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Corporate taxation and financial strategies under asymmetric information

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Abstract In this article, we study the effects of corporate taxation on credit market equilibria in presence of asymmetric information. We develop a screening model that accounts for the following five facts: the existence of a tax incentive to borrow, the presence of asymmetric information in credit markets, the screening activity of lenders, the negative relationship between leverage and profitability, and the business cycle effects on the spread between high-yield and investment-grade interest rates on corporate loans. Assuming the existence of two types of firms, we show that either a separating or a pooling credit market equilibrium can arise, depending on the level of taxation. Finally, we analyze the joint effects of business cycle and taxation on the credit market equilibrium.

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1 Introduction

The deductibility of interest payments ensures a tax benefit to debt-financed firms. Accordingly, a fair amount of research has found evidence that debt usage is positively affected by corporate tax rates, as argued by Graham (2003). These results support the idea that companies can trade-off the tax benefits of debt finance with the expected costs of default, therefore obtaining an optimal capital structure.[1]

As stressed by Gordon (2010), corporate financial choices can also be explained by information asymmetries. In particular, Akerlof (1970) lemon problem fits well with capital markets. As pointed out by Myers and Majluf (1984), when corporations seek outside finance, investors learn that the firms need funds. For this reason, firms with less pressing needs for cash (those who are doing well) will forego outside finance, even at the cost of foregoing good investment projects. Only weaker firms borrow.[2] This fact is supported by robust evidence, showing that the use of debt declines when profitability rises and led Myers (1993) to state that taxation is irrelevant in terms of financial choices. Subsequently, he added that it is "of third-order importance" (Myers et al. 1998).[3]

This lively debate demonstrates that there is much to learn about the possible interactions between taxation and corporate finance. It is worth noting that this literature mainly focuses on the demand side of capital markets, thereby investigating the determinants of corporate capital structure. This is somewhat surprising, since lenders (in particular, banks and other financial institutions) crucially affect both the amount and the cost of debt. In our view, both sides of financial markets should be investigated. For this reason, we develop a screening

[1] This literature starts with Kraus and Litzenberger (1973) and has a relevant contribution by Leland (1994). More recently, Graham et al. (2011), e.g., find that firms with more debt and lower bond ratings in 1928 became financially distressed more frequently during the depression; this is consistent with the trade-off theory of leverage and the information production role of credit rating agencies (cross-country works). Similar evidence is found when tax effects on multinationals' capital structure are investigated [see e.g., the articles quoted in Miniaci et al. (2014)].

[2] A useful survey of the effects of corporate finance on capital structure is provided by Harris and Raviv (1991). Tirole (2006) develops a user-friendly analysis of all kinds of finance problems under asymmetric information. More recently, van Binsbergen et al. (2010) have shown that both tax and non-tax factors play a crucial role in determining the cost of debt. In particular, they point out that "default cost of debt amounts to approximately half of the total cost of debt, implying that agency costs and other nondefault costs contribute about half of the total ex ante costs of debt" (p. 2131).

[3] As shown by Strebulaev (2007) however, a negative relation between debt and profitability is also compatible with a dynamic trade-off model, where firms adjust their capital structure over time.

model that aims to study the effects of corporate taxation on credit market equilibria under asymmetric information.

To the best of our knowledge, only a few papers have dealt with public policies and the supply side of capital market.[4] Relevant exceptions are (de Meza and Webb 1999, 2000) who focus on public policy and welfare analysis, under credit rationing. Building upon the well-known contributions by Stiglitz and Weiss (1981) and de Meza and Webb (1987). Boadway and Keen (2006) generalize the findings of both papers by analyzing screening and signaling equilibria. In particular, they assume a continuum of potential firms, each with its own project characterized by a given probability and return in case of success, and a competitive banking sector. They investigate welfare-improving policy interventions. However, they admit that "it would be dangerous to draw any strong conclusions for policy", from their results and that "it is tempting to invoke the principle of insufficient reason to ... seek to impose any corrective tax or subsidy at all" (p. 501). In the same vein, Fuest and Tillessen (2005) study public assistance programs for entrepreneurial investment based on closed ended subsidies, namely, tax benefits granted only up to a certain absolute limit. To deal with the optimality of this policy they apply a three-stage model where banks offer loan contracts, then firms apply for the contract they prefer and finally banks decide whether to accept the application or not. They show that under asymmetric information, banks distort investment in order to prevent mimicking. In this case, open ended (i.e., unlimited) taxes or subsidies are preferable.

More recently, Minelli and Modica (2009) use the Stiglitz and Weiss (1981) approach to find optimal policies under asymmetric information. By assuming the existence of banks with market power, they study three kinds of policy tools: interest rate subsidies; investment subsidies; loan guarantees. They show that interest rate subsidies and loan guarantees are optimal to correct market equilibrium inefficiency. Simon (2011) provides an explanation for a government to discriminate between debt and equity financing. Assuming that entrepreneurs are risk-averse, she shows that equity generates more surplus than debt, because it also provides insurance. If, therefore, the government aims at extracting surplus from entrepreneurs it should tax equity-financed income more heavily.

The following interesting aspect, however, has been disregarded by public policy papers using asymmetric information: the effect of the business cycle on credit market conditions. As shown in Fig. 1, the spread between the high-yield and the investment-grade interest rates on corporate loans in the EU and US crucially depends on the business cycle.[5] In particular, downturns in 2001–2 and 2008–9 led to a sharp increase of this variable. We can claim that the interest rate paid by corporations of different types is closer (more different) during a recovery (downturn).

[4] See, e.g., the surveys by Graham (2003) and Hanlon and Heitzman (2010). See also Graham (1999, 2000), Graham et al. (1998), and Kaplow (2008).

[5] The source is Global Financial Stability Report published by the International Monetary Fund (2013) and according to which both Stock Market volatility and the expected GDP growth rate are crucial determinants of bank lending standards. Of course, industry or firm outlook also matters.

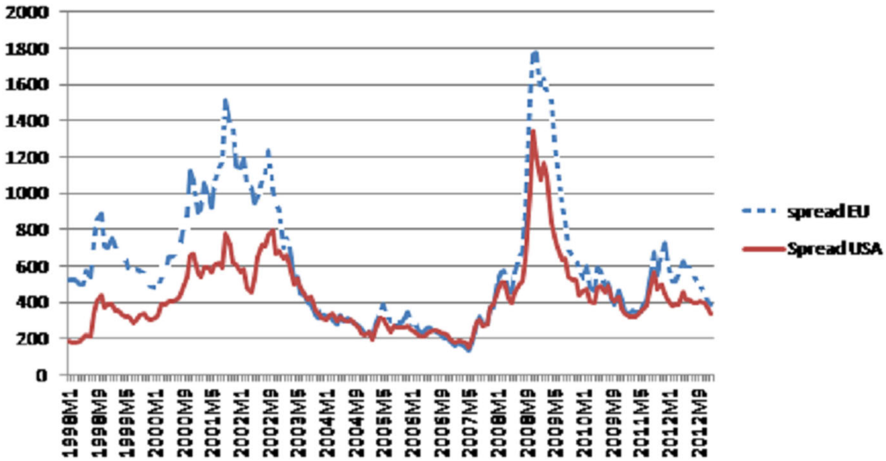

Fig. 1 The spread between the high-yield and the investment-grade interest rates on corporate loans (Global Financial Stability Report, October, 2013)

Our paper departs from the above articles in several respects. Firstly, we aim to set up a theoretical environment where five pieces of evidence are accounted for: (1) the existence of a tax incentive to borrow [see e.g., Miniaci et al. (2014)]; (2) the presence of asymmetric information in credit markets [see Gordon (2010), and the papers cited herein]; (3) the screening activity of lenders [see e.g., Bester (1985) and, especially, Besanko and Thakor (1987), who, as in our framework, use the loan size as a screening device]; (4) the negative relationship between leverage and profitability [see e.g., Miniaci et al. (2014)]; finally, (5) the business cycle effects on the spread between the high-yield and the investment-grade interest rates on corporate loans (see Fig. 1). This would lead us to consider both sides of capital markets. In addition, we highlight and investigate the joint effects of the business cycle and of taxation on credit market equilibrium.[6] In order to focus on the relationship between corporate taxation and the financial market, we depart from de Meza and Webb (1999, 2000) by assuming that credit is unconstrained.

Our two-period model assumes a given number of risk-neutral firms that invest under taxation. Firms can issue equity and/or apply for a loan from external lenders to finance an investment project, whose cost is normalized to unity. There are two types of firms: bad firms' projects succeed with lower probability and yield lower expected returns than good firms' ones. We assume the existence of a capital market with at least two homogeneous risk-neutral lenders competing *à la* Bertrand. In particular, they operate in an asymmetric information context, where firms'

[6] Our framework has some similarities with Cheong (1999), in that both articles study the interactions between taxation and corporate finance under asymmetric information. However, Cheong (1999) uses a signalling model where equilibria are separating, hence the level of corporate tax rate does not affect the type of equilibrium; at one of these equilibria, the debt-equity ratio of firms decreases with their profitability. Unlike our paper, the effect of the business cycle on the equilibrium is not studied in Cheong (1999).

probability of success in unverifiable. Borrowing is regulated through a loan contract characterized by interest rate and amount of funding. In addition, we let the lenders decide whether to commit or not to the contract proposed to firms, but not yet signed by the parties. In case of non-commitment, the lenders can reject loan applications. The converse is true if they commit.[7] Given these assumptions, we find three main results.

Firstly, if the percentage of bad firms in the economy is low relatively to that of good firms, a pooling equilibrium without commitment is found, where bad and good firms sign the same loan contract. Interestingly, the pooling equilibrium disappears when the option of non-commitment is absent, i.e., when the lenders cannot reject firms' applications for loans. By contrast, when the percentage of bad firms is large enough, a separating equilibrium arises, with or without commitment. In this case, good firms pay a lower interest rate but receive less debt than bad firms. Put differently, firms with less pressing needs for cash (i.e., good ones) have lower leverage.[8]

Secondly, the above result crucially depends on corporate taxation, in that the threshold portion of bad firm below (above) which a pooling (separating) equilibrium exists is affected by the level of corporate tax rate.

Finally, we provide some comparative statics on the portion of bad firms. We expect such a portion to increase during a downturn. In this case, we prove that the rise in the corporate spread between the high-yield (i.e., bad firms) and the investment-grade (good firms) interest rates, highlighted in Fig. 1, is more likely when the corporate tax rate is high enough. When, however, the portion of bad firms decreases (e.g., following a recovery), the reduction in the corporate spread, observed in Fig. 1, is more likely when the corporate tax rate is relatively low. Overall, we conclude that the impact of the business cycle on the credit market equilibrium can be affected by taxation. In the working-paper version of the paper (Cohen et al. 2014), we also provide a welfare analysis and discuss corporate tax policy implications.

The structure of the paper is as follows. The model is presented in Sect. 2, and describes financial choices under both symmetric and asymmetric information. Section 3 derives comparative statics results. Section 4 summarizes our findings and concludes. Appendices 1 and 5 contain the proofs of our results.

2 The model

Let us introduce a two-period model, where a continuum of risk-neutral firms decide whether and how to finance risky investment projects. For simplicity, each project requires a fixed amount of money, which is normalized to 1.

[7] The idea of contracts without commitment was first introduced by Wilson (1977) in the context of insurance markets with adverse selection. For a recent contribution, see Koufopoulos (2010).

[8] Note that, following the Wilson approach of contracts without commitment, a solution to the game played by firms and lenders always exists and is unique within the two parametric intervals. In this way, our paper overcomes the well-known problem of nonexistence of equilibrium in competitive screening games.

Let us assume that there are two types of firms, denoted by $i = L, H$. Each project yields A with probability $p_i \in (0, 1)$ or $a < A$ with probability $(1 - p_i)$.[9] We let $0 < p_L < p_H < 1$. Therefore, the expected gross return of firm i, when investing one unit of capital, is equal to

$$1 + R_i = 1 + p_i A + (1 - p_i)a, \tag{1}$$

with $R_H > R_L$. Firms earning the expected (net) return R_H (R_L) are defined good (bad) firms. A proportion $\lambda \in (0, 1)$ of firms is bad. The remaining proportion $(1 - \lambda)$ is good. Our firms have no cash holding and have access to two sources of finance, i.e., they can issue equity $E \in [0, 1]$ at zero cost and/or apply for a loan $B \in [0, 1]$ from external lenders.

Lenders operate in a competitive screening environment. Accordingly, there are at least two homogeneous risk-neutral lenders, who compete à la Bertrand. Due to asymmetric information they cannot observe the firms' good-state-return probability p_i. Borrowing is regulated through a loan contract characterized by a pair $\{\rho, B\}$. The parameter ρ denotes the interest rate and B *is* the amount lent. In addition, the contract contains parameter $k \in \{0, 1\}$, which specifies whether the lenders are committed to the contract, $k = 1$, or not committed, $k = 0$. If $k = 1$ the lenders cannot reject applications for the contracts offered. If however we have $k = 0$, the lenders can reject it. Finally, if the firms are unable to repay the debt, the lenders become shareholders at zero cost.

Let us next introduce the following two assumptions.

Assumption 1 The bad-state (net) return, a, belongs to interval $[-1, r)$, where $r > 0$ is the risk-free interest rate.

Assumption 2 The inequality $(R_H >)R_L \geq r$ holds.

Assumption 1 states that the bad-state gross return $1 + a$ can be neither less than zero nor higher than $1 + r$. In the former case, a "black swan" event, where (net) returns are less than -100%, is excluded. In the latter case, the upper bound holds by definition: a state of nature is bad if a firm's (net) return is less than the opportunity cost r. Assumption 2 ensures that the (net) expected return of a bad firm, R_L, cannot be less than the risk-free interest rate r.[10]

Let us finally introduce taxation. By assumption, a firm's profit is taxed at a corporate rate $t \in (0, 1]$. For simplicity, we assume that lenders are instead tax-exempt.

The timing of events is as follows.

Before time 0:

Stage 1 Nature selects the risk type of each firm.

Stage 2 The Government sets the corporate tax rate t.

[9] For simplicity, we assume that default costs are nil. Moreover, we focus on two types of firms. We leave both the introduction of bankruptcy costs and the analysis of a continuum of firm types for future research.

[10] Note that Assumptions 1 and 2 imply that probability p_L has a lower bound. In symbols, $p_L \geq \frac{r-a}{A-a} \in (0, 1)$.

At time 0:

Stage 1 $N \geq 2$ lenders compete *à la* Bertrand by simultaneously offering loan contracts to the firms. Each contract is a pair $\{\rho_i; B_i\}$, plus the commitment parameter k_i, $i = L, H$. Since there are only two types of firms, there is no loss of generality if we assume that the lenders offer at most a pair of contracts.

Stage 2 Firms decide whether or not to invest in the project. If they do not invest, the game ends. If firms choose to invest, they can decide whether to accept a loan contract. If they do not accept a loan contract, they issue equity E to finance their investment project.

Stage 3 After observing the contracts offered by rival lenders and those chosen by the firms, the lenders who did not commit to their contracts at Stage 1, i.e., those who chose $k_i = 0$, decide whether to withdraw the contract or not. If a contract is withdrawn, the firms which signed it decide whether to invest and, if so, they resort to equity E. All other agreements, i.e., contracts with or without commitment that were not withdrawn, are signed by the parties.

Stage 4 If firm i decided to invest and to borrow, its budget is equal to

$$E_i + B_i = 1. \tag{2}$$

At time 1: Each firm's (net) return is either A or a. If a firm has enough cash, it repays the lenders.

Given these assumptions, we will study pure-strategy subgame perfect Nash equilibria (SPNEs) of the four-stage game played by lenders and firms at time 0.[11] In principle, the solutions to our game could be:

1. Separating equilibria, when the two types of firms sign two different loan contracts.
2. Pooling equilibria, when bad and good firms accept the same loan contract.
3. Rationing equilibria, when one type of firm signs a contract, while the other type signs no contract.

Before proceeding, it is useful to invoke a Bertrand argument to state the following:

Claim 1 In a pooling or rationing equilibrium, the lenders earn zero profit. In a separating equilibrium, the lenders earn zero profits on each type of contract.

2.1 Symmetric information

Let us start with a benchmark case, where probability p_i is observed by the lenders. Under Bertrand competition, studying the SPNEs of the above four-stage game amounts to solve the following problem: at time 0, any firm i chooses E_i and B_i to maximize its net present value, subject to the the lenders' zero-profit condition.

The firm i's net present value at time 0 (NPV_i) depends on the firm's ability to repay the debt, that is in turn affected by the amount of loan B_i. Suppose first the inequality

[11] Notice that the set of SPNEs is equivalent to that of perfect Bayesian equilibria, in a competitive screening game.

$$(1+\rho_i)B_i \leq 1+a \tag{3}$$

holds. In this case firm i can always repay because the total amount to be repaid, $(1+\rho_i)B_i$, is not larger than the bad-state gross return. No default thus occurs. According to Claim 1 lenders earn zero profits, i.e.,

$$p_i(1+\rho_i)B_i + (1-p_i)(1+\rho_i)B_i = (1+r)B_i, \tag{4}$$

where $(1+r)B_i$ is the lenders' opportunity cost of lending B_i. Solving (4) for ρ_i gives

$$\rho_i = r. \tag{5}$$

Substituting $\rho_i = r$ into (3) and rearranging gives $rB_i \leq 1+a-B_i$. Next, using the relevant discount factor $\frac{1}{1+r}$ gives firm i's net present value:

$$NPV_i = \begin{cases} -E_i + \dfrac{(1-t)(R_i - rB_i) + E_i}{1+r} & \text{for} \quad \mathrm{rB_i \leq a}, \\ -E_i + p_i\dfrac{(1-t)(A - rB_i) + E_i}{1+r} + (1-p_i)\dfrac{(a - rB_i) + E_i}{1+r} & \text{for} \quad \mathrm{a < rB_i \leq 1 + a - B_i}, \end{cases} \tag{6}$$

As can be seen, the corporate tax base is given by the difference between gross revenue and the interest expenses rB_i. Note that firm i makes positive profits with probability 1 when $rB_i \leq a$. When however $rB_i \in (a, 1+a-B_i]$ firm i repays the debt but the return a is not sufficient to cover the debt costs rB_i. In this case, the firm's loss is supposed to be tax-exempt. Put differently, no subsidy is paid by the Government in case of loss. We are focusing on an asymmetric tax system where the relevant tax rate is lower when a firm makes losses. For simplicity, our model states that the tax rate is nil.

Suppose now the inequalities

$$1+a < (1+\rho_i)B_i \leq 1+A \tag{7}$$

hold. In this case, the loan contract $\{\rho_i, B_i\}$ is such that the gross cost of borrowing is higher than the firm i's before-tax gross revenue in the bad case and is weakly lower in the good case. This means that the probability of default is $(1-p_i)$. If default occurs, lenders become shareholders. The lenders' zero-profit condition is equal to

$$p_i(1+\rho_i)B_i + (1-p_i)(1+a) = (1+r)B_i. \tag{8}$$

Solving (8) for ρ_i gives

$$\rho_{0,i} = \frac{rB_i - (1-p_i)(a+E_i)}{p_iB_i}. \tag{9}$$

It is easy to see that $\rho_{0,i}$ exceeds r. Namely, lenders require a risk premium when a positive probability of default arises. Moreover,

$$\frac{\partial \rho_{0,i}}{\partial B_i} = \frac{(1-p_i)(1+a)}{pB_i^2} > 0. \tag{10}$$

This means that the higher the debt level $B_i \in \left(\frac{1+a}{1+r}, 1\right]$, the higher the break-even interest rate $\rho_{0,i}$ is. Since firms are characterized by limited liability and default causes a full loss for previous shareholders, firm i's NPV is equal to:

$$NPV_i = -E_i + p_i \frac{(1-t)\left(A - \rho_{0,i}B_i\right) + E_i}{1+r} + (1-p_i) \times 0. \tag{11}$$

In Appendix 1 we show that the firm i' net present value is maximized under full debt-finance. More precisely, we prove the following:

Lemma 1 *Under symmetric information, the SPNE of the four-stage game played by lenders and firms at time 0 is a separating equilibrium where lenders break even and fully finance the project by offering loan contracts with or without commitment to firms. In symbols*

$$\left\{\rho_i^*, B_i^*\right\} = \left\{\frac{r-(1-p_i)a}{p_i}, 1\right\}, k_i^* = \{0,1\}, \quad \text{and} \quad \mathrm{E_i^*} = 0.$$

This result crucially depends on the tax deductibility of interest expenses. Under full debt finance, a firm's positive profit net of the interest expenses is taxed at the corporate tax rate t. Therefore, the more a firm borrows, the lower the tax liability is. On the other hand, under equity finance no tax saving is ensured. As shown above, the probability of firms' default is zero if $B_i \in \left[0, \frac{1+a}{1+r}\right]$, while it is equal to $0 < (1-p_i) < 1$, hence unaffected by the level of B_i, when $B_i \in \left(\frac{1+a}{1+r}, 1\right]$.[12] Since the default probability is independent of the leverage ratio $\frac{B_i}{B_i+E_i} = B_i \in \left(\frac{1+a}{1+r}, 1\right]$, full debt finance is always the best choice under symmetric information.

2.2 Asymmetric information

Let us next turn to asymmetric information. In this case, the lenders cannot verify the firms' type and only know the proportion λ of bad firms.

Remember that a firm's ability to repay the debt depends on the level of borrowing B. In particular, both types of firms can repay the lenders if B is low enough, i.e., if $B \in \left[0, \frac{1+a}{1+r}\right]$. In this case, the lenders' break-even interest rate is equal to the risk-free one, r. If however the leverage ratio is high enough, i.e.,

[12] The latter result departs from the standard trade-off Theory [see, e.g., Kraus and Litzenberger (1973), and Leland (1994)]. This will allow us to focus on tax effects under asymmetric information with a tractable framework.

$B_i \in \left(\frac{1+a}{1+r}, 1\right]$, the probability of repayment is p_i. Given the risk of default, the lenders' break-even interest rate is $\rho > r$.

We first focus on interval $B_i \in \left(\frac{1+a}{1+r}, 1\right]$, thereby solving the four-stage game played by lenders and firms at time 0. Then, we will show that disregarding interval $B \in \left[0, \frac{1+a}{1+r}\right]$ is without loss of generality. We adopt a graphical approach by considering a (ρ, B) plane, with $B \in \left(\frac{1+a}{1+r}, 1\right]$ and $\rho > r$. To do so, we will define five curves, which are drawn in Fig. 2:[13]

1. lenders' zero-profit curve for each separating contract, that is OH (contract with good firms) and OL (contract with bad firms), where point O is characterized by $\rho = r$ and $B = \frac{1+a}{1+r}$;
2. lenders' zero-profit curve for a pooling contract, denoted by OP;
3. a good firms' indifference curve, denoted by $H'H''$, and a bad firms' one, denoted by LL'.

The lenders' profit function is given by

$$p_i(1 + \rho_i)B_i + (1 - p_i)(1 + a) - (1 + r)B_i. \qquad (12)$$

As pointed out, firm i repays debt, i.e., $(1 + \rho_i)B_i$, with probability p_i. Of course, the probability of default is $(1 - p_i)$. In this case the lenders seize $1 + a$. Term $(1 + r)B_i$ is the lenders' opportunity cost of lending the amount B_i.[14]

In Appendix 5.1, we show that: (1) the three lenders' zero-profit curves, OH, OL, and OP, are upward sloping in the (ρ, B) plane and that the lenders are better-off (worse-off) when moving south–east (north–west) from any point on the curves; (2) OH is steeper than OL. Result (1) is due to the fact that ρ enters positively in (12), whilst B enters negatively. The reasoning for result (2) is as follows: for any given increase in ρ, the lenders' zero-profit condition, i.e., 12 =0, holds if B also increases. It is worth noting that such an increase must be higher along OH because ρ is paid with higher probability by good firms. Finally, the pooling zero-profit curve OP is a linear combination of OH and OL. It collapses to OH when all firms are good, $\lambda = 0$, and to OL when all firms are bad, $\lambda = 1$. Intuitively, OP is increasing in ρ and flatter (steeper) than OH (OL).

Let us next focus on the firms' indifference curves. Firm i's net present value is given by

$$NPV_i = -(1 - B_i) + p_i \frac{(1 - t)(A - \rho_i B_i) + (1 - B_i)}{1 + r}, \qquad (13)$$

[13] In all figures the benchmark parameter values are: $p_L = .95$; $p_H = .99$; $r = .05$; $A = .5$; $a = -.1$; $t = .3$; $\lambda = 0.5$.

[14] See Appendix 1 for further details.

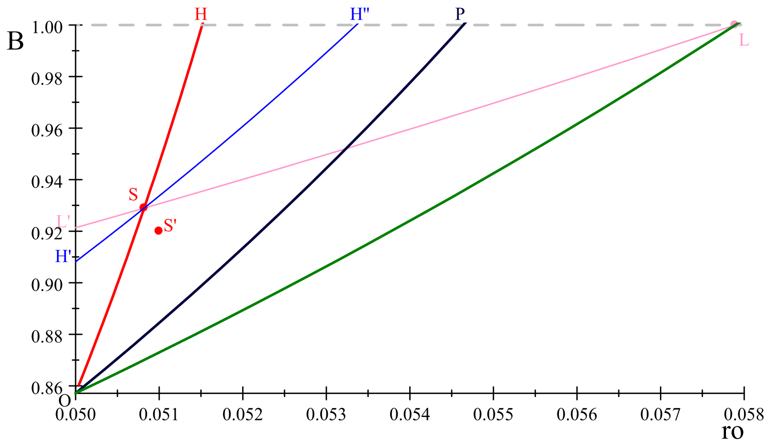

Fig. 2 Separating equilibrium

where $(1 - B_i)$ denotes the equity issue, $\frac{1}{1+r}$ is the discount factor and $(A - \rho_i B_i)$ is the relevant tax base in the event of success.[15] In Appendix 5.2 we show that: (1) the firms' indifference curves $H'H''$ and LL' are upward sloping and that the firms are better-off (worse-off) when moving north–west (south–east) from any point on the same curves. This is due to the fact that ρ enters negatively and B enters positively in NPV_i; (2) good firms' indifference curves are steeper than bad firms' curves because an increase in ρ causes higher costs for good firms since they repay with higher probability. As a result, good firms must borrow a larger amount of B in order to be indifferent.

Let us next analyze the pure-strategy SPNE of the four-stage game played by lenders and firms.

2.2.1 Separating equilibrium

As a first step, we prove that an equilibrium, where separating contracts are signed, exists only if the share λ of bad firms is high enough.

Lemma 1 shows that a separating equilibrium, $\{\rho_L^*, 1\}$ and $\{\rho_H^*, 1\}$, exists under symmetric information. In this case the lenders earn zero profits by offering first-best type-dependent contracts, with or without commitment. When however p_i is not verified by the lenders, these first-best contracts cannot be an equilibrium. Given $\rho_L^* > \rho_H^*$, bad firms would prefer contract $\{\rho_H^*; 1\}$ to contract $\{\rho_L^*; 1\}$. The lenders want to prevent bad firms from choosing H. For this reason, they offer L to bad firms and a contract to good firms which is worse than $H = (\rho_H^*; 1)$.

According to Claim 1, lenders earn zero profits on each per-type contract in a separating equilibrium, if any. Hence, the equilibrium separating contract offered to good firms must lie on the zero-profit curve OH. We argue that the separating

[15] See Appendix 1 for further details.

equilibrium consists of two contracts: contract $L = \left(\rho_L^*; 1\right)$ for bad firms, as mentioned, and contract $S = (\rho_S; B_S)$ for good ones. As shown in Fig. 2, point S is given by the intersection between $L'L$ (the bad firms' indifference curve through L) and OH (the lenders' zero-profit curve for good firms). It is easy to check that contract L is unique under Bertrand competition. Similarly, contract S is unique because any contract lying on OS would be undercut by the other lenders and any contract lying on SH would also be chosen by bad firms. In symbols, contract S is given by

$$\rho_S = \frac{r(p_H - p_L)(1+a) + t(1+r-p_H)(r-a+ap_L)}{(p_H - p_L)(1+a) + t[p_H(r-a) + p_L(1+a-p_H)]} < \rho_H^* \tag{14}$$

and

$$B_S = \frac{(1-p_H)(1+a)}{1+r-p_H(1+\rho_S)} < 1. \tag{15}$$

Substituting ρ_S and B_S into (13), with $i = H$, gives the good firms' NPV under contract $S = \{\rho_S; B_S\}$

$$NPV_{H,S} = -(1-B_S) + p_H \frac{(1-t)(A - \rho_S B_S) + (1-B_S)}{1+r}. \tag{16}$$

Similarly, substituting ρ_L^* and $B_L = 1$ into (13), with $i = L$, gives the bad firms' NPV:[16]

$$NPV_{L,S} = p_L \frac{(1-t)\left(A - \rho_L^*\right)}{1+r}. \tag{17}$$

Interestingly, the separating equilibrium (L, S) vanishes if the share λ of bad firms is low enough. The intuition is straightforward, if we look at the pooling contract $P = \{\rho_P; 1\}$, where[17]

$$\rho_P = \frac{r - a[\lambda(1-p_L) + (1-\lambda)(1-p_H)]}{\lambda p_L + (1-\lambda)p_H}. \tag{18}$$

It is easy to see that ρ_P is increasing in λ, i.e. ,

$$\frac{\partial \rho_P}{\partial \lambda} = \frac{(p_H - p_L)(r-a)}{[\lambda p_L + (1-\lambda)p_H]^2} > 0. \tag{19}$$

This is due to the fact that the lenders' expected repayment rate, i.e., $\lambda p_L + (1-\lambda)p_H$, decreases with the percentage of bad firms. Therefore, contract P turns out to be particularly appealing as λ approaches 0 and may be preferred by good firms to the separating contract S.

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[16] In Appendix 5.3 we check that both good and bad firms' participation constraints are fulfilled at the separating equilibrium (L, S).

[17] See Appendix 5.4 for computations.

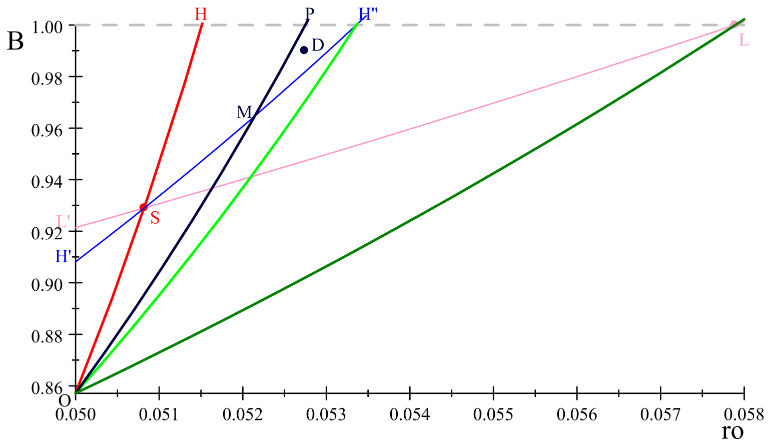

Fig. 3 No separating equilibrium when $\lambda < \lambda^{\circ}(t)$

Figure 3 provides a graphical proof of the non-existence of the separating equilibrium when λ is low enough. OP is depicted for $\lambda = .2$, instead of the initial value, .5. As λ diminishes the pooled zero-profit curve OP rotates counterclockwise and may intersect curve $H'H''$ at a point M with $B_M < 1$. In this case, a profitable deviation is available to at least one lender when all rivals offer the pair of separating contracts (L, S). A new contract $D = \{\rho_D; B_D\}$ with $k = 1$ (i.e., with commitment) may be offered. This contract lies in area MPH'' , where both types of firms are better-off and the lenders make profits. Accordingly, all firms sign contract D because at least one lender is committed to it.

The minimum share λ, below which the separating equilibrium (L, S) fails to exist, is given by the intersection between the pooled zero-profit line OP and $H'H''$ at $B = 1$. As shown in Appendix 5.5, we obtain

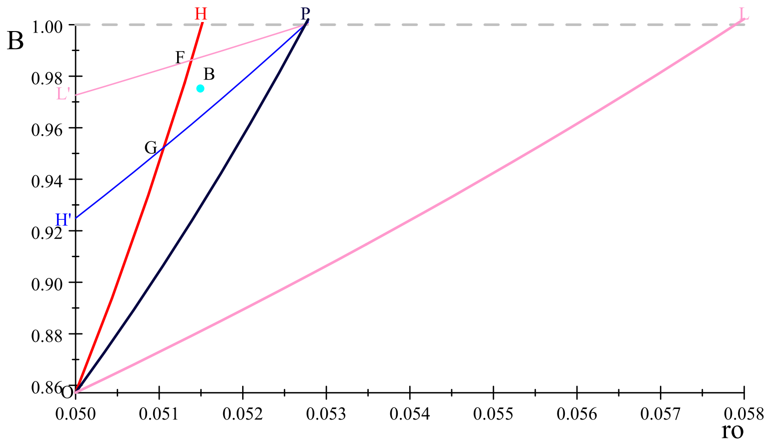

Fig. 4 Pooling equilibrium without commitment when $\lambda < \lambda^{\circ}(t)$

$$\lambda^{\circ}(t) = \frac{p_H t(1 + r - p_H)}{(1 + r)(p_H - p_L) + p_H t(1 + r - p_H)} \in (0, 1). \tag{20}$$

2.2.2 Pooling equilibrium

A pooling equilibrium contract, if any, must lie on the pooled zero-profit curve *OP* according to Claim . In Appendix 5.6 we prove that the only candidate pooling equilibrium contract is $P = (\rho_P; 1)$.

Let us now show that when the separating contracts (L, S) are not an equilibrium, i.e., when $\lambda < \lambda^{\circ}(t)$, the agreement $P = \{\rho_P; 1\}$ without commitment is the only pooling equilibrium. To prove this, we introduce Fig. 4, which is based on Fig. 3, and depict two new curves: $L'P$ is bad firms' and $H'P$ is good firms' indifference curve through contract *P*.

First note that if all lenders offer $P = \{\rho_P; 1\}$ with commitment, $k = 1$, to both types, at least one lender can propose a rationing contract $B = (\rho_B; B_B)$. This is a profitable deviation since *B* lies in the *GFP* area. It is therefore accepted only by good firms and lies to the south–east of the zero-profit curve *OH*. As a result, $P = \{\rho_P; 1\}$ with commitment is not an equilibrium solution.

It is worth noting that no contract in area *GFP* is profitable if all lenders offer $P = \{\rho_P; 1\}$ without commitment, i.e., with $k = 0$. Since contract *B* attracts only good firms, *P* is chosen by bad firms with the effect that the lenders make losses. As a result, at Stage 3, contract *P* is withdrawn. This is possible because *P* is without any commitment. Anticipating that, at Stage 2 bad firms also choose contract *B* since it is the only one available.[18] In this case, *B* causes losses to the lenders since it lies to the north−west of the pooled zero-profit curve *OP*. We can therefore conclude that there is no profitable deviation from *P* and that contract *P* without commitment will not be withdrawn at Stage 3.[19]

Given this result, we can substitute ρ_P and $B_P = 1$ into 13 to obtain firm *i*'s *NPV* when the equilibrium pooling contract $P = \{\rho_P; 1; 0\}$ is signed:

$$NPV_{i,P} = p_i \frac{(1 - t)(A - \rho_P)}{1 + r}. \tag{21}$$

One can check that at contract *P* the participation constraint of both types of firms is fulfilled.

Finally, in Appendix 5.7, we demonstrate that no rationing contract exists in equilibrium.

We can therefore sum up our findings as follows:

Proposition 1 *Under asymmetric information:*

[18] One can easily check that contract *B* is preferred by the firms to their outside option.

[19] For the sake of precision, the pooling equilibrium without commitment when $\lambda < \lambda^{\circ}$. is a Wilson equilibrium (Wilson 1977), defined as a (set of) contracts such that no lender has a deviation that remains profitable (contract *B* in our case) when existing contracts that become unprofitable after the deviation (contract *P* in our case) are withdrawn.

1. *If the share of bad firms in the economy is relatively low,* $\lambda < \lambda^{\circ}(t)$*, the unique SPNE of the four-stage game played by lenders and firms at time 0 is a pooling equilibrium, where both good and bad firms sign contract* $P = \{\rho_P; 1\}$ *and the lenders are not committed, i.e.,* $k = 0$.
2. *If the share of bad firms in the economy is relatively high,* $\lambda \geq \lambda^{\circ}(t)$ *,the unique SPNE is a separating equilibrium, where bad firms sign their first best contract* $L = \{\rho_L^*; 1\}$ *,whilst good firms sign contract* $S = \{\rho_S; B_S\}$*, with* $\rho_S < \rho_H^* (< \rho_L^*)$ *and* $B_S < 1$ *, and issue equity* $E_S = 1 - B_S$*. The lenders may be committed or not to contracts L and S, i.e.,* $k = \{0, 1\}$.

Note that, for any given t, bad firms prefer the pooling contract P to the separating contract L. Both agreements entail full debt finance, but the former prescribes a lower interest rate because bad firms are cross-subsidized by good firms. We can therefore say that the good firms' equilibrium strategy drives the results of Proposition 1. Moreover, when few bad firms exist, $\lambda < \lambda^{\circ}(t)$, the pooling interest rate ρ_P is relatively low because the lenders expect a relatively high average probability of debt repayment, $\lambda p_L + (1 - \lambda) p_H$. For this reason the good firms select contract P. In this context, firms receive the same amount of borrowing, 1, as that obtained under symmetric information. When however, inequality $\lambda \geq \lambda^{\circ}(t)$ holds, the interest rate ρ_P is too high for good firms. For this reason, they prefer the separating contract S. The explanation is simple: though they receive less credit, $B_S < B_P = 1$, they pay a lower interest rate, $\rho_S < \rho_P$. This latter effect overcompensates the former.[20] In Appendix 5.8 we prove that disregarding interval $B \in [0, (1 + a)/(1 + r)]$ by focusing on $B_i \in ((1 + a)/(1 + r), 1]$ does not affect the generality of our findings.

The result of Proposition 1 is novel. Unlike previous research, it shows that the credit market equilibrium can be affected by taxation. In particular, the threshold value $\lambda^{\circ}(t)$ is increasing t. Differentiating $\lambda^{\circ}(t)$ in 20 w.r.t. t gives indeed

$$\frac{\partial \lambda^{\circ}(t)}{\partial t} = \frac{p_H(p_H - p_L)(1 + r)(1 + r - p_H)}{[(1 + r)(p_H - p_L) + p_H t(1 + r - p_H)]^2} > 0.$$

Figure 5 draws the threshold $\lambda^{\circ}(t)$ as a function of t. It is easy to see that $\lambda^{\circ} = 0$ when $t = 0$, i.e., $\lambda^{\circ}(0) = 0$. When however $t = 1$, $\lambda^{\circ}(1)$ is strictly less than 1:

$$\lambda^{\circ}(1) = \frac{p_H(1 + r - p_H)}{(1 + r)(p_H - p_L) + p_H(1 + r - p_H)} \in (0, 1). \tag{22}$$

As a result, if the existing proportion λ of bad firms is higher than or equal to $\lambda^{\circ}(1)$, the separating contracts L and S are the only SPNE of the four-stage game played by lenders and firms at time 0 because $\lambda \geq \lambda^{\circ}(t)$ for any t. By contrast, when λ is less than $\lambda^{\circ}(1)$ as in Fig. 5, the level of corporate tax rate t affects the equilibrium described in Proposition 1. To understand tax effects better, let us now calculate the tax rate ensuring that the cutoff value $\lambda^{\circ}(t)$ equals the existing

[20] Note that ρ_S is unaffected by λ, thus the difference $\rho_P - \rho_S$ increases with λ.

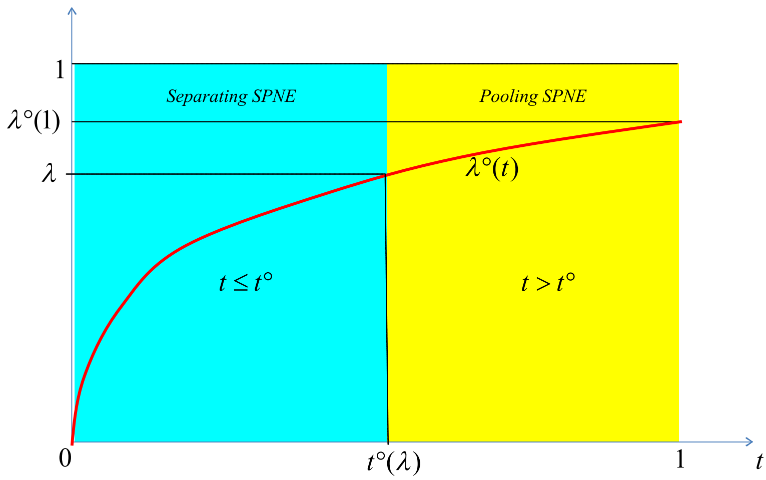

Fig. 5 Threshold λ° as a function of t

proportion λ of bad firms. We therefore set $\lambda^{\circ}(t) = \lambda$ and solve 20 for t, thereby obtaining the threshold corporate tax rate

$$t^{\circ}(\lambda) = \frac{\lambda}{1-\lambda}\frac{p_H - p_L}{p_H}\frac{1+r}{1+r-p_H}. \tag{23}$$

Note that $t^{\circ}(\lambda) < 1 \Leftrightarrow \lambda < \lambda^{\circ}(1)$. This means that, according to Fig. 5, if the Government chooses $t \leq t^{\circ}(\lambda)$, then the cutoff λ° is weakly lower than the actual fraction of bad firms and the SPNE is separating. By contrast, if the Government raises t beyond $t^{\circ}(\lambda)$, the inequality $\lambda^{\circ} > \lambda$ holds and the SPNE is pooling. This result, which is a corollary of Proposition 1, is highlighted in the following:

Corollary 1 *For any given portion λ of bad firms in the economy, if the Government sets $t \leq t^{\circ}(\lambda)$, the SPNE is separating; if $t > t^{\circ}(\lambda)$, the SPNE is pooling.*

Corollary 1 states that the Government can affect the credit market equilibrium and that a relatively high tax rate t leads to a pooling equilibrium. The mechanism is straightforward. As the rate t rises, the pooling contract $P = \{\rho_P; 1\}$ becomes more appealing to good firms. This is because contract P entails full debt finance, $B_P = 1$, which gives increasingly large tax savings in terms of interest deductibility.

3 Comparative statics

In order to understand our findings and their implications better, let us next provide a comparative statics analysis. In particular, we are interested in looking how parameter λ affects the following equilibrium values:

1. the threshold value $t^{\circ}(\lambda)$ of the corporate tax rate;
2. the differential between the interest rates paid by bad and good firms in equilibrium, which we refer to as the spread.

We focus on parameter λ because an increase (decrease) in the fraction of bad firms can be considered a proxy for a macroeconomic downturn (recovery).

By virtue of see (19), the pooling equilibrium interest rate ρ_P increases with λ because the average probability of repayment, $\lambda p_L + (1-\lambda)p_H$, decreases as the percentage of bad firms rises. By contrast, λ does not affect the interest rates ρ_L^* and ρ_S paid by bad and good firms, respectively, at the separating equilibrium. We can conclude that good firms, whose optimal choice drives the equilibrium results, are relatively less (more) attracted by the pooling contract P when λ increases (decreases). Put differently, an increase (decrease) in λ restricts (enlarges) the domain of existence of a pooling equilibrium, i.e.,

$$\frac{\partial t^{\circ}(\lambda)}{\partial \lambda} = \frac{(p_H - p_L)(1+r)}{p_H(1+r-p_H)(1-\lambda)^2} > 0. \tag{24}$$

This result allows us to investigate the joint effect of taxation and the business cycle on the credit market equilibrium and the spread. There are two possible scenarios.

Scenario 1

Suppose the corporate tax rate is $t \le t^{\circ}(\lambda)$. This is always true if $t^{\circ}(\lambda) \ge 1$, or equivalently, $\lambda \ge \lambda^{\circ}(1)$. According to Fig. 5, the equilibrium is separating and the spread is $\rho_L^* - \rho_S > 0$. Since $t^{\circ}(\lambda)$ is positively affected by λ, an economic downturn, proxied by an increase in λ, alters neither this type of equilibrium nor the spread $\rho_L^* - \rho_S$.

In contrast, a recovery proxied by a decrease in λ reduces $t^{\circ}(\lambda)$ and may lead to a pooling equilibrium. This occurs if the threshold $t^{\circ}(\lambda)$ is less than t. In this case, the spread $\rho_L^* - \rho_S > 0$ goes to zero. If however, the decrease in λ is small enough, equilibrium is still separating and the spread does not change.

Scenario 2

Suppose the tax rate is $t > t^{\circ}(\lambda)$ and therefore, the equilibrium is pooling.[21] Given this starting point, we can say that an economic downturn proxied by an increase in λ may lead to a separating equilibrium. This occurs if the threshold $t^{\circ}(\lambda)$ increases above t. In this case, the spread increases from 0 to $\rho_L^* - \rho_S > 0$. If, however, the increase in λ is small enough, the equilibrium is still pooling and the spread does not change.[22]

In contrast, a recovery reduces $t^{\circ}(\lambda)$ with the effect that the equilibrium is still pooling. The spread does not change (but the equilibrium interest rate ρ_P decreases).

Given these results we can say that:

Proposition 2 *(1) During a downturn, captured in our model by an increase in λ, the spread, if any, between the interest rate charged to bad firms and that charged to good firms is unaffected when $t \le t^{\circ}(\lambda)$ or may increase when $t > t^{\circ}(\lambda)$. (2) During a recovery, captured in our model by an decrease in λ, the spread, if any, between the interest rate charged to bad firms and that charged to good firms is unaffected when $t > t^{\circ}(\lambda)$ or may decrease when $t \le t^{\circ}(\lambda)$.*

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[21] As we know, for the inequality $t > t^{\circ}$ to hold, it is necessary that $t^{\circ} < 1$, or equivalently, $\lambda < \lambda^{\circ}(1)$.

[22] The only effect in that case is an increase in the equilibrium pooling interest rate ρ_P: see (19).

As we have seen, Proposition 1 proves that for any given tax rate t, the equilibrium in a credit market characterized by asymmetric information depends on the distribution of bad and good firms. Corollary 1 shows that such an equilibrium can be affected by the Government: for any given percentage λ of bad firms, a relatively low (high) tax rate t is likely to lead to a separating (pooling) equilibrium. Putting together these two results, Proposition 2 enables us to explain the effects of both the business cycle, captured by λ, and taxation t on the credit market equilibrium.

For this aim, let us remember Fig. 1, which shows that the corporate spread between the high-yield (i.e., bad firms) and the investment-grade (good firms) interest rates tends to be high during downturns. According to Proposition 2, an increase in the spread is more likely when t is relatively high, i.e., higher than $t^{\circ}(\lambda)$. In this case, the credit market may shift from a pooling to a separating equilibrium. The spread is instead not affected if $t \leq t^{\circ}(\lambda)$ because the equilibrium is always separating.

On the contrary, Fig. 1 shows that the corporate spread between bad and good firms is generally low during recoveries. Proposition 2 adds that a decrease in the spread is more likely when t is lower than $t^{\circ}(\lambda)$. In this case, the credit market may shift from a separating to a pooling equilibrium, while the spread is not affected if $t > t^{\circ}(\lambda)$.

Overall, we can state that the effects of the business cycle on the credit market equilibrium may depend not only on asymmetric information and the screening activity by banks, but also on taxation.

4 Conclusion

In this article, we have analyzed the effects of corporate taxation on credit market equilibrium under asymmetric information. In doing so, we have developed a framework where points are accounted for: (1) the existence of a tax incentive to borrow, (2) the existence of asymmetric information in credit markets, (3) the screening activity of lenders, (4) the negative relationship between leverage and profitability, and (5) the business cycle effects on the spread between the high-yield and the investment-grade interest rates on corporate loans.

As we have shown, the characteristics of the equilibrium crucially depend on the distribution of high- and low-profit firms in the economy. If the fraction of bad firms is low enough, lenders offer a pooling contract to firms, which are fully debt-financed. If however, the number of bad firms is relatively high, a separating equilibrium is found. In this case, bad firms are fully debt-financed, whereas good firms are partially debt-financed. This is in line with the empirical evidence that firms with less pressing needs for cash (i.e., good ones) have a lower leverage.

By departing from the relevant literature, we have also shown that corporate taxation affects the credit market equilibrium: *ceteris paribus*, the higher (lower) the tax rate, the more likely the pooling (separating) equilibrium is. This is because an increase in the corporate tax rate increases the benefit of interest deductibility. As a result, good firms, whose equilibrium choices determine the credit market outcome, prefer a pooling contract that contains a larger amount of debt.

Finally, we have proved that the effects of the business cycle on the credit market equilibrium may work not only through asymmetric information and the screening activity by banks, but also through the level of corporate tax rate.

Appendix 1: Symmetric information

To prove Lemma 1, we first stress the fact that firm i's net present value at time 0 (NPV_i) depends on the its ability to repay the debt. For this reason we study two different scenarios: a no-default and a default one.

Default-free scenario

Substituting $\rho_i = r$ into (3) and using $E_i = 1 - B_i$ we can rewrite (6) as follows:

$$\max_{B_i}\begin{cases} -(1-B_i)+\dfrac{(1-t)(R_i-rB_i)+(1-B_i)}{1+r} & \text{for } \mathrm{rB_i} \leq \mathrm{a} \\ -(1-B_i)+p_i\dfrac{(1-t)(A-rB_i)+(1-B_i)}{1+r}+(1-p_i)\dfrac{(a-rB_i)+(1-B_i)}{1+r} & \text{for } \mathrm{rB_i} \in (\mathrm{a}, 1+\mathrm{a}-\mathrm{B_i}] \end{cases}$$
$$\mathrm{s.t.B_i} \leq \frac{1+\mathrm{a}}{1+\mathrm{r}}, \tag{25}$$

where $\frac{1+a}{1+r} \in [0,1)$ is dealt with in Assumption 1.

The derivative of (25) w.r.t. B_i is $\frac{tr}{1+r} > 0$ for $rB_i \leq a$ and is equal to $\frac{p_i tr}{r+1} > 0$ for $rB_i \in (a, 1 + a - B_i]$, which means that (25) is increasing in B_i. Of course, this result is due to the deductibility of interest expenses rB_i. Since no tax relief is ensured to equity issues, firm i maximizes B_i and, of course, minimizes E_i. Thus, the unique solution to program (25) is

$$B^{\circ} = \frac{1 + a}{1 + r} < 1, \tag{26}$$

and $E^{\circ} = 1 - \frac{1+a}{1+r}$.

Default scenario

Using $E_i = 1 - B_i$, we can thus rewrite (11) as

$$\max_{B_i}\left\{-(1 - B_i) + p_i\frac{(1 - t)\left(A - \rho_{0,i}B_i\right) + (1 - B_i)}{1 + r}\right\}$$
$$\mathrm{s.t.}\ \frac{1 + \mathrm{a}}{1 + \mathrm{r}} < \mathrm{B_i} \leq 1, \tag{27}$$

The derivative of (27) with respect to B_i is $\frac{t(1+r-p_i)}{1+r} > 0$. This implies that firm i is fully debt-financed. Of course we have $E^* = 0$. Substituting $B^* = 1$ and $E^* = 0$ into (9) and solving for the lending interest rate now gives

$$\rho_i^* = \frac{r - (1 - p_i)a}{p_i}, \tag{28}$$

where $\rho_i^* > r$ (see Assumption 1). Moreover, substituting $B^* = 1$ and (28) into (27), the firm's *NPV* under default risk is equal to:

$$NPV_i^* = \frac{p_i(1-t)\left(A - \frac{r-(1-p_i)a}{p_i}\right)}{1+r}. \tag{29}$$

Let us next check whether firm i's participation constraint is fulfilled in equilibrium. As pointed out, at time 0, Stage 2 of the model's timing in Sect. 2, the firms' outside option is the maximum between 0 and an equity-financed project: its *NPV* is given by (25) with $B_i = 0$:

$$OO_i = \max\left\{0, \begin{array}{ll} \dfrac{(1-t)[p_i A + (1-p_i)a] - r}{1+r} & \text{for} \quad \mathrm{a} \geq 0, \\ \dfrac{p_i(1-t)A + (1-p_i)a - r}{1+r} & \text{for} \quad \mathrm{a} < 0. \end{array}\right\}$$

Given Assumption 2, OO_i is never higher than NPV_i^*.

Finally, the case $(1+\rho_i)B_i > 1 + A$ is ruled out by Assumption 2. Indeed, inequality $(1+\rho_i)B_i \leq 1 + A$ can be rewritten as

$$\left(1 + \frac{rB_i - (1-p_i)(a + E_i)}{p_i B_i}\right)B \leq 1 + A \tag{30}$$

after substituting (9). Since $E_i + B_i = 1$, the LHS of the above inequality reaches its maximum when $B_i = 1$ (and $E_i = 0$). Substituting $B_i = 1$ and $E_i = 0$ into (30) gives $1 + \frac{r-(1-p_i)a}{p_i} \leq 1 + A$, which is fulfilled under Assumption 2 since $\frac{r-(1-p_L)a}{p_L} > \frac{r-(1-p_H)a}{p_H}$.

Appendix 2: Asymmetric information

Lenders' zero-profit curves

Curves *OH* and *OL* derive from the lenders' zero-profit condition (8) under default:

$$[p_i(1+\rho) - (1+r)]B + (1-p_i)(1+a) = 0. \tag{31}$$

Solving (31) for B gives

$$B = \frac{(1-p_i)(1+a)}{1 + r - p_i(1+\rho)}. \tag{32}$$

Substituting p_H (p_L) into (32) gives *OH* (*OL*). The derivative of (32) w.r.t. ρ is

$$\frac{\partial\left[\frac{(1-p_i)(1+a)}{1+r-p_i(1+\rho)}\right]}{\partial\rho} = p_i\frac{(1-p_i)(1+a)}{[1+r-p_i(1+\rho)]^2},$$

which is positive due to Assumption 1. This proves that *OH* and *OL* are upward-sloping. The cross derivative of (32) w.r.t. ρ and p is

$$\frac{\partial^2\left[p_i\frac{(1-p_i)(1+a)}{(1+r-p_i(1+\rho))^2}\right]}{\partial\rho\partial p} = (1+a)\frac{1+r-p_i(1+2r-\rho)}{[1+r-p_i(1+\rho)]^3}.$$

To show that the above value is positive we must first stress that the numerator is increasing ρ. Its minimum value is equal to $(1+r)(1-p_i)>0$ and is obtained if $\rho=r$: this means that the numerator is always positive. Let us next focus on the denominator. As can be seen, $[1+r-p_i(1+\rho)]$ is decreasing in ρ. Its minimum value, $\left[1+r-p_i\left(1+\frac{r-(1-p_i)a}{p_i}\right)\right]$, is obtained when $\rho=\rho_i^*=\frac{r-(1-p_i)a}{p_i}$. Simplifying such a value gives $(1-p_i)(1+a)>0$. This proves that *OH* is steeper than *OL*.

Firms' indifference curves

Firm i's indifference curve is obtained by equating its NPV_i under default to the *NPV* obtained by firm i when signing any given contract $X=\{\rho_X, B_X\}$, i.e.,

$$\begin{aligned} &-(1-B)+p_i\frac{(1-t)(A-\rho B)+(1-B)}{1+r} \\ &= -(1-B_X)+p_i\frac{(1-t)(A-\rho_X B_X)+(1-B_X)}{1+r}. \end{aligned} \tag{33}$$

Solving (33) gives

$$B=\frac{B_X\{1+r-p_H[1+(1-t)\rho_X]\}}{1+r-p_i[1+\rho(1-t)]}. \tag{34}$$

Let us next calculate the derivative of (34) w.r.t. ρ

$$\frac{\partial\left[\frac{B_X[1+r-p_i(1+(1-t)\rho_X)]}{1+r-p_i(1+\rho(1-t))}\right]}{\partial\rho} = p_i(1-t)B_X\frac{1+r-p_i[1+\rho_X(1-t)]}{\{1+r-p_i[1+\rho(1-t)]\}^2}. \tag{35}$$

As can be seen, the numerator of (35) is decreasing in ρ. Its minimum value, obtained by setting $\rho=\rho_i^*=\frac{r-(1-p_i)a}{p_i}$, is $1-p_i+rt+a(1-t)(1-p_i)>0$. Since the denominator is positive, we can thus conclude that $\frac{\partial\left[\frac{B_X\left[1+r-p_i\left(1+(1-t)\rho_X\right)\right]}{1+r-p_i(1+\rho(1-t))}\right]}{\partial\rho}>0$.

Let us next calculate the cross derivative of 34 w.r.t. ρ and p. We obtain

$$\frac{\partial^2\left[\frac{B_X[1+r-p_i(1+(1-t)\rho_X)]}{1+r-p_i(1+\rho(1-t))}\right]}{\partial\rho\partial p}=B_X(1+r)(1-t)\frac{1+r-p_i[1+(2\rho_X-\rho)(1-t)]}{\{1+r-p_i[1+\rho(1-t)]\}^3}. \tag{36}$$

Again, (36) is positive. This can be proven by showing that its numerator is decreasing in $(2\rho_X-\rho)$ and hence, is minimum when $(2\rho_X-\rho)$ reaches its maximum value, i.e., $\left[2\frac{r-(1-p_i)a}{p_i}-r\right]$. Substituting term $\left[2\frac{r-(1-p_i)a}{p_i}-r\right]$ into (36) gives $2a(1-p_i)(1-t)+(1-r)(1-p_i)+rt(2-p_i)>0$. This entails that good firms' indifference curves are steeper than bad firms' ones.

Separating equilibrium

We show that both good and bad firms' participation constraints are satisfied at the separating equilibrium (L,S). Let us first consider bad firms. They sign their first-best agreement $(\rho_L^*,1)$. Hence, their participation constraint is satisfied as shown in Appendix 1. Let us next turn to good firms. Their payoff in separating equilibrium is $NPV_{H,S}$, see (16). Hence, their participation constraint is satisfied if and only if

$$NPV_{H,S}\geq OO_H=\max\left\{0,\begin{array}{ll}\dfrac{(1-t)[p_HA+(1-p_H)a]-r}{1+r} & \text{for}\quad a\geq 0,\\ \dfrac{p_H(1-t)A+(1-p_H)a-r}{1+r} & \text{for}\quad a<0.\end{array}\right\}$$

First notice that $NPV_{H,S}\geq\frac{(1-t)[p_HA+(1-p_H)a]-r}{1+r}$ for $a\geq 0$ implies that $NPV_{H,S}\geq\frac{p_H(1-t)A+(1-p_H)a-r}{1+r}$ for $a<0$. Moreover, after substituting (1), (14) and (15), the former inequality can be rewritten as

$$t\frac{(p_H-p_L)[a(1-p_H)+rp_H+ar(1-t)]+(1-p_H)[atp_L+tp_H(r-a)]+r^2tp_H}{(1+r)[(1+r)(p_H-p_L)+tp_L(1-p_H)+rtp_L]}\geq 0,$$

which holds. Finally we need to show that $NPV_{H,S}\geq 0$. To do so, we first stress the fact that $NPV_{H,S}$ is continuous in $t\in(0,1]$. Secondly, we have $NPV_{H,S}=0\Leftrightarrow t_1=-\frac{(p_H-p_L)(1+r)(R_H-r)}{p_H(1+r-p_H)(R_L-r)}<0$ and $t_2=1$. Thirdly, $NPV_{H,S}$ is positive when $t=0$ (in this case it is equal to $\frac{R_H-r}{1+r}$). We can therefore say that the inequality $NPV_{H,S}\geq 0$ is proven for $t\in(0,1]$.

Pooling contract

Under pooling contracts, both types of firms are attracted. Thus, the equation of the pooling zero-profit curve OP is given by the following average zero-profit condition:

$$\lambda\{[p_L(1+\rho)-(1+r)]B+(1-p_L)(1+a)\} \\ +(1-\lambda)\{[p_H(1+\rho)-(1+r)]B+(1-p_H)(1+a)\}=0.$$

Substituting $B=1$ into the above equality and solving by λ gives (18).

Cutoff value $\lambda^{\circ}(t)$

To calculate $\lambda^{\circ}(t)$ we first substitute ρ_S and B_S into (34) with $i=H$: this gives the indifference curve $H'H''$ which passes through S. In symbols we have

$$B=\frac{B_S\{1+r-p_H[1+(1-t)\rho_S]\}}{1+r-p_H[1+\rho(1-t)]}.$$

Substituting $B=1$ and solving for ρ gives the value of $\rho_{H''}$ in contract $H''=(\rho_{H''},1)$ (see Fig. 3):

$$\rho_{H''}=\frac{1+r-p_H-B_S[1+r-p_H(1+(1-t)\rho_S)]}{p_H(1-t)}.$$

Let us next equate $\rho_{H''}$ to ρ_P given by (18). Solving this equality for λ yields

$$\lambda=\frac{p_H\{1+rt-p_H+a(1-p_H)(1-t)-B_S[(1+r-p_H)-\rho_S p_H(1-t)]\}}{(p_H-p_L)\{1+r-p_H-ap_H(1-t)-B_S[(1+r-p_H)-\rho_S p_H(1-t)]\}}. \tag{37}$$

Substituting ρ_S [derived in (14)] and B_S [derived in (15)] into (37) and rearranging gives the threshold value $\lambda^{\circ}(t)$.

Candidate pooling equilibrium contract

To analyze candidate pooling equilibria we use Fig. 6. Suppose that all lenders offer a pooling contract $Q=(\rho_Q;B_Q)$ lying on the pooled zero-profit line OP, with $\rho_Q<\rho_P$ and $B_Q<1$. Curves $H'H''$ and $L'L''$ are H- and L-firms' indifference curve, respectively, through contract Q. Notice that contract Q cannot be an equilibrium, since at least one lender is able to offer another pooling contract with commitment, $Q'=(\rho_{Q'};B_{Q'})$ and $k=1$, placed in area QPH'', with $\rho_Q<\ \rho_{Q'}$ and $B_Q<B_{Q'}\leq 1$. Contract Q' would be preferred by both types of firms and would ensure positive profits to the lender. This reasoning holds for any contract whose debt size is less than one. As a consequence, $P=(\rho_P;1)$ is the only candidate pooling equilibrium contract.

Rationing contracts

Let us study the existence of rationing equilibrium contract(s), where one type of firms signs a contract, while the other type signs no contract.

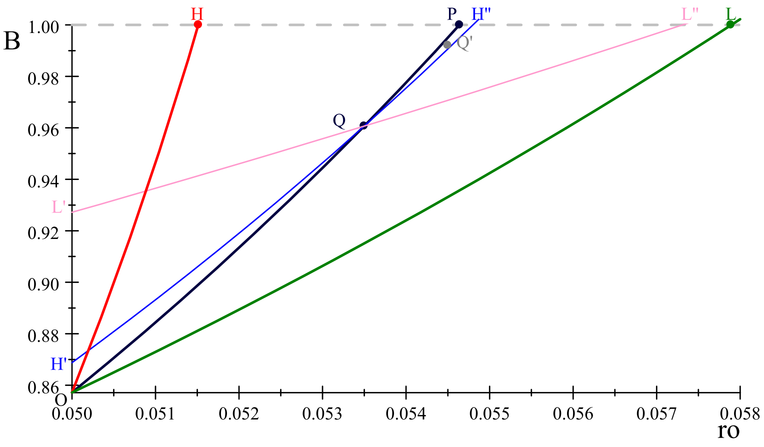

Fig. 6 No pooling equilibrium with commitment

1. Assume that the rationing equilibrium contract, if any, is accepted only by good firms. Given Bertrand competition, therefore, it must be contract $H = \left\{\rho_H^*; 1\right\}$. As pointed out however, contract H would also be chosen by bad firms. This implies that H cannot be a rationing equilibrium.
2. Assume now that the rationing equilibrium contract is accepted only by bad firms. Again, given Bertrand competition, it must be contract $L = \left\{\rho_L^*; 1\right\}$. If however all lenders offer L, at least one lender can profitably deviate. If $\lambda < \lambda^\circ(t)$ she can offer the pooling contract with commitment, $D = \{\rho_D; B_D\}$ and $k = 1$, thereby earning positive profit (see Fig. 3). If $\lambda \geq \lambda^\circ(t)$, she can propose both L and a second contract $S' = \{\rho_{S'}; B_{S'}\}$, with $k = 1$, $\rho_{S'} \geq \rho_S$ and $B_{S'} \leq B_S$ (see Fig. 2), both with commitment. The latter contract is signed only by good firms and yields positive profit. We can therefore conclude that no rationing equilibrium contract exists.

Candidate SPNE in $B \in \left[0, \frac{1+a}{1+r}\right]$

As shown in Appendix 1, when $B \in \left[0, \frac{1+a}{1+r}\right]$ both types of firms always repay and the only candidate SPNE is a pooling equilibrium, where each firm i signs contract $\left\{r, \frac{1+a}{1+r}\right\}$: see (5) and (26). This contract is denoted by O in Figs. 2, 3, and 4. It is easy to check that, in Fig. 2, the indifference curves of bad and good firms passing through L and S, (curves $L'L$ and $H'H''$) lie to the north−west of the corresponding curves through O. The same is true for the indifference curves $L'P$ and $H'P$ which pass through P, in Fig. 4. We conclude that contract O is dominated both by separating contracts L and S and by the pooling one P and is not, therefore a SPNE of the game.

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