Complex Organizations, Leverage, and Interest Rates

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Keywords: Capital structure, LBOs, securitization, multinationals, monetary policy

JEL Classifications: G32, H32, L32

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Complex Organizations, Leverage, and Interest Rates⋆

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Abstract

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1. Introduction

Trade-off models predict that lower interest rates reduce optimal leverage because they compress the tax advantage of debt (Fischer et al. 1989; Ju and Ou-Yang 2006). Yet borrowing by highly leveraged sponsored entities often expands when financing conditions ease, despite their sensitivity to tax and distress considerations.[2]

This paper reconciles this tension. We study a trade-off model in which a sponsor provides contingent support to a backed unit and chooses leverage across entities.[3] The sponsor's support relaxes the backed unit's borrowing constraint, allowing leverage to be reallocated within the organization. Lower interest rates reduce sponsor leverage incentives, but also increase the value of preserving financial flexibility to support the backed unit. As a result, leverage may shift toward backed entities as rates fall.

Leverage responds heterogeneously not only within but also across organizations. We show that stand-alone firms (modeled as in Leland 2007) optimally delever when interest rates fall, while backed units may increase borrowing at increasing spreads, default probabilities, and losses given default. This occurs when rates become sufficiently low, so that the sponsor may optimally choose zero leverage in order to maximize support capacity. These results imply that organizational form shapes the transmission of monetary conditions to leverage and credit risk. In complex organizations, lower rates do not uniformly relax financing constraints. Instead, they induce a tax-driven internal reallocation of leverage toward less constrained entities.

The interaction between tax shields and contingent support within the organization is key. Lower interest rates reduce the tax advantage of debt for both stand-alone firms and sponsors, weakening their incentives to borrow. In contrast, sponsor support alters the backed unit's tax–default trade-off by reducing expected default costs for a given debt level. As a result, leverage can shift toward the backed unit. The standard trade-off prediction of deleveraging may therefore reverse within complex organizations, potentially increasing total organizational debt as interest rates fall.

These results matter for policy reasons, as well. The high leverage of complex organizations, in low interest rates environments, raises concerns about their contribution to financial instability

2. See Gompers et al. 2016, Jiangli et al. 2007, Hanlon and Heitzman 2022; Brok 2024 for evidence that complex entities respond to tax incentives, and Axelson et al. 2013, Aramonte and Avalos 2019 for examples where leverage increases when aggregate credit conditions ease.

3. Support arrangements are prevalent in private equity (Bernstein et al. 2019; Hotchkiss et al. 2021; Haque et al. 2023), in groups (Bodie and Merton 1992; Beaver et al. 2019; Shi et al. 2023), securitization (Gorton and Souleles 2006), banks (Segura and Zeng 2020) and shadow banks (Allen et al. 2023).

when interest rates eventually return to higher levels.[4] Our model implies that default costs peak when interest rates fall to sufficiently low levels, rather than when they subsequently rebound. Moreover, heterogeneity across organizational forms may dampen aggregate default risk, as stand-alone firms delever.

We illustrate the model using two benchmark parameterizations based on Leland (2007) and Nicodano and Regis (2019). In the first, resembling securitization structures, the sponsor delevers as interest rates fall while the backed unit expands borrowing. In the second, resembling an LBO structure, the sponsor is optimally zero-leverage and the backed unit carries substantially more debt than an equivalent stand-alone firm. Across both cases, lower interest rates reallocate leverage toward backed units and increase their default risk. These effects are amplified when sponsor and backed-unit cash flows are more correlated, increasing the value of contingent support. Importantly, borrowing expands despite higher spreads and losses given default. The mechanism is therefore not cheaper financing, but the preservation of tax benefits on risky debt within the organization.

Our paper contributes to the trade-off theory of capital structure. Seminal models characterize firms' optimal leverage as the outcome of a trade-off between tax benefits and distress costs, with lower interest rates generally reducing optimal debt by compressing the tax advantage of leverage (Leland 1994, Leland and Toft 1996, Goldstein et al. 2001, Ju and Ou-Yang 2006). We show that this comparative static need not hold once financing decisions are jointly determined within a multi-entity organization.

The paper also relates to the literature on internal capital markets and organizational design. Existing work studies resource allocation across conglomerate divisions and business-group affiliates (Stein 1997, Rajan et al. 2000, Inderst and Müller 2003, Cestone and Fumagalli 2005, Almeida and Wolfenzon 2006, Shi et al. 2023), but largely abstracts from capital structure choices and their sensitivity to interest rates. Related research on private equity, structured finance, and sponsor-backed firms features layered financial structures and contingent support arrangements (Axelson et al. 2009, DeMarzo 2005, Luciano and Nicodano 2014), yet does not analyze how organizational structure modifies the response of optimal leverage to changes in interest rates.

More broadly, the paper contributes to the literature on monetary policy transmission and corporate risk-taking. Existing mechanisms emphasize either improved debt-service capacity when

4. See Andersson et al. 2025, Aramonte and Avalos 2021, European Systemic Risk Board 2024, for private equity; European Securities and Markets Authority 2019, Powell 2019, and Rosengren 2019, for securitization.

rates fall (Greenwald 2019,Lian and Ma 2021) or greater risk-taking induced by search-for-yield incentives (Martinez-Miera and Repullo (2017) and Becker and Ivashina (2015)). Our mechanism is different. In our setting, lower interest rates can increase borrowing even though lenders correctly price risk and spreads rise. The response arises from the interaction between taxes and contingent support within complex organizations, which preserve the value of risky debt despite lower interest rates.

Overall, we show that organizational structure alters how leverage responds to changes in interest rates, generating comparative statics absent from standard trade-off models. The results therefore highlight a corporate-governance dimension of monetary conditions in multi-entity firms.

The paper unfolds as follows. Section 2 studies both the stand alone and the complex organization's leverage choice. In Sections 3 and 4 we provide insights on numerical leverage, default probability and lenders' losses-upon-default adjustments following a change in interest rates. While Section 3 studies the case of a zero-leverage sponsor, Section 4 shifts attention to a leveraged sponsor. Section 5 concludes. All proofs are gathered in the Appendix.

2. The Model

This section introduces the model in two steps. We first characterize the benchmark stand-alone firm, highlighting the standard t trade-off between tax benefits and default costs. We then introduce a complex organization with a sponsor providing contingent support to a backed unit. We show how this organizational structure alters the response of optimal leverage to interest rates. At time 0, a controlling entity owns two units, $i = S, B$. Each unit has a random exogenous operating cash flow, X_i, that is realized at time T. The symbol $G(\cdot)$ denotes the cumulative distribution function and $f(\cdot)$ the density of X_i at time T, which we assume to be identical for the two units; $g(\cdot, \cdot)$ is the joint distribution of X_S and X_B and ρ their correlation coefficient. At time 0, the controlling entity issues a zero-coupon debt with maturity T to finance the cash-flows in the two units. The face value F_i of the debt issued maximizes the total arbitrage-free value (ν_{SB}) of equity, E_i, and debt, D_i in the two units:

$$\nu_{SB} = \max_{F_S, F_B} \sum_{i=S,B} (E_i + D_i) . \tag{1}$$

Each unit pays a flat proportional income tax at an effective rate $0 < \tau_i < 1$ and loses a proportion, $0 < \alpha_i < 1$, of its cash flows in default. Interests on debt are entirely deductible from taxable income. This tax advantage of debt generates a trade-off. On the one hand, increasing leverage generates tax savings, while on the other it increases expected default costs because – everything else being equal – higher leverage increases default likelihood.

At time T, cash flows are realized and distributed in the following order. First, corporate income taxes are paid. Then, debt obligations are fulfilled, if possible. When a unit cannot meet its debt obligations, its income, net of both taxes and default costs, is distributed to the lenders. Shareholders will receive net residual cash flows, if any, after debt is fully reimbursed.

The expressions for the values of equity and debt, E_i and D_i, are in the Appendix.

Because cash flows are exogenous and markets are frictionless except for taxes and default costs, maximizing firm value is equivalent to minimizing the sum of expected tax burden (T_i) and expected default costs (C_i):

$$\nu_{SB} = \min_{F_S, F_B} \sum_{i=S,B} T_i + C_i. \tag{2}$$

The expected tax burden of each unit is proportional to its expected operational cash flow X_i, net of the tax shield X_i^Z, which captures the interest deductibility benefit of debt. Since debt is modeled as a zero-coupon bond, interests – and hence the tax shield – are equal to the difference between the face value of debt, F_i, and its market value D_i: $X_i^Z = F_i - D_i$. Default costs are proportional to operating cash flows.

Below, we model two different ways of owning the two units. In the first case, they are separately owned and they constitute two stand-alone entities. In the other case, units are connected through a conditional support guarantee. In such a complex organization, leverage choices are interdependent, since borrowing in one unit affects the marginal value of borrowing in the other.

2.1. The Stand-Alone Units

We begin with the case of unconnected, stand-alone units, which isolates the standard tax–default trade-off and serves as a benchmark for the effects of organizational structure. By risk neutrality, the value of the tax burden in each stand-alone (SA) unit is equal to:

$$T_i^{SA}(F_i) = \tau_i \phi \mathbb{E}[(X_i - X_i^Z)^+], \tag{3}$$

where $\phi = \frac{1}{(1+r)^T}$ is the discount factor for the time-T horizon at which the cash flows are realized. The superscripts and subscripts, i, indicate whether the stand-alone unit is endowed with the sponsor ($i = S$) or backed unit ($i = B$) parameters.

Each stand-alone unit defaults when its realized net cash flow is lower than the face value of debt. In other words, default occurs when cash flows are lower than a default threshold, X_i^d, defined as the minimum cash flow required to fully repay debt: $X_i^d = F_i + \frac{\tau_i}{1-\tau_i} D_i$. Expected default costs, that are a dead-weight loss, are equal to:

$$C_i^{SA}(F_i) = \alpha_i \phi \mathbb{E}\left[X_i 1_{\{0<X_i<X_i^d\}}\right]. \tag{4}$$

They are proportional to the default cost parameter, α_i, and increase in realized cash flows, when the unit goes bankrupt. A rise in the nominal value of debt, F_i, increases the default threshold, X_i^d, thereby increasing the expected default costs.

When units are owned separately, the value of the objective function (2) is simply the sum of the values of the taxes and default costs in each unconnected unit. Notice that the optimal value of each unit is equal to:

$$V_i(F_i^*(\phi); \phi) = V_i(0; \phi) + TS_i(F_i^*(\phi); \phi) - C_i(F_i^*(\phi); \phi), \tag{5}$$

where $F_i^*(\phi)$ is the optimal face value of debt in unit i, $V_i(0; \phi)$ is the value of a zero-leverage unit, and $TS_i(F_i; \phi) = T_i^{SA}(0; \phi) - T_i^{SA}(F_i; \phi)$ is the present value of the tax savings from leverage, equal to the difference between the taxes paid by a zero-leverage unit and a unit which issues debt F_i. Equation (5) highlights that, among other parameters, the optimal solution depends on the discount factor ϕ, and thus on the risk-free rate.

It is worth recalling some properties of the components of the stand-alone unit's value. The tax shield is a convex function of F_i. In fact, increasing the face value of debt increases the tax shield, thereby reducing the tax burden. This occurs because the market value of debt, D_i, increases with F_i at a decreasing rate (due to higher risk). The default threshold X_i^d is instead concave in the face value of debt, F_i. Luciano and Nicodano (2014) prove that a stand-alone unit has positive optimal debt if the sum of tax burden and default costs is convex in the face value of debt. Nicodano and Regis (2019) further show that it raises positive debt even with a zero risk-free rate because the endogenous spread generates a positive tax shield. The spread, defined as

$$s_i = \left(\frac{F_i}{D_i}\right)^{\frac{1}{T}} - \left(\frac{1}{\phi}\right)^{\frac{1}{T}}, \tag{6}$$

is indeed the part of the rate of return on debt due to its riskiness.

We can now analyze the optimal response to a reduction in the risk-free rate that increases the discount factor, ϕ. Throughout the analysis, while we let ϕ vary, we keep the cash flow distribution fixed. Indeed, we assume that valuation is always performed under the risk neutral probability and let the expected present value of cash flows vary with ϕ. Unfortunately, since the solution of problem (1) is not available in closed-form, even in the case of stand-alone units, we can not directly study the sensitivity of optimal debt to interest rate changes. However, we obtain some interesting results at fixed debt levels. We first prove a lemma on the spread. [5]

Lemma 1. *The spread, s_i, falls as the interest rate, r, declines holding fixed the face value of debt, F_i.*

The lemma establishes that, when interest rates decrease, the increase in the market value of debt, that reduces the yield, prevails over the increase due to the lowering of the risk-less rate. An implication of the previous lemma is that the incentive to borrow for tax deductions falls in the risk-free rate. This is the signature feature of trade-off capital structure models.

We now study how a decline in interest rates, hence an increase in the discount factor, affects the tax shield and default costs at a given level of debt. Two opposing forces are at play (see equations (3) and (4)). First, the higher discount factor directly reduces the expected discounted value of both tax deductions and default costs. Second, it indirectly affects both the tax shield, X_i^Z, and the default threshold, X_i^d, by changing the market value of debt, D_i. The proposition below summarizes these effects.

Proposition 1. *Assume the interest rate falls. Then, in a stand-alone company with fixed face value of debt F_i, (a) the tax shield falls and the no-default threshold increases; (b) if $\tau < 0.5$, the former effect dominates; (c) the expected values of both taxes and default costs increase.*

While results concerning taxes (in Part (a) and (c) of the proposition) are straightforward, because the tax shield falls together with both the interest rate and the spread, the ones concerning default costs are subtler. They stem from a reduction in net after-tax cash flows available to repay debt, due to the reduction in the tax shield. This indeed leads to an increase in the probability of default. Part (b) establishes that, for reasonable values of the tax rate ($\tau < \frac{1}{2}$), the loss of tax benefits from leverage is first order relative to the increase in default costs.

5. See the Appendix for all the proofs.

We are now able to determine the value changes in both debt and equity due to the interest rate reduction. First, a discount factor effect raises the value of both debt and equity. Second, the variations in both the tax shield and no default thresholds captured by Proposition 1 increase the default probability, reducing both market values. The first effect prevails, as the next Proposition proves.

Proposition 2. *Assume the interest rate falls. Then, in a stand-alone company, the market values of both debt and equity increase holding fixed the face value of debt.*

Since the market value of both debt and equity increase as the interest rate falls, the market value of the stand-alone company increases for any F_i.

We now turn to the analysis of the optimal level of debt for the stand-alone firm. Proposition 4 in the Appendix highlights that, even in the stand-alone case, a decline in interest rates does not mechanically reduce optimal leverage. Leverage decreases when, at the optimum, the increase in marginal default costs (MDC) outweighs the change in marginal tax savings (MTS) (see condition 20). In normal circumstances, this is the relevant case. Lower interest rates compress the tax advantage of debt by reducing both components of the tax-deductible cost of debt, the risk-free rate and the spread (see Lemma 1), while simultaneously increasing default risk since the lower tax shield shrinks cash-flows available for the service of debt. As a result, MTS fall and MDC rise, leading firms to delever.

The condition (20) may however fail in extreme cases. First, marginal default costs may decrease if the firm is already highly levered, so that the default threshold lies on a sufficiently downward-sloping region of the cash-flow density ($|f'(X^d)| < 0$). Second, marginal tax benefits may increase if the decline in interest rates raises the sensitivity of debt value to face value sufficiently strongly— an effect that becomes relevant only when the tax shield is already large. Both cases require leverage levels well above those typically observed at the optimum.

In sum, the familiar implication of trade-off models holds unless the stand alone unit is initially very highly levered. But for extreme parameter values, lower interest rates reduce marginal tax incentives while increasing marginal default costs, leading to a decline in optimal debt.

2.2. The Sponsor and its Backed Unit

We now consider two connected units linked by a conditional guarantee, following Luciano and Nicodano (2014). This arrangement introduces a governance margin: the sponsor endogenously allocates leverage across units by trading off its own tax benefits against the borrowing capacity of the backed unit. The guarantee allows the sponsor to transfer resources to an insolvent but viable backed unit when doing so prevents default. Formally, the sponsor covers the shortfall $F_B - X_B^n$ provided its own net resources suffice to meet both its obligations and the transfer, i.e., $(X_S^n - F_S \geq F_B - X_B^n)$. This implies that the sponsor retains limited liability with respect to the backed unit's debt outside these contingencies. The value of the guarantee is given by the expected default costs saved in the backed unit thanks to the transfer. For given F_S and F_B such value is

$$\Gamma(F_S, F_B) = \phi\alpha_B \left[\int_0^{X_B^Z} \int_{h_1(x)}^{+\infty} x f(x,y)\, dy\, dx + \int_{X_B^Z}^{X_B^d} \int_{h_2(x)}^{+\infty} x f(x,y)\, dy\, dx \right], \tag{7}$$

where $h(\cdot)$ is defined in the Appendix. The Appendix reports also the values of equity and debt of the sponsor and of the backed unit. It is evident that the presence of the guarantee alters the value of the equity of the sponsor and of the debt of the backed unit, because of the transfer of resources. The change in the value of debt of the backed unit, D_B, however, has also an indirect effect, because its tax shield X_B^Z and default threshold X_B^d depend on D_B. For a given debt level F_S the sponsor's taxes and default costs remain identical to those of a stand-alone firm. Those of the backed unit are instead:

$$T_B = \phi\tau_B \mathbb{E}\left[(X_B - X_B^Z) 1_{\{X_B \geq X_B^Z\}} \right],$$

$$C_B = \phi\alpha_B \mathbb{E}\left[X_B 1_{\{X_B \leq X_B^d\}} \right] - \Gamma(F_S, F_B).$$

In these expressions, we highlight that X_B^Z and X_B^d, differently from the sponsor's case, are different from their stand-alone counterparts, because the debt value of the backed unit changes for fixed F_B. Summarizing, the backed unit's trade-off is altered. On the one hand, expected default costs fall because the guarantee covers default states in which the sponsor can intervene. On the other hand, the tax burden increases because the higher market value of debt reduces the tax shield. The first effect dominates, so the guarantee is value-enhancing at a given risk-free rate.

The ex-post transfer from sponsor's shareholders to the lenders in the backed unit affects both ex ante leverage choices and value and, in particular, leverage choices become interdependent across units. Reducing sponsor leverage increases the likelihood that it can provide support, which relaxes the backed unit's borrowing constraint. As shown in Luciano and Nicodano (2014), it may therefore be optimal to forego the sponsor's tax shield in order to expand borrowing—and tax benefits—in the backed unit, if their tax-bankruptcy parameters are equal. Below we show that a zero-leverage sponsor is optimal, for unrestricted parameters, when interest rates are sufficiently low.

Proposition 3. *Assume a convex objective function in (2). Then, there exists a threshold interest rate level ($\bar{r}(\tau_S, \tau_B, \alpha_B, G, g)$) such that, for all ($r \leq \bar{r}$), the optimal sponsor's debt is zero, $F_S^* = 0$. Holding other parameters fixed, $\bar{r}$ decreases with τ_S for $\tau_S < 0.5$.*

As in the stand-alone case, lower interest rates reduce the value of the sponsor's tax shield. However, in a multi-entity structure, they also increase the value of preserving financial slack to support the backed unit. When rates are sufficiently low, this second effect dominates, leading the sponsor to specialize in providing support rather than borrowing.

As a result, leverage is reallocated within the organization towards the backed unit, as the numerical analysis in the next section shows. This reallocation increases both the tax shield at the group level, and exposure to default in the backed unit. The threshold interest rate, $\bar{r}$, is thus lower when the sponsor's own tax incentives are stronger. Numerical analysis also reveals that the threshold rate increases in the backed unit' borrowing incentives, i.e. with lower α_B and higher τ_B.

In sum, while stand-alone firms adjust leverage through a standard tax–default trade-off, complex organizations introduce the internal allocation of debt as additional margin. This margin is key to understanding how leverage responds to interest rates.

3. Optimal Leverage and Credit Risk Sensitivity to the Risk-Free Rate

In this section, we numerically analyze the changes in the optimal capital structure associated with variation in the risk-free rate. We also analyze the changes in the endogenous default probability, spread and loss given default. We compare stand-alone units to the connected units belonging to a complex organization, assuming they display the same parameters.

Table 1 displays the base-case calibration parameters, as in Leland (2007), which refer to a typical BBB company. We set the tax rate and the proportional bankruptcy costs to $\tau_i = 20\%$ and $\alpha_i = 23\%$, $i = S, B$ respectively, and then proceed to parametric changes. We fix the marginal distributions of cash flows at maturity (5 years) to a normal distribution with mean $100 * (1.05)^5$ and standard deviation $\sigma = 22 * \sqrt{5}$ and we maintain a joint normality assumption for connected units, letting correlation vary.

We start by assessing the capital structure changes in the stand-alone unit, when the risk-free rate falls from 5% to 1%.

Table 1: Base-case parameters		
Symbol	**Parameter**	**Value**
τ	Tax rate	20%
α	Default costs rate	23%
r	Annual risk-free rate	5%
$\phi = \frac{1}{(1+r)^5}$	Discount factor	0.78
$X(0)$	Cash flow present value	100
V_U	Zero-leverage unit after-tax present value	80.05
T	Time horizon	5
σ	Cash flow volatility at T	$22\sqrt{5}$
ρ	Cash flow correlation	0.2

Table 1: This table displays the base-case parameters, following Leland (2007). The zero-leverage value, (V_U), is the present value of positive cash flows net of taxes. The annual cash-flow volatility, 22, is scaled to the 5-year horizon.

3.1. The Stand-Alone Company

Our first result is that lower interest rates reduce incentives to lever in the stand-alone case (see Table 2). The optimal face value of debt falls by about 40%, from 57.1 to 34.3, and the market value of debt declines from 42.2 to 31.8.[6]

While the value of the hypothetical zero-leverage firm increases sharply due to lower discounting (from 80.05 to 97.20), the value of leverage -the difference between the optimally leveraged and the zero-leverage unit value- collapses (from 1.42 to 0.25). This reflects a compression in the tax shield, which falls from 14.89 to 2.46, and in tax savings (from 2.32 to 0.47).

Lower leverage reduces the default threshold (from 67.65 to 42.26), leading to a decline in expected default costs (from 0.89 to 0.22) and in default probability (from 11.14% to 4.13%). As a result, spreads fall from 1.23% to 0.50%. Losses given default decline in absolute terms due to the lower face value of debt, although they increase as a fraction of the principal conditional on default. As the default threshold moves towards zero with lower borrowing, recovery upon default falls from 50% to 41% of the principal, since defaults occur when after-tax cash flows are smaller.

These patterns are robust across (unreported) parameter variations. The decline in leverage is milder when incentives to lever are stronger—namely, when volatility or tax rates are higher, or

6. It is well-known that observed leverage falls short of trade-off predictions, a gap that can be explained by the opportunity cost of borrowing now rather than preserving the option to borrow later (DeAngelo et al. 2011, tax avoidance (Brok 2026), risk-neutral rather than physical default probabilities resulting in higher risk premia (Almeida and Philippon 2007), and agency considerations such as covenant constraints (Nini et al. 2012).

Table 2: Optimal Stand-Alone Organization			
Variable	**Formula**	Interest rate 5%	Interest rate 1%
Optimal zero-coupon bond principal	F^*	57.10	34.30
Optimal levered value	$V^* = D^* + E^*$	81.47	97.45
Value of optimal debt	D^*	42.21	31.84
Value of optimal equity	E^*	39.26	65.61
Tax shield	$X_Z^* = F - D$	14.89	2.46
No-default threshold	$X^d = F + \frac{\tau}{1-\tau} D$	67.65	42.26
Zero-leverage unit value	V_U	80.05	97.20
Value of optimal leverage	$V^* - V_U$	1.42	0.25
Debt yield	$y^* = (F^*/D^*)^{\frac{1}{5}} - 1$	6.23%	1.50%
Spread	$s^* = \left(\frac{F}{D}\right)^{\frac{1}{5}} - \left(\frac{1}{\phi}\right)^{\frac{1}{5}}$	1.23%	0.50%
Taxes	$T^* = \tau\phi\mathbb{E}[(X - X^Z)^+]$	17.70	23.84
Tax savings	$TS^* = T(0) - T^*$	2.32	0.47
Default costs	$C^* = \alpha\phi\mathbb{E}\left[X\mathbf{1}_{\{0<X<X^d\}}\right]$	0.89	0.22
5-year default probability	$DP^* = \int_{-\infty}^{X^d} f(x)\,dx$	11.14%	4.13%
Loss given default	$LGD^* = \frac{F^* - D^* \frac{1}{\phi}}{DP^*}$	28.96	20.16

Table 2: This table displays the optimal structure of a stand-alone unit with parameters as in Table 1, for two levels of interest rates, 5% and 1%. Yields and spreads are annualized. The default probability is defined as the probability that the unit is not able to repay its lenders after $T = 5$ years, when the cash flows are realized. The cash flow distribution is fixed at T: $X \sim N(127.63, 49.19)$.

proportional default costs are lower.

We can summarize these results as follows, assuming that everything else is unchanged including the distribution of future cash flows:

Observation 1. *When the risk-free interest rate decreases, the optimal leverage of a stand-alone company falls together with its expected default costs, default probability and losses given default.*

3.2. A Zero-Leverage sponsor: the LBO Case

We now consider a sponsor-backed unit. We begin from the base-case calibration in Table 1 and focus on a low cash-flow correlation (0.2) benchmark, illustrated in Figures 1, 2 and Table 3.

At $r = 5\%$, the optimal allocation of leverage within the organization is highly asymmetric: the sponsor is zero-leverage, while the backed unit issues more debt than two comparable stand-alone firms combined (220 vs. 114). This configuration resembles LBO structures (Cohn et al. 2014). The key mechanism is governance-based: by forgoing its own tax shield, the sponsor preserves financial slack and thereby maximizes its capacity to provide contingent support. This support relaxes the backed unit's default constraint ex-post, enabling it to borrow more ex-ante and extract a substantially larger tax shield (103 vs. 14.9 in the stand-alone benchmark), albeit at the cost of higher expected default costs.

When the risk-free rate declines to 1%, this internal reallocation margin becomes even more pronounced. The sponsor remains optimally zero-leverage, while the backed unit further expands debt (to 247). In contrast to the stand-alone benchmark, lower interest rates induce more, not less, leverage in the backed unit. Quantitatively, tax savings in the backed unit increase (from 14.6 to 19.1), but this comes with a sharp rise in default costs (from 8.1 to 14.5) and default probability (from 47% to 63%). Spreads and losses given default rise accordingly. Thus, the expansion in borrowing is not driven by cheaper financing, but by a reallocation of debt toward an entity with looser cash-flow constraint. Importantly, sponsor support does not eliminate default risk. While support reduces expected default costs for a given debt level, equilibrium borrowing shifts distress toward states with lower recovery and higher losses given default. As a result, debt in the backed unit remains risky and spreads may increase even as interest rates fall. The mechanism is therefore distinct from standard guarantee or cheap-credit stories: borrowing expands because risky debt continues to generate valuable tax shields within the organization.

Note in fact that further borrowing does not operate through additional sponsor deleveraging, since the sponsor *remains* zero-leverage (see Proposition 3). Instead, the backed unit adjusts along its own tax–default margin. To understand this adjustment, let us compare the stand-alone unit and the backed unit for fixed debt. In the stand-alone benchmark a decline in the interest rate increases the value of debt thereby reducing the tax shield and the spread (see Lemma 1), thereby raising expected default costs (see Proposition 1), leading—under standard conditions—to a decline in optimal leverage (see Proposition 4).

This logic changes in the backed unit because support alters the distribution of default states rather than eliminating distress risk. Lower rates shift probability mass toward states in which the backed unit pays taxes but still defaults, since taxes increase the cash flow shortfall for given face value of debt. In these states, lenders receive only partial recovery. Thus the market value of debt rises due to lower discounting thereby reducing the tax shield, but not enough to compress the spread.[7]

7. An unreported quantitative assessment of lower rates, holding debt at the optimum level when r=5%, is revealing. For the stand-alone firm, the probability of default while paying taxes increases only slightly (from 10% to 11.3%), the tax shield more than halves (from 14.89 to 6.15), the spread remains low (roughly at

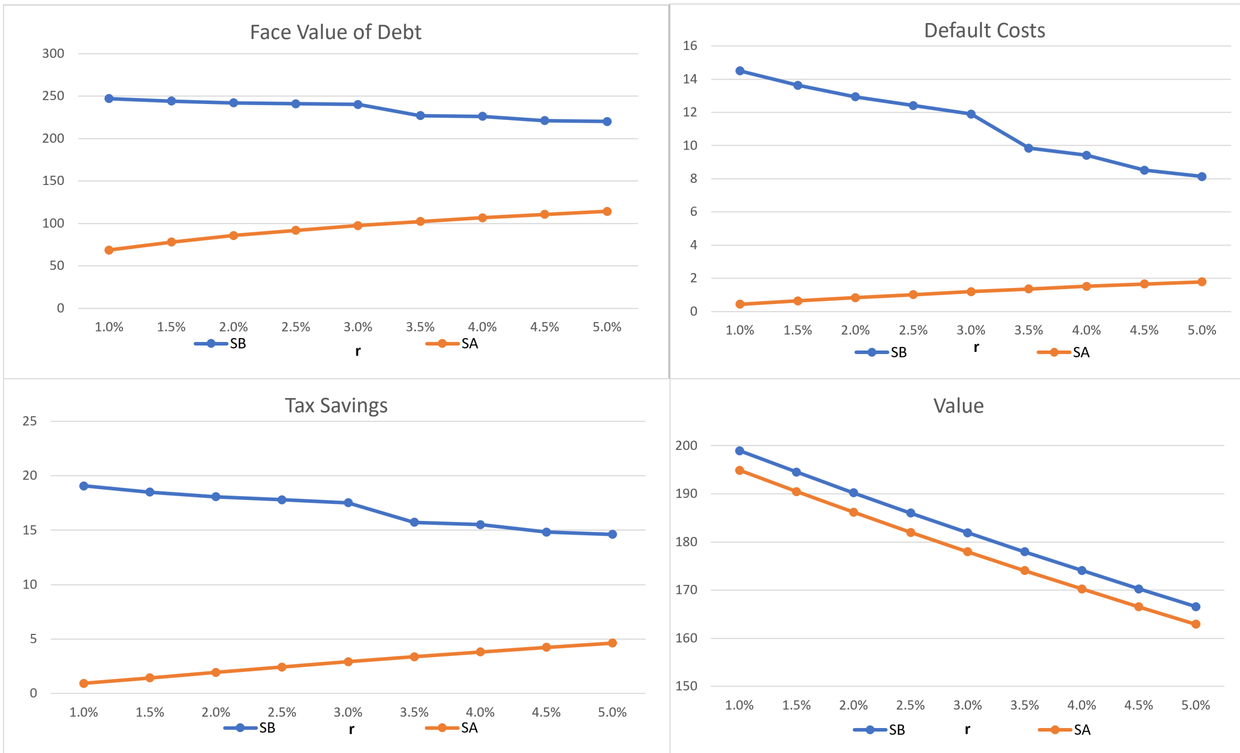

Figure 1: The four panels report the optimal face value of debt, 5-year default probability, annualized spread, and loss given default for the backed unit supported by a zero-leverage sponsor (in blue) and the equivalent stand-alone (in orange), as the risk-free rate varies from 1% to 5%. Parameters are as in Table 1. Cash flows are jointly normal, with 0.2 correlation.

When debt is then optimized, the backed unit exploits this persistent spread, since increasing debt face value raises the tax shield despite lower risk-free rates. The mechanism leading to higher debt in the backed unit is therefore unrelated to cheaper funding; it is the interaction of support, risky debt pricing, and interest deductibility.

This pattern is robust across interest-rate levels and strengthens with cash-flow correlation (see Table 3). Higher correlation increases the value of support by raising the likelihood that the sponsor can intervene in distress states. The backed-unit optimal face value of debt and the default probability top 257 and 64.73%, respectively, when cash flow correlation and the interest rate are equal to 0.8 and 1%. The table also shows that, irrespective of correlation, the joint default probability of the complex organization is negligible because of the zero-default-probability of the zero-leverage sponsor.

1.23%). In the backed unit, for $\rho = 0.2$, the probability of default while paying taxes markedly increases (from 47% to 63%), the tax shield falls by only 16% (from 103 to 86.5), while the spread increases substantially (from 8.5% to 12%).

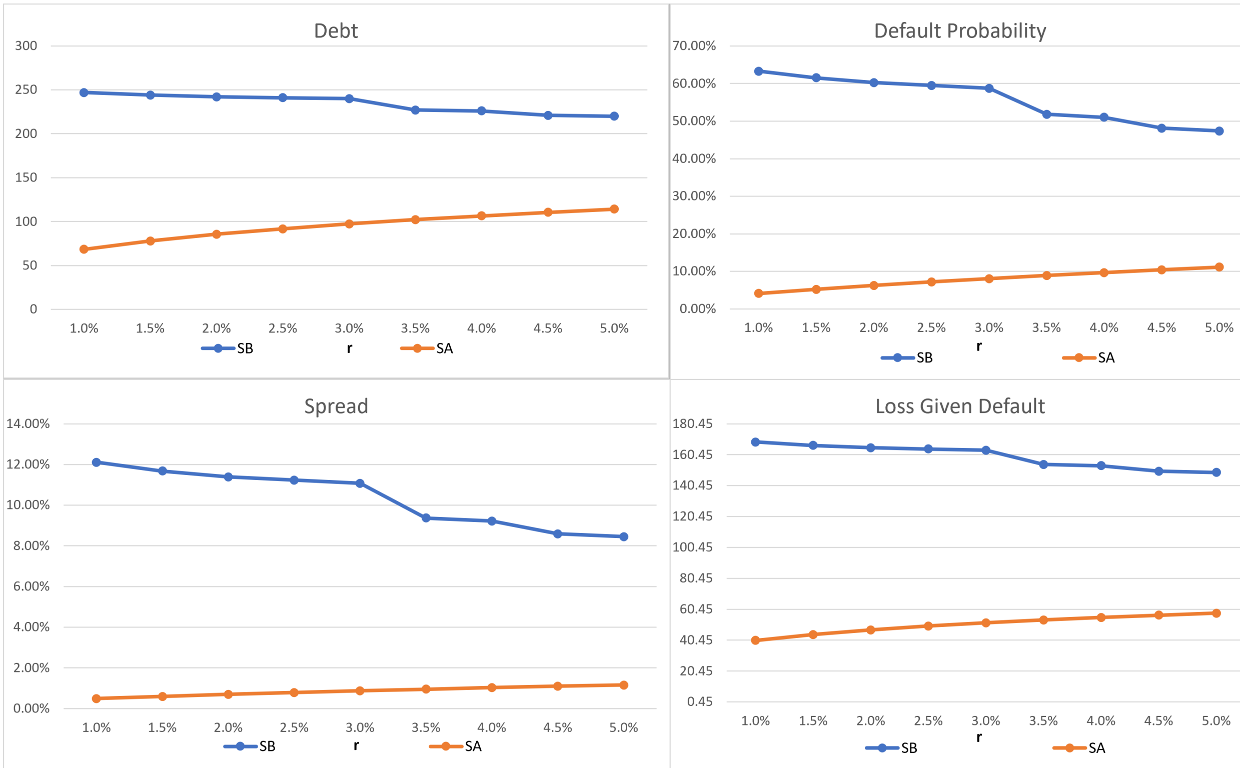

Figure 2: The four panels report the optimal face value of debt, 5-year default probability, annualized spread, and loss given default for the backed unit supported by a zero-leverage sponsor (in blue) and the equivalent stand-alone (in orange), as the risk-free rate varies from 1% to 5%. Parameters are as in Table 1. Cash flows are jointly normal, with 0.2 correlation.

The statement below summarizes some of these patterns, assuming that only the risk-free rate varies:

Observation 2. *When the risk-free rate falls, a backed unit supported by a zero-leverage sponsor increases borrowing, spreads, default probability, and losses given default. These effects are amplified by higher cash-flow correlation.*

Our results bear implications for empirical work. They imply that information on the structure of organizations is essential to understand leverage choices, as the response to interest rates may be opposite for a stand-alone and a backed unit with the same characteristics. In this respect, our findings are broadly consistent with the observed divergent response, by public companies and comparable LBO targets, to lower interest rates. Axelson et al. (2013) find that the ratio of debt to EBITDA is higher in LBO targets but not in matched public companies when interest rates fall. The spreads they find depend on the type of debt. The median spread is equal to 262bp and 937bp for senior and junior bank loans respectively, reaching up to 916bp and 1048bp for senior

Table 3: Optimal Value and Debt — Sponsor / Backed Unit						
	Correlation					
	-0.8		0.2		0.8	
Variable	Interest Rate		Interest Rate		Interest Rate	
	5%	1%	5%	1%	5%	1%
Face Value of Debt	183 (0;183)	201 (0;201)	220 (0;220)	247 (0;247)	227 (0;227)	257 (0;257)
Market Debt Value	133.58 (0;133.58)	153.38 (0;153.38)	117.06 (0;117.06)	133.43 (0;133.43)	115.53 (0;115.53)	133.55 (0;133.55)
Equity Value	32.74 (32.74;0)	42.88 (42.88;0)	49.52 (49.52;0)	65.53 (65.53;0)	51.84 (51.84;0)	66.70 (66.70;0)
Total Value	166.32 (32.74;133.58)	196.26 (42.88;153.38)	166.59 (49.52;117.06)	198.96 (65.53;133.43)	167.36 (51.83;115.53)	200.24 (66.70;133.54)
Value of Leverage	6.23	1.86	6.50	4.56	7.27	5.86
Tax Savings	7.57 (0;7.57)	8.87 (0;8.87)	14.62 (0;14.62)	19.07 (0;19.07)	15.50 (0;15.50)	20.16 (0;20.16)
Taxes	32.45 (20.01;12.44)	39.73 (24.30;15.43)	25.40 (20.01;5.39)	29.53 (24.30;5.23)	24.52 (20.01;4.51)	28.44 (24.30;4.14)
Default Costs	1.91 (0;1.91)	7.29 (0;7.29)	8.13 (0;8.13)	14.50 (0;14.50)	8.24 (0;8.24)	14.29 (0;14.29)
Yield	(N/A;6.50%)	(N/A;5.56%)	(N/A;13.45%)	(N/A;13.11%)	(N/A;14.46%)	(N/A;13.99%)
Spread	(N/A;1.50%)	(N/A;4.56%)	(N/A;8.45%)	(N/A;12.11%)	(N/A;9.46%)	(N/A;12.99%)
Default Probability	(0%;11.05%)	(0%;30.76%)	(0%;47.38%)	(0%;63.30%)	(0%;50.43%)	(0%;64.73%)
Joint Default Probability	0.01%	0.22%	0.47%	0.47%	0.47%	0.47%
Loss Given Default	(0;113.28)	(0;129.38)	(0;148.98)	(0;168.68)	(0;157.77)	(0;180.21)

Table 3: This table reports the optimal capital structure and credit-risk measures of a sponsor–backed unit organization. Both units have the parameters in Table 1. Sponsor and backed-unit values are reported in parentheses; totals are reported outside parentheses. Cash flows are jointly normal, with marginal distributions as in Table 1 and correlation $\rho \in \{-0.8, 0.2, 0.8\}$. Yields and spreads are annualized. Default probabilities are 5-year probabilities.

and subordinated bonds respectively. The spread implied by our model, when 1% (5%) is the level of interest rates, is equal to 441bp (130bp) when cash flow correlation between the fund and the LBO target is -0.8, reaching 1130bp (762bp) when cash flow correlation is 0.2. Our numerical exercise also shows that these spreads allow to reduce the tax burden of the LBO target to up to one fifth of the taxes paid by a similar zero-leverage company.Furthermore, while we know that information about the complex structure improves on default prediction (Beaver et al. 2019), our model suggests a flip in the sign of the prediction depending on the presence of the sponsor.

Our analysis also sheds light on regulators' concerns of potential financial instability observing the rise – from below 4 to above 5 - in the multiple of average total debt to EBITDA for leveraged transactions priced at or above LIBOR + 225bp, as interest rates were falling (Rosengren 2019). Our results indicate that when leverage increases in response to lower interest rates, both default probabilities and, to a lesser extent, lenders' losses given default also rise with respect to the stand-alone benchmark.

However, a fuller quantitative assessment would require allowing for differences in parameters across organizational forms. For instance, private equity research suggests that leveraged buyout targets may display higher expected cash flows, lower cash-flow volatility, shorter and matched debt maturity, than stand-alone counterparts. The comparison should also account for the presence of sponsors that rarely default relative to independent units. Moreover, default probabilities need not move uniformly across firm types: distress risk in sponsored structures may increase precisely when other firms become safer and cash flows improve under easier monetary conditions. These last considerations suggest that organizational heterogeneity may smooth aggregate default risk across interest-rate scenarios.

The numerical exercise should therefore be interpreted as isolating how organizational structure alone affects the relationship between interest rates and credit risk.

4. A Leveraged Sponsor: the Parent-Subsidiary and Securitization Cases

We now turn to the case in which the sponsor is initially leveraged, which is empirically relevant for multinational groups and securitization arrangements.[8] We therefore allow for a higher tax rate in the sponsor than in the backed unit ($\tau_S = 24\%$; $\tau_B = 16\%$), and also increase cash flow volatility ($\sigma_S = \sigma_B = \sigma = 44 * \sqrt{5}$) to ensure stronger incentives to borrow. We begin with the baseline correlation ($\rho = 0.2$) and refer to Figure 3, Figure 4 and Table 4.

At the initial level of interest rates ($r = 5\%$), the complex organization raises more total debt than two equivalent stand-alone firms (199 vs. 169), but allocates it asymmetrically: the backed unit issues more debt than the sponsor (124 vs. 75), despite the sponsor's stronger tax incentives. This reflects a governance trade-off. The sponsor internalizes the value of contingent support and therefore limits its own leverage relative to a stand-alone benchmark (75 vs. 103), preserving financial slack. The backed unit, in turn, borrows more than its stand-alone counterpart (124 vs. 68), benefiting from relaxed effective borrowing constraints. This reallocation raises total tax savings (10.58 vs. 10.32) and reduces aggregate default costs (5.67 vs. 6.09) relative to stand-alone firms, increasing total value (170.59 vs. 169.88).

8. See respectively Anantavrasilp et al. 2020; Bianco and Nicodano 2006; Brok 2024; and Allen et al. 2023; Jiangli et al. 2007; Gorton and Souleles 2006.

When the interest rate declines, two forces interact. First, as in the stand-alone case, lower rates compress the sponsor's tax advantage. Second, they increase the value of preserving financial flexibility to support the backed unit (Proposition 4). As a result, total leverage displays a non-monotonic response: it initially declines as rates fall from 5% to 3%, and then increases. This contrasts sharply with the monotonic deleveraging of stand-alone firms.

The reallocation of leverage has first-order implications for credit risk. As borrowing concentrates in the backed unit, both default probabilities and losses given default increase sharply. For instance, at r=1%, backed-unit default costs are 11 times those of a stand-alone unit (9.08 vs. 0.79). The (5-year) default probability reaches 54%, up from 37.8% in the baseline 5% interest rate. Losses given default also deteriorate, rising to 175.42 from 88.42 (75.61% vs. 71.31% in percentage terms), and spreads rise from 5.86% to 12.20%.

Importantly, this increase in borrowing is not driven by cheaper funding. Instead, it reflects the persistence—and in some cases amplification—of spreads. As leverage rises, a larger fraction of states falls into tax-paying default, where lenders receive only partial recovery. This keeps debt risky and does not allow the market value of debt from converging to its face value. The resulting wedge between the two sustains the tax advantage of debt even as interest rates decline. Thus, the key mechanism is governance-based: lower interest rates shift leverage toward backed entities where debt remains risky. Their tax shields are preserved through endogenous spreads.

Thus, for our selected parameters, we observe a transformation of the levered parent-subsidiary arrangement to a zero-leverage LBO fund and it highly leveraged portfolio company. The likelihood of this transformation depends on cash-flow correlation (see Table 4). Higher correlation increases the value of the guarantee by raising the probability that the sponsor can intervene in distress states. Consequently, the zero-leverage sponsor outcome is more likely when correlation is high, i.e., when diversification is limited.

This generates the following prediction:

Observation 3. *Lower interest rates can induce discrete organizational changes, reallocating leverage toward backed units and transforming parent–subsidiary structures into LBO-like arrangements.*

These results speak to the empirical literature. They are consistent with evidence that leveraged private firms increase borrowing at higher spreads during monetary expansions, while comparable public firms delever (Caglio et al. 2022; Axelson et al. 2013). They also provide a structural rationale for the expansion of securitization activity in low-rate environments (Powell 2019). A caveat regarding implications for groups has to do with unmodeled, but frequently observed, dividend payments from subsidiaries,[9] which enhance the sponsor's incentive to borrow (see Nicodano and Regis 2019). We expect the threshold interest rate, $\bar{r}$, triggering the sale of a subsidiary to a private equity fund, to be lower for sponsors receiving larger dividend distributions.

From a policy perspective, the model highlights a composition effect in risk-taking. As interest rates fall, risk is reallocated within organizations rather than uniformly reduced. Backed units become more leveraged and riskier, while sponsors reduce leverage and default risk. This implies that aggregate default risk may evolve differently from firm-level risk, and that monitoring organizational structure is essential for financial stability assessments.

At the same time, the analysis points to a potential divergence between privately optimal and socially optimal structures. At low interest rates, complex organizations maximize value by concentrating leverage in backed units, but this may increase total default costs relative to stand-alone firms. Such divergence does not occur at the higher interest rate level, as complex organizations are both privately and socially optimal.

9. See e.g. Almeida and Wolfenzon 2006; Anantavrasilp et al. 2020; Desai et al. 2004.

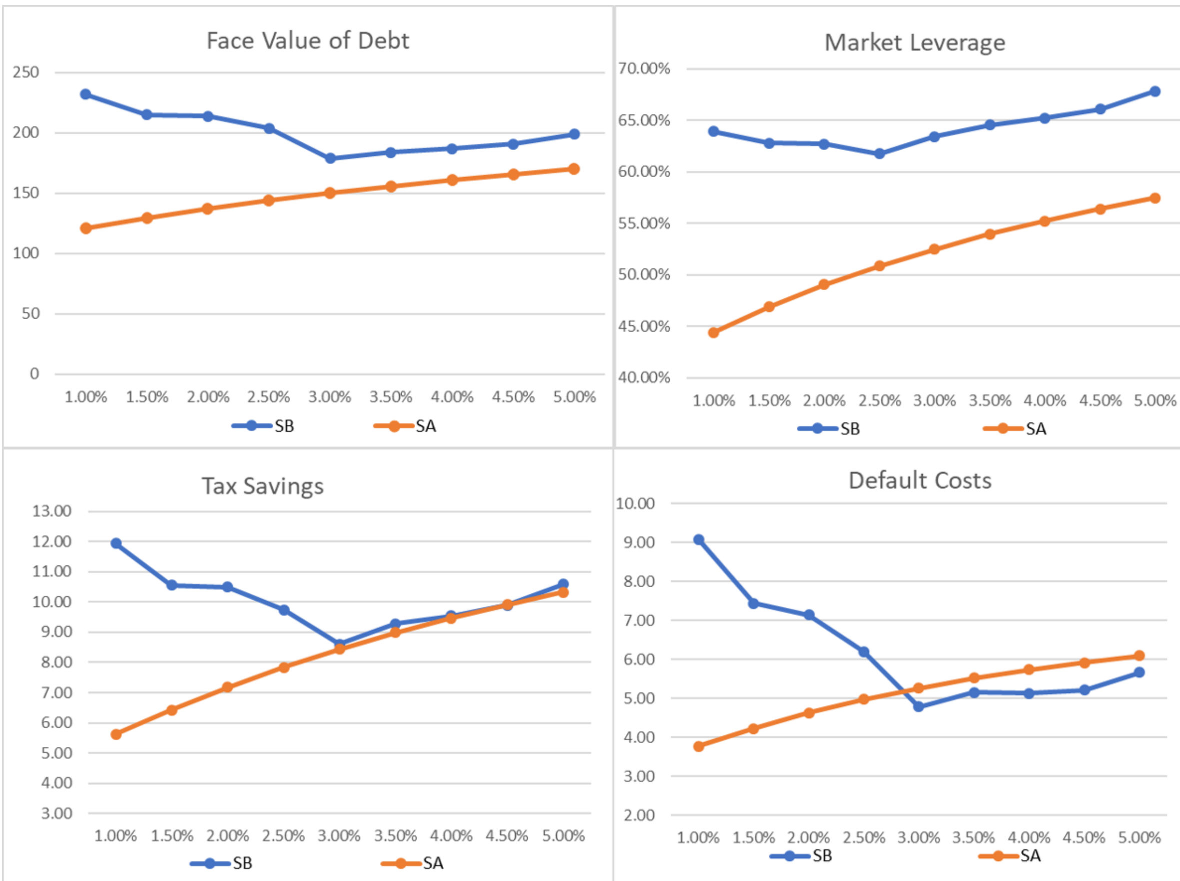

Figure 3: This figure portrays the optimal debt (face value and market value), default costs and tax savings of the sponsor/backed unit arrangement (in blue) when interest rate ranges from 1% to 5% and compares the figures with those of equivalent stand-alone units (orange). In the upper left panel, the red line depicts the optimal debt of the sponsor.

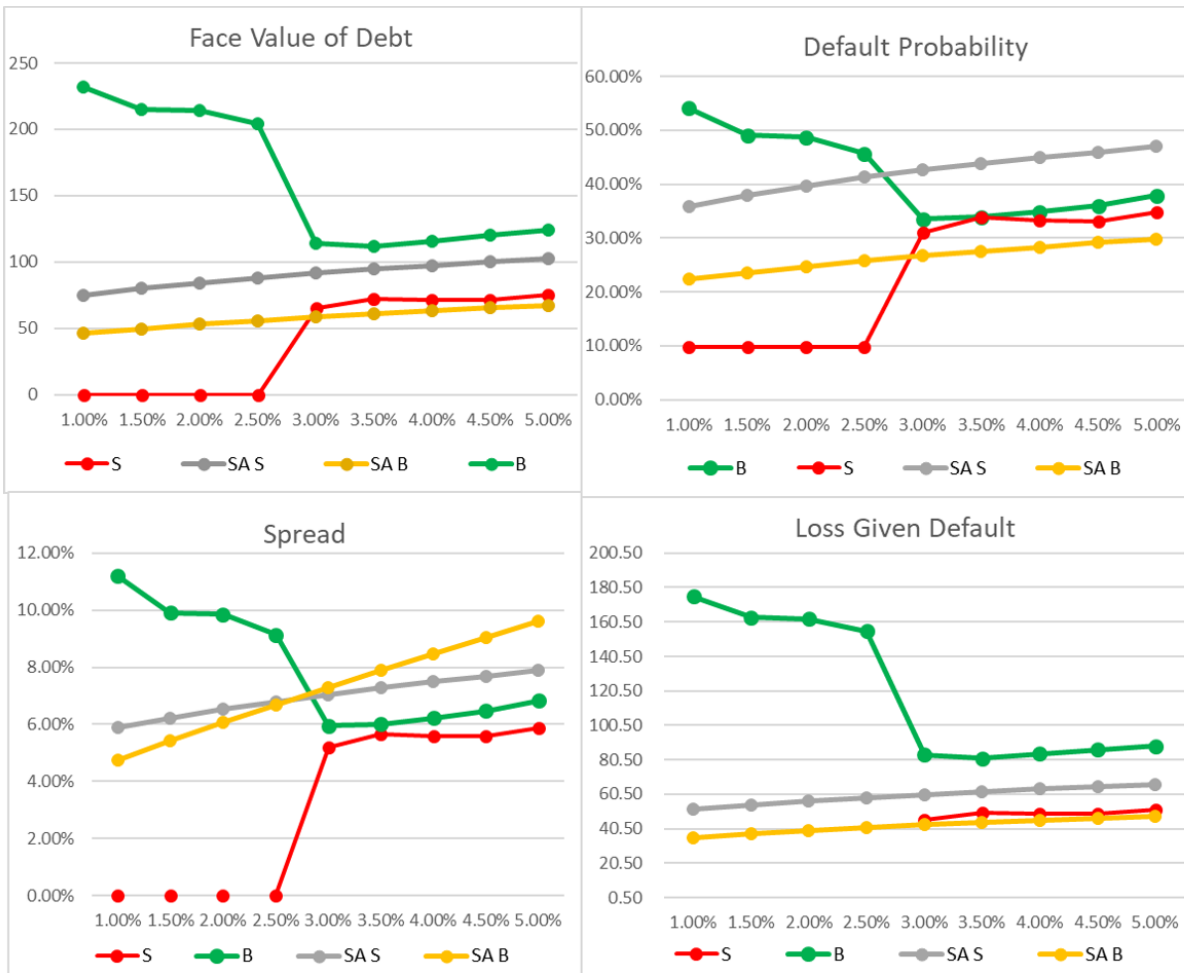

Figure 4: This figure portrays the debt (face value), default probabilities, spreads and loss given defaults of the sponsor (red), the backed unit (green) and compares their figures with those of equivalent stand-alone units (in grey and yellow, respectively). Spreads are annualized, the default probabilities are the probabilities that lenders are not repaid in full when the cash flows are realized at $T = 5$ years.

Table 4: Optimal Value and Debt — Transformation of a Complex Organization

Variable	Correlation -0.8, Interest Rate 5%	-0.8, 1%	-0.2, 5%	-0.2, 1%	0, 5%	0, 1%	0.2, 5%	0.2, 1%	0.8, 5%	0.8, 1%
Face Value of Debt	187	171	186	158	190	192	199	232	239	251
	(73;114)	(54;117)	(82;104)	(58;100)	(80;110)	(0;192)	(75;124)	(0;232)	(29;210)	(0;251)
Market Value of Debt	116.79	133.82	111.76	120.42	112.86	124.74	115.70	130.49	116.64	131.22
	(43.83;72.96)	(41.21;92.61)	(47.92;63.85)	(43.79;76.62)	(47.04;65.82)	(0;124.74)	(44.79;70.91)	(0;130.49)	(19.48;97.16)	(0;131.22)
Equity Value	54.33	70.27	58.94	83.20	57.79	79.01	54.89	73.60	54.54	74.53
	(28.58;25.75)	(41.62;28.65)	(29.14;29.80)	(46.33;36.87)	(30.24;27.56)	(71.05;7.96)	(32.16;22.72)	(70.12;3.48)	(49.39;5.14)	(74.53;0)
Total Value	171.12	204.09	170.70	203.62	170.66	203.75	170.59	204.10	171.18	205.75
	(72.41;98.71)	(82.83;121.26)	(77.06;93.64)	(90.13;113.49)	(77.28;93.38)	(71.05;132.70)	(76.95;93.64)	(70.12;133.97)	(68.88;102.30)	(74.53;131.22)
Value of Leverage	5.47	2.94	5.05	2.47	5.01	2.60	4.96	2.98	5.53	4.66
Taxes	32.20	44.42	31.51	44.27	31.28	41.83	30.83	38.35	29.15	36.77
	(20.06;12.14)	(27.57;16.85)	(19.28;12.23)	(27.29;16.98)	(19.46;11.82)	(30.17;11.66)	(19.89;10.94)	(30.17;8.17)	(23.25;5.90)	(30.17;6.59)
Tax Savings	9.22	5.86	9.90	6.02	10.13	8.45	10.58	11.94	12.26	13.52
	(4.79;4.42)	(2.60;3.26)	(5.66;4.33)	(2.89;3.13)	(5.39;4.74)	(0;8.45)	(4.96;5.62)	(0;11.94)	(1.60;10.66)	(0;13.52)
Default Costs	3.78	3.10	4.86	3.58	5.15	6.01	5.67	9.08	6.76	8.97
	(2.12;1.66)	(1.39;1.71)	(2.77;2.09)	(1.64;1.94)	(2.62;2.53)	(0;6.01)	(2.26;3.41)	(0;9.08)	(0.26;6.50)	(0;8.97)
Yield	(10.74%;9.34%)	(5.55%;4.79%)	(11.34%;10.25%)	(5.78%;5.47%)	(11.20%;10.82%)	(N/A;9.01%)	(10.86%;11.83%)	(N/A;12.20%)	(8.28%;16.67%)	(N/A;13.85%)
Spread	(5.74%;4.34%)	(4.55%;3.79%)	(6.34%;5.25%)	(4.78%;4.47%)	(6.20%;5.82%)	(N/A;8.01%)	(5.86%;6.83%)	(N/A;11.20%)	(3.28%;11.67%)	(N/A;12.85%)
Default Probability	(33.91%;23.98%)	(26.88%;21.37%)	(37.82%;29.44%)	(28.52%;25.38%)	(36.93%;32.62%)	(9.73%;41.90%)	(34.77%;37.88%)	(9.73%;54.07%)	(17.37%;53.97%)	(9.68%;57.44%)
Joint Default Probability	3.94%	2.63%	14.14%	10.08%	17.71%	7.93%	21.72%	9.30%	17.36%	9.74%
Loss Given Default	(50.30;87.11)	(39.76;92.05)	(55.12;76.46)	(41.97;76.71)	(54.04;79.69)	(0;145.34)	(51.29;88.42)	(0;175.42)	(23.80;159.34)	(0;196.88)

Table 4: This table displays the optimal figures of a complex organization when the parameters for the two units are those in Table 1, apart from $\tau_P = 24\%, \tau_S = 16\%$, $\sigma_P = \sigma_S = \sigma = 44\%$, for two levels of interest rates, 5% and 1%. Sponsor and backed unit figures are reported in parentheses, respectively, while the total figure is outside the parenthesis. Cash flows are jointly normally distributed, with marginal distributions as in Table 1 and correlation parameter ranging from -0.8 to 0.8.

5. Concluding Remarks

This paper studies how organizational structure shapes the response of optimal leverage to changes in interest rates. In a multi-entity organization with contingent support arrangements, the standard trade-off prediction of deleveraging need not hold uniformly across affiliated entities. Instead, financing choices reflect both the tax benefits of debt and the value of preserving internal support capacity. As a result, changes in interest rates may alter not only the level of borrowing, but also its allocation within the organization and the associated distribution of credit risk.

The analysis uncovers a new channel of monetary transmission to leverage. Higher debt arises from the interaction between tax shields and internal support arrangements rather than from cheaper borrowing, moral hazard, or investors' search for yield. Importantly, greater borrowing may coexist with higher spreads and expected losses upon default, implying that financing conditions need not become safer even when interest rates decline.

These insights apply to a broad range of organizational forms, including leveraged buyout structures, securitization vehicles, and other entities connected through internal guarantees or support arrangements. More generally, the results imply that organizational structure is essential for understanding how interest rates affect leverage choices and credit risk across firms with otherwise similar characteristics.

The paper also carries implications for financial stability. In the model, changes in interest rates can increase leverage concentration and expected distress costs within particular organizational structures even in the absence of agency distortions. At the same time, risk may become redistributed rather than uniformly amplified, implying that aggregate outcomes depend on the composition of organizational forms within the economy. A fuller assessment of these equilibrium interactions remains an important avenue for future research. More broadly, the paper highlights how internal organizational arrangements shape the transmission of monetary conditions to leverage and credit risk.

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6. Appendix

6.1. Definition of the $h(\cdot)$ function

The function $h(X_B)$ defines the set of states of the world in which the sponsor has enough funds to intervene and save its affiliate from default, while at the same time remaining solvent. The rescue occurs if the cash flows of the sponsor X_S are enough to cover both its own debt obligations and the remaining part of those of the affiliate. The function $h(X_B)$, which defines the level of parent cash flows above which the rescue occurs, is defined as:

$$h(X_B) = \begin{cases} X_S^d + \frac{F_B}{1-\tau_B} - \frac{X_B}{1-\tau_B} = h_1(X_B) & X_B < X_B^Z, \\ X_S^d + X_B^d - X_B = h_2(X_B) & X_B \geq X_B^Z. \end{cases}$$

6.2. Expressions for $D_i^{SA}, E_i^{SA}, D_S, D_B, E_S, E_B$

This subsection collects the formal definitions of debt and equity values for stand-alone companies, sponsors, and backed units.

$$D_i^{SA} = \phi \left[(1-\alpha_i) \int_0^{X_i^Z} x f(x) dx + (1-\alpha_i-\tau_i) \int_{X_i^Z}^{X_i^d} x f(x) dx + \tau_i X_i^Z \int_{X_i^Z}^{X_i^d} f(x) dx + F_i \int_{X_i^d}^{+\infty} f(x) dx \right]. \tag{8}$$

$$E_i^{SA} = \phi \left[(1-\tau_i) \int_{X_i^d}^{+\infty} x f(x) dx + (\tau_i X_i^Z - F_i) \int_{X_i^d}^{+\infty} f(x) dx \right]. \tag{9}$$

$$D_S = \phi \left[(1-\alpha_S) \int_0^{X_S^Z} x f(x) dx + (1-\alpha_S-\tau_S) \int_{X_S^Z}^{X_S^d} x f(x) dx + \tau_S X_S^Z \int_{X_S^Z}^{X_S^d} f(x) dx + F_S \int_{X_S^d}^{+\infty} f(x) dx \right]. \tag{10}$$

$$E_S = \phi \left[(1-\tau_S) \int_{X_S^d}^{+\infty} x f(x) dx + (\tau_S X_S^Z - F_S) \int_{X_S^d}^{+\infty} f(x) dx \right] - \Psi(F_S, F_B). \tag{11}$$

$$D_B = \phi \Bigg[(1-\alpha_B) \int_0^{X_B^Z} \int_{-\infty}^{h_1(x)} x f(x,y) dx dy +$$

$$+(1-\alpha_B-\tau_B) \int_{X_B^Z}^{X_B^d} \int_{-\infty}^{h_2(x)} x f(x,y)\, dx\, dy + \tau_B X_B^Z \int_{X_B^Z}^{X_B^d} \int_{-\infty}^{h_2(x)} f(x,y) dx dy +$$

$$+F_B \left[\int_{X_B^d}^{+\infty} f(x)\, dx + \int_0^{X_B^Z} \int_{h_1(x)}^{+\infty} f(x,y)\, dx\, dy + \int_{X_B^Z}^{X_B^d} \int_{h_2(x)}^{+\infty} f(x,y)\, dx\, dy \right] \Bigg] + \Psi(F_S, F_B). \tag{12}$$

$$E_B = \phi \left[(1-\tau_B) \int_{X_B^d}^{+\infty} x f(x) dx + (\tau_B X_B^Z - F_B) \int_{X_B^d}^{+\infty} f(x) dx \right]. \tag{13}$$

$$\Psi(F_S, F_B) = \phi \left[\int_0^{X_B^Z} \int_{h_1(x)}^{+\infty} (F_B - x) f(x,y)\, dy\, dx + \int_{X_B^Z}^{X_B^d} \int_{h_2(x)}^{+\infty} \Big(F_B - \big[(1-\tau_B)x + \tau_B X_B^Z \big] \Big) f(x,y)\, dy\, dx \right] \tag{14}$$

Notice that

$$D_B = D_B^{SA}(F_B; D_B) + \Psi(F_S, F_B) + \Gamma(F_S, F_B), \tag{15}$$

where $D_B^{SA}(F_B, D_B)$ indicates the debt value of a stand-alone whose face value is F_B and whose thresholds X_B^Z and X_B^d are evaluated at the debt value D_B.

6.3. Proof of Lemma 1

We suppress the subscript i for simplicity. The derivative of the spread with respect to ϕ is

$$\frac{\partial s}{d\phi} = (-F^{\frac{1}{T}} \frac{1}{T} D^{-\frac{1}{T}-1} \frac{\partial D}{d\phi} + \frac{1}{T} \phi^{-\frac{1}{T}-1}) = \frac{1}{T} (\phi^{-\frac{1}{T}-1} - \left(\frac{F}{D}\right)^{\frac{1}{T}} \frac{1}{D} \frac{\partial D}{d\phi}).$$

This derivative is positive whenever

$$\phi^{-\frac{1}{T}-1} \geq F^{\frac{1}{T}} D^{-\frac{1}{T}-1} \frac{\partial D}{d\phi}$$

and, since $\frac{\partial D}{d\phi} \leq \frac{D}{\phi}$, a sufficient condition for $\frac{\partial s}{d\phi} \geq 0$ is

$$\phi^{-\frac{1}{T}-1} \geq F^{\frac{1}{T}} D^{-\frac{1}{T}-1} \frac{D}{\phi}.$$

This is true iff

$$\left(\frac{1}{\phi}\right)^{\frac{1}{T}} \geq \left(\frac{F}{D}\right)^{\frac{1}{T}},$$

which implies $\phi \leq \frac{D}{F}$. This is never the case unless $F = 0$ because $D \leq \phi F, D < F$ when $F > 0$.

6.4. Proof of Proposition 1

The derivatives of the expected discounted values of taxes and default costs are respectively (we suppress dependence on F_i and the subscript i for notational convenience):

$$\begin{aligned} \frac{\partial T}{d\phi} &= \frac{T}{\phi} - \frac{\partial X^Z}{d\phi}(1 - F(X^Z))\phi\tau && (16) \\ \frac{\partial C}{d\phi} &= \alpha\phi\frac{\partial X^d}{d\phi}X^d f(X^d)\phi\alpha + \frac{C}{\phi}. && (17) \end{aligned}$$

Recalling that $X^Z = F - D$, $X^d = F + \frac{\tau}{1-\tau}D$, indeed we have:

$$\frac{\partial X^Z}{d\phi} = -\frac{\partial D}{d\phi}, \tag{18}$$

$$\frac{\partial X^d}{d\phi} = \frac{\tau}{1-\tau}\frac{\partial D}{d\phi}. \tag{19}$$

Hence, we need to focus on the derivative of market debt value with respect to ϕ, for fixed F (dependence of D on F is suppressed for notational convenience):

$$\begin{aligned} \frac{\partial D}{d\phi} &= \frac{D}{\phi} + \phi\left[(1-\alpha)\frac{\partial X^d}{d\phi}X^d f(X^d) - \tau\frac{\partial X^d}{d\phi}\left(X^d - X^Z\right)f(X^d) + \tau\frac{\partial X^Z}{d\phi}\left[G(X^d) - G(X^Z)\right] + \right. \\ &- \left. F\frac{\partial X^d}{d\phi}f(X^d)\right] \\ \frac{\partial D}{d\phi} &= \frac{D}{\phi} + \phi\left[(1-\alpha)\frac{\partial X^d}{d\phi}\left(\frac{\tau}{1-\tau}D\right)f(X^d) - \alpha F\frac{\partial X^d}{d\phi}f(X^d) - \tau\frac{\partial X^d}{d\phi}\left(X^d - X^Z\right)f(X^d) + \right. \\ &+ \left. \tau\frac{\partial X^Z}{d\phi}\left[G(X^d) - G(X^Z)\right]\right] \\ \frac{D}{\phi} &= \frac{\partial D}{d\phi}\left[1 - \phi(1-\alpha)\left(\frac{\tau}{1-\tau}\right)\left(\frac{\tau}{1-\tau}D\right)f(X^d) + \phi\alpha F\frac{\tau}{1-\tau}f(X^d) + \right. \\ &+ \left. \phi\tau\frac{\tau}{1-\tau}\left(X^d - X^Z\right)f(X^d) + \phi\tau\left[G(X^d) - G(X^Z)\right]\right] \implies \frac{\partial D}{d\phi} = \frac{D}{\phi}\frac{1}{\kappa} \end{aligned}$$

Since $\frac{D}{\phi} \geq 0$, the sign of $\frac{\partial D}{d\phi}$ depends on the sign of κ. Rearranging it, we have:

$$\begin{aligned}
\kappa &= 1 - \phi(1-\alpha)\left(\frac{\tau}{1-\tau}\right)\left(\frac{\tau}{1-\tau}D\right) f(X^d) + \phi\alpha F \frac{\tau}{1-\tau} f(X^d) + \\
&+ \phi\tau \frac{\tau}{1-\tau}\frac{D}{1-\tau} f(X^d) + \phi\tau\left[F(X^d) - F(X^Z)\right] = \\
&= 1 + \phi\alpha\left(\frac{\tau}{1-\tau}\right)\left(\frac{\tau}{1-\tau}D\right) f(X^d) + \phi\alpha F \frac{\tau}{1-\tau} f(X^d) + \phi\tau\left[F(X^d) - F(X^Z)\right] \geq 1.
\end{aligned}$$

As a consequence, using (18) and (19), we have $\frac{\partial X^Z}{d\phi} \leq 0$ and $\frac{\partial X^d}{d\phi} \geq 0$, i.e. the tax shield decreases (increases) and the no-default threshold increases (decreases) with the discount factor ϕ (the interest rate r). This proves part (a) of the proposition.

Also, we have that

$$\left|\frac{\partial X^Z}{d\phi}\right| > \left|\frac{\partial X^d}{d\phi}\right| \implies 1 > \frac{\tau}{1-\tau}$$
$$i.e.\ \tau < \frac{1}{2}.$$

which proves part (b) of the proposition.

Using (16) and (17), it follows directly from part (a) that $\frac{\partial T}{d\phi} \geq 0$ and $\frac{\partial C}{d\phi} \geq 0$, which proves part (c).

6.5. Proof of Proposition 2

When proving Proposition 1, we proved that $\frac{\partial D}{d\phi} \geq 0$ for fixed F. To prove that the value of the SA is increasing with ϕ, we have to prove now that the equity value is increasing in ϕ as well, for fixed F:

$$\begin{aligned}
\frac{\partial E}{d\phi} &= \frac{E}{\phi} + \phi\left[-(1-\tau)\frac{\partial X^d}{d\phi}X^d f(X^d) + F\frac{\partial X^d}{d\phi}X^d f(X^d)\right] = \\
&= \frac{E}{\phi} + \phi\frac{\partial X^d}{d\phi} f(X^d)\left[\tau X^d - \frac{\tau}{1-\tau}D\right] = \frac{E}{\phi} + \phi\frac{\partial X^d}{d\phi} f(X^d)\left[\tau F + \tau\frac{\tau}{1-\tau}D - \frac{\tau}{1-\tau}D\right] = \\
&= \frac{E}{\phi} + \phi\frac{\partial X^d}{d\phi} f(X^d)\left[\tau F - \tau D\right].
\end{aligned}$$

The above expression is always strictly greater than zero, as long as $F \geq D$. This implies that the value of the firm, which is the sum of D and E, increases in ϕ (decreasing in the interest rate) for any F.

6.6. The optimal face value of debt in the stand alone unit.

Proposition 4. *Assume convexity of the objective (2) and $\frac{\partial^2 D}{\partial F \partial \phi} > 0$, so that a decline in the interest rate raises the marginal contribution of leverage to the debt value. Then the optimal face value of debt in a stand alone unit decreases as the interest rate falls if*

$$\frac{\partial MDC}{\partial \phi} > \frac{\partial MTS}{\partial \phi}, \tag{20}$$

with all terms evaluated at the optimum. This condition holds for every $\alpha > 0, \tau > 0$ if $f'(X^d) \geq 0$ and $\frac{\partial^2 D}{\partial F \partial \phi}(1 - G(X^Z)) - (1 - \frac{\partial D}{\partial F})f(X^Z)\frac{\partial D}{\partial \phi} \geq 0$. If we let $\alpha \to 1$ the condition is verified for every $0 < \tau < 1$. If $\tau \to 0$ optimal (zero) debt is unaffected by a change in the interest rate.

Proof. Let us derive the condition. First, we turn to the F.O.C. for the stand alone firm. Define $\Psi(F, \phi)$ as the sum of the marginal tax burden and default costs. It reads

$$\Psi(F, \phi) = -\tau \frac{dX^Z}{dF}\left(1 - G(X^Z)\right) + \alpha X^d f(X^d) \frac{dX^d}{dF}. \tag{21}$$

We know that

$$\Psi(F^*, \phi) = 0$$

where F^* is the optimum. Since F^* is $F^*(\phi)$, we have

$$\Psi(F^*(\phi), \phi) = 0$$

Let us differentiate both sides wrt ϕ now:

$$\frac{\partial \Psi}{\partial F} \cdot \frac{dF^*}{d\phi} + \frac{\partial \Psi}{\partial \phi} = 0$$

Then, we have :

$$\frac{dF^*}{d\phi} = -\frac{\frac{\partial \Psi}{\partial \phi}|_{F=F^*}}{\frac{\partial \Psi}{\partial F}|_{F=F^*}}.$$

For simplicity, from here onwards we omit dependence of the derivatives on the r.h.s. and all of the following quantities on F^*, which is the value of F at which they are evaluated. $\frac{\partial \Psi}{\partial F} > 0$, because F^* is a minimum. As a consequence, the sign of $\frac{dF^*}{d\phi}$ is opposite to the sign of $\frac{\partial \Psi}{\partial \phi}$. Then, to ensure

$\frac{dF^*}{d\phi} < 0$ (F^* decreasing with ϕ,i.e. increasing with r), we obtain the following condition:

$$\underbrace{-\tau\frac{\partial^2 X^Z}{\partial F\partial\phi}[1-G(X^Z)] + \tau\frac{\partial X^Z}{\partial F}f(X^Z)\frac{\partial X^Z}{\partial\phi}}_{\text{Marginal tax burden change}} + \tag{22}$$

$$+\,\alpha\underbrace{\left[\frac{\partial^2 X^d}{\partial F\partial\phi}X^d f(X^d) + \frac{\partial X^d}{\partial F}\frac{\partial X^d}{\partial\phi}f(X^d) + \frac{\partial X^d}{\partial F}X^d f'(X^d)\frac{\partial X^d}{\partial\phi}\right]}_{\text{Marginal default cost change}} > 0. \tag{23}$$

It follows that

$$\frac{\alpha}{\tau} > \frac{\frac{\partial^2 X^Z}{\partial F\partial\phi}[1-G(X^Z)] - \frac{\partial X^Z}{\partial F}f(X^Z)\frac{\partial X^Z}{\partial\phi}}{\frac{\partial^2 X^d}{\partial F\partial\phi}X^d f(X^d) + \frac{\partial X^d}{\partial F}\frac{\partial X^d}{\partial\phi}f(X^d) + \frac{\partial X^d}{\partial F}X^d f'(X^d)\frac{\partial X^d}{\partial\phi}}, \tag{24}$$

where the numerator of the r.h.s. is the marginal tax benefit change when ϕ changes, for a unitary tax rate, and the denominator is the marginal default cost change when ϕ changes, for a unitary default cost rate.

The assumption $\frac{\partial^2 D}{\partial F\partial\phi} > 0$ implies that $\frac{\partial^2 X^Z}{\partial F\partial\phi} < 0$ and $\frac{\partial^2 X^d}{\partial F\partial\phi} > 0$.

Hence:

- $-\tau\frac{\partial^2 X^Z}{\partial F\partial\phi}[1-G(X^Z)] > 0$.
- $\tau\frac{\partial X^Z}{\partial F}f(X^Z)\frac{\partial X^Z}{\partial\phi} < 0$.
- $\frac{\partial^2 X^d}{\partial F\partial\phi}X^d f(X^d) > 0$.
- $\frac{\partial X^d}{\partial F}\frac{\partial X^d}{\partial\phi}f(X^d) > 0$.
- $\frac{\partial X^d}{\partial F}X^d f'(X^d)\frac{\partial X^d}{\partial\phi}$: its sign depends on whether the slope of the density is positive or negative.

Since by assumption $\frac{\partial^2 D}{\partial F\partial\phi} > 0$, the denominator of the r.h.s. of (24) is surely positive as soon as $f'(X^d) \geq 0$. Assume this is the case. Since $\frac{\partial X^Z}{\partial\phi} = -\frac{\partial D}{\partial\phi}$, $\frac{\partial X^d}{\partial\phi} = \frac{\tau}{1-\tau}\frac{\partial D}{\partial\phi}$, we can rewrite the numerator in (24) as:

$$(1-\frac{\partial D}{\partial F})f(X^Z)\frac{\partial D}{\partial\phi} - \frac{\partial^2 D}{\partial F\partial\phi}(1-G(X^Z)). \tag{25}$$

When this numerator is negative, tax benefits are decreasing in ϕ and F^* is decreasing in ϕ for any α and τ. This happens if

$$\frac{\partial^2 D}{\partial F\partial\phi}(1-G(X^Z)) > (1-\frac{\partial D}{\partial F})f(X^Z)\frac{\partial D}{\partial\phi}.$$

To complete the proof, let us notice that, when $\alpha \to 1$ and $\tau > 0$, then $F^* \to 0$. Then, looking at equation (23), it is easy to see that the l.h.s. is always positive. When $\tau \to 0$, instead, the l.h.s. is always zero and the F.O.C. is unaffected by a change in ϕ. ■

6.7. Proof of Proposition 4

Following Nicodano and Regis (2019), a necessary and sufficient condition for the sponsor to be zero-leverage is:

$$\begin{aligned}\frac{\tau_S(1-G(0))(1-\phi(1-G(0)))}{\alpha_B\left[1+\frac{\tau_S}{1-\tau_S}\phi(1-G(0))\right]} \quad &\leq \quad \int_0^{X_B^{Z,*}} xg\left(x, \frac{F_B^*}{1-\tau_B} - \frac{x}{1-\tau_B}\right)dx + \\ &+ \quad \int_{X_B^{Z,*}}^{X_B^{d,*}} xg\left(x, X_B^{d,*} - x\right)dx, \qquad (26)\end{aligned}$$

where $X_B^{Z,*}, X_B^{d,*}$ indicate the tax shield and the no-default threshold of an optimally leveraged backed unit. The condition ensures that, when the sponsor's debt marginally increases, the increase in the sponsor's tax savings (on the lhs) is no larger than the increase in the backed unit's default costs (on the rhs) which are saved through the guarantee.

The left hand side of the above inequality is decreasing in ϕ (increasing with r), because its derivative with respect to ϕ is negative and it reaches a finite lower bound when $\phi \to \infty$, while the right hand side is increasing in ϕ for a fixed F_B and diverges when ϕ goes to infinity. Then, a $\bar{\phi}$ (or, equivalently, $\bar{r}$) such that (26) is satisfied as an equality exists and, for any $\phi \geq \bar{\phi}$ or, alternatively, for $r \leq \bar{r}$, the condition will be satisfied and the sponsor will be zero-leverage. Since the right hand side is increasing in F_B, it is sufficient to evaluate the condition at a (fixed) level of $F_B \geq F_B^*$ to obtain a necessary condition for the sponsor to be zero-leverage. Since the rhs of (26) does not depend on τ_S, then $\bar{r}$ increases in τ_S as soon as it is < 0.5. This happens because the lhs of (26) increases in τ_S as soon as $\tau_S < 0.5$.

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