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Abstract

After the global financial crisis, the use of taxes to enhance financial stability received new attention. This paper compares two ways of taxing bank leverage, namely, an allowance for corporate equity (ACE), which addresses the debt bias in corporate taxation, and a Pigovian tax on bank debt (bank levy). We emphasize financial stability gains driven by lower bank asset risk and develop a principal-agent model, in which risk taking depends on the bank's capital structure and, by extension, on the tax treatment of debt and equity because of moral hazard. We find that (i) the ACE unambiguously reduces risk taking, (ii) bank levies reduce risk taking if they are independent of bank performance but may be counterproductive otherwise, (iii) high corporate tax rates render the bank levies less effective, and (iv) taxes are especially effective if capital requirements are low.

Keywords

Pigovian taxes, corporate tax reform, bank risk taking, financial stability

JEL Classification

G21, G28, H25

1 Introduction

Since the global financial crisis, governments have increasingly relied on taxes both to improve the stability of the banking sector and to complement prudential regulation. Most prominently, several European countries, for example, Germany, the United Kingdom, Sweden, and Austria, introduced Pigovian taxes on bank liabilities. These so-called 'bank levies' aim at internalizing fiscal externalities in the banking sector, which often emerge due to implicit government guarantees for bank debt, and at reducing excessive debt. Comparable levies are also in place to finance the single resolution funds (SRF), an integral part of the European banking union.

Introducing such Pigovian taxes stands in stark contrast to the existing corporate tax system that usually favors debt, thereby contributing to high firm and bank leverage. In most countries, the cost of debt is tax-deductible, while the cost of equity is not. Eliminating this 'debt bias' can indeed significantly change bank behavior as demonstrated, for example, by a corporate tax reform in Belgium 2006.

This paper analyzes how taxing bank leverage can improve financial stability and compares two tax reforms: (i) the allowance for corporate equity (ACE), which eliminates the debt bias in corporate taxation by introducing a deduction of a notional cost of equity, and (ii) the introduction of Pigovian tax on bank liabilities ('bank levy'). Both aim at reducing the incentive for excessive debt. Specifically, the paper compares the ACE and the bank levy in terms of their effectiveness and robustness in enhancing financial stability. We also study the interaction between both taxes, for example, to see whether the corporate income tax strengthens or weakens the effects of bank levies. In a similar spirit, we shed light on potential complementarities between taxes and capital regulation.

Unlike prior literature that has predominantly focused on the financial stability gains driven by larger equity buffers and improved loss-absorbing capacity of banks (Langedijk et al., 2015; Keen and de Mooij, 2016, e.g.), this paper analyzes a complementary channel, namely, reduced risk taking and better portfolio quality. As emphasized in banking theory, risk taking should importantly depend on banks' capital structure and, by extension, on the tax treatment of debt and equity because of informational frictions. Understanding this channel is important given that the empirical evidence (e.g., Schepens, 2016; Devereux et al., 2019; Célérier et al., 2019) points to countervailing risk-taking effects of ACE and bank levies despite having similar effect on bank leverage.

The present paper sets out a principal-agent model of risk taking. At the core is the bank's endogenous portfolio choice: It can invest either in a 'prudent' or a 'gambling' portfolio. Thereby, the bank faces the classical risk-return trade-off as gambling offers higher returns but entails higher insolvency risk. Moral hazard emerges because the portfolio is unobservable, and indebted banks have a strong incentive for gambling (risk shifting). The use of equity is thus primarily motivated by this agency problem: It increases banks' 'skin in the game' and thereby prevents gambling ('incentive function'). Thus, only banks with sufficient equity will invest in the low-risk, prudent portfolio.

However, raising equity is expensive for two reasons: First, banks can deduct the cost of debt but not the cost of equity from the corporate income tax (debt bias). Second, they earn a subsidy on deposits due to implicit government guarantees. This distorts the costs of debt and equity, and too many banks gamble in equilibrium.

In the model, the ACE and the bank levy influence risk taking mainly via the cost of equity, which prudent banks must raise to have proper incentives. Both policies render equity less expensive *relative* to deposits either by reducing the tax cost of equity (ACE) or by lowering the net subsidy on deposits (bank levy). To evaluate the robustness of

Pigovian taxes, we distinguish between (i) a *performance-dependent* levy paid ex post by all solvent banks and (ii) a *performance-independent* levy paid ex ante by all banks. The former mirrors a design adopted, for example, in Germany where loss-making banks had to pay a significantly lower tax.

Our analysis yields four main results: First, the ACE unambiguously discourages risk taking and improves financial stability as fewer banks invest in the gambling portfolio. Intuitively, it mitigates the debt bias and thereby facilitates the use of equity in setting incentives for the safer portfolio. The ACE also offers welfare gains as risk taking is excessive in equilibrium. Nevertheless, it only eliminates distortions caused by the corporate tax system but not the fiscal externality due to government guarantees.

Second, a Pigovian tax on bank debt can address such fiscal externalities and further reduce risk taking if appropriately designed. As long as all banks pay the levy regardless of their performance, it discourages risk taking by lowering the subsidy on deposits, which particularly benefits gambling banks. A levy paid ex post only by solvent banks, in contrast, has less robust effects and may even encourage risk taking, for instance, if the subsidy is large. Intuitively, the effective levy rate is higher for prudent banks because the latter are more likely to remain solvent and pay the tax.

Third, corporate tax rates influence how bank levies affect risk taking. In a corporate tax system characterized by the debt bias, a high tax rate renders levies less effective or, in one case, counterproductive. Since introducing a levy tightens the incentive constraint of banks, they need even larger equity to prevent gambling. The latter is particularly expensive if corporate tax rates are high.

Fourth, capital regulation and taxes are generally substitutes with regard to risk taking. Both the ACE and the bank levy have a more pronounced impact on risk taking if capital requirements are low. In this case, prudent banks need large additional equity to set proper incentives, and the tax-induced changes in this extra cost have strong effects on the portfolio choice.

This paper contributes to two strands of the literature in the intersection between public economics and finance, which analyze (i) the corporate income tax and bank behavior and (ii) Pigovian taxes in banking.

On the one hand, the empirical evidence implies that the debt bias in corporate taxation is a major source of high bank leverage (e.g., Hemmelgarn and Teichmann, 2014; Keen and de Mooij, 2016; Bond et al., 2016; Horváth, 2018). Although the capital structure of banks is heavily regulated, taxes do matter, for example, because many banks have more equity than required by regulation (Keen and de Mooij, 2016). Consequently, mitigating the debt bias significantly reduces bank leverage and increases equity as shown, for example, by Schepens (2016), who analyzes the Belgian ACE adopted 2006, and by Martin-Flores and Moussu (2019), who examine a tax allowance for marginal equity in Italy between 1997 and 2002. In a similar vein, quantitative studies suggest large financial stability gains from eliminating the debt bias. Langedijk et al. (2015), for instance, estimate that introducing an ACE in several European countries could lower the fiscal costs of financial crises by 40 to 77 percent.

The existing tax literature has predominantly focused on stability gains from the ACE driven by lower bank leverage. A complementary source is reduced risk taking. The latter should be sensitive to tax-induced changes in the capital structure given common agency problems like risk shifting emphasized in the theoretical banking literature (e.g., Hellmann et al., 2000; Allen and Gale, 2000; Repullo, 2004; Hakenes and Schnabel, 2011; Repullo, 2013). Empirical evidence from Belgium (Schepens, 2016; Célérier et al., 2019) and Italy (Martin-Flores and Moussu, 2019) suggests that the ACE indeed improves the quality of loan portfolios. On the theoretical side, Kogler (2021) rationalizes these findings in a risk-taking model with moral hazard. Well capitalized banks have more 'skin in the game' and stronger incentives for investing in safe assets. The ACE renders equity less expensive, leading to better capitalized banks and improved risk-taking incentives. Moreover, Célérier et al. (2019) set out a portfolio model with capital requirements. They show that the ACE affects a bank's portfolio shares of loans and securities. A lower cost of equity relaxes capital requirements, and banks allocate the additional equity to assets with higher regulatory risk weights - typically loans.

On the other hand, the paper relates to the literature on Pigovian taxes in banking. Several theoretical papers have proposed bank levies and characterized their design: The use of such taxes is commonly motivated by externalities associated with the collapse and bailout of banks (Keen, 2011), short-term debt financing (Perotti and Suarez, 2011), and systemic risk and undercapitalization (Acharya et al., 2017). Diemer (2017), in turn, considers different types of bank levies and analyzes whether they reduce risk taking. In a model of risk taking and debt market competition à la Hotelling, he shows that levies on secured and unsecured liabilities lower the range where banks invest in high-risk assets.

The bank levies introduced in European countries have been evaluated in several empirical studies: Devereux et al. (2019) and Célérier et al. (2019) consider the effects on capital structure and portfolio risk and find that bank levies did raise the capital ratio and the volume of bank equity but they also tend to increase portfolio risk. This is reflected in a higher share of loans and a lower share of securities, for example. Both papers point to risk-based capital requirements as potential drivers of these countervailing results: By raising equity and relaxing regulatory constraints, the levy allows banks to shift the portfolio composition towards assets associated with higher risk weights. Furthermore, Bremus et al. (2016) provide evidence that the corporate income tax influences the effectiveness of bank levies in increasing equity. They find that banks respond less strongly to a levy if corporate tax rates are high.

Related papers estimate the effects of bank levies on interest rates to assess the tax incidence (e.g., Buch et al., 2016; Capelle-Blancard and Havrylchyk, 2017; Kogler, 2019). They find that banks at least partly pass the tax burden onto customers and that the pass-through, for example, the increase in loan rates, is stronger in concentrated banking markets and in case of weakly capitalized banks.

The present paper contributes to these literature in three ways: First, it develops one of the first theoretical models of corporate and Pigovian taxes and bank risk taking, which differs from prior literature that has predominantly considered effects on bank leverage. After all, the stability rests on both a sufficient loss-absorbing equity and a low-risk asset portfolio. The tax treatment of debt and equity should be especially important for risk taking because of moral hazard, which creates an 'incentive function' of equity (Gale, 2010). Second, we compare two distinct ways of taxing bank leverage, the ACE and the bank levy. Both lower the cost of equity relative to debt although one involves a tax cut, while the other is a additional tax. This approach enables us to explain the counteracting effects of the two policies on bank asset rise found in empirical research. Third, our analysis informs about the interaction between corporate and Pigovian taxes and, more generally, between taxes and capital regulation.

More specifically, our analysis differs from other theoretical papers in this literature: While the model set-up builds on earlier work in Kogler (2021), the research question is different: This paper compares the risk-taking and financial stability effects of Pigovian taxes and the ACE, while Kogler (2021) exclusively focuses on the corporate income tax in general. Compared to the mean-variance model of Célérier et al. (2019), we consider another outcome, namely, the choice between portfolios with distinct risk profiles instead of the portfolio shares of loans and securities, and emphasize a fundamentally different mechanism. In our model, the bank levy and the ACE influence bank asset risk via a common agency problem (risk shifting) rather than via risk-based capital requirements. In a similar vein, the paper differs from Diemer (2017), who largely abstracts from informational frictions in bank risk taking and instead highlights the role of imperfect competition in debt markets.

The remainder of this paper is organized as follows: Section 2 sets out the model. Section 3 characterizes the equilibrium, and Section 4 summarizes the main results from a comparative statics analysis. Eventually, Section 5 concludes.

2 Model

We model risk taking as a bank's choice between two stylized portfolios with different risk profiles under moral hazard. Unlike in Kogler (2021), banks are subject to both a corporate income tax and a Pigovian tax on liabilities. The latter aims at internalizing the fiscal cost of implicit government guarantees for deposits.

2.1 Portfolios

There is a continuum of measure one of heterogeneous banks. Each bank invests one unit of capital either in the *prudent* or in the *gambling* portfolio with stochastic returns: Portfolio $j = \{P, G\}$ yields (i) an intermediate return $1 + \alpha_m$ with probability θ_m^j, (ii) a high return $1 + \alpha_h > 1 + \alpha_m$ with probability θ_h^j, or (iii) zero with the complementary probability $\theta^j_l = 1-\theta^j_h-\theta^j_m$. Figure 1 illustrates. If the portfolio return is zero, the bank's assets are worthless and it fails. The bank's survival (i.e., solvency) probability thus equals the probability of an intermediate or high return, $\theta^j \equiv \theta^j_h+\theta^j_m$. With the risk-free interest rate of r, the expected net return equals $r^j \equiv \theta^j(1+\alpha_m)+\theta^j_h(\alpha_h-\alpha_m)-(1+r)$.

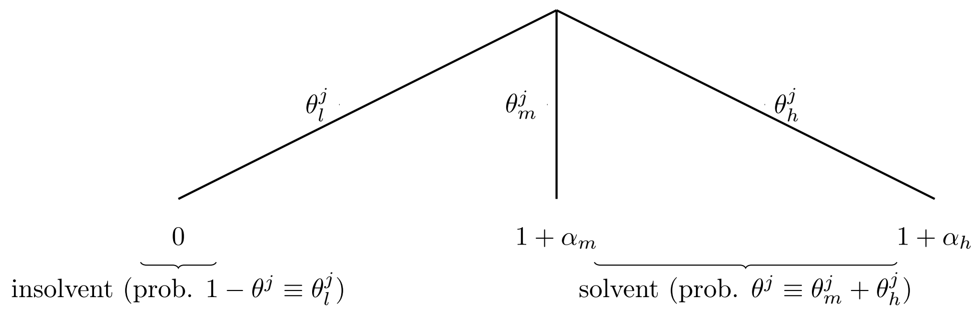

Figure 1: *Portfolio Returns*

Portfolio $j = \{G, P\}$ offers the high (gross) return $1+\alpha_h$ with probability θ^j_h, the intermediate return $1+\alpha_m$ with probability θ^j_m, and zero else.

The set of returns $\{\alpha_h, \alpha_m, 0\}$ is the same for both portfolios but they are drawn from two different distributions:

ASSUMPTION 1 *The probability of a high return is higher when investing in the gambling portfolio, $\theta^G_h > \theta^P_h$, while the probability of any positive (i.e., intermediate or high) is higher when investing in the prudent portfolio, $\theta^P \equiv \theta^P_h+\theta^P_m > \theta^G_h+\theta^G_m \equiv \theta^G$. Both portfolios offer the same expected return, $r^P = r^G = \bar{r}$.*

Gambling is a mean-preserving spread.[1] Since extreme returns are more and the intermediate return is less likely, there is a trade-off between risk and return: Gambling banks have a better chance for the high return α_h but exhibit higher insolvency risk. Intuitively, the prudent asset may represent a well-diversified loan portfolio, whereas the gambling portfolio consists of more correlated loans subject to common shocks.

Outsiders observe the realized return (i.e., α_h, α_m, or 0) but not the portfolio because

[1]The three- rather than the more common two-points distribution helps assure that gambling is indeed a mean-preserving spread. With the same set of two returns, gambling would be strictly dominated.

the set of returns is the same for both. Hence, they cannot infer the portfolio from the realized payoff, and the portfolio choice is not contractible, giving rise to moral hazard.

With a discrete portfolio choice, risk taking is determined at the extensive margin. An interior solution at the industry level requires heterogeneous banks with some types investing in the prudent, others in the gambling portfolio. We follow Repullo (2013) and introduce differences in bank profitability:

ASSUMPTION 2 *Each solvent bank earns a rent* Ω *in addition to the portfolio return* α_h *or* α_m. *Types are observable and uniformly distributed on* $[0, \overline{\Omega}]$.

One may interpret Ω as a bank-specific rent due to market power, which differs across market segments. Total earnings equal $1 + \alpha_m + \Omega$ and $1 + \alpha_h + \Omega$ if the portfolio return is intermediate and high, respectively. If the latter is zero, the rent is forgone. This assumption ensures that types do influence the portfolio choice: Banks with the potential to earn high additional returns are ceteris paribus less inclined to gamble because the forgone rent is too large. Given Assumption 1, the gambling portfolio is inefficient for all banks with a positive rent, $\Omega > 0$.

2.2 Capital Structure

Each bank is financed with equity e and deposits $d = 1 - e$ provided by outside shareholders and depositors. Both are risk-neutral and elastically supply those funds at the risk-free rate r. Deposits are implicitly guaranteed by the government: Like in Keen and de Mooij (2016), it may bail out depositors with some probability $\nu < 1$ after the bank fails. It compensates depositors with the principal plus risk-free interest, $1 + r$. This motivates the pricing condition for deposits:

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

With probability θ^j, the bank succeeds and repays principal and interest $1+i^j$. Otherwise, depositors receive $1+r$ from the government with probability $\nu \in (0,1)$ and zero else.

Guarantees entail an implicit subsidy because deposits are not priced on a risk-adjusted basis such that raising debt is artificially cheap for banks. Per unit of deposits, a bank with portfolio j earns an expected subsidy of

$$\bar{\nu}^j \equiv 1 + r - \theta^j(1 + i^j) = \nu(1 - \theta^j)(1 + r) > 0. \tag{2}$$

The expected interest expense on deposits is smaller than the risk-free rate. Gambling banks earn a larger subsidy than prudent banks, $\bar{\nu}^G > \bar{\nu}^P$.

Banks are subject to minimum capital requirements: Their capital ratio has to satisfy $e \geq k$. One can interpret k as the leverage ratio in Basel III. We define *voluntary or additional bank equity* as equity in excess of the regulatory minimum, $\varepsilon \equiv e - k \geq 0$.

2.3 Taxes

Banks are subject to (i) a Pigovian tax on liabilities ('bank levy') and (ii) the corporate income tax, which may discriminate between debt and equity ('debt bias').

Bank levy: The tax base consists of bank deposits, $d = 1 - e$. The levy rate ℓ is constant. This reflects the most common design of European bank levies although some countries exempt insured deposits to avoid double taxation. In this model, however, bank debt is uninsured and guaranteed only implicitly.

Whether the levy depends on bank performance (i.e., the realized return) is crucial: Ideally, a Pigovian tax on bank debt is paid ex ante irrespective of financial performance. All banks pay the levy and thus internalize fiscal externalities when choosing capital structure and portfolio. Banks which subsequently fail will have already paid the tax. In reality, however, some countries explicitly condition the tax on performance. For example, Germany charged loss-making banks a significantly smaller levy and also imposed a ceiling to limit the tax payment by a percentage of profits.

We thus consider two variants of the bank levy: First, the levy is *performance-dependent* and collected at the end of the period. Banks that make a loss and fail because of a low portfolio return are unable to pay the levy. Consequently, only solvent banks pay. The expected tax liability of $\theta^j \ell d$ depends on the portfolio choice.

Second, the levy is *performance-independent* and collected at the beginning of the period when each bank pays ℓd. One challenge is that banks may finance this ex ante payment with additional deposits, for instance, by raising $d = 1 - e + \ell d$ rather than $d = 1 - e$. The larger debt burden would lead to very similar incentive effects as the performance-dependent levy. To overcome this problem, we follow Diemer (2017) and assume that bank shareholders pay the levy upfront. Their outlays thus consist of equity e plus the levy ℓd.

The indicator $\zeta = \{0, 1\}$ equals one (zero) if the levy is performance-independent (-dependent). The expected end-of-period tax liability of a bank with portfolio j is

$$L^{j,\zeta} = \ell^{j,\zeta} d, \quad \ell^{j,\zeta} \equiv [(1 - \zeta)\theta^j + \zeta(1 + r)]\ell, \tag{3}$$

where $\ell^{j,\zeta}$ denotes the effective levy rate. In addition to the statutory levy rate, $\ell^{j,\zeta}$ reflects the performance dependence ζ as well as the bank's survival probability θ^j. The effective levy rate is higher for prudent banks in such a system (due to the higher survival probability $\theta^P > \theta^G$), while it is the same for prudent and gambling banks if the levy does not depend on performance.

Corporate income tax: Profit consisting of the realized return, $\alpha_m + \Omega$ or $\alpha_h + \Omega$, minus the actual interest expense on deposits, $i(1-e)$ is taxed at a rate τ. In addition, a fraction $s \in [0, 1]$ of the risk-free opportunity cost of equity re can be deducted from the tax base. The parameter s characterizes the tax allowance (ACE): $s < 1$ corresponds to a *distortionary tax* that exhibits a debt bias, whereas $s = 1$ describes a *neutral tax* that allows for the deduction of the entire cost of capital.

Deducting the actual interest rate on debt and the risk-free cost of equity is consistent with the shareholder tax in Bond and Devereux (2003). After all, firms and banks deduct actual debt interest rates from corporate taxes in most OECD countries. In a similar vein, we assume that profits and losses are treated symmetrically (full loss offset): Shareholders of banks that fail receive a tax rebate in proportion to their loss e and the tax-deductible cost of equity sre. The payment is made directly to shareholders and not appropriated by creditors of the insolvent bank.

The levy payments are deductible from the corporate income tax. Whenever the levy is paid ex ante ($\zeta = 1$), the bank deducts its end-of-period value $(1+r)\ell d$ from the base. Conditional on the realized return, the corporate tax liability is:

$$\begin{aligned} T_m &= \tau[\alpha_m + \Omega - i(1-e) - sre - (1+\zeta r)\ell(1-e)], \\ T_h &= \tau[\alpha_h + \Omega - i(1-e) - sre - (1+\zeta r)\ell(1-e)], \\ T_l &= -\tau[(1+rs)e + \zeta(1+r)\ell(1-e)]. \end{aligned} \tag{4}$$

The expected tax liability of a bank with portfolio $j = \{G, P\}$ equals $T^j = \theta^j_h T_h + \theta^j_m T_m + (1-\theta^j)T_l$ or, after substituting (4),

$$T^j = \tau[\bar{r} + \theta^j\Omega + (1 + r - \theta^j(1+i))(1-e) + (1-s)re - L^{j,\zeta}]. \tag{5}$$

2.4 Bank Profit

The after-tax profit, that is, the expected surplus of bank shareholders, equals the expected total return net of the interest expense on deposits, taxes, and the required return on equity. Accordingly, the after-tax profit of a bank of type Ω which raises equity e, borrows from depositors at rate i, and invests in portfolio $j = \{G, P\}$ is

$$\begin{aligned} \pi^j(e, i; \Omega) &= \theta^j[1 + \alpha_m + \Omega - (1 + i)(1 - e)] + \theta_h^j \Delta\alpha - T^j - L^{j,\zeta} - (1 + r)e \\ &= (1 - \tau)\left[\bar{r} + \theta^j\Omega + (1 + r - \theta^j(1 + i) - \ell^{j,\zeta})(1 - e)\right] - \tau(1 - s)re. \end{aligned} \tag{6}$$

The second equality substitutes (3) and (5) and rewrites after-tax profit as the economic rent minus all taxes.

3 Equilibrium

3.1 Moral Hazard and Capital Structure

The bank's portfolio is unobservable for outsiders. This creates a risk-shifting problem à la Hellmann et al. (2000) and Repullo (2013): Indebted banks have an incentive to exploit limited liability by gambling. The latter promises a better chance for the high return but exhibits higher default risk. Equity, in turn, increases the 'skin in the game' of bank owners and alleviates risk shifting. This agency problem is the reason why risk taking and capital structure are intertwined.

Incentive compatibility constraint: The bank chooses the portfolio after attracting deposits d and equity e and agreeing upon a deposit rate i. Its goal is maximizing the expected surplus of its shareholders. It thus invests in the prudent portfolio as long as this promises a larger after-tax profit conditional on capital structure e and deposit rate i, $\pi^P(e, i; \Omega) \geq \pi^G(e, i; \Omega)$.

We substitute (6) for bank profits, use the effective levy rate differential $\ell^{P,\zeta} - \ell^{G,\zeta} = \Delta\theta(1-\zeta)\ell$ implied by (3), and note that total equity consists of the regulatory minimum plus voluntary equity, $e = k + \varepsilon$. This allows us to express the incentive compatibility constraint as a minimum voluntary equity requirement:

$$\varepsilon \geq \varepsilon_0(i;\Omega) \equiv 1 - k - \frac{\Omega}{1+i+(1-\zeta)\ell}. \tag{7}$$

The bank only chooses the prudent portfolio if its voluntary equity is sufficiently high. This reflects the 'incentive function' of equity (Gale, 2010), which make sure that shareholders have enough 'skin in the game'. They thus favor a safer portfolio in order to reduce the risk of losing their own equity investment in the bank.

Minimum voluntary equity $\varepsilon_0(i;\Omega)$ is independent of corporate taxes. The reason is the symmetric taxation of profits and losses: The tax allowance thus benefits prudent and gambling banks alike, and it does not affect risk-taking incentives for any given capital structure.[2] The bank levy, in contrast, matters and requires larger voluntary equity provided that it depends on performance ($\zeta = 0$). Since it is paid only by solvent banks, prudent banks with low insolvency risk are subject to a higher effective levy rate. The levy disproportionately lowers their expected profit and thus tightens the incentive constraint. A performance-independent bank levy, in contrast, proportionately lowers profits of prudent and gambling banks, leaving risk-taking incentives unchanged.

Some banks with a very large rent $\Omega \geq \Omega^\circ \equiv [1+i+(1-\zeta)\ell](1-k)$ satisfy (7) even without any additional equity, $\varepsilon_0(i;\Omega^\circ) = 0$. They always opt for the prudent portfolio because the cost of forgoing the rent is too high.

[2] The ACE may, however, relax the incentive constraint under imperfect loss offset when it disproportionately benefits prudent banks with low insolvency risk as demonstrated by Kogler (2021).

Deposit contract: The interest rate on deposits i^j is determined by (1) and ensures an expected return of r. However, depositors do not observe the bank's portfolio choice and can therefore not directly condition the deposit rate on the portfolio. Nevertheless, depositors do observe the bank's type Ω and its capital ratio e. They can impose the minimum equity requirement (7) that prevents gambling. The deposit contract is thus a combination of interest rate and voluntary equity: Depositors lend at the low interest rate i^P only to banks with sufficient equity, $\varepsilon \geq \varepsilon_0(i^P, \Omega)$. They anticipate that such banks will invest in the prudent portfolio and repay deposits with the high probability θ^P. Otherwise, depositors anticipate gambling, which is associated with higher insolvency risk, and thus charge the interest rate $i^G > i^P$.

3.2 Equilibrium Allocation

In equilibrium where deposits are priced according to (1) and entail an implicit subsidy as in (2), the expected after-tax profit of banks in (6) becomes

$$\pi^j(\varepsilon, i; \Omega) = (1-\tau)\left[\bar{r} + \theta^j\Omega + \nu^j - \ell^{j,\zeta}\right] - [\tau(1-s)r + (1-\tau)(\bar{\nu}^j - \ell^{j,\zeta})](k+\varepsilon). \tag{8}$$

It equals the economic rent consisting of total returns plus a net subsidy after taxes minus the extra cost of total equity $k + \varepsilon$. This cost arises due to both the debt bias and the forgone net subsidy. We henceforth assume that the levy rate ℓ is so small at the outset that equity is always more expensive than deposits.

Maximum profit: Each bank compares two options - combinations of risk taking, capital structure and deposit rate - that are incentive-compatible and satisfy (7), consistent with pricing of deposits (1), and maximize expected profits (8). First, the bank may raise at least minimum voluntary equity $\varepsilon \geq \varepsilon_0(i^P; \Omega)$, borrow from depositors at the low interest rate i^P, and invest in the prudent portfolio. It solves the maximization problem $V^P(\Omega) = \max_\varepsilon \pi^P(\varepsilon, i^P, \Omega)$ subject to the minimum equity requirement $\varepsilon \geq \varepsilon_0(i^P; \Omega)$. Since equity is expensive due to guarantees and debt bias, voluntary equity is exactly ε_0. The maximum profit of the *prudent option* is

$$V^P(\Omega) = (1-\tau)\left[\bar{r} + \theta^P\Omega + \bar{\nu}^P - \ell^{P,\zeta}\right] - [\tau(1-s)r + (1-\tau)(\bar{\nu}^P - \ell^{P,\zeta})](k + \varepsilon_0(i^P; \Omega)). \quad (9)$$

Second, it may choose smaller voluntary equity $\varepsilon < \varepsilon_0(i^G; \Omega)$, borrow at the high interest rate i^G, and gamble. It solves $V^G(\Omega) = \max_\varepsilon \pi^G(\varepsilon, i^G; \Omega)$ subject to $\varepsilon < \varepsilon_0(i^G; \Omega)$. Due to expensive equity, the constraint is fulfilled with $\varepsilon_0 = 0$, and the *gambling option* promises a maximum profit of

$$V^G(\Omega) = (1-\tau)\left[\bar{r} + \theta^G\Omega + \bar{\nu}^G - \ell^{G,\zeta}\right] - [\tau(1-s)r + (1-\tau)(\bar{\nu}^G - \ell^{G,\zeta})]k. \quad (10)$$

Equilibrium risk taking: Each bank chooses these two options. Bank heterogeneity rationalizes different choices in equilibrium. The pivotal bank Ω^* is indifferent, $V^P(\Omega^*) = V^G(\Omega^*)$. Substituting (9) and (10) for maximum profits and rearranging yields the risk-taking cut-off:

$$\Omega^* = [\nu(1+r) + (1-\zeta)\ell](1-k) + \frac{[\bar{\tau}(1-s)r + \bar{\nu}^P - \ell^{P,\zeta}]\varepsilon_0(i^P; \Omega^*)}{\Delta\theta}, \quad \bar{\tau} \equiv \frac{\tau}{1-\tau}. \quad (11)$$

Profitable banks with large rents $\Omega \geq \Omega^*$ raise some voluntary equity $\varepsilon_0(\Omega, i^P)$ and invest in the prudent portfolio. Less profitable ones $\Omega < \Omega^*$ attract no such additional equity and gamble. Intuitively, the latter forgo only little if they fail but would need to raise a large amount of costly equity to satisfy the incentive constraint.

Substituting for voluntary equity of the pivotal bank $\varepsilon_0(i^P; \Omega^*)$, which is dependent on Ω^*, yields the closed-form solution:

$$\Omega^* = \left[\nu(1+r) + (1-\zeta)\ell + \frac{\chi(1+r)(1-\nu)}{\theta^P}\right](1-k). \quad (12)$$

This formulation uses the *agency cost* of equity $\chi \in [0, 1)$ defined as

$$\chi \equiv \frac{\bar{\tau}(1-s)r + \bar{\nu}^P - \ell^{P,\zeta}}{\Delta\theta[1 + i^P + (1-\zeta)\ell] + \bar{\tau}(1-s)r + \bar{\nu}^P - \ell^{P,\zeta}}. \tag{13}$$

It represents the extra cost incurred by the pivotal bank when setting proper incentives for the prudent portfolio. This requires additional equity $\varepsilon_0(i^P; \Omega^*)$ to satisfy the incentive constraint. The latter is expensive because (i) the cost of equity is not fully tax-deductible due to the debt bias reflected by $\bar{\tau}(1-s)r$ and (ii) the bank forgoes a net subsidy on deposits $\bar{\nu}^P - \ell^{P,\zeta}$ because of implicit guarantees. The agency cost is caused by the combination of moral hazard and expensive equity due to debt bias and guarantees. It only disappears with a neutral corporate income tax ($s = 1$) and a zero subsidy on deposits ($\nu = 0$, in which case fulfilling the incentive constraint with some voluntary equity would entail no additional cost.

Apart from the agency cost represented by χ, the risk-taking cut-off (12) positively depends on guarantees because gambling banks benefit from a larger net subsidy per unit of deposit, $\bar{\nu}^G - \ell^{G,\zeta} > \bar{\nu}^P - \ell^{P,\zeta}$. This effect is represented by the term $\nu(1+r)+(1-\zeta)\ell$, and is even larger if the levy is performance-dependent ($\zeta = 0$) due to a higher levy rate for prudent banks.

Noting the pricing of deposits in (1), the risk-taking cut-off Ω^* in (12) is strictly below the zero-equity cut-off $\Omega^\circ = \Omega^* + (1-\chi)(1+r)(1-v)(1-k)/\theta^P$. Therefore, voluntary equity of the pivotal bank is strictly positive:

$$\varepsilon_0^* \equiv \varepsilon(i^P, \Omega^*) = \frac{(1+r)(1-\nu)(1-\chi)(1-k)}{\theta^P[1 + i^P + (1-\zeta)\ell]} < 1 - k. \tag{14}$$

The inequality follows from substituting $\theta^P(1+i^P) = (1+r)(1-\nu) + \theta^P\nu(1+r)$ on account of the pricing condition for deposits. As illustrated in Figure 3, three groups of banks which differ in risk taking and capital structure emerge in equilibrium:

- $\Omega \geq \Omega^\circ$: Highly profitable banks do not need any voluntary equity because the risk of losing the return Ω outweighs any benefits from gambling. Accordingly, they raise equity k, opt for the prudent portfolio, and succeed with probability θ^P.

- $\Omega^\circ > \Omega \geq \Omega^*$: The rent alone does not provide sufficient discipline, which is why these banks choose the prudent portfolio only with some additional equity, $\varepsilon_0 > 0$. Those banks raise total equity $k + \varepsilon_0$, invest in the prudent portfolio, and succeed with probability θ^P.

- $\Omega < \Omega^*$: The small rent makes gambling is more attractive. Accordingly, these banks only raise minimum equity k, gamble, and succeed with probability θ^G.

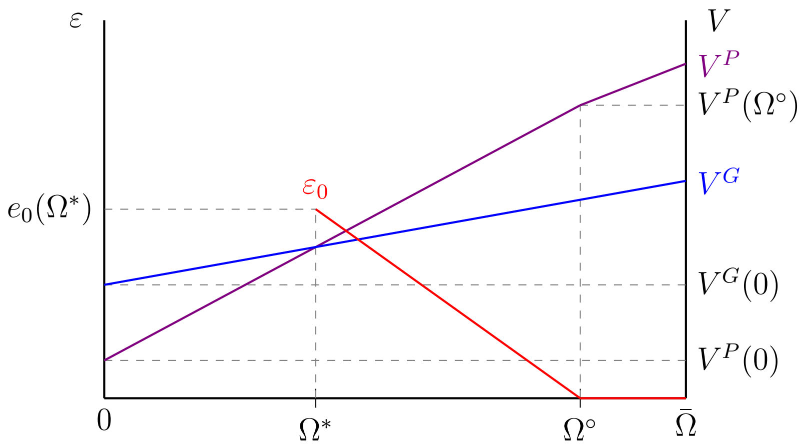

Figure 2: *Equilibrium*

This figure depicts voluntary equity ε_0 (in red, left axis) and maximum profit from prudent and gambling portfolio V^P and V^G (in blue and violet, right axis) and the cut-offs Ω^* and Ω° in the presence of a distortionary tax with $\tau > 0$ and $s < 1$.

3.3 Welfare Properties

To evaluate efficiency properties of equilibrium, we define social welfare as the aggregate surplus generated by the banking sector. It equals total bank profits V plus corporate tax revenue T minus the net fiscal outlays of bank failure C, $W = V + T - C$. The latter measure the fiscal externality that arise from implicit guarantees: The government compensates depositors of each failed bank by paying $(1+r)d$ with probability ν, leading to an expected cost of $\nu(1-\theta^j)(1+r)d = \bar{\nu}^j d$ per bank. Part of this cost is covered by revenue from bank levies, giving net outlays of

$$C \equiv \int_0^{\Omega^*} (\bar{\nu}^G - \ell^{G,\zeta})(1-k)dF(\Omega) + \int_{\Omega^*}^{\bar{\Omega}} (\bar{\nu}^P - \ell^{P,\zeta})[1-k-\varepsilon_0(i^P;\Omega)]dF(\Omega) \tag{15}$$

By using (15) together with aggregate profits $V \equiv \int_0^{\Omega^*} V^G(\Omega)dF(\Omega) + \int_{\Omega^*}^{\bar{\Omega}} V^P(\Omega)dF(\Omega)$ and corporate tax revenue $T \equiv \int_0^{\Omega^*} T^G dF(\Omega) + \int_{\Omega^*}^{\bar{\Omega}} T^P(\Omega)dF(\Omega)$, one concludes that social welfare equals the aggregate economic returns of the banking sector:

$$W = \int_0^{\Omega^*} \bar{r} + \theta^G \Omega dF(\Omega) + \int_{\Omega^*}^{\bar{\Omega}} \bar{r} + \theta^P \Omega dF(\Omega). \tag{16}$$

The welfare-maximizing share of gambling banks is zero as implied by the first-order condition $dW/d\Omega^* = -\Delta\theta\Omega^* f(\Omega^*) = 0$. After all, gambling is inefficient for all banks with $\Omega > 0$ because it only increases the risk of forgoing the rent without raising the expected return.

The equilibrium risk-taking cut-off in (12) is strictly positive, $\Omega^* > 0$, however. Hence, there is excessive risk taking, and lowering the share of gambling banks to zero would increase welfare. Excessive risk taking emerges due to government guarantees ($\nu > 0$) and the debt bias ($s < 1$): First, both render equity expensive by implicitly subsidizing deposits and creating a tax burden on equity. This cost discourages some banks from using additional equity in order to solve their agency problem. Instead, they gamble despite smaller economic returns. This effect is captured by the expression proportional to the agency cost χ in (12). Second, guarantees directly raise the risk-taking cut-off irrespective of moral hazard because gambling banks benefit from a larger expected subsidy on deposits than prudent banks, $\bar{\nu}^G > \bar{\nu}^P$. This effect is reinforced by a performance-dependent levy ($\zeta = 0$) paid ex post. It is represented by the term $\nu(1+r) + (1-\zeta)\ell$ in (12). An efficient allocation with no gambling, $\Omega^* = 0$, requires the absence of any government guarantees and a neutral corporate tax system.

4 Main Results

How can the ACE and a Pigovian tax reduce risk taking and improve financial stability? The key outcome in the comparative statics analysis is the risk-taking cut-off Ω^* in (12), which pins down the share of gambling and prudent banks in equilibrium. The pivotal bank earns exactly the same expected profit on either portfolio. Hence, the tax sensitivities of risk taking reflect the differential impact of taxes on the maximum profits from investing in either portfolio. Since there is excessive risk taking in equilibrium, any decrease in the cut-off Ω^* is welfare-improving.

We focus on two measures of financial stability that are both functions of the endogenous cut-off Ω^*. First, the *average probability of bank failure* defined as $\pi \equiv (1-\theta^P)[1-F(\Omega^*)] + (1-\theta^G)F(\Omega^*)$ measures insolvency risk in the banking sector. Any increase in the share of gambling banks $F(\Omega^*)$ mechanically raises this probability. Second, the *net fiscal cost of bank failure* C in (14) represents the taxpayer's cost of government guarantees. It prominently features in quantitative studies (e.g., Langedijk et al., 2015). It can be expressed as a function of the average failure probability π and aggregate voluntary equity $\bar{\varepsilon} \equiv \int_{\Omega^*}^{\bar{\Omega}} \varepsilon_0(i^P;\Omega)dF(\Omega)$:

$$C = \pi\nu(1+r)(1-k) - (\bar{\nu}^P - \ell^{P,\zeta})\bar{\varepsilon} - [(1-\zeta)(1-\pi) + \zeta(1+r)]\ell(1-k). \qquad (17)$$

4.1 Allowance for Corporate Equity

A more generous ACE mitigates the debt bias in corporate taxation and ensures a more symmetric tax treatment of debt and equity:

PROPOSITION 1 *A larger allowance for corporate equity s unambiguously lowers the risk-taking cut-off Ω^*. It thereby discourages gambling, reduces the average probability of bank failure π and the net fiscal cost of bank failure C, and improves welfare.*

Proof: See Appendix A.

The ACE reduces the tax burden on equity and thereby facilitates the use of equity in solving the risk-shifting problem. Specifically, it lowers the agency cost χ, which disproportionately benefits prudent banks because they have larger equity to satisfy the incentive constraint. This finding is similar to Kogler (2021) but derived under full loss offset.[3] This result is also consistent with empirical evidence showing that the ACE improves the quality of banks' loan portfolios, for instance, reflected in a smaller share of non-performing loans (Schepens, 2016; Célérier et al., 2019).

By reducing risk taking, the ACE offers financial stability gains in terms of lower average failure risk and a smaller net fiscal cost of bank failure. In addition to the reduced insolvency risk, the fiscal outlays fall because more banks rely on additional equity and raise fewer guaranteed deposits.

Not only does the ACE improve financial stability, it reduces excessive risk taking and thereby shifts the economy closer to the first best with $\Omega^* = 0$. However, risk taking remains inefficient even if there is a full ACE, $\Omega^*_{|s=1} > 0$. A corporate tax reform alone cannot eliminate all distortions because guarantees still subsidize debt and contribute to excessive risk taking.

How effectively the ACE alleviates excessive risk taking depends on capital regulation:

COROLLARY 1 *Tight capital requirements k diminish the marginal effect of the ACE on risk taking.*

Proof: The marginal effect of the tax allowance $d\Omega^*/ds$ is proportional to $1 - k$, see (A.2) in Appendix A. ■

[3] Kogler (2021) shows that without loss offset the ACE relaxes the incentive constraint because prudent banks more likely benefit from the ACE. This allows for lower minimum equity, which reinforces the relative gains of prudent banks.

Tight regulation renders the risk taking less sensitive to corporate taxes. Intuitively, capital requirements lower the size of voluntary equity ε_0, which helps banks set proper risk-taking incentives, see (7). With low voluntary equity, the extra tax burden for prudent banks $\tau(1-s)r\varepsilon_0$ is small and the ACE only has a weak effect on relative profits.

4.2 Performance-dependent Bank Levy

A performance-dependent levy ($\zeta = 0$) is paid ex post. The effective levy rate is $\ell^{j,0} = \theta^j \ell$ and depends on portfolio risk because only solvent, profitable banks pay. By differentiating the cut-off Ω^* with respect to ℓ and evaluating the sensitivities at $\ell = 0$, one obtains the effects of introducing a small levy:

PROPOSITION 2 *Introducing a performance-dependent levy on bank liabilities only lowers the risk-taking cut-off* Ω^* *and discourages gambling if*

$$1 < \frac{(1+r)(1-\nu)(1-\chi)}{\theta^P(1+i^P)}\left[1 + \frac{(1-\chi)\theta^G}{\Delta\theta}\right]. \tag{18}$$

This requires small agency costs of equity χ. *Otherwise, the levy encourages gambling.*

Proof: See Appendix A.

The ambiguity mirrors three countervailing forces: First, the pivotal bank has larger taxable liabilities if it gambles in which case equity equals the regulatory minimum k. The larger base implies a larger tax burden compared to prudent banks. Second, the effective levy rate is higher for prudent banks due to their low insolvency risk, $\ell^{P,0} > \ell^{G,0}$. The levy thus diminishes their expected profit relative to gambling banks. Third, the levy tightens the incentive constraint for the same reason, requiring prudent banks to raise even more additional equity ε_0. The latter is expensive and further lowers their profit. The first effect reduces gambling in equilibrium, while the reverse is true for the last two effects.

Inequality (18) ensures that the first, negative effect prevails and the bank levy effectively reduces bank risk taking. However, it is quite restrictive and requires a small agency cost χ and limited government guarantees ν. This suggests that the levy is effective in reducing gambling precisely when the government is unlikely to bail out depositors (i.e., low ν) such that the fiscal externality is small and no strong case for a Pigovian tax exists in the first place. A performance-dependent bank levy is thus unlikely to offer large stability gains. Rather on the contrary, it tends to be counterproductive and increase gambling whenever the relative cost of equity, which it should lower, is high. This may explain why empirical research has found a positive effect of bank levies on asset risk (e.g., Devereux et al., 2019; Célérier et al., 2019).

Even tough a performance-dependent bank levy may not reduce gambling, it may still lower the net fiscal costs of bank failure defined in (17). Apart from risk taking and insolvency risk, the social cost - negatively - depends on aggregate bank equity and revenue from bank levies, which both increase in the bank levy.

Whether and how effective the bank levy is in reducing risk taking depends on the corporate tax rate and on capital regulation:

COROLLARY 2 *A high corporate tax rate τ diminishes any negative and magnifies any positive effect of introducing a bank levy on risk taking, $d\Omega^*/d\ell_{|\ell=0}$, if the corporate income tax is distortionary. Tight capital requirements k weaken the levy's effect.*

Proof: See Appendix A.

To illustrate this result, consider the following numerical example. Figure 3 plots the marginal effect of introducing a levy with $\ell = 0.5\%$ on the risk-taking cut-off Ω^* depending on the corporate tax rate τ. For low tax rates, the levy lowers the share of gambling banks. The marginal effect rises with the corporate tax rate: Above $\tau \approx 40\%$, the bank levy induces more gambling.

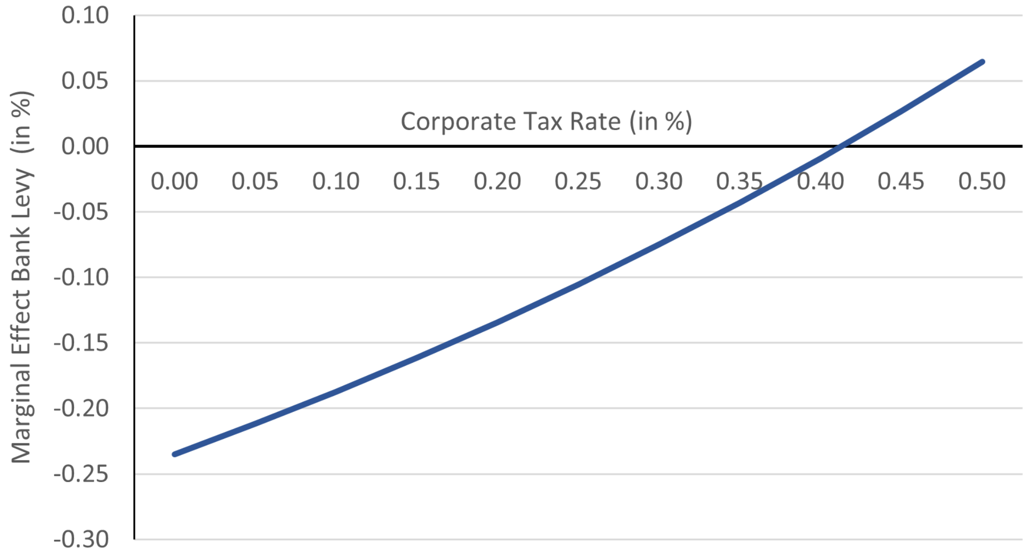

Figure 3: *Bank Levy and Corporate Tax Rate*
This figure depicts the marginal effect of introducing a levy with $\ell = 0.5\%$ on the risk-taking cut-off, $\Delta\Omega^*/\Omega^*$. The share of guaranteed deposits is $\nu = 0.6$, the required return is $r = 0.05$, and capital requirements are $k = 0.05$. The corporate income tax is distortionary with $s = 0$. The probabilities of a positive portfolio return are $\theta^P = 0.9$ and $\theta^G = 0.7$.

The intuition for this result is as follows: First, the levy tightens the incentive constraint and forces prudent banks to raise more additional equity ε_0. Because of the debt bias, this increase is especially expensive under high corporate tax rates. The levy thereby lowers the expected profit of a prudent compared to a gambling bank. Second, a high corporate tax rate directly induces more gambling by exacerbating the debt bias. The pivotal bank thus earns a larger rent Ω^* and satisfies the incentive constraint with smaller equity ε_0^*, see (7). As a result, the difference in taxable liabilities when investing in the prudent ($d = 1 - k - \varepsilon_0^*$) and gambling portfolio ($d = 1 - k$) shrinks. With a more similar base, the differential effect of the levy on relative bank profits is weaker. To sum up, a high corporate tax rate reinforces one positive and weakens one negative effect of the levy on risk taking.

This result only holds under a distortionary corporate income tax. In a neutral system with a full ACE, the cut-off Ω^* is independent of corporate taxes, see (12) - (13). The tax rate has no effect on how the bank levy influences risk taking.

Tighter capital requirements, in turn, diminish any effect of the bank levy on risk taking, which is proportional to $1-k$. They reduce the magnitude but do not alter the sign. By lowering ε_0, capital requirements narrow the gap in taxable liabilities between prudent and gambling banks such that the effect of the levy on the portfolio choice is less pronounced.

4.3 Performance-independent Bank Levy

The performance-independent levy ($\zeta = 1$) is paid ex ante by bank shareholders. The effective levy rate for prudent and gambling banks is thus the same, $\ell^{P,1} = \ell^{G,1} = (1+r)\ell$. Again, we consider the introduction of a small levy and assume $\ell = 0$ at the outset:

PROPOSITION 3 *Introducing a Pigovian tax on bank liabilities ℓ paid ex ante by shareholders discourages risk taking. It reduces the net fiscal costs of bank failure C as it lowers the average probability of bank failure π, increases aggregate equity $k + \bar{\varepsilon}$, and generates revenue. By reducing excessive risk taking, the bank levy is welfare-improving.*

Proof: See Appendix A.

The performance-independent bank levy unambiguously lowers the share of gambling banks in equilibrium. the profit of the pivotal bank Ω^* falls disproportionately if the latter gambles because its taxable liabilities are larger ($1-k$ instead of $1-k-\varepsilon_0^*$). Since the effective tax rate is independent of the portfolio, the levy does not affect the incentive constraint. The differential impact on relative bank profits is entirely driven by the larger tax base of gambling banks. This finding is consistent with Diemer (2017) but the mechanism is fundamentally different: In his model, reduced risk taking results from the fact that gambling banks disproportionately lower the deposit rate to pass the tax onto depositors and thus attract fewer deposits, which diminishes profit.

Reduced risk taking improves welfare and financial stability. The decrease in the fiscal cost of bank failure has three sources: First, fewer banks gamble, leading to a lower average probability of bank failure π. Guarantees are therefore less likely to be used. Second, the volume of guaranteed deposits shrinks, reflecting larger aggregate bank equity. This is driven by a larger share of prudent banks that raise equity in excess of the regulatory minimum to address the risk-shifting problem, $\bar{\varepsilon} \equiv \int_{\Omega^*}^{\bar{\Omega}} \varepsilon_0(i^P, \Omega) dF(\Omega)$.[4] Third, a standard revenue effect reinforces the decline in the net fiscal costs.

The bank levy does have the desired stabilizing and welfare-increasing effect whenever it is paid irrespective of performance. Nevertheless, implementing such a design may face some challenges: First, the levy has to be paid ex ante. While straightforward in a static model, it is more difficult in a dynamic context when the levy is repeatedly collected at the beginning of each period. By reducing the present value of future profits, a permanent levy may create a disproportionate burden on prudent banks. This charter value effect likely exacerbates risk shifting and diminishes the financial stability gains from the bank levy. Second, we emphasize that a levy paid by shareholders. If banks instead attracts additional debt to finance the upfront payment, the levy will increase bank debt, which induces more gambling. Hence, a levy paid ex ante with debt would thus be very similar to a performance-dependent paid ex post.

We finally explore the interaction with corporate taxes and capital regulation:

COROLLARY 3 *A high corporate tax rate τ diminishes the effect of introducing a bank levy on risk taking $d\Omega^*/d\ell_{|\ell=0}$, if the corporate tax is distortionary ($s < 1$). Tight minimum capital requirements k also diminish the levy's effect.*

[4] The intensive margin is, in contrast, unchanged because an individual bank's voluntary equity $\varepsilon_0(i^P, \Omega)$ is independent of the levy if $\zeta = 1$, see (7).

Proof: See Appendix A.

A high tax rate reduces the magnitude of the levy's effect but does not affect its sign. In a distortionary tax system, it directly contributes to more gambling, reflected in a higher cut-off Ω^*. Consequently, the pivotal bank earns a larger rent and affords smaller voluntary equity. Taxable liabilities of gambling and prudent banks thus becomes more similar, and differential effect of the levy on relative profits is less pronounced.

5 Discussion and Conclusion

This paper investigates how taxing bank leverage can improve the stability of the banking sector. Unlike prior work that focused on how taxes affect the capital structure of banks, we emphasize a complementary source of financial stability gains: reduced bank risk taking. The tax treatment of bank debt and equity is a key determinant of risk taking because moral hazard (risk shifting) gives rise to the 'incentive function' of equity, which prevent banks from inefficiently investing in high-risk assets ('gambling')

Our analysis yields four main results: First, eliminating the debt bias with an ACE unambiguously reduces bank risk taking and improves financial stability in terms of lower insolvency risk and smaller fiscal costs of bank failure. However, even a full ACE cannot restore a first best and prevent gambling altogether. After all, it only eliminates distortions caused by the corporate income tax itself but not those by government guarantees. Second, such fiscal externalities can be internalized by introducing a Pigovian tax on liabilities. A bank levy further reduces risk taking whenever it is paid by all banks regardless of their performance. However, implementing a performance-independent levy might be challenging in reality. A bank levy that does depend on performance has less certain risk-taking effects and may even by counterproductive and encourage risk taking.

Intuitively, if only solvent banks are taxed, those taking fewer risks are more likely to pay the levy, which increases their effective levy rate compared to gambling banks. This offers one explanation for the positive effect of bank levies on asset risk found in empirical research (e.g., Devereux et al., 2019; Célérier et al., 2019). Third, the corporate income tax influences how effective a bank levy is in discouraging risk taking. As long as there is a debt bias, high corporate tax rates render the levy less effective and, in one case, even counterproductive. The intuition is that the levy tightens the incentive constraint of banks, which thus need more equity to prevent gambling. This is particularly expensive if corporate tax rates are high. Finally, we shed light on the interaction between capital regulation and taxes, which are generally substitutes for improving financial stability. Both the ACE and the bank levy have weaker effects on risk-taking behavior if minimum capital requirements are tight.

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A Appendix: Proofs

Proof of Proposition 1: The risk-taking cut-off Ω^* in (12) depends on the distortion term $\chi \in [0,1)$ defined in (13). The latter decreases in the tax allowance:

$$\frac{\partial \chi}{\partial s} = -\frac{\bar{\tau} r\,(1-\chi)}{\Delta\theta[1+i^P+(1-\zeta)\ell]+\bar{\tau}(1-s)r+\bar{\nu}^P-\ell^{P,\zeta}} < 0. \tag{A.1}$$

Hence, the ACE unambiguously decreases the risk-taking cut-off:

$$\frac{\partial \Omega^*}{\partial s} = \frac{(1+r)(1-\nu)(1-k)}{\theta^P}\frac{\partial \chi}{\partial s} < 0. \tag{A.2}$$

The decrease in Ω^* raises welfare as $dW/d\Omega^* < 0$ in equilibrium. It also lowers the average probability of bank failure decreases, $d\pi = \Delta\theta f(\Omega^*) \cdot d\Omega^*$.

The tax allowance affects the net fiscal cost C of bank failure defined in (15) by changing aggregate voluntary equity $\bar{\varepsilon}$ and the risk-taking cut-off Ω^*:

$$\begin{aligned}\frac{\partial C}{\partial s} &= -\bar{\nu}^P \cdot \frac{\partial \bar{\varepsilon}}{\partial s} + \nu(1+r)(1-k)\Delta\theta f(\Omega^*) \cdot \frac{\partial \Omega^*}{\partial s} \\ &= [\nu(1+r)(1-k)\Delta\theta + \bar{\nu}^P \varepsilon_0^*] f(\Omega^*) \frac{\partial \Omega^*}{\partial s} < 0.\end{aligned} \tag{A.3}$$

The second equality uses the fact that changes in π and $\bar{\varepsilon} \equiv \int_{\Omega^*}^{\Omega^\circ} \varepsilon_0 dF(\Omega)$ are one-to-one related to the induced changes in the cut-off and accordingly substitutes $d\pi = \Delta\theta f(\Omega^*) \cdot d\Omega^*$ and $d\bar{\varepsilon} = -\varepsilon_0^* f(\Omega^*) \cdot d\Omega^*$. ■

Proof of Proposition 2: The levy rate decreases the distortion term χ defined in (13):

$$\frac{\partial \chi}{\partial \ell} = -\frac{\theta^P - \theta^G \chi}{\Delta\theta(1+i^P+\ell)+\bar{\tau}(1-s)r+\bar{\nu}^P-\theta^P \ell} < 0. \tag{A.4}$$

Introducing a small bank levy from $\ell = 0$ affects the risk-taking cut-off according to

$$\begin{aligned}\frac{\partial \Omega^*}{\partial \ell} =& 1-k+\frac{(1+r)(1-\nu)(1-k)}{\theta^P}\frac{\partial \chi}{\partial \ell} \\ =&(1-k)\left[1-\frac{(1+r)(1-\nu)}{\theta^P}\frac{\theta^P-\theta^G\chi}{\Delta\theta(1+i^P)+\bar{\tau}(1-s)r+\bar{\nu}^P}\right] \\ =&(1-k)\left[1-\frac{(1+r)(1-\nu)(1-\chi)}{\theta^P(1+i^P)}\frac{\theta^P-\theta^G\chi}{\Delta\theta}\right].\end{aligned} \tag{A.5}$$

The third equality uses the definition of the distortion term in (12). The expression in square brackets determines the sign of the net effect as stated in (18). Only if it is negative, the levy reduced the cut-off and thereby decreases excessive risk taking and the average probability of bank failure. ■

Proof of Corollary 2: The normalized corporate tax rate $\bar{\tau} \equiv \tau/(1-\tau)$ influences the effect of the performance-dependent bank levy $d\Omega^*/d\ell$ in (A.5) according to:

$$\begin{aligned}\frac{\partial^2\Omega^*}{\partial\ell\partial\bar{\tau}} =&\frac{(1+r)(1-\nu)(1-k)}{\theta^P(1+i^P)}\left[\frac{\theta^P-\theta^G\chi}{\Delta\theta}+\frac{\theta^G(1-\chi)}{\Delta\theta}\right]\frac{\partial\chi}{\partial\bar{\tau}}\\ =&\varepsilon_0^*\left[\frac{\theta^P-\theta^G\chi}{\Delta\theta}+\frac{\theta^G(1-\chi)}{\Delta\theta}\right]\frac{(1-s)r}{\Delta\theta(1+i^P)+\bar{\tau}(1-s)r+\bar{\nu}^P}.\end{aligned} \tag{A.6}$$

The second equality uses (14) and $d\chi/d\bar{\tau}$. This expression is positive for $s<1$ suggesting that a higher tax rate $\bar{\tau}$ increases the effect of the levy on risk taking and zero for $s=1$.

Noting that the distortion term χ is independent of k, one finally observes that capital requirements diminish the magnitude of the effect $d\Omega^*/d\ell$ in (A.5). ■

Proof of Proposition 3: The distortion term χ defined in (13) unambiguously decreases in ℓ:

$$\frac{\partial\chi}{\partial\ell}=-\frac{(1+r)(1-\chi)}{\Delta\theta(1+i^P)+\bar{\tau}(1-s)r+\bar{\nu}^P-(1+r)\ell}=\frac{(1+r)(1-\chi)^2}{\Delta\theta(1+i^P)}<0. \tag{A.7}$$

The cut-off Ω^* in (12) responds to the levy in proportion to the induced change in χ:

$$\frac{\partial\Omega^*}{\partial\ell}=\frac{(1-\nu)(1+r)(1-k)}{\theta^P}\frac{\partial\chi}{\partial\ell}=-\frac{(1-\nu)(1+r)^2(1-k)(1-\chi)^2}{\theta^P(1+i^P)\Delta\theta}<0. \tag{A.8}$$

Changes in the net fiscal costs of bank failure C defined in (17) reflect changes in the average probability of bank failure π and aggregate voluntary equity $\bar{\varepsilon}$. Since voluntary equity of each individual bank $\varepsilon_0(i^P,\Omega)$ is independent of the levy, changes in $\bar{\varepsilon}$ only result from the extensive margin. We use $d\pi=\Delta\theta f(\Omega^*)\cdot d\Omega^*$ and $d\bar{\varepsilon}=-\varepsilon_0^* f(\Omega^*)\cdot d\Omega^*$ to compute the effect of introducing a performance-independent levy:

$$\begin{aligned}\frac{\partial C}{\partial\ell}_{|\ell=0}&=\nu(1+r)\frac{\partial\pi}{\partial\ell}-\bar{\nu}^P\frac{\partial\bar{\varepsilon}}{\partial\ell}-(1+r)(1-k-\bar{\varepsilon})\\ &=[\nu(1+r)\Delta\theta+\bar{\nu}^P\varepsilon_0^*]f(\Omega^*)\frac{\partial\Omega^*}{\partial\ell}-(1+r)(1-k-\bar{\varepsilon})<0.\end{aligned} \tag{A.9}$$

■

Proof of Corollary 3: This proof follows the proof of Corollary 1. The normalized corporate tax rate $\bar{\tau}$ influences the effect of the levy $d\Omega^*/d\ell$ in (A.8) according to:

$$\begin{aligned}\frac{\partial^2\Omega^*}{\partial\ell\partial\bar{\tau}} &= \frac{2(1-\nu)(1+r)^2(1-k)(1-\chi)}{\theta^P(1+i^P)\Delta\theta}\frac{\partial\chi}{\partial\bar{\tau}} \\ &= \frac{2(1-\nu)(1+r)^2(1-k)(1-\chi)}{\theta^P(1+i^P)\Delta\theta}\frac{(1-s)r}{\Delta\theta(1+i^P)+\bar{\tau}(1-s)r+\bar{\nu}^P}.\end{aligned} \tag{A.10}$$

This expression is positive if $s < 1$, and a higher tax rate $\bar{\tau}$ diminishes the negative effect of the levy on risk taking. Again, one observes that capital requirements diminish the magnitude of the effect $d\Omega^*/d\ell$ in (A.8). ■