

Koussis, Nicos; Menoncin, Francesco; Panteghini, Paolo M.

Working Paper

The Relationship Between Leverage and Profitability: The Role of Tax Depreciation Allowances

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The relationship between leverage and profitability: the role of tax depreciation allowances

Nicos Koussis*, Francesco Menoncin[†] and Paolo M. Panteghini[‡]

May 21, 2025

Abstract

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JEL Classification: G32, H25.

Keywords: capital structure, contingent claims, corporate taxation, profitability, trade-off model.

*Corresponding author. Frederick University Cyprus. Department of Business Administration, 7, Y. Frederickou Str. Pallouriotisa, Nicosia 1036, Cyprus. Email: n.koussis@frederick.ac.cy.

[†]Università degli Studi di Brescia and Fondazione Eni Enrico Mattei (FEEM). Email: francesco.menoncin@unibs.it.

[‡]Università degli Studi di Brescia and CESifo. Email : paolo.panteghini@unibs.it

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[†]Università degli Studi di Brescia and Fondazione Eni Enrico Mattei (FEEM).

[‡]Università degli Studi di Brescia and CESifo.

1 Introduction

There is an extensive debate about the impact of corporate taxation on financial decisions. The two leading theories—the Pecking Order Theory (POT) and the TOT—offer competing explanations of firms’ financing behavior. According to POT, firms prefer internal financing over debt and equity, with debt favored over new equity due to lower information costs (Myers; 1984, 1993). This implies that more profitable firms tend to borrow less. Hence, the POT predicts a negative relationship between leverage and profitability, a pattern often supported by empirical evidence. Supporters of POT argue that corporate taxation has a negligible effect on financing decisions. Despite its success, there is evidence that taxation affects capital structure decisions (e.g., Heider and Ljungqvist; 2015). There is also evidence that when tax depreciation is accelerated, firms enjoy greater tax savings, enabling them to expand investments, increase employment, improve total factor productivity, or reduce IPO underpricing (Zeng et al.; 2025).

The TOT provides a natural framework to understand the effect of taxes, but it is often criticized for not explaining the negative leverage-profitability relationship. However, TOT models can also produce this result, albeit with added complexity. Generalizing the TOT framework of Goldstein et al. (2001), Sarkar and Zapatero (2003) shows that with a mean-reverting process the relationship between leverage and profitability comes negative. Their model is static, assuming that indebtedness cannot be adjusted over time. In contrast, dynamic TOT-based models, such as Strebulaev (2007), also predict a negative leverage-profitability relationship when debt adjustment is infrequent due to frictions. More recently, Agliardi et al. (2024) demonstrate that the leverage-profitability relationship becomes U-shaped in the presence of growth options, regardless of the earnings process.

This article develops a simple static TOT framework and demonstrates the ambiguity of the leverage-profitability relationship. We use a model similar to Goldstein et al. (2001), but with a key modification: we assume that EBITDA, rather than EBIT, is stochastic. This change allows us to explicitly model TDA. While DeAngelo and Masulis (1980) show that non-debt tax shields can substitute for debt leverage, their analysis focuses on personal taxation differences among claimholders. In contrast, our approach enables the study of TDA within a contingent claims, under the TOT.

Focusing on standard TOT arguments, our model predicts a positive relationship between TDA and leverage. Importantly, for a wide range of realistic parameter values, it also generates a negative leverage-profitability relationship, without relying on complexities such as mean reversion, adjustment frictions, or information asymmetries. A key source of divergence between our results and EBIT-based models lies in the elasticity of interest payments with respect to EBITDA. In EBIT-based models, this elasticity is always one, so leverage remains unaffected by profitability. In our model, however, TDA reduce this elasticity, leading to under-reaction of interest payments to EBITDA changes. This mechanism helps explain the ambiguous sign of the leverage-profitability relationship.

For most realistic parameter values, we find a negative relationship consistent with empirical findings (e.g., Frank and Goyal; 2009). However, the relationship turns positive under high business volatility. Notably, other standard predictions of TOT remain intact: leverage is negatively related to volatility and bankruptcy costs, and positively related to tax rates. Furthermore, leverage increases as the expected firm duration shortens, while the introduction of a possible sudden stop (finite horizon) has no effect on the leverage–profitability relationship.

The remainder of the article is structured as follows: Section 2 introduces the model, Section 3 presents the numerical findings, and Section 4 concludes with key policy implications.

2 The model

Let us focus on a representative firm’s EBITDA, defined as Π_t , that evolves as follows:

$$\frac{d\Pi_t}{\Pi_t} = \mu dt + \sigma dz_t \text{ with } \Pi_0 > 0, \quad (1)$$

where μ is a deterministic drift, σ is the instantaneous standard deviation of $\frac{d\Pi_t}{\Pi_t}$, and dz is the increment of a Wiener process. Moreover, we also introduce a Poisson process. Accordingly, any time t , there is a probability λdt that the existing investment project (i.e., a machinery or plant) suddenly stops producing during the short interval dt . As shown by Dixit and Pindyck (1994, p. 270), the expected lifetime of a firm’s assets is $\mathbb{E}[T] = 1/\lambda$. Moreover, we introduce the following assumptions.

Assumptions:

1. Economic depreciation is constant and equal to λI where $\lambda > 0$, in line with the asset’s expected useful finite (though uncertain) life, and I is the initial asset. However, the TDA is calculated based on what can be recognized by tax authorities, at the rate $\lambda_F \leq \lambda$.
2. At time 0, the firm decides how much to borrow from a perfectly competitive risk-neutral financial market. Given the risk-free rate r , C is the coupon paid to lenders. Under no-arbitrage conditions, the market value of debt can then be derived (see Leland; 1994).
3. Debt is not renegotiable, in accordance with the static TOT.
4. If the firm does not meet its debt obligations (i.e., the firm’s EBITDA falls below a given threshold) and shareholders decide not to inject further resources, default occurs: the firm’s unlevered asset value—net of bankruptcy costs—is therefore expropriated by lenders, who become the new shareholders.
5. Default causes a cost which is given by the product between $\alpha \in (0, 1)$ and the unlevered firm’s value.

Given these assumptions, the after-tax cash flow is:

$$\Pi_t^N = (1 - \tau) (\Pi_t - C) + \tau \lambda_F I. \quad (2)$$

We therefore calculate $D(\Pi_t)$ and $E(\Pi_t)$, the values of debt and equity, respectively. Following Leland (1994), shareholders calculate the default threshold point $\underline{\Pi}$. Given $\underline{\Pi}$, the optimal coupon is then chosen.

As shown in Appendix A, the value of equity is:

$$E(\Pi_0) = (1 - \tau) \left(\frac{\Pi_0}{\delta + \lambda} - \frac{C}{r + \lambda} \right) + \frac{\tau \lambda_F I}{r + \lambda} - \frac{1}{\beta_2} \frac{1 - \tau}{\delta + \lambda} \underline{\Pi} \left(\frac{\Pi_0}{\underline{\Pi}} \right)^{\beta_2}, \quad (3)$$

where $\delta = r - \mu > 0$ is required for convergence (see Dixit and Pindyck; 1994), and

$$\underline{\Pi} = \frac{\beta_2}{\beta_2 - 1} \frac{\delta + \lambda}{r + \lambda} \left(C - \frac{\tau}{1 - \tau} \lambda_F I \right) \quad (4)$$

is the default threshold level.

We note that the final term in (3) captures the limited liability value of the equity option for shareholders which is positive since $\beta_2 < 0$.

Following the same procedure (Appendix A), the value of debt is:

$$D(\Pi_0) = \begin{cases} (1 - \alpha) \left[(1 - \tau) \frac{\Pi}{\delta + \lambda} + \frac{\tau \lambda_F I}{r + \lambda} \right], & \text{after default,} \\ \frac{C}{r + \lambda} + \left[(1 - \alpha) \left[(1 - \tau) \frac{\Pi}{\delta + \lambda} + \frac{\tau \lambda_F I}{r + \lambda} \right] - \frac{C}{r + \lambda} \right] \left(\frac{\Pi_0}{\underline{\Pi}} \right)^{\beta_2} & \text{before default.} \end{cases} \quad (5)$$

Using (3), (5) and (4), the Net Present Value at time 0 is given by:

$$\begin{aligned} NPV(\Pi_0) &= \frac{1 - \tau}{\delta + \lambda} \Pi_0 + \frac{\tau}{r + \lambda} (C + \lambda_F I) - I \\ &\quad + \frac{1}{r + \lambda} \left(\phi C + \frac{\alpha}{\beta_2 - 1} \tau \lambda_F I \right) \left(\frac{\Pi_0}{C - \frac{\tau}{1 - \tau} \lambda_F I} \frac{r + \lambda}{\delta + \lambda} \frac{\beta_2 - 1}{\beta_2} \right)^{\beta_2}, \end{aligned}$$

where $\phi \equiv -\tau - (1 - \tau) \alpha \frac{\beta_2}{\beta_2 - 1} < 0$.

The optimal coupon is therefore obtained by solving:

$$\max_C NPV(\Pi_0). \quad (6)$$

Appendix B shows that the optimal coupon C solves the following non-linear equation:

$$1 = \left(1 - \frac{\beta_2 (1 + \alpha \frac{1 - \tau}{\tau}) C}{C - \frac{\tau}{1 - \tau} \lambda_F I} \right) \left(\frac{\Pi_0}{C - \frac{\tau}{1 - \tau} \lambda_F I} \frac{r + \lambda}{\delta + \lambda} \frac{\beta_2 - 1}{\beta_2} \right)^{\beta_2}, \quad (7)$$

subject to the constraint $C > \frac{\tau}{1 - \tau} \lambda_F I$ which ensures $\Pi_0 > 0$. (7) shows that the relationship between Π and C is non-linear. To gain further insight, we

compute the elasticity $\varepsilon \equiv \frac{dC}{C} \frac{\Pi_0}{d\Pi_0}$. Using Dini's implicit function theorem on (7) gives:

$$\varepsilon = \frac{1}{1 - \frac{\beta_2(\frac{\tau}{1-\tau} + \alpha)\lambda_F I}{(1 - \beta_2 - \alpha\beta_2\frac{1-\tau}{\tau})C - \frac{\tau}{1-\tau}\lambda_F I}} \left(1 - \frac{\tau}{1-\tau}\lambda_F \frac{I}{C}\right). \quad (8)$$

If $\lambda_F = 0$, (8) simplifies to $\varepsilon = 1$. This result matches that obtained in an EBIT-based model and implies that the leverage-ROA relationship is flat (i.e., no relationship). However, when $\lambda_F > 0$, (8) becomes non-linear and more complex. From the shareholder's perspective, depreciation provides additional tax shields and delays the default timing, thereby increasing equity value. Lenders also benefit: the default trigger point may be lower, and they may enjoy the TDA through unlevered assets. These offsetting effects introduce non-linearities, making a numerical analysis essential for fully understanding the leverage-profitability relationship.

3 Numerical analysis

Let us next analyze the relationship between the leverage ratio, defined as $L \equiv D(\Pi_0) / (D(\Pi_0) + E(\Pi_0))$, and the Return on Assets, given by $(ROA = \Pi_0/I - \lambda)$ using parameter values.¹

TABLE 1 ABOUT HERE

Table 1 reports the relevant parameter values. The drift parameter μ is set to 1%. We use a benchmark volatility of 20%, and also consider a higher-volatility context with $\sigma = 40\%$. The risk-free interest rate is 3%. The depreciation rate is set equal to either 10% or 25%, corresponding to expected lifespans of 10 and 4 years, respectively. The investment cost is normalized to $I = 1$. As for default costs, empirical evidence is heterogeneous.² We adopt an intermediate and set $\alpha = 20\%$. The tax rate τ reflects the EU's average statutory tax rate and is close to the US rate.

FIGURES ABOUT HERE

Figures present our results across a broad range of ROA values, while checking the feasibility conditions $C - \frac{\tau}{1-\tau}\lambda_F I > 0$ (i.e., $\Pi_0 > 0$) and $NPV_t > 0$. Projects with very low ROA values may not satisfy these conditions and are therefore excluded from the figures, as such projects would not be undertaken. To avoid distorting TDA, we set $\lambda = \lambda_F$.

¹Similar results are obtained if one uses Π_0/I , a common definition in the literature. As pointed out by Singh et al. (2024) however the relevant literature focuses on our definition of ROA.

²Andrade and Kaplan (1998) estimate distress costs of 10–23% of firm value for a sample of 31 highly leveraged transactions. Branch (2002) finds a total default-related cost that ranges between 12.7% and 20.5%. Glover (2016) finds that the average firm expects a default cost equal to 45% of its value under default, though this figure drops to less than 25% among actual defaulting firms.

Figure 1 shows that, in the absence of TDA (i.e., when $\lambda_F = 0$), leverage remains invariant to ROA. This result aligns with EBIT-based models, such as Goldstein et al. (2001), where the elasticity of coupon with respect to profitability is one (see 8). In this case, increases in profitability lead to proportional increases in both debt and equity, keeping the leverage ratio constant.

In contrast, when TDA are positive, a negative relationship between leverage and ROA emerges. Our extensive sensitivity analysis (Figures 2–6) shows that, with $\lambda_F > 0$ (i.e., positive TDA), and across a wide range of parameter values, debt generally increases with profitability less compared to equity. This occurs because the elasticity $\varepsilon < 1$, leading to a decline in the leverage ratio as profitability rises. However, under conditions of very high business volatility (see Figure 2), this relationship may reverse and become positive.

Moreover, traditional predictions from the TOT are preserved. Leverage is decreasing in σ , μ and α , and is increasing in τ consistent with theory. Figure 6 demonstrates that faster depreciation (higher λ_F) leads to higher leverage. After default lenders indeed enjoy a more generous tax treatment. However, this effect diminishes and the relationship flattens at high ROA levels. This complementary role of TDA in supporting leverage contrasts with DeAngelo and Masulis (1980), who argued that TDA substitute for debt tax shields. Their analysis was based on personal taxation, whereas ours focuses on corporate tax allowances within a TOT framework.

Hence, we have provided a simple yet powerful framework for testing the predictions of the static TOT. Interestingly, the negative leverage–ROA relationship estimated by the empirical literature arise naturally within a static TOT by simply incorporating TDA. Other predictions also align with empirical findings (e.g., Frank and Goyal; 2009; Agliardi et al.; 2024).

We argue that the impact of TDA on leverage may be ambiguous, depending on whether personal taxation (as in DeAngelo and Masulis; 1980) or corporate tax credits (as in our model) dominate. Our analysis has important policy implications, suggesting that corporate capital structures are influenced not only by tax rates but also by government policies on TDA. While a negative leverage–ROA relationship generally holds, our sensitivity analysis shows that this relationship may weaken—or even reverse—in environments with low tax rates or high business volatility.

4 Conclusion

In this article, we have minimized the assumptions required to generate an ambiguous relationship between leverage and profitability (ROA). Despite our simplifying framework, the analysis highlights the critical role of volatility and TDA. Specifically, leverage and profitability may be negatively related in low-volatility environments, but this relationship can reverse and become positive under high-volatility conditions.

Our findings suggest that policymakers can influence corporate leverage decisions not only through statutory tax rates but also via the design of the tax

base, particularly through TDA. These allowances emerge as a key determinant of firms' capital structure. Furthermore, broader market conditions—such as business risk (proxied by EBITDA volatility) and features of the legal system that affect expected bankruptcy costs—also play an important role. These factors should be carefully considered when designing policies aimed at shaping corporate financial behavior.

A Appendix

Using dynamic programming (Dixit and Pindyck; 1994), the value of equity can be written as:

$$E(\Pi_t) = [(1 - \tau)(\Pi_t - C) + \tau\lambda_F I] dt + (1 - \lambda dt) e^{-r dt} \mathbb{E}[E(\Pi_t + d\Pi_t)]. \quad (9)$$

Using Itô's Lemma and simplifying (9) gives

$$(r + \lambda) E(\Pi_t) = [(1 - \tau)(\Pi_t - C) + \tau\lambda_F I] + \mu \Pi_t \frac{\partial E(\Pi_t)}{\partial \Pi_t} + \frac{\sigma^2}{2} \Pi_t^2 \frac{\partial^2 E(\Pi_t)}{\partial \Pi_t^2}, \quad (10)$$

whose general solution is

$$E(\Pi_t) = (1 - \tau) \left(\frac{\Pi_t}{\delta + \lambda} - \frac{C}{r + \lambda} \right) + \frac{\tau\lambda_F I}{r + \lambda} + H_1 \Pi_t^{\beta_1} + H_2 \Pi_t^{\beta_2}, \quad (11)$$

where $\beta_j = \frac{1}{2} - \frac{\mu}{\sigma^2} \pm \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2(r + \lambda)}{\sigma^2}}$ are the roots to the quadratic equation $\Psi(\beta_j) \equiv \frac{\sigma^2}{2} \beta_j (\beta_j - 1) + \mu \beta_j - (r + \lambda) = 0$, $j \in \{1, 2\}$. Using the Value Matching $E(\underline{\Pi}) = 0$ and Smooth Pasting condition $\left. \frac{\partial E(\Pi_t)}{\partial \Pi_t} \right|_{\Pi_t = \underline{\Pi}} = 0$ (see Panteghini; 2007) gives (3 and 4).

Similarly, the value of debt is:

$$D(\Pi_t) = \begin{cases} (1 - \alpha) [(1 - \tau) \Pi_t + \tau\lambda_F I] dt + (1 - \lambda dt) e^{-r dt} \mathbb{E}_t [D^j(\Pi_t + d\Pi_t)] & \text{after default,} \\ C dt + (1 - \lambda dt) e^{-r dt} \mathbb{E}_t [D^j(\Pi_t + d\Pi_t)] & \text{before default.} \end{cases} \quad (12)$$

Applying the Value Matching condition at the default threshold to (12) gives (5).

B Appendix

Solving the problem (6) gives the following F.O.C.:

$$\begin{aligned}
\frac{\partial NPV(\Pi_0)}{\partial C} &= \frac{\tau}{r+\lambda} + \epsilon \frac{\phi}{r+\lambda} \left(\frac{\Pi_0}{\frac{C}{r+\lambda} - \frac{\tau}{1-\tau} \frac{\lambda_F}{r+\lambda} I} \right)^{\beta_2} \\
&\quad - \beta_2 \epsilon \left(\phi \frac{C}{r+\lambda} - \frac{\alpha}{1-\beta_2} \frac{\tau \lambda_F}{r+\lambda} I \right) \left(\frac{\Pi_0}{\frac{C}{r+\lambda} - \frac{\tau}{1-\tau} \frac{\lambda_F}{r+\lambda} I} \right)^{\beta_2} \frac{\left(\frac{C}{r+\lambda} - \frac{\tau}{1-\tau} \frac{\lambda_F}{r+\lambda} I \right)^{-1}}{r+\lambda} \\
&= 0.
\end{aligned}$$

Rearranging gives (7). The S.O.C. is negative if $C - \frac{\tau}{1-\tau} \lambda_F I > 0$ (namely, $\Pi_0 > 0$).

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Tables and Figures

Table 1: The parameter values

Parameter	Base value	Alternative value
μ	0.01	
σ	0.2	0.4
r	0.03	
λ	0.1	0.25
λ_F	0.1	0.25
Π_0	Varies so that ROA=[0,0.2]	
α	0.2	
τ	0.25	

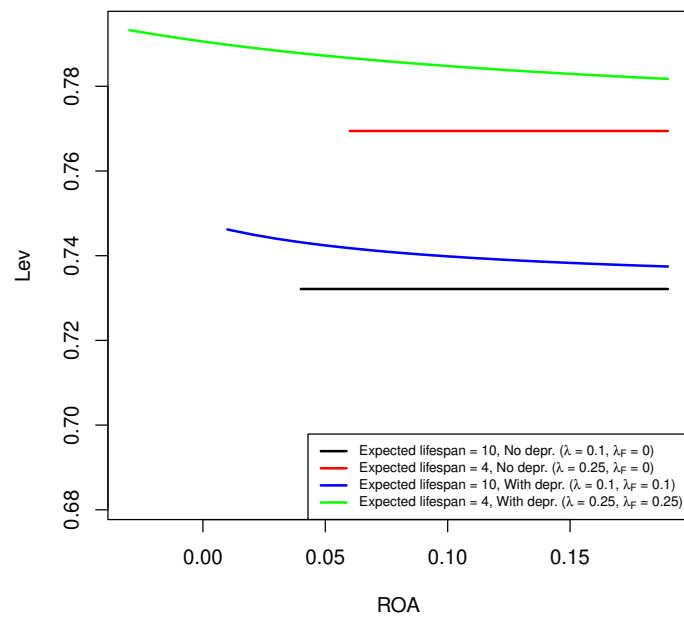


Figure 1: The effect of TDA on the leverage-ROA relation.

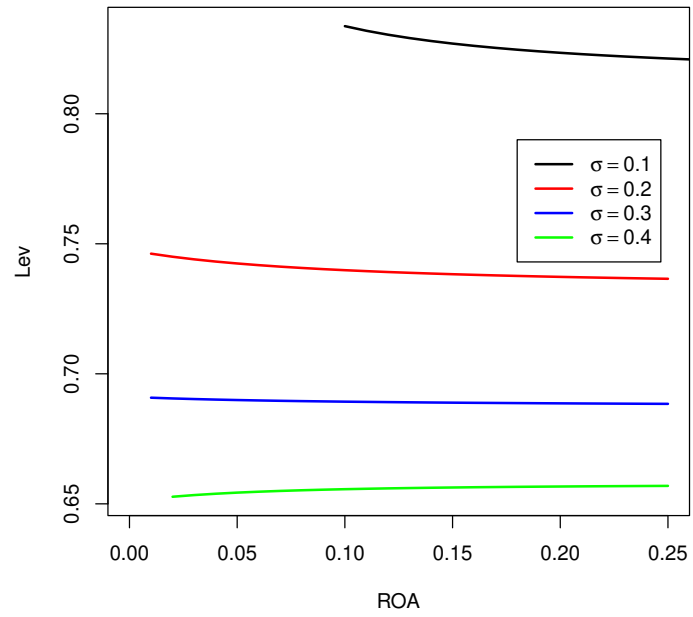


Figure 2: The effect of volatility.

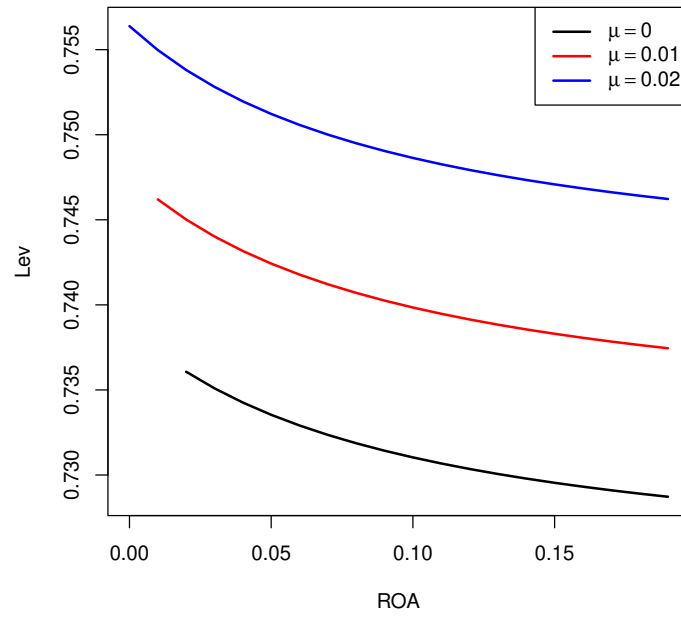


Figure 3: The effect of growth rate.

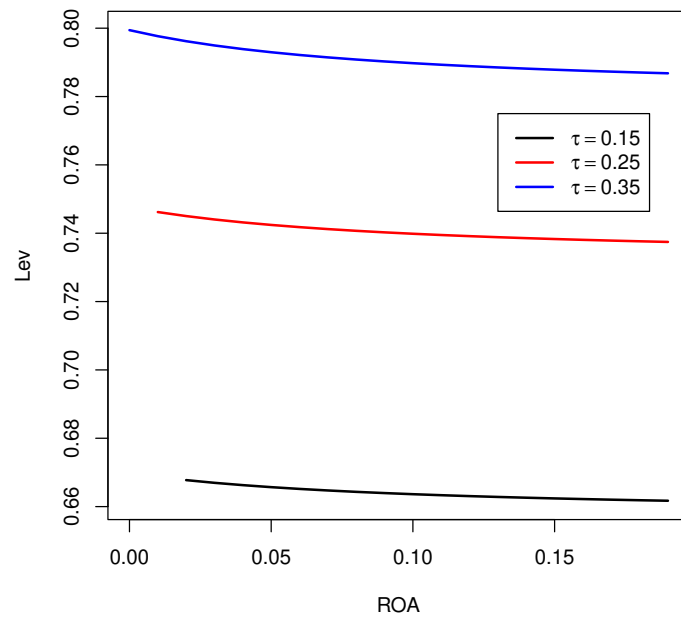


Figure 4: The effect of the tax rate.

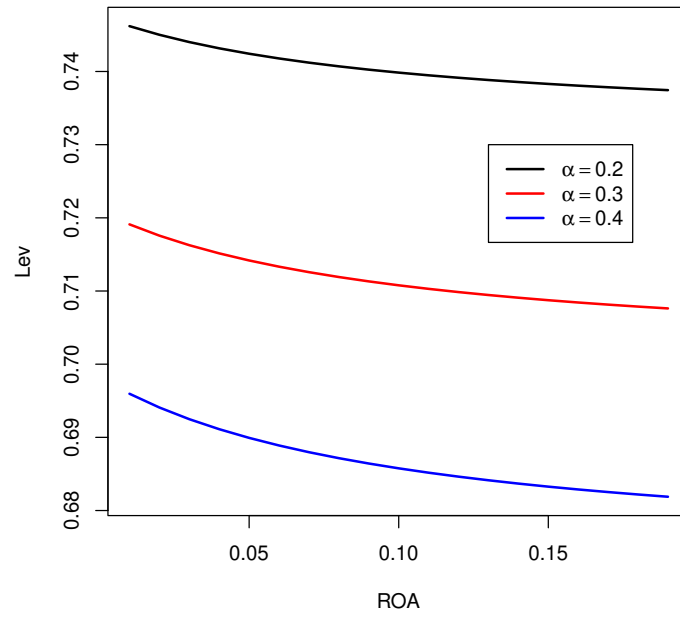


Figure 5: The effect of bankruptcy costs.

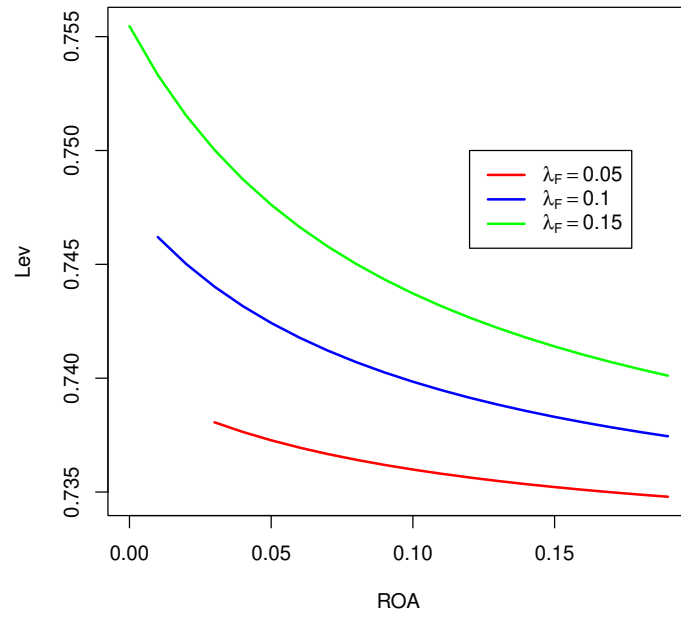


Figure 6: TDA with constant expected firm duration.