reflected in the charter value provide discipline, alleviate moral hazard, and discourage risk taking (Hellmann et al., 2000). The theoretical literature has emphasized competition in deposit and loan markets (e.g., Keeley, 1990; Allen and Gale, 2000; Repullo, 2004; Boyd and De Nicolò, 2005), capital regulation (e.g., Rochet, 1992; Besanko and Kanatas, 1996; Repullo, 2004; Hakenes and Schnabel, 2011), and deposit insurance and government guarantees (e.g., Merton, 1977; Keeley, 1990), which all influence capital structure and future profits, as more fundamental determinants of bank risk taking.

In this spirit, several papers explore the scope for Pigovian taxes in banking and also analyze how such taxes influence the risk-taking incentives of banks. Examples are Perotti and Suarez (2011) who analyze a Pigovian tax on short-term funding, and Devereux et al. (2015) who study levies on bank liabilities adopted by several European countries after the financial crisis. They explicitly model how such levies influence the capital structure and asset risk of banks.

Our paper shares several key model elements with the risk-taking literature. The role of bank equity as a disciplining device that mitigates risk shifting is especially important for our reasoning because equity is influenced by taxation. More specifically, our model

of the bank's portfolio choice as well as the extension with an endogenous charter value are borrowed from Hellmann et al. (2000). This paper contributes to this literature as it identifies corporate taxation as a novel institutional determinant of bank risk taking in addition to established factors like competition, regulation, and deposit insurance.

The remainder of this paper is organized as follows: Section 2 sets out the model. Section 3 introduces the corporate income tax and derives its effects on bank risk taking and financial stability. Section 4 adds two extension. Eventually, Section 5 concludes.

2 Model

We build on the risk-taking model of Hellmann et al. (2000), which pictures the bank's choice between a *prudent portfolio* with low risk and a low return if successful and *gambling portfolio* with high risk and return. The portfolio choice is unobservable giving rise to moral hazard. Hence, the capital structure and charter value of banks become key determinants of risk taking. In our baseline model, the charter value is taken as given and provides a source of bank heterogeneity that rationalizes different risk-taking strategies in equilibrium. We endogenize the charter value as an extension in Section 4.2. Unlike in Hellmann et al. (2000), deposits are correctly priced in this model, and equity does not require a fixed excess return. Importantly, the debt bias in corporate taxation will provide a microfoundation for such an excess return.

2.1 Banks and Portfolios

There is a continuum of measure one of heterogeneous banks. Each bank raises funds of size one consisting of deposits and equity, which are elastically supplied by investors who demand an expected gross return $1 + r$. Since deposits are risky, banks must offer a

risk-adjusted deposit rate i .

The bank can invest either in a *prudent* or in a *gambling* portfolio. Portfolio $j = \{P, G\}$ offers (i) a high payoff $1 + \alpha + \gamma$ with $\alpha > 0$ and $\gamma > 0$ with probability θ_h^j , (ii) an intermediate payoff $1 + \alpha$ with probability θ_m^j , and (iii) zero with the complementary probability $\theta_l^j = 1 - \theta_h^j - \theta_m^j$. In case of a zero payoff, the bank fails; it cannot repay outstanding deposits and exits. Defining the success probability $\theta^j \equiv \theta_h^j + \theta_m^j$, the portfolio's expected (net) return is $r^j \equiv \theta^j(1 + \alpha) + \theta_h^j\gamma - (1 + r)$.

While the (state-dependent) payoffs are the same for both portfolios, the corresponding probabilities, θ_k^j , differ and satisfy:

ASSUMPTION 1. *The gambling portfolio is more likely to offer the high payoff, $\theta_h^G > \theta_h^P$, but less likely to offer the intermediate payoff than the prudent portfolio, $\theta_m^G < \theta_m^P$. The probability of a positive payoff is higher when investing in the prudent portfolio, $\theta^P \equiv \theta_h^P + \theta_m^P > \theta_h^G + \theta_m^G \equiv \theta^G$.*

Gambling banks have a better chance to earn the high return γ but have a higher risk of failure than prudent banks. Modeling a portfolio with three possible outcomes allows us to capture this classical trade-off between risk and return in a setup with an unobservable portfolio choice but observable payoffs.¹ The latter are a prerequisite for profit taxation. Once a bank raised deposits and equity, it can invest in either portfolio. Outsiders do observe the realized payoff but it remains private information of the bank whether it was generated by the prudent or the gambling portfolio.

Each bank has a charter value Ω that equals the net present value of its future profits.

The bank fails with probability $1 - \theta^j$ depending on the portfolio choice: In this case,

¹With only two payoffs (e.g., $\alpha^j > 0$ and 0), gambling would be strictly dominated due to the lower success probability if those payoffs were the same, $\alpha^P = \alpha^G$. If they were different, $\alpha^P \neq \alpha^G$, one could infer the portfolio choice from the realized payoff, which would eliminate moral hazard in the first place.

its license is revoked, and the charter value is lost. With a discrete portfolio choice, the model pictures the extensive margin of risk taking. For that purpose, we assume that banks are heterogeneous and differ in those charter values:

ASSUMPTION 2. Ω is distributed on $[0, \bar{\Omega}]$ with cumulative density $F(\Omega)$.

A large charter value reflects attractive long-term lending opportunities that promise high future profits. One could alternatively argue that heterogeneity stems from different discount factors with which banks evaluate the very same future profits (see Section 4.2). As a result, equilibrium exhibits differences in risk taking as banks with a large charter value are ceteris paribus less inclined to gamble. Heterogeneous risk-taking incentives are also emphasized in a related paper by Perotti and Suarez (2011).

The timing is as follows: (i) banks raise deposits and equity, they offer a financing contract to depositors that specifies the deposit interest rate, (ii) banks choose the portfolio, and (iii) the payoff is realized, if the bank fails, it is closed down and the license is revoked. Otherwise, it continues and realizes the charter value.

2.2 Risk Taking

For given interest rate on deposits i and capital ratio e , a bank's expected profit from investing in portfolio $j = \{G, P\}$ equals:

$$\begin{aligned} \pi^j(e, i) &= \theta^j[1 + \alpha - (1 + i)(1 - e)] + \theta_h^j \gamma - (1 + r)e \\ &= r^j + [(1 + r) - \theta^j(1 + i)](1 - e). \end{aligned} \tag{1}$$

Depositors are repaid $1 + i$ if the bank succeeds, outside shareholders are promised an expected return on equity of $1 + r$. With probability $\theta^j = \theta_h^j + \theta_m^j$, the bank earns at least the intermediate return $1 + \alpha$, succeeds, and repays deposits; with probability θ_m^j , it receives the extra return γ as well. The second line rewrites profit as the portfolio's

expected net return r^j plus a limited liability effect from a potential default on deposits. Taking into account future profits are only realized if the bank succeeds, the bank value of type Ω is:

$$V^j(e, i; \Omega) = \pi^j(e, i) + \theta^j \Omega. \quad (2)$$

Portfolio Choice and Capital Structure: The portfolio choice is not contractible, which causes moral hazard (risk shifting). Once a bank raised funds and agreed on a deposit contract, it chooses the portfolio. A bank with charter value Ω , capital ratio e , and deposit rate i invests in the prudent portfolio if $V^P(e, i; \Omega) \geq V^G(e, i; \Omega)$ or, equivalently,

$$\pi^G(e, i) - \pi^P(e, i) \leq \Delta\theta\Omega, \quad \Delta\theta \equiv \theta^P - \theta^G > 0. \quad (3)$$

This *no-gambling condition* ensures that the (short-term) gain from risk-taking $\pi^G - \pi^P$ must be smaller than the (long-term) loss in charter value $\Delta\theta\Omega$. Substituting for profits using (1) and dividing by $\Delta\theta$ gives

$$\tilde{r} + (1+i)(1-e) \leq \Omega, \quad \tilde{r} \equiv \frac{r^G - r^P}{\Delta\theta}. \quad (4)$$

Short-term gains from risk-taking on the left-hand side result from a higher expected return of the gambling portfolio if $\tilde{r} > 0$ and from the typical risk-shifting effect due to limited liability (i.e., the gambling bank defaults more often on deposits), $\Delta\theta(1+i)(1-e)$. The latter decreases in the capital ratio e and vanishes if $e = 1$. Equity thus plays the typical disciplining role and helps banks alleviate moral hazard.

Solving the no-gambling condition (4) for e yields the minimum capital ratio that preserves the incentive to invest in the prudent portfolio

$$e \geq e_0(i; \Omega) \equiv 1 + \frac{\tilde{r} - \Omega}{1+i}. \quad (5)$$

Only with a capital ratio of at least e_0 , a bank will invest in the prudent portfolio.

Otherwise, it is privately optimal to take more risk and to gamble. Importantly, minimum equity is type-specific and decreases in charter value.

Banks with a very high charter value always prefer the prudent portfolio even with no equity. Intuitively, the risk of losing the charter value is so large that they are better off by choosing the safer portfolio that promises the highest chance of success and of being able to realize the large future profits. This reflects the standard result in the risk-taking literature that charter value and bank equity have comparable incentive effects. The zero-equity cutoff

$$\Omega^\circ(i) = 1 + i + \tilde{r} \tag{6}$$

pins down the type that prefers the prudent portfolio even with no equity, $e_0(i; \Omega^\circ) = 0$.

Moreover, if gambling offers an expected gain, $\tilde{r} > 0$, equation (5) implies $e_0 > 1$ for some banks with small charter values, $\Omega < \tilde{r}$. Such banks cannot be provided with incentives for investing in the prudent portfolio because the forgone charter value is too small. These types thus always opt for the gambling portfolio.

Bank Value and Deposit Rate: In the beginning, the bank raises deposits d and equity e and promises a deposit rate i . Depositors require an expected return r and a compensation for bearing the risk of bank failure. This motivates the standard pricing condition for deposits:

$$1 + r = \theta^j (1 + i^j). \tag{7}$$

It pins down the risk-adjusted deposit rate i^j conditional on the subsequent portfolio choice $j = \{G, P\}$. Due to $\theta^P > \theta^G$, a gambling bank pays a higher deposit rate, $i^G > i^P$. Correct pricing ensures that expected bank profit is simply equal to the portfolio's expected return, $\pi^j = r^j$.

Most importantly, risk taking is not observable and banks take capital structure and interest rate as given when deciding about the portfolio at a later stage. Deposit rate and capital ratio thus need to be incentive-compatible and must satisfy both the minimum equity (5) and the pricing condition (10). Otherwise, the bank will have an incentive to deviate, and deposits will be mis-priced ex post.

Consider first a bank that intends to invest in the prudent portfolio. It attracts deposits at interest rate $i^P = (1 + r)/\theta^P - 1$ and must have a capital ratio $e \geq e_0(i^P; \Omega)$. Substituting for i^P and (5) gives the constrained maximization problem

$$V^P(\Omega) = \max_{e, \lambda} V^P(e, i^P; \Omega) + \lambda[e - e_0(i^P; \Omega)] \quad (8)$$

with $V^P(e, i^P; \Omega) = r^P + \theta^P \Omega$; λ denotes the multiplier. The first-order condition for equity gives $\lambda = 0$ such that according to complementary slackness, the minimum equity condition does not bind and any capital ratio $e \geq e_0(i^P; \Omega)$ is optimal. Banks may raise voluntary capital buffers in excess of e_0 . The reason is that equity is no more expensive or scarcer than debt. The maximum bank value is $V^P(\Omega) = r^P + \theta^P \Omega$.

Next, consider a bank that plans to invest in the gambling portfolio. It needs to offer depositors the higher interest rate $i^G = (1 + r)/\theta^G - 1$. Its capital ratio satisfies $e < e_0(i^G; \Omega)$ giving the constrained maximization problem

$$V^G(\Omega) = \max_{e, \lambda} V^G(e, i^G; \Omega) + \lambda[e_0(i^G; \Omega) - e] \quad (9)$$

with $V^G(e, i^G; \Omega) = r^G + \theta^G \Omega$. Again, one obtains $\lambda = 0$ such that the constraint is slack and any capital ratio $e < e_0(i^G; \Omega)$ is optimal. The corresponding bank value is $V^G(\Omega) = r^G + \theta^G \Omega$.

Equations (8) and (9) characterize the two options of a bank that are incentive-compatible and maximize profits. Each bank initially compares those options and decides whether it (i) raises some equity $e \geq e_0$, attracts deposits at the low interest rate i^P , and

invests in the prudent portfolio or (ii) raises little or no equity, offers depositors the high interest rate i^G , and gambles.

2.3 Equilibrium

Since banks are heterogeneous, some of them opt for the prudent, others for the gambling portfolio. The charter value influences the value of investing in the prudent portfolio V^P directly and via minimum equity e_0 . The pivotal type with charter value Ω^* that is indifferent between the two portfolios is defined by $V^P(\Omega^*) = V^G(\Omega^*)$. Substituting for bank values yields the risk-taking cutoff:

$$\Omega^* = \tilde{r}. \quad (10)$$

Banks with a charter value larger than this cutoff, $\Omega \geq \Omega^*$, invest in the prudent asset, whereas others, $\Omega < \Omega^*$, gamble. Should gambling not offer any expected short-term gains, that is, if $r^G \leq r^P$ and $\tilde{r} \leq 0$, all banks choose the prudent portfolio. In any case, $\Omega^* < \Omega^\circ(i^P) = (1+r)/\theta^P + \Omega^*$ holds such that some prudent banks must raise positive equity. Substituting (10) into minimum equity (5) reveals that the pivotal type is an all-equity financed bank, $e(\Omega^*) = 1$.

As a result, three groups of banks emerge in equilibrium:

- $\Omega \geq \Omega^\circ(i^P)$: The large charter value alone ensures that banks invest in the prudent portfolio. They may have zero equity, and succeed with probability θ^P .
- $\Omega^\circ(i^P) > \Omega \geq \Omega^*$: The charter value is not large enough to provide discipline. Such banks have a strictly positive capital ratio, $e \geq e_0 > 0$, choose the prudent portfolio. They succeed with probability θ^P .
- $\Omega < \Omega^*$: Banks with a small charter value gamble, have a capital ratio smaller than

e_0 , and are successful with probability θ^G .

In equilibrium, a fraction $1 - F(\Omega^*)$ of banks invests in the prudent and a fraction $F(\Omega^*)$ invests in the gambling portfolio. A share $F[\Omega^\circ(i^P)] - F(\Omega^*)$ attracts positive equity.

Finally, one can show that bank risk taking is efficient in this model despite incomplete contracts. Welfare equals aggregate bank value²

$$W = \int_0^{\Omega^*} V^G(\Omega) dF(\Omega) + \int_{\Omega^*}^{\bar{\Omega}} V^P(\Omega) dF(\Omega) \quad (11)$$

with $V^j(\Omega) \equiv r^j + \theta^j \Omega$ due to correct deposit pricing. By applying the Leibniz rule, one finds that the welfare-maximizing cutoff fulfills $[V^G(\Omega^*) - V^P(\Omega^*)] F(\Omega^*) = 0$ or, after substituting for bank values, $\Omega^* = \tilde{r}$. A comparison with (10) immediately reveals that market equilibrium satisfies this optimality condition although risk taking is not contractible. Intuitively, banks can raise equity at no extra cost to set proper incentives. As soon as taxes or guarantees make bank equity more costly relative to debt, risk taking will be distorted.

3 Corporate Income Tax

This section introduces a corporate income tax, which potentially discriminates between debt and equity ('debt bias'). The tax rate equals τ , and the tax base is profit equal to the realized payoff, which is either α or $\alpha + \gamma$, net of the interest expense on deposits, $i(1 - e)$. A fraction $s \in [0, 1]$ of the cost of bank equity can be deducted from the tax base. We assume that the notional return on equity is equal to the interest rate on deposits i . After all, both types of funds require the same expected return r at the outset. The tax-deductible cost of equity thus equals *sie*. The parameter s characterizes

²Risk-neutral depositors are compensated with a risk-adjusted return and thus earn a zero surplus; outside shareholders earn an expected return that matches their opportunity costs.

the allowance: $s = 0$ reflects the traditional tax with the debt bias, and $s = 1$ describes a neutral tax that allows for the full deduction of the cost of capital. This setup allows us to distinguish between the level effect of changes in the tax rate and the effect of a tax reform that addresses the debt bias with a larger allowance for equity.

Depending on which portfolio return is realized, the tax liability is:

$$T_m = \tau[\alpha - i(1 - e) - sie], \quad T_h = \tau[\alpha + \gamma - i(1 - e) - sie], \quad T_l = 0. \quad (12)$$

A bank's expected tax burden when investing in portfolio $j = \{G, P\}$ is $T^j = \theta_m^j T_m + \theta_h^j T_h = \theta^j T_m + \theta_h^j \tau \gamma$; the second equality uses $T_h = T_m + \tau \gamma$. By substituting and collecting terms, one obtains:

$$T^j = \tau[\theta^j(\alpha - i(1 - (1 - s)e) + \theta_h^j \gamma)] = \tau[r^j + (1 + r) - \theta^j(1 + i) + (1 - s)\theta^j ie] \quad (13)$$

Equity increases the expected tax burden because of the debt bias, $s < 1$. Only if the corporate income tax is neutral with $s = 1$, it is independent of the capital structure. In any case, gambling banks pay a higher expected tax than prudent banks, $T^G \geq T^P$. This follows from higher expected returns, $r^G \geq r^P$, and fewer opportunities to deduct the costs of deposits and (potentially) equity, $\theta^P > \theta^G$. Noting (1), the short-term after-tax profit from portfolio j equals

$$\begin{aligned} \pi^j(e, i) &= r^j + [(1 + r) - \theta^j(1 + i)](1 - e) - T^j \\ &= (1 - \tau)[r^j + (1 + r) - \theta^j(1 + i)(1 - e)] - \tau(1 - s)\theta^j ie. \end{aligned} \quad (14)$$

3.1 Risk Taking

Portfolio Choice and Capital Structure: For a given deposit rate and capital ratio, the bank chooses the prudent portfolio as long as $\pi^G(e, i) - \pi^P(e, i) \leq \Delta\theta\Omega$. Substituting (13) and (14) and dividing by $\Delta\theta$ yields the no-gambling condition:

$$\tilde{r} + (1 + i)(1 - e) - \tau[1 + i + \tilde{r} - (1 - s)ie] \leq \Omega. \quad (15)$$

The short-term gains from risk taking on the left-hand side reflect three factors: First, the gambling portfolio usually a higher expected return, $\tilde{r} \geq 0$. Second, there are more opportunities to default and not repay deposits $(1+i)(1-e)$ in case of gambling. Third, gambling is associated with a larger expected tax burden as shown earlier. This effect, which is represented by the third term, diminishes the short-term gains from risk taking.

Solving (15) yields the minimum capital ratio which ensures that the bank invests in the prudent portfolio

$$e \geq e_0(i; \Omega) \equiv \frac{(1-\tau)(1+i+\tilde{r})-\Omega}{1+i'} \quad (16)$$

with $i' \equiv i[1-\tau(1-s)] \leq i$. This capital ratio is zero, $e_0(i; \Omega^\circ) = 0$, whenever the charter value is so large that it provides sufficient discipline, $\Omega > \Omega^\circ = (1-\tau)(1+i+\tilde{r})$. Compared to the model without taxes, more banks can afford zero equity without violating the no-gambling condition because taxes lower the short-term gains from risk taking.

Bank Value and Deposit Rate: A bank which subsequently invests in the prudent portfolio raises deposits at interest rate $1+i^P = (1+r)/\theta^P$ and must have a minimum capital ratio $e \geq e_0(i^P; \Omega)$ according to (16). The constrained problem is

$$V^P(\Omega) = \max_{e, \lambda} V^P(e, i^P; \Omega) + \lambda[e - e_0(i^P; \Omega)] \quad (17)$$

with $V^P(e, i^P; \Omega) = (1-\tau)r^P - \tau(1-s)\theta^P i^P e + \theta^P \Omega$ by (14). The first-order condition for equity implies a binding constraint, $\lambda = \tau(1-s)\theta^P i^P > 0$. Since equity is more expensive than the debt, the bank exactly raises minimum equity, $e = e_0$. The prudent portfolio yields the bank value $V^P(\Omega) = V^P(e_0, i^P; \Omega) = (1-\tau)r^P - \tau(1-s)(1+r-\theta^P)e_0 + \theta^P \Omega$. In the presence of a distorting tax, bank value is reduced by an extra cost. Banks with a high charter value, $\Omega \geq \Omega^\circ$, and zero equity do not incur such a tax cost. Their value depends only on the tax rate but not on the allowance, $V^P(\Omega) = \pi^P + \theta^P \Omega$.

The value of a prudent bank responds as follows:

$$dV^P = \theta^P \cdot d\Omega - \tau(1-s)(1+r-\theta^P) \cdot de_0 + \tau(1+r-\theta^P)e_0 \cdot ds - [r^P + (1-s)(1+r-\theta^P)e_0] \cdot d\tau. \quad (18)$$

It rises with charter value Ω but falls with the minimum capital ratio e_0 because the latter is associated with an extra tax cost of $\tau(1-s)\theta^P i^P = \tau(1-s)(1+r-\theta^P)$ due to the debt bias. A larger allowance for equity s boosts bank value exactly by reducing this cost. A higher tax rate τ , in contrast, reduces the value as it lowers the after-tax return and magnifies the cost of equity. Once the charter value is so large that a zero capital ratio is sufficient, $\Omega > \Omega^\circ$, bank value is insensitive to the allowance and less sensitive to the tax rate.

If a bank intends to choose the gambling portfolio, it must offer the deposit rate $1+i^G = (1+r)/\theta^G$ and its capital ratio has to be smaller than $e < e_0(i^G; \Omega)$:

$$V^G(\Omega) = \max_{e, \lambda} V^G(e, i^G; \Omega) + \lambda[e_0(i^G; \Omega) - e] \quad (19)$$

with $V^G(e, i^G; \Omega) = (1-\tau)r^G - \tau(1-s)\theta^G i^G e + \theta^G \Omega$ by (14). The first-order condition for equity implies $\lambda = -\tau(1-s)\theta^G i^G < 0$. The bank value is maximized if the constraint is fulfilled with a zero capital ratio giving $V^G(\Omega) = V^G(0, i^G; \Omega) = (1-\tau)r^G + \theta^G \Omega$.

It increases in the charter value and decreases in the tax rate but is insensitive to the allowance because gambling banks have no equity:

$$dV^G = \theta^G \cdot d\Omega - r^G \cdot d\tau. \quad (20)$$

3.2 Equilibrium

The pivotal type with charter value Ω^* is indifferent between the two portfolios, $V^P(\Omega^*) = V^G(\Omega^*)$. Substituting (17) and (19) yields the risk-taking cutoff

$$\Omega^* = (1-\tau)\tilde{r} + \frac{\tau(1-s)(1+r-\theta^P)e_0(i^P; \Omega^*)}{\Delta\theta}. \quad (21)$$

Minimum equity $e_0(i^P; \Omega^*)$ itself depends on the pivotal type according to (16). The closed-form solution is

$$\Omega^* = (1 - \tau) [\tilde{r} + \chi(1 + i^P)] \quad (22)$$

with $\chi \in [0, 1)$ being a measure of the tax distortion. It reflects the extra tax cost of equity:

$$\chi = \frac{\tau(1 - s)(1 + r - \theta^P)}{\Delta\theta(1 + i') + \tau(1 - s)(1 + r - \theta^P)}. \quad (23)$$

Recall $i' = i^P[1 - \tau(1 - s)]$. If the tax is neutral and the bank can deduct the full cost of equity from the tax base, $s = 1$, the distortion disappears, $\chi = 0$, giving $\Omega^* = (1 - \tau)\tilde{r}$.

In equilibrium, the risk-taking cutoff is always smaller than the zero-equity cutoff, $\Omega^* = (1 - \tau)[\tilde{r} + \chi(1 + i^P)] \leq (1 - \tau)(1 + i^P + \tilde{r}) \equiv \Omega^\circ(i^P)$, due to $\chi < 1$. A strictly positive fraction of banks with $\Omega \in (\Omega^*, \Omega^\circ)$ raises equity and subsequently invests in the prudent portfolio. Three different groups of banks emerge in equilibrium as illustrated in Figure 1:

- $\Omega \geq \Omega^\circ(i^P)$: Banks with a very large charter value have zero equity, invest in the prudent portfolio, and succeed with probability θ^P .
- $\Omega^\circ(i^P) > \Omega \geq \Omega^*$: The charter value is not large enough to provide discipline alone, and those banks need to raise positive equity, $e_0 > 0$, to set incentives for the prudent portfolio. The latter promises a larger value such that those banks invest in the prudent portfolio and succeed with probability θ^P .
- $\Omega < \Omega^*$: The charter value is small. Those banks can realize a larger value by gambling, raise no equity, and succeed with probability θ^G .

Once the risk-taking cutoff Ω^* is known, one can characterize financial stability with two key measures: The average probability of bank failure π reflects that a fraction $F(\Omega^*)$

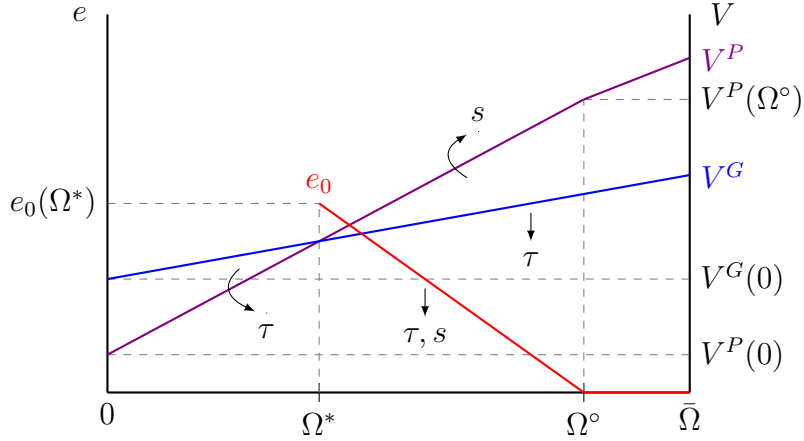


Figure 1: *Equilibrium*

This figure depicts minimum equity e_0 (in red, left axis) and bank values from prudent and gambling portfolio V^P and V^G (in blue and violet, right axis) and the risk-taking and zero-equity cutoffs Ω^* and Ω° in the presence of a distorting corporate income tax with $\tau > 0$ and $s < 1$.

of banks gambles and fails with probability $1 - \theta^G$, whereas a fraction $1 - F(\Omega^*)$ chooses the prudent portfolio and fails with a lower probability $1 - \theta^P$:

$$\pi = 1 - \theta^P + \Delta\theta F(\Omega^*). \quad (24)$$

Average failure risk is higher the larger the share of gambling banks $F(\Omega^*)$ that emerges endogenously. As a result, tax policy can reduce failure risk in the banking sector by influencing risk taking at the extensive margin.

Another common measure of financial stability is the aggregate capital ratio of the banking sector:

$$\bar{e}_0 = \int_{\Omega^*}^{\Omega^\circ} e_0(\Omega) dF(\Omega). \quad (25)$$

Given the unit mass of banks, \bar{e}_0 also equals the average capital ratio of a bank. In equilibrium, banks with a small, $\Omega < \Omega^*$, and banks with a large charter value, $\Omega > \Omega^\circ$, have no equity but they invest in different portfolios (see Figure 1). Banks with intermediate charter values, $\Omega \in (\Omega^*, \Omega^\circ)$, have a positive capital ratio that ranges between $e_0(i^P; \Omega^\circ) = 0$ and $e_0(i^P; \Omega^*) = (1 - \tau)(1 - \chi)(1 + i^P)/(1 + i') < 1$.

3.3 Results

Equity helps some banks set correct risk-taking incentives and ensures that the no-gambling condition holds. Differentiating individual minimum equity in (16) gives:

$$de_0 = -\frac{1}{1+i'} \cdot d\Omega - \frac{\tau ie_0}{1+i'} \cdot ds - \frac{1+i+\tilde{r}-(1-s)ie_0}{1+i'} \cdot d\tau. \quad (26)$$

It decreases in the charter value because the latter has comparable incentive effects: Banks that expect high future profits lose a lot if they fail, and they thus opt for the prudent portfolio even with little equity. Noting $(1-s)e_0 < 1$, the corporate income tax affects the capital ratio of an individual bank as follows:

LEMMA 1. *The minimum capital ratio of a bank decreases in the corporate tax rate τ and in the allowance for bank equity s .*

Proof: Follows from Equation (26).

These sensitivities mirror how the tax affects risk-taking incentives: A more generous allowance and a higher tax rate diminish the short-term gains from risk taking, see (15). As gambling becomes relatively less attractive, a lower capital ratio suffices to preserve the incentive for the prudent portfolio.

To evaluate how the corporate income tax influence the portfolio decision of banks, we derive the sensitivities of the pivotal type Ω^* . If the latter rises, more banks will gamble and take risks. Starting from $dV^P(\Omega^*) = dV^G(\Omega^*)$, we substitute (18) and (20).

Collecting terms and dividing by $\Delta\theta$ gives

$$\begin{aligned} \left[1 - \tau(1-s)\zeta \frac{de_0}{d\Omega}\right] \cdot d\Omega^* = & -\tau\zeta \left[e_0 - (1-s)\frac{de_0}{ds}\right] \cdot ds \\ & - \left[\tilde{r} - (1-s)\zeta \left(e_0 + \tau \frac{de_0}{d\tau}\right)\right] \cdot d\tau. \end{aligned} \quad (27)$$

which uses the definition $\zeta \equiv (1+r-\theta^P)/\Delta\theta$. The coefficients of s and τ mirror how the tax affects the values associated with the two portfolios. Corporate taxation influences

relative profits directly and also change minimum equity. The latter affects the value from the prudent portfolio because of the debt bias.

A larger allowance boosts the value from the prudent portfolio V^P because only such banks have equity and benefit. Minimum equity also declines, which further reduces the extra tax cost. A rising corporate tax rate involves several offsetting effects. It shrinks the short-term gains from gambling as the corresponding after-tax return falls more strongly. This is captured by the first term $\tilde{r} \geq 0$. In addition, prudent banks incur higher costs of equity, which provides the necessary discipline. However, the total tax costs of equity, $\tau(1-s)(1+r-\theta^P)e_0$, may rise or fall: While the per-unit cost is unambiguously higher, the amount of equity e_0 decreases, see (26).

We summarize the net effects of taxes on risk taking in the following proposition:

PROPOSITION 1. *The risk-taking cutoff Ω^* responds to the tax according to*

$$d\Omega^* = -(\sigma_s \cdot ds + \sigma_\tau \cdot d\tau) \quad (28)$$

with coefficients

$$\sigma_s = \frac{\chi(1+i^P)e_0(\Omega^*)}{1-s} > 0, \quad \sigma_\tau = \tilde{r} + \chi(1+i^P) \left[1 - \frac{e_0(\Omega^*)}{\tau} \right].$$

A larger allowance for equity s unambiguously discourages risk taking. The cutoff falls, and more banks invest in the prudent portfolio. A rising corporate tax rate τ discourages risk taking if the capital ratio of the pivotal type $\Omega = \Omega^$ is low, $e_0(\Omega^*) \leq \tau$. The risk-taking cutoff falls in this case; otherwise, it may increase or decrease.*

Proof: Equation (28) follows from substituting the sensitivities of minimum equity stated in (26) and evaluated for the pivotal type Ω^* into Equation (27) and rearranging.

First, a more generous allowance enables banks to deduct a larger share of the return on equity from the tax base. Therefore, both the per-unit tax cost of equity falls and smaller equity is sufficient. This boosts the value from investing in the prudent portfolio

but leaves the value from gambling unchanged. Therefore, a larger share of banks invests in the prudent portfolio and takes fewer risks, which is reflected in a declining risk-taking cutoff.

Second, a rising tax rate affects the cutoff in either way as discussed above. It discourages risk taking, $\sigma_\tau > 0$, if the capital ratio of the pivotal type is relatively low. More precisely, it should not exceed the tax rate by much. The effect of the declining capital ratio dominates the higher per-unit cost in this case. The total cost of equity falls such that the value of prudent investment V^P always declines by less than the value of gambling V^G . Whenever $e_0 > \tau$, the rising tax rate magnifies the total costs of equity. The overall effect is still negative if tax distortion χ is small or the short-run gain from risk taking \tilde{r} is large. Otherwise, a higher tax rate raises the cutoff charter value thereby inducing more banks to gamble.

Overall, these findings are consistent with the empirical literature: The evidence suggests that introducing a tax allowance for equity tends to improve portfolio quality in terms of non-performing loans (e.g., Schepens, 2016; Martin-Flores and Moussu, 2018), while a higher corporate tax rate is associated with lower asset risk measured by the average regulatory risk weight or non-performing loans (Horvath, 2014).³

An important case is a neutral tax system, which allows for the full deduction of the cost of equity from the tax base (i.e., $s = 1$):

PROPOSITION 2. *If the tax system is neutral, a higher tax rate unambiguously decreases the cutoff charter value Ω^* and discourages risk taking.*

Proof: A full tax allowance, $s = 1$, removes the tax distortion, $\chi = 1$, on account of

³Horvath (2014) points to a different channel in explaining the lower average risk weight: When higher tax rates reduce equity and capital requirements bind, banks must reduce their risk-weighted assets. They can achieve this by improving the quality or the volume of assets.

(23). Evaluating the coefficient of Equation (28) suggests $\sigma_\tau = \tilde{r} > 0$.

In this case, issuing equity does not entail any extra costs that depresses the value of prudent banks. The risk-taking cutoff simply equals $\Omega^* = (1 - \tau)\tilde{r}$, it decreases in the tax rate because the latter reduces the after-tax return from gambling by more.

The central implication of this finding is a revenue-neutral tax reform which introduces a full allowance for equity, $s = 1$, and then raises the tax rate to account for the shrinking tax base will discourage risk taking in two ways: The allowance eliminates the debt bias and boosts the value from the prudent portfolio relative to gambling such that the cutoff charter value Ω^* falls. Once the tax is neutral, raising the tax rate τ further discourages risk taking as $d\Omega^*/d\tau|_{s=1} < 0$.

Changes in risk taking at the extensive margin are the source of potential financial stability gains of tax reform. One can make use of the results in Proposition 1 to precisely characterize how corporate taxation two common measures of financial stability.

Reflecting changes in the share of gambling banks, $F(\Omega^*)$, the average probability of bank failure, $\pi = (1 - \theta^P) + \Delta\theta F(\Omega^*)$, decreases in the allowance for equity s but responds more ambiguously to changes in the tax rate τ :

$$d\pi = -\Delta\theta f(\Omega^*)[\sigma_s \cdot ds + \sigma_\tau \cdot d\tau] \quad (29)$$

A tax reform that mitigates the debt bias discourages bank risk taking, $\sigma_s > 0$, thereby reducing the failure risk in the banking sector. Higher corporate tax rates also have a stabilizing effect as long as minimum equity of the pivotal type is not too large, $\sigma_\tau > 0$.

Moreover, the corporate income tax influences the aggregate (minimum) capital ratio of the banking sector \bar{e}_0 defined in (25). Applying the Leibniz rule, a larger allowance for

bank equity and a higher corporate tax rate affect the aggregate capital ratio as follows:

$$d\bar{e}_0 = \sum_{h \in \{s, \tau\}} \left[\int_{\Omega^*}^{\Omega^\circ} \frac{de_0(\Omega)}{dh} dF(\Omega) - e_0^* f(\Omega^*) \frac{d\Omega^*}{dh} \right] \cdot dh \quad (30)$$

Recall that $e_0(\Omega^\circ) = 0$ by construction. The net effect of taxation thus reflects how banks with positive equity adjust their individual capital ratio e_0 and of whether the share of such banks grows or shrinks. The latter is represented by changes in the risk-taking cutoff Ω^* . The net effect is a priori ambiguous: On the one hand, all banks with positive equity reduce their capital ratio when facing a higher tax rate or a larger allowance, see (14). On the other hand, the share of banks which attract positive equity to set proper risk-taking incentives typically expands in both cases, see (28). To make clear-cut predictions about the net effect on aggregate bank equity, we assume that charter values are uniformly distributed with density $f(\Omega) = 1/\bar{\Omega}$.

Evaluating Equations (29) and (30) motivates the following proposition:

PROPOSITION 3. *A larger allowance for bank equity reduces the average probability of bank failure and raises the aggregate capital ratio of the banking sector. A higher tax rate reduces both the average probability of bank failure and the aggregate capital ratio.*

Proof: The effects on the average probability of bank failure directly follow from (29).

The effects on the aggregate capital ratio are derived in Appendix A assuming a uniform distribution of charter values, $\Omega \sim U[0, \bar{\Omega}]$.

The predictions about how aggregate equity in the banking sector responds to taxation are in line with the empirical evidence, namely, positive effects of a tax reform which abolishes the debt bias (e.g., Schepens, 2016; Célérier et al., 2017) and negative effects of a higher corporate tax rate (e.g., Hemmelgarn and Teichmann, 2014; Horvath, 2014) on either the capital ratio or the voluntary capital buffer of banks.

4 Extensions

We extend the theoretical framework by introducing capital requirements, which oblige all banks to raise positive equity irrespective of portfolio choice and charter value. This helps us shed light on the interaction between bank regulation and taxes and, specifically, on whether capital standards reinforce or weaken the risk-taking effects of taxation. The second extension explicitly models future bank profit thereby endogenizing the charter value. This establishes another channel of how taxation influences risk-taking incentives that is especially important when considering permanent tax changes.

4.1 Capital Requirements

Suppose each bank is subject to capital requirements and must have a capital ratio of at least k . One can decompose the overall capital ratio e into the regulatory minimum k and a voluntary buffer ε , $e = k + \varepsilon$.

4.1.1 Risk Taking

Portfolio Choice and Capital Structure: Bank profit (14) and the no-gambling condition (15) are unchanged as they depend on the overall capital ratio e only. Using $e = k + \varepsilon$ when solving the latter gives the minimum voluntary capital buffer that ensures no-gambling:

$$\varepsilon \geq \varepsilon_0(i; \Omega) \equiv \frac{(1 - \tau)(1 + i + \tilde{r}) - \Omega}{1 + i'} - k. \quad (31)$$

For any given deposit rate i , a bank of type Ω needs to raise at least a buffer of $\varepsilon_0(i; \Omega)$ to set incentives for choosing the prudent portfolio.

Types $\Omega \geq \Omega^\circ(i) = (1 - \tau)(1 + i + \tilde{r}) - (1 + i')k$ choose the prudent portfolio even without such a buffer, $\varepsilon_0(i; \Omega^\circ) = 0$. If capital standards are tight, the share of banks for

which the no-gambling condition is satisfied irrespective of the voluntary buffer, $1 - F(\Omega^\circ)$, is large.

Bank Value and Deposit Rate: A bank investing in the prudent portfolio raises deposits at the interest rate $1 + i^P = (1 + r)/\theta^P$ and must have a minimum capital buffer $\varepsilon \geq \varepsilon_0$. It maximizes expected bank value

$$V^P(\Omega) = \max_{\varepsilon, \lambda} V^P(k + \varepsilon, i^P; \Omega) + \lambda[\varepsilon - \varepsilon_0(i^P; \Omega)] \quad (32)$$

with $V^P(k + \varepsilon, i^P; \Omega) = (1 - \tau)r^P - \tau(1 - s)\theta^P i^P(k + \varepsilon) + \theta^P \Omega$. The first-order condition for the capital buffer implies a binding constraint such that the bank exactly raises the minimum, $\varepsilon = \varepsilon_0$. The prudent portfolio yields a maximum value $V^P(\Omega) = V^P(k + \varepsilon_0, i^P; \Omega) = (1 - \tau)r^P - \tau(1 - s)(1 + r - \theta^P)(k + \varepsilon_0) + \theta^P \Omega$. It changes according to

$$\begin{aligned} dV^P &= \theta^P \cdot d\Omega - \tau(1 - s)(1 + r - \theta^P) \cdot d\varepsilon_0 + \tau(1 + r - \theta^P)e_0 \cdot ds \\ &\quad - [r^P + (1 - s)(1 + r - \theta^P)e_0] \cdot d\tau. \end{aligned} \quad (33)$$

If a bank intends to choose the gambling portfolio instead, its voluntary buffer cannot exceed $\varepsilon(i^G; \Omega)$:

$$V^G(\Omega) = \max_{\varepsilon, \lambda} V^G(k + \varepsilon, i^G; \Omega) + \lambda[\varepsilon_0(i^G; \Omega) - \varepsilon] \quad (34)$$

with $V^G(k + \varepsilon, i^G; \Omega) = (1 - \tau)r^G - \tau(1 - s)\theta^G i^G(k + \varepsilon) + \theta^G \Omega$ by (14). Bank value is maximized with no buffer, $\varepsilon = 0$. Gambling banks exactly fulfill the regulatory requirements and can expect a value of $V^G(\Omega) = V^G(k, i^G; \Omega) = (1 - \tau)r^G - \tau(1 - s)(1 + r - \theta^G)k + \theta^G \Omega$.

The latter changes according to

$$dV^G = \theta^G \cdot d\Omega + \tau(1 + r - \theta^G)k \cdot ds - [r^G + (1 - s)(1 + r - \theta^G)k] \cdot d\tau. \quad (35)$$

Unlike in the baseline model, the value from gambling is also sensitive to the allowance for equity because gambling banks now have positive equity due to capital requirements.

An important aspect in our analysis is that the notional return on equity, which banks

can deduct from the tax base, equals to the interest rate on deposits. The latter is higher for gambling than for prudent banks reflecting their higher failure risk. Gambling banks thus incur a larger tax cost when simply fulfilling capital requirements:

$$\tau(1-s)\theta^G i^G k = \tau(1-s)(1+r-\theta^G)k > \tau(1-s)(1+r-\theta^P)k = \tau(1-s)\theta^P i^P k.$$

Once the voluntary capital buffer is so small that $e_0 \approx k$, any change in the tax cost will thus have a stronger effect on the value associated with the gambling than on the value associated with the prudent portfolio.

4.1.2 Equilibrium

In parallel to our standard model, equalizing bank values from the two portfolios, $V^P(\Omega^*) = V^G(\Omega^*)$, defines the risk-taking cutoff:

$$\Omega^* = (1-\tau)\tilde{r} + \frac{\tau(1-s)(1+r-\theta^P)\varepsilon_0(i^P; \Omega^*)}{\Delta\theta} - \tau(1-s)k. \quad (36)$$

The pivotal charter value exactly compensates a prudent bank for the lower short-term return compared to gambling and for the extra cost of the necessary capital buffer. Since each bank must have positive equity k , however, gambling entails a larger per unit cost of equity represented by the third, negative term.

Substituting (31) for $\varepsilon_0(i^P; \Omega^*)$ gives the closed-form solution

$$\Omega^* = (1-\tau) [\tilde{r} + \chi(1+i^P)] - \tilde{\chi}(1+i')k \quad (37)$$

with $\chi \in [0, 1)$ defined earlier and $\tilde{\chi} \equiv \chi \cdot (1+r-\theta^G)/(1+r-\theta^P) > \chi$ being measures of the tax distortion. Unless the capital standard k is very tight, we have $\Omega^* < \Omega^\circ$, and some banks have a positive buffer to set correct risk-taking incentives:

$$k < \frac{(1-\tau)(1-\chi)(1+i^P)}{(1+i')(1-\tilde{\chi})} = \frac{1-\tau}{1-\tau(1-s)}. \quad (38)$$

The second equality uses the definition of χ in (23). It is very plausible that this condition

is satisfied: The corporate tax rate τ typically ranges between 20% and 30% implying a maximum capital standard in the range of 70% to 80% even without a tax allowance, while the minimum capital requirement k is 8% in terms of risk-weighted assets.

4.1.3 Results

When inspecting the pivotal type (37), one observes the well-known effect that capital requirements reduce risk taking and lower the cutoff Ω^* . All banks have to raise additional equity, which is relatively more expensive for gambling than for prudent banks. Hence, gambling is less attractive. This effect is stronger if the tax distortion χ is large either due to a high tax rate or a pronounced debt bias. In a neutral tax system, profit and bank value are independent of the capital structure such that changes in regulation do not influence risk taking. Capital regulation only influences the portfolio choice as long as equity is more expensive than debt. Therefore, tax reforms which favor equity tend to diminish the sensitivity of bank risk taking to capital requirements:

PROPOSITION 4. *A low tax rate and a large allowance for equity renders bank risk taking less sensitive to capital requirements.*

Proof: Follows from equation (37).

Next, we consider how the corporate income tax influences risk taking represented by the pivotal type Ω^* . Differentiating the voluntary capital buffer ε_0 defined in (31) gives:

$$d\varepsilon_0 = -\frac{1}{1+i'} \cdot d\Omega - \frac{\tau i e_0}{1+i'} \cdot ds - \frac{1+i+\tilde{r}-i(1-s)e_0}{1+i'} \cdot d\tau \quad (39)$$

with $e_0 = \varepsilon_0 + k$. Its sensitivities are identical to those of the overall capital ratio e_0 in (26).

To derive the responses of the risk-taking cutoff, we start with $dV^P(\Omega^*) = dV^G(\Omega^*)$,

collect terms, and divide by $\Delta\theta$:

$$\begin{aligned} \left[1 - \tau(1-s)\zeta\frac{d\varepsilon_0}{d\Omega}\right] \cdot d\Omega^* = & -\tau \left[\zeta \left(\varepsilon_0 - (1-s)\frac{d\varepsilon_0}{ds} \right) - k \right] \cdot ds \\ & - \left[\tilde{r} + (1-s)k - (1-s)\zeta \left(\varepsilon_0 + \tau\frac{d\varepsilon_0}{d\tau} \right) \right] \cdot d\tau \end{aligned} \quad (40)$$

with $\zeta \equiv (1+r-\theta^P)/\Delta\theta$. A larger allowance s lowers both size and cost of the voluntary buffer thereby, which makes the prudent portfolio more attractive. However, gambling banks incur a higher per-unit tax cost of equity and benefit relatively more from the larger allowance. A higher tax rate τ , in turn, tends to lower the cutoff: On the one hand, it reduces the short-term gain from risk taking, makes satisfying the capital standard k relatively more expensive for gambling banks, and allows for a smaller voluntary capital buffer. On the other hand, the cost of raising the voluntary capital buffer is higher. Combining (39) and (40) establishes:

PROPOSITION 5. *The risk-taking cutoff Ω^* responds to the tax according to*

$$d\Omega^* = -(\sigma_s \cdot ds + \sigma_\tau \cdot d\tau) \quad (41)$$

with the coefficients defined as

$$\begin{aligned} \sigma_s &= \frac{\chi(1+i^P)e_0(\Omega^*)}{1-s} - \tau(1-\chi)(1+\zeta)k \\ \sigma_\tau &= \tilde{r} + \chi(1+i^P) \left[1 - \frac{e_0(\Omega^*)}{\tau} \right] + (1-s)(1-\chi)(1+\zeta)k. \end{aligned}$$

The cutoff tends to decrease in the allowance for equity s and in the tax rate τ . A larger allowance and higher tax rates induce more banks to invest in the prudent portfolio.

Proof: Follows from substituting (39) for de_0 in (40) and rearranging.

In the presence of capital standards, profit taxation influences risk taking in a largely comparable way. However, the allowance for equity is generally less effective in limiting risk taking, while the risk-taking effect of higher tax rates is more likely to be negative.

These contrasting implications emerge from the fact that the extra tax cost, which each bank incurs irrespective of the portfolio choice as to satisfy the capital standard k , is

proportional to the deposit rate and thus larger for gambling banks. This particular cost rises with the tax rate and falls with the allowance. In addition to diminishing short-term gains from risk taking and allowing for a smaller voluntary capital buffer, a rising tax rate makes complying with capital standards relatively more expensive for gambling banks. The latter makes gambling less attractive such that the net effect σ_τ is more likely to be negative. The cutoff falls, and a larger share of banks purchase the prudent portfolio. This finding is consistent with Horvath (2014) who estimates that the effect of a rising corporate tax rate on asset risk represented by the average regulatory risk weight is more negative in countries where capital regulation is more stringent.

A generous tax allowance, in turn, also benefits gambling banks because their cost of satisfying capital requirements falls relative to prudent banks. This partly offsets the negative direct effect on the risk-taking cutoff in the first place. Since capital requirements are usually quite low, the first effect is unlikely to prevail such that a larger allowance still tends to discourage risk taking, however.

4.2 Endogenous Charter Value

The charter value has so far been considered exogenous and the main source of bank heterogeneity. However, taxes also influence bank profits in the future. Provided that tax changes are permanent and banks correctly anticipate their future tax burden, corporate taxation directly impacts the charter value that serves as an important disciplining device. This effect on future profits establishes another through which the corporate income tax influences risk-taking incentives. In this spirit, all measures that lower the (future) tax burden will increase charter value and thus favor the prudent portfolio.

We adopt a dynamic approach to endogenize the charter value. Following Hellmann

et al. (2000), we consider banks that operate for $t = 0, 1, 2, \dots, T$ periods. In each period, they attract deposits and equity, invest in either of the two portfolios, and pay out dividends if successful. Portfolio returns and interest rates are constant over time. In case of failure, the bank's license is revoked.⁴

Given a per-period expected profit from portfolio $j = \{G, P\}$, π_t^j , the discounted value of future bank profits equals $V = \sum_{t=0}^T (\delta\theta^j)^t \pi_t^j$; $\delta \in [0, 1]$ denotes the discount factor. Like Hellmann et al. (2000), we consider the limit with $T \rightarrow \infty$. Banks will choose their strategies corresponding to an infinitely repeated Nash equilibrium. Omitting time indices, discounted expected profits thus equal $V^j = \pi^j / (1 - \delta\theta^j)$.

To preserve bank heterogeneity, we assume that banks differ in their discount factors:

ASSUMPTION 3. *Discount factors δ are distributed with cumulative density $F_t(\delta)$ over the unit interval.*

This assumption suggests that some banks are more forward-looking than others. For instance, such differences may emerge due to different time preferences of owners or managers: One might argue that privately owned banks tend to focus more on creating long-term value, while publicly traded banks owned by dispersed shareholders put more emphasis on the current performance.

4.2.1 Risk Taking

Portfolio Choice and Capital Structure: For any given deposit rate i and equity e , the per-period after-tax profit from portfolio j is given by (14). With constant returns, interest rates, and taxes, the discounted bank profit $V^j = \pi^j / (1 - \delta\theta^j)$ equals:

$$V^j(e, i; \delta) = \frac{(1 - \tau)r^j + (1 - \tau)[(1 + r) - \theta^j(1 + i)](1 - e) - \tau(1 - s)\theta^j i^j e}{1 - \delta\theta^j}. \quad (42)$$

⁴For each bank which exits, the regulator assigns a license to a new bank to preserve a competitive banking market.

All banks earn the same per-period profit π^j but they evaluate future profits differently. Thus, the bank value V^j differs across types.

For any given interest rate and capital ratio, a bank invests in the prudent portfolio as long as $V^P \geq V^G$. Substituting for bank values and rearranging gives the no-gambling condition $\pi^G - \pi^P \leq \Delta p \delta V^P$. The short-term gain from gambling must be smaller than the long-term loss resulting from a higher probability of failure, in which case the charter value δV^P is lost. We first reformulate the no gambling condition by substituting (42) and dividing by $\Delta \theta$:

$$\begin{aligned} \tilde{r} + (1+i)(1-e) - \tau[\tilde{r} + (1+i^P) - (1-s)ie] \leq \\ \frac{\delta [(1-\tau)r^P + (1-\tau)[(1+r) - \theta^P(1+i)](1-e) - \tau(1-s)\theta^P i^P e]}{1 - \delta \theta^P}. \end{aligned} \quad (43)$$

The corporate income tax reduces the gains from risk taking on the left-hand side. Unlike in the baseline model, it also lowers future profits and charter value (right-hand side).

One can solve the no-gambling condition for the minimum capital ratio $e \geq e_0$:

$$e_0(i; \delta) = (1-\tau)\tilde{e}_0(i; \delta), \quad \tilde{e}_0(i; \delta) \equiv \frac{1+i+\tilde{r}-\tilde{\delta}[r^P+(1+r)-\theta^P(1+i)]}{1+i'-\tilde{\delta}[(1+r)-\theta^P(1+i)+\tau(1-s)\theta^P i]}. \quad (44)$$

This formulation uses the definitions $\tilde{\delta} \equiv \delta/(1-\delta\theta^P) > \delta$ and $i' \equiv i[1-\tau(1-s)]$.

Bank Value and Deposit Rate: In each period, the bank raises deposits and equity and promises a risk-adjusted deposit rate depending on the subsequent portfolio choice, $\theta^j(1+i^j) = 1+r$. Deposit rate and capital structure need to be incentive-compatible.

A bank that intends to invest in the prudent portfolio can attract deposits at interest rate $1+i^P = (1+r)/\theta^P$ and must have a capital ratio $e \geq e_0(i^P; \delta)$. Substituting for i^P and (5) gives the constrained maximization problem

$$V^P(\delta) = \max_{e, \lambda} V^P(e, i^P; \delta) + \lambda[e - e_0(i^P; \delta)] \quad (45)$$

with $V^P(e, i^P; \delta) = [(1-\tau)r^P - \tau(1-s)\theta^P i^P e]/(1-\delta\theta^P)$. Complementary slackness with

$\lambda = \tau(1-s)\theta^P i^P / (1 - \delta\theta^P) > 0$ implies no voluntary capital buffers, $e = e_0(i^P; \delta)$. The corresponding bank value is $V^P(e, i^P; \delta) = [(1-\tau)r^P - \tau(1-s)(1+r-\theta^P)e_0(i^P; \delta)] / (1 - \delta\theta^P)$. It responds according to

$$dV^P = -\frac{\tau(1-s)(1+r-\theta^P)}{1-\delta\theta^P} \cdot de_0 - \frac{r^P + (1-s)(1+r-\theta^P)e_0}{1-\delta\theta^P} \cdot d\tau + \frac{\tau(1+r-\theta^P)e_0}{1-\delta\theta^P} \cdot ds + \frac{\theta^P V^P}{1-\delta\theta^P} \cdot d\delta. \quad (46)$$

The bank value increases in the discount factor and in the allowance for equity, and it decreases in the tax rate and in minimum equity.

A bank that intends to gamble needs to offer a higher interest rate $1+i^G = (1+r)/\theta^G$.

Its capital ratio is at most $e_0(i^G; \delta)$. The maximization problem is

$$V^G(\delta) = \max_{e, \lambda} V^G(e, i^G; \delta) + \lambda[e_0(i^G; \delta) - e] \quad (47)$$

with $V^G(e, i^G; \delta) = [(1-\tau)r^G - \tau(1-s)\theta^G i^G e] / (1 - \delta\theta^G)$. Higher equity reduces bank value $dV/de = -\tau i^G(1-s) / (1 - \delta\theta^G) - \lambda < 0$, and $e = 0$ is optimal. The bank value $V^G(\delta) = (1-\tau)r^G / (1 - \delta\theta^G)$ falls with the tax rate and rises with the discount factor:

$$dV^G = -\frac{r^G}{1-\delta\theta^G} \cdot d\tau + \frac{\theta^G V^G}{1-\delta\theta^G} \cdot d\delta. \quad (48)$$

4.2.2 Equilibrium

Given correct deposit pricing, the equilibrium capital ratio of a prudent bank is:

$$e_0(\delta) = (1-\tau)\tilde{e}_0(\delta), \quad \tilde{e}_0(\delta) \equiv \frac{1+r+\theta^P(\tilde{r}-\tilde{\delta}r^P)}{1+r-\tau(1-s)(1+r-\theta^P)(1+\tilde{\delta}\theta^P)}. \quad (49)$$

Substituting this into V^P and setting $V^P(\delta) \geq V^G(\delta)$ gives

$$\frac{r^P - \tau(1-s)(1+r-\theta^P)\tilde{e}_0(\delta)}{1-\delta\theta^P} \geq \frac{r^G}{1-\delta\theta^G}. \quad (50)$$

Unlike in the baseline model, the direct effect of the corporate income tax cancels out because it reduces the values from both portfolios proportionately. This leaves the total cost of bank equity $\tau(1-s)(1+r-\theta^P)\tilde{e}_0$ as the only channel through which taxation influences bank risk taking.

One can implicitly define the pivotal type: Banks choose the prudent portfolio as long as their discount factor is at least

$$\delta \geq \frac{\tilde{r} + \tau(1-s)\zeta\tilde{e}_0(\delta^*)}{\theta^G [\tilde{r} + \tau(1-s)\zeta\tilde{e}_0(\delta^*)] + r^G} \equiv \delta^*, \quad \zeta \equiv \frac{1+r-\theta^P}{\Delta\theta}. \quad (51)$$

4.2.3 Results

In equilibrium, the capital ratio of type $\delta \geq \delta^*$ equals $e_0(\delta) = (1-\tau)\tilde{e}_0(\delta)$. Differentiating minimum equity yields

$$de_0 = (1-\tau) \cdot d\tilde{e}_0 - \tilde{e}_0 \cdot d\tau \quad (52)$$

with

$$\begin{aligned} d\tilde{e}_0 = & - \frac{\theta^P}{(1-\delta\theta^P)^2} \frac{r^P - \tau(1-s)(1+r-\theta^P)\tilde{e}_0}{1+r-\tau(1-s)(1+r-\theta^P)(1+\tilde{\delta}\theta^P)} \cdot d\delta \\ & + \frac{\tilde{e}_0(1+r-\theta^P)(1+\tilde{\delta}\theta^P)}{1+r-\tau(1-s)(1+r-\theta^P)(1+\tilde{\delta}\theta^P)} [(1-s) \cdot d\tau - \tau \cdot ds]. \end{aligned}$$

The first term is always positive in equilibrium on account of equation (50), which implies $r^P - \tau(1-s)(1+r-\theta^P)\tilde{e}_0 \geq (1-\delta\theta^P)r^G/(1-\delta\theta^G) > 0$. Hence, forward-looking banks need less equity as they already have a strong incentive for the safer portfolio as they put more emphasis on continuation and future profits. A larger allowance permanently reduces the tax cost of equity. This boosts the value from the prudent portfolio both in the short and long run and allows for lower minimum equity.

The effect of a higher tax rate τ on minimum equity is more ambiguous, however: On the one hand, it lowers the short-term gains from gambling but on the other hand, it reduces future profits and charter value, see (43). The second effect is captured by the increase in \tilde{e}_0 . The net effect

$$\frac{de_0}{d\tau} = - \frac{\tilde{e}_0 \left[1+r - (1-s)(1+r-\theta^P)(1+\tilde{\delta}\theta^P) \right]}{1+r-\tau(1-s)(1+r-\theta^P)(1+\tilde{\delta}\theta^P)}$$

is usually negative such that a higher tax rate allows reducing the capital ratio in parallel to the baseline model. A rising tax rate unambiguously reduces minimum equity if either

the tax system is neutral with $s \rightarrow 1$ or if the bank is myopic with $\delta \rightarrow 0$. Otherwise, the effect of larger tax costs of equity in the future can be quite strong for forward-looking banks. Minimum equity may even rise with the tax rate for $\delta \rightarrow 1$ [and $\tilde{\delta} \rightarrow 1/(1 - \theta^P)$] provided that the tax is distorting, $s < 1$.

To evaluate how profit taxation influences risk taking, we differentiate the pivotal discount factor δ^* starting with $dV^P(\delta^*) = dV^G(\delta^*)$. This eventually establishes:

PROPOSITION 6. *The risk-taking cutoff δ^* responds to the tax according to*

$$\sigma_\delta \cdot d\delta^* = -\sigma_s \cdot ds + \sigma_\tau \cdot d\tau \quad (53)$$

with all coefficients defined positive. The cutoff decreases in the allowance for equity and increases in the tax rate.

Proof: Equation (53) follows from combining dV^P in (46) and dV^G in (48) and substituting (52) for the sensitivities of minimum equity, de_0 . Appendix A states and signs the three coefficients.

A larger tax allowance induces even rather impatient banks to invest in the prudent portfolio. Like in the baseline model, such a reform discourages risk taking and enhances financial stability. Short- and long-term effects are qualitatively comparable. A higher tax rate, however, raises the risk-taking cutoff in this model variant. This suggests that more banks gamble. Permanently higher tax rates depress future profits and charter value, which is an important disciplining device. In the long run, a rising tax rate thus encourages bank risk taking. This result contrasts with the more ambiguous, likely negative risk-taking effect of a more temporary tax hike explored in the baseline model, in which the charter value was considered exogenous and invariant to changes in taxation.

Once the corporate income tax is neutral with a full allowance, $s = 1$, taxation does not affect bank risk taking, and permanent changes in the tax rate do not entail

any financial stability gains or losses. Short- and long-term effects - smaller gains from gambling today and lower profits in the future - exactly offset each other.

5 Conclusion

At the individual bank level, there are two main sources of financial stability: a robust capital structure with large equity buffers that absorb losses and a safe, well-diversified portfolio of loans and other assets. Corporate taxation influence both capital structure and risk taking of banks. Stability gains from tax reforms can thus result from larger bank equity and lower portfolio risk.

This paper provides a first theoretical analysis of the risk-taking channel. Following Hellmann et al. (2000), we develop a model, in which banks choose between a *prudent* and a *gambling* portfolio. The former is less risky but yields lower returns if successful. Importantly, there is moral hazard because risk taking is not contractible, and banks need to raise equity to have an incentive for choosing the prudent portfolio. Under-capitalized banks will engage in risk shifting and gamble.

Our analysis identifies at least three channels through which corporate taxation influences bank risk taking: the relative profits of the two portfolios, the costs of bank equity needed to set correct risk-taking incentives, and, in the long run, future profits and charter value.

The first set of results demonstrates that reforms which reduce the debt bias in corporate taxation promise financial stability gains. More banks attract equity buffers and thus find it optimal to invest in a comparably safe portfolio that is less likely to cause bank failure. In addition, permanent tax reforms boost future profits thereby further strengthening the incentive to choose a safe portfolio.

A second set of results considers changes in the tax rate. A higher corporate tax rate can enhance financial stability at least in the short run. It discourages risk taking mainly by taxing the short-term gains from a risky portfolio with a high return if successful. This effect prevails unless banks need large equity to alleviate moral hazard. As a result, a revenue-neutral tax reform with a full allowance for equity compensated by higher tax rates will substantially improve financial stability. In the long run, however, tax hikes permanently raise the cost of equity due to the debt bias. Future profits and charter value fall, which encourages risk taking and weakens financial stability.

Eventually, the corporate income tax interacts with bank regulation: A model extension demonstrates that tax reforms have a weaker risk-taking effect, while tax hikes are more likely to discourage risk taking if capital standards are tight. In turn, tax reforms weaken the sensitivity of risk taking to capital regulation: Once equity is less expensive, banks voluntarily raise capital buffers and choose the prudent portfolio in the first place.

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A Appendix

Proof of Proposition 3: We first show show that a larger allowance for equity s raises

aggregate capital ratio in (30) if charter values are uniformly distributed:

$$\begin{aligned}
\frac{d\bar{e}_0}{ds} &= -\frac{\tau i^P}{1+i'} \int_{\Omega^*}^{\Omega^\circ} e_0(\Omega) dF(\Omega) + e_0^* f(\Omega^*) \sigma_s \\
&= \frac{1}{\bar{\Omega}} \left[e_0^* \sigma_s - \frac{\tau i^P}{1+i'} \frac{(1-\tau)(1+i+\tilde{r})\Omega - \Omega^2/2}{1+i'} \Big|_{\Omega^*}^{\Omega^\circ} \right] \\
&= \frac{1}{\bar{\Omega}} \left[e_0^* \sigma_s - \frac{\tau i^P}{1+i'} \left(\frac{(1-\tau)(1+i+\tilde{r})(\Omega^\circ - \Omega^*)}{1+i'} - \frac{\Omega^{\circ 2} - \Omega^{*2}}{2(1+i')} \right) \right] \\
&= \frac{1}{\bar{\Omega}} \left[e_0^* \sigma_s - \frac{\tau i^P}{1+i'} \frac{\Omega^\circ - \Omega^*}{1+i'} \left(\Omega^\circ - \frac{\Omega^\circ + \Omega^*}{2} \right) \right] \tag{A.1} \\
&= \frac{e_0^*}{\bar{\Omega}} \left[\sigma_s - \frac{\tau i^P}{1+i'} \frac{\Omega^\circ - \Omega^*}{2} \right] = \frac{e_0^*}{\bar{\Omega}} \left[\sigma_s - \frac{\tau i^P}{2} e_0^* \right] \\
&= \frac{e_0^{*2}}{\bar{\Omega}} \left[\frac{(1+i^P)\chi}{1-s} - \frac{\tau i^P}{2} \right] = \frac{\tau i^P e_0^{*2}}{\bar{\Omega}} \left[\frac{\theta^P(1+i^P)}{\Delta\theta(1+i') + \tau(1-s)\theta^P i^P} - \frac{1}{2} \right] \\
&= \frac{\tau i^P e_0^{*2}}{2\bar{\Omega}} \frac{\theta^P(1+i^P) + \theta^G(1+i')}{\Delta\theta(1+i') + \tau(1-s)\theta^P i^P} > 0.
\end{aligned}$$

We use $\Omega^\circ = (1-\tau)(1+i+\tilde{r})$, $e_0^* = (1-\tau)(1-\chi)(1+i^P)/(1+i')$, and $\Omega^\circ - \Omega^* = (1-\tau)(1-\chi)(1+i^P) = e_0^*(1+i')$,

Second, we derive the negative effect of the tax rate τ in (30):

$$\begin{aligned}
\frac{d\bar{e}_0}{d\tau} &= \int_{\Omega^*}^{\Omega^\circ} \frac{de_0(\Omega)}{d\tau} dF(\Omega) - e_0^* f(\Omega^*) \frac{d\Omega^*}{d\tau} \\
&= \frac{1}{\bar{\Omega}} \left[-\frac{(1+i^P+\tilde{r})(\Omega^\circ - \Omega^*)}{1+i'} + \frac{(1-s)i^P}{1+i'} \int_{\Omega^*}^{\Omega^\circ} e_0(\Omega) d\Omega - e_0^* \sigma_\tau \right] \\
&= -\frac{1}{\bar{\Omega}} \left[e_0^*(1+i^P+\tilde{r}) - e_0^* \sigma_\tau - \frac{(1-s)i^P}{1+i'} \frac{(1-\tau)(1+i+\tilde{r})\Omega - \Omega^2/2}{1+i'} \Big|_{\Omega^*}^{\Omega^\circ} \right] \\
&= -\frac{1}{\bar{\Omega}} \left[e_0^*(1+i^P+\tilde{r}) - e_0^* \sigma_\tau - \frac{(1-s)i^P e_0^*}{1+i'} \frac{\Omega^\circ - \Omega^*}{2} \right] \tag{A.2} \\
&= -\frac{e_0^*}{\bar{\Omega}} \left[1+i+\tilde{r} - \sigma_\tau - \frac{(1-s)i^P e_0^*}{2} \right] \\
&= -\frac{e_0^*}{\bar{\Omega}} \left[(1+i)(1-\chi) + \frac{\chi(1+i^P)e_0^*}{\tau} - \frac{(1-s)i^P e_0^*}{2} \right] \\
&= -\frac{e_0^*}{\bar{\Omega}} (1+i)(1-\chi) - \frac{(1-s)i^P e_0^{*2}}{\bar{\Omega}} \left[\frac{\theta^P(1+i^P)}{\Delta\theta(1+i') + \tau(1-s)\theta^P i^P} - \frac{1}{2} \right] \\
&= -\frac{e_0^*}{\bar{\Omega}} (1+i)(1-\chi) - \frac{(1-s)i^P e_0^{*2}}{2\bar{\Omega}} \frac{\theta^P(1+i^P) + \theta^G(1+i')}{\Delta\theta(1+i') + \tau(1-s)\theta^P i^P} < 0.
\end{aligned}$$

Proof of Proposition 5: Capital requirements affect the pivotal type according to

$$\frac{\partial \Omega^*}{\partial k} = -\tilde{\chi}(1+i') \leq 0, \quad \tilde{\chi} \equiv \frac{1+r-\theta^G}{1+r-\theta^P}. \quad (\text{A.3})$$

The derivative is zero if $\chi = 0$, that is, no debt bias, $s = 0$. A higher tax rate magnifies and a larger allowance for equity weakens the effect of rising capital requirements on the pivotal type:

$$\begin{aligned} \frac{\partial^2 \Omega^*}{\partial k \partial \tau} &= \frac{1+r-\theta^G}{1+r-\theta^P} \left[i(1-s)\chi - (1+i') \frac{\partial \chi}{\partial \tau} \right] > 0, \\ \frac{\partial^2 \Omega^*}{\partial k \partial s} &= -\frac{1+r-\theta^G}{1+r-\theta^P} \left[\tau i \chi + (1+i') \frac{\partial \chi}{\partial s} \right] < 0. \end{aligned} \quad (\text{A.4})$$

The effects are signed taking into account the sensitivities of the tax distortion χ :

$$\frac{d\chi}{ds} = -\frac{\chi^2 \Delta \theta (1+i^P)}{\tau(1-s)^2(1+r-\theta^P)} < 0, \quad \frac{d\chi}{d\tau} = \frac{\chi^2 \Delta \theta (1+i^P)}{\tau^2(1-s)(1+r-\theta^P)} > 0.$$

Proof of Proposition 6: We first differentiate $V^P(\delta^*) = V^G(\delta^*)$ and replace both sides by (46) and (48), respectively. We then substitute the sensitivities of minimum equity, de_0 , using (52). Rearranging and collecting terms gives equation (53) with the coefficients defined according to:

$$\begin{aligned} \sigma_\delta &= \frac{V}{(1-\delta\theta^P)^2} \left[\frac{1-\delta\theta^P}{1-\delta\theta^G} \Delta \theta + \frac{\tau(1-s)\theta^P \zeta}{1+r-\tau(1-s)(1+r-\theta^P)(1+\tilde{\delta}\theta^P)} \right] > 0, \\ \sigma_s &= \frac{\tau(1+r-\theta^P)e_0}{1-\delta\theta^P} \frac{1+r}{1+r-\tau(1-s)(1+r-\theta^P)(1+\tilde{\delta}\theta^P)} > 0, \\ \sigma_\tau &= \frac{(1-s)(1+r-\theta^P)e_0}{1-\delta\theta^P} \frac{1+r}{1+r-\tau(1-s)(1+r-\theta^P)(1+\tilde{\delta}\theta^P)} > 0. \end{aligned} \quad (\text{A.5})$$

Note $V \equiv V^P(\delta^*) = V^G(\delta^*)$. By inspection, they are all nonnegative.