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TAXATION AND CORPORATE CHOICES UNDER CREDIT MARKET ASYMMETRIC INFORMATION

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Taxation and Corporate Choices Under Credit Market Asymmetric Information*

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Abstract

In this paper we extend the literature on tax effects on corporations' choices in two directions. Firstly, we analyze corporate and dividend tax effects when not only equity issues and retained profits but also debt finance is allowed. Secondly, we introduce asymmetric information between lenders and firms and assume the existence of two types of firms, bad and good ones. The former ones are characterized by low expected returns where the latter have a higher expected profitability. Given these assumptions, we show that if the portion of bad firms is low (high) enough, a pooling (separating) equilibrium exists. In separating equilibrium, good firms are credit rationed: this may explain why good firms do not use more debt. Moreover, we show that tax effects on credit market equilibria do depend on whether firms have enough cash to self-finance their investment projects or not.

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1 Introduction

The dispute between Old and New View on the effects of dividend taxation has been lasted for about thirty years. After so much time, a winner has not yet emerged. The empirical evidence shows that neither Views can explain the effects of dividend taxation on companies' choices.[1] Curiously, the analysis of dividend taxation on real decisions is based on the comparison between two possible sources of finance (equity issues and retained profits) whereas debt is (almost) always disregarded, although it is often less costly.[2] Moreover, tax papers deal with debt under symmetric information.[3] This is quite surprising, since credit markets are usually characterized by asymmetric information, although there are some unanswered questions.[4] In particular, it is unclear why firms do not use more debt, especially profitable firms (see Graham, 2003) and how taxation affects credit market equilibrium.

To address these issues we build a theoretical framework aimed at analyzing the effects of both corporate and dividend taxation when debt finance is allowed (along with equity issues and retained profits) and information is asymmetric. This article is thus related to two streams of literature. The first deals with the effects of dividend taxation on companies' strategies. This literature directly focuses on the dispute between Old and New View. As pointed out by Auerbach and Hassett (2003) however, "there is no reason to argue that one view is "correct" and another is "incorrect." What matters for tax policy decisions is the relative importance of the different views, in terms of the extent to which dividend taxes affect the cost of capital". Given these results, scholars have been trying to depart from previous work, by designing alternative and complementary models. For instance, Bernheim (1991) proposed a signaling theory. Chetty and Saez (2007) and Gordon and Dietz (2006)

[1] Well-known references for the Old view are: Harberger (1962), Feldstein (1970), and Poterba and Summers (1985). The New view is dealt with by King (1974), Auerbach (1979), and Bradford (1981).

[2] To the best of our knowledge, Auerbach and Hassett (2003) is the only exception that deals with debt explicitly: they estimate the determinants of the dividend/assets ratio and find a negative coefficient on initial debt. They argue that this is consistent with their expectation that a higher debt level discourages firms from additional borrowing and forces them to find alternative sources of funds. Moreover, they find that: i) firms with weak capital-market access — with no bond rating or analysts on record — are more sensitive in their dividend decisions than are other firms; ii) large firms with high bond ratings and several analysts following them, have dividends which are more responsive to cash needs. However, with greater access to borrowing than the typical firm likely to issue shares, these large firms may be relying on debt, rather than external equity, as a source of funds; iii) firms with a high probability of new issues tend to be those in between the two extremes, and also to exhibit dividend behavior more consistent with the traditional view of dividend taxation, with dividends substantially more responsive to cash flow than to investment. In their survey, Hanlon and Heitzman (2010) deal with the dispute between different views of dividend taxation. In a footnote they state that: "this discussion does not touch on the more complicated issues. Extant Theory typically ignores what happens when firms can finance with debt. Because projects are evaluated based on their net present value using a discount rate that factors in capital structure, a project financed with new debt is implicitly financed with a combination of debt and internal equity. A firm with existing debt that raises new equity may be closer to the traditional view. But because dividend taxation does not affect the cost of debt, at least directly, the investing decision of firms with more debt are likely to be lees sensitive to dividend taxation. This general proposition is not surprising if firms with extreme debt levels are compared. Further, the reality of tax law changes makes a determination of what is temporary and what is permanent difficult, although this distinction is crucial for new view model's implications for firm behavior" (pp. 160-161, footnote 133).

[3] Two notable exceptions are Boadway and Keen (2006); and Gordon (2010). See also Minelli and Modica (2009).

[4] Since Jensen and Mecklin (1976), debt finance under asymmetric information has been widely studied by financial economists who have however almost ignored taxation.

applied an agency theory. We depart from this work by introducing debt, which is usually less costly than others sources and thus deserves some analysis.

The second stream of research we refer to deals with the effects of taxation on capital structure. Despite the large number of articles dealing with this topic it is so far unclear why firms do not use more debt, especially profitable firms (see Graham, 2003). In order to address the tax effects on capital structure Gordon (2010) has analyzed three different models: an Agency-Cost, a Signaling and a Trade-Off model of debt finance. He has explored the implications of these models and concluded that the existing empirical evidence is more supportive of a "lemons" model in which lack of information about the viability of borrowing firms inhibits use of debt. It is worth noting however that neither Gordon (2010) nor other scholars, to our knowledge, investigate to what extent taxation affects borrowing contracts.

To address these issues we develop a model where two kinds of risk-neutral firms operate: bad firms, with lower success probability and expected returns and good firms, with higher success probability and expected returns. To keep the model as simple as possible, we focus on infra-marginal firms that can invest even under taxation. This means that, by assumption, the number of operating firms is given.

When information is symmetric, i.e., lenders can observe firms' returns, debt is the preferred source because of interest deductibility. When however information is asymmetric and firms' returns are private knowledge, we let competing lenders decide whether to commit or to not commit to the contracts they have offered. After observing both other lenders' contracts and the choices made by firms, each lender who did not commit can decide whether to withdraw the contract.

In this article we will also focus on two different scenarios: in the first one, firms are cash-rich, since they have enough retained profits to finance in the investment project. In the second one, firms are cash-poor in that retained profits are not enough. In both cases, we find two possible subgame perfect Nash equilibria (SPNEs): one separating equilibrium with or without commitment and one pooling equilibrium without commitment. In the separating equilibrium, only bad firms sign the first-best financial agreement with full debt finance, whereas good firms are credit-rationed, in that the amount of debt is less than the first-best one. Given these results we can respond to Graham's question and explain why profitable (good) firms use less debt than expected and bad ones are more indebted.

Moreover, we show that tax effects depend on whether firms are rich or poor. In particular, we show that, when firms are rich, only corporate taxation affects the equilibrium obtained, while dividend taxation is neutral. Interestingly, increasing the corporate tax rate does not affect bad firms' contract, while it reduces rationing for good firms since interest deductibility is enhanced and external debt becomes even more attractive. However, the separating equilibrium disappears if the share of good firms is relatively high. In this case, a pooling contract (i.e., a financial contract accepted by both bad and good firms) is now preferred by all firms. Moreover, we show that a higher corporate tax rate may decrease the likelihood of the unique separating equilibrium, since it reduces the maximum proportion of good firms below which such an equilibrium exists. The reason is still related to the increase in interest deductibility: because of this increased tax benefit, good firms are more attracted by contracts with both higher debt and interest rate. Since bad firms are always fully debt financed, the difference between good firms' contracts and bad firms' ones is now lower. This means that, in terms of optimal debt finance, good firms' choices are closer to bad firms' ones and therefore it is more likely that a lender offers a pooling contract. Also good firms, choosing a pooling one, are now better off.

A similar result holds when firms are cash-poor: if the number of bad firms is low enough, an unique pooling equilibrium without commitment arises. If however, the number of bad firms is large enough a separating equilibrium arises: in this case, bad firms receive their first-best contract, while good firms are credit rationed. Under the unique pooling equilibrium, no firm is credit rationed. In a cash-poor context, both corporate and dividend taxation affect the credit market equilibrium. In particular the higher these rates, the larger the cut-off number of bad firms, below which a pooling equilibrium arises.

The structure of the paper is as follows. The model is laid out in Section 2. Section 3 describes financial choices under symmetric information. Section 4 extends the model by introducing asymmetric information between firms and lenders. Section 5 discusses policy implications and provides some welfare analysis. Section 6 concludes.

2 The model under symmetric information

In this section, we introduce a two-period model where risk-neutral firms decide how to finance an investment project. Investment size is exogenously given and, for simplicity, normalized to 1.

By assumption there are two types of firms, denoted by $i = L, H$, whose probability of success is

$$0 < p_L < p_H < 1. \tag{1}$$

Firm i's expected return is thus equal to

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

where $R_H > R_L$. We denote good and bad firms by H- and L-firms, respectively.

We let firm i own cash holdings $\bar{M} \geq 0$, which can be distributed to its shareholders. Moreover, it can decide whether to issue equity $E \in [0, 1]$ and/or to borrow an amount of resources $B \in [0, 1]$ from external lenders. The timing of events is as follows:

Time 0 The firm pays out dividends

$$D = \bar{M} - M \tag{2}$$

and decides whether to invest the amount

$$M + E + B = 1 \tag{3}$$

in the project.

Time 1 The project yields either A with probability $p_i \in (0,1)$ or $a < A$ with probability $(1-p_i)$. Therefore the firm's expected return is equal to

$$R_i = p_i A + (1-p_i)\,a. \tag{4}$$

When returns accrue, the firm repays the money to the lenders if it has enough can and then distributes dividends, if any.

Let us next introduce two assumptions on the state of nature.

Assumption 1 *The good-state return $A_H \equiv A_L \equiv A$ is weakly higher than $\widetilde{A} \equiv \max\left\{\frac{r-(1-p_L)a}{p_L}; \frac{r-(1-p_H)a}{p_H}\right\}$.*

Assumption 2 *The bad-state return a belongs to interval $[-1, r]$, where $r > 0$ is the risk-free interest rate.*

Assumption 2 states that the bad-state gross return $1+a$ can be neither less than zero nor higher than $1+r$. This means that, in the former case, a "black swan" event (with returns 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 return is less than the opportunity cost r. Given (4), the inequality $A \geq \widetilde{A}$ of Assumption 1 can be rewritten as $R_i \geq r$: this means that the investment project is creditworthy for any $B \in [0,1]$.

2.1 Lenders

Let us assume the existence of a capital market with at least two homogeneous risk-neutral lenders competing à la Bertrand. Borrowing is regulated through a standard debt contract: if the firm is not able to repay, the lenders seize the firm's assets and become shareholders. Let ρ be the interest rate on debt. Hence a debt contract is characterized by the pair $\{\rho, B\}$. Since lenders operate in a Bertrand environment, the optimal interest rate ρ is determined by their break-even condition.

2.2 Taxation

Let us next introduce taxation. By assumption, a firm's profit is taxed both at the corporate level and when it is distributed at the shareholder level. Accordingly, we denote $t_c \in (0,1)$ and $t_d \in (0,1)$ by the corporate and dividend tax rate, respectively. Under this tax system, retained profit M (which has already been taxed at the corporate level) is subject to dividend taxation whenever is distributed.

The after-tax net present value of a firm is given by the summation between the investment cost at time 0 and the present value of gross return at time 1. More generally, suppose 1 unit of dividends paid out by the firm is worth $(1-t_d)$ to the shareholder after personal dividend taxation. If the firm retains M units of profit, the investment project's cost borne by the shareholder at time 0 is $-(1-t_d)\,M$. At time 0, firm's investment is given by retained profits plus equity:

$$-(1-t_d)\,M - E. \tag{5}$$

For simplicity, we also introduce the following:

Assumption 3 *Lenders are tax-exempt.*

Assumption 3 can be justified by the fact that the tax burden on capital income is relatively low or even close to zero in most cases. As pointed out by Cooper and Nyborg (2006), moreover, default risk entails that the evaluation of debt "depends upon the tax position of insolvent firms and the tax treatment of debt write-downs" (p. 366). In particular, they refer to the tax treatment of debt write-downs in the USA: according to the law, no tax liability is accounted for if the insolvent firm's liabilities exceed its assets.[5] Since we aim to focus on a real default case rather than a debt restructuring one, Assumption 3 well fits with our aim.

At time 1, the firm's expected value depends on its ability to repay the debt, which is in turn affected by the amount of borrowing: two cases are then considered.

Case 1 *The inequality*

$$(1+\rho)\,B \leq 1+a \tag{6}$$

holds: the debt contract $\{\rho, B\}$ *is such that the gross cost of borrowing,* $(1+\rho)\,B$*, is weakly lower than the before-tax gross value of the project's return in the bad state,* $(1+a)$*.*

If inequality (6) holds, of course the firm can repay debt. Accordingly, default never occurs and the lenders' break-even condition writes as

$$p_i\,(1+\rho)\,B + (1-p_i)\,(1+\rho)\,B = (1+r)\,B \tag{7}$$

or, equivalently, $\rho = r$, where $(1+r)\,B$ is the lenders' opportunity cost of lending the amount B. The firm's expected value at time 1 is therefore given by

$$(1-t_d)\,[(1-t_c)\,(R_i - rB) + M] + E + B - B, \tag{8}$$

that is the gross production function minus debt costs rB. Summing (5) and (8) and using the discount factor $\frac{1}{1+r}$ gives the firm's net present value (hereafter NPV):

$$-\,(1-t_d)\,M - E + \frac{(1-t_d)\,[(1-t_c)\,(R_i - rB) + M] + E}{1+r}. \tag{9}$$

Case 2 *The inequalities*

$$1+a < (1+\rho)\,B \leq 1+A \tag{10}$$

hold: the debt contract $\{\rho, B\}$ *is such that the gross cost of borrowing is higher than the firm's before-tax gross value in the bad case and is weakly lower than the firm's one in the good case. Here default occurs with probability* $(1-p_i)$ *and in this case, the lenders become shareholders. Accordingly, their break-even condition writes as follows:*

$$p_i\,(1+\rho)\,B + (1-p_i)\,(1+a) = (1+r)\,B. \tag{11}$$

[5] Notice that the tax treatment of debt write-downs is similar in many other countries.

Solving for ρ gives

$$\rho_{0,i} \equiv \frac{rB - (1-p_i)(a+M+E)}{p_i B}. \tag{12}$$

It is worth noting that (10) requires ρ to exceed r in order to satisfy (11): lenders require a risk premium when a positive probability of default arises.[6] In this case, the firm's NPV is calculated by accounting for the probability of default and is therefore equal to:

$$-(1-t_d)M - E + p_i \frac{(1-t_d)\left[(1-t_c)\left(A-\rho_{0,i}B\right)+M\right]+E}{1+r} + (1-p_i)\times 0, \tag{13}$$

3 A firm's problem under symmetric information

Let us next study the problem of a firm that maximizes its NPV with respect to M, E and B. Of course, if $\max NPV > 0$, investment is undertaken and vice versa. In order to focus on a firm's financial strategy we first need to know how much is the NPV under each single source of finance. For this reason, we first focus on shareholders' funds and then turn to debt finance.

3.1 Shareholders' funds

Shareholders can avoid debt-finance by either using retained profit or issuing new equities.

3.1.1 Full Self-financing

In this case, we have $E = B = 0$. Given (3) we thus obtain $M = 1$. Of course, full-self financing is feasible if cash holdings are enough, *i.e.*, $\bar{M} \geq 1$: in this case, the firm pays out dividends $D = \bar{M} - 1$ at time 0, according to (2). Substituting $E = B = 0$ into (9) thus gives a firm's NPV under full-self financing:

$$NPV_{M,i} \equiv -(1-t_d) + \frac{(1-t_d)\left[(1-t_c)R_i + 1\right]}{1+r} = \frac{1-t_d}{1+r}\left[(1-t_c)R_i - r\right]. \tag{14}$$

As can be seen, t_d does not affect the sign of $NPV_{M,i}$. This result is referred to as the "New View" theory: under self-finance, shareholders will save dividend taxes at time 0 and pay them at time 1. The net saving due to the postponement of the dividend payoff is nil and therefore, dividend taxation does not matter in terms of investment choices.[7]

[6] Case $(1+\rho)B > 1+A$ is ruled out by Assumption **??**. Indeed $(1+\rho)B \leq 1+A$ can be rewritten as

$$\left(1+\frac{rB-(1-p)(a+M+E)}{pB}\right)B \leq 1+A \tag{a}$$

after substituting (12). The LHS of the above inequality is maximum for $B = 1$. Substituting $B = 1$ into (a) gives

$$1+\frac{r-(1-p)a}{p} \leq 1+A$$

which is equivalent to Assumption **??**.

[7] For further details, see Auerbach (2002).

3.1.2 Full Equity-financing

Under full equity finance, we have $E = 1$ and $B = M = 0$. This means that, given (2), at time 0 the firm distributes $\bar{M}$. Substituting $E = 1$ and $B = M = 0$ into (9) and rearranging gives the fully equity-financed NPV:

$$NPV_{E,i} \equiv -1 + \frac{(1-t_d)(1-t_c)R_i + 1}{1+r} = \frac{(1-t_d)(1-t_c)R_i - r}{1+r}. \tag{15}$$

In this case, the higher the rate t_d the lower the $NPV_{E,i}$ is. An investment decision of an equity-financed firm is, therefore, affected by dividend taxation. This result is in line with the Old View, according to which the marginal source of funds is new equity, and thus dividend taxation affects investment decisions. Moreover, it is easy to see that $NPV_{M,i} > NPV_{E,i}$ for any $t_d > 0$. This means that, due to dividend taxation, self-financing is preferred to equity.

3.2 Debt finance

Unlike self- and equity-finance, debt might lead to default. For this reason, we must analyze two different scenarios, which depend on the amount of borrowing: a *default-free scenario*, when the inequality (6) holds, and a *default scenario*, described by (10).

3.2.1 Default-free debt

If (6) holds, no default occurs and the lenders' break-even condition is $\rho = r$. Using (6) and substituting $M = 1 - E - B$ (from (3)) into (9) the firm's problem can be written as follows:

$$\max_{E,B} \left\{ -(1-t_d)(1-E-B) - E + \frac{(1-t_d)\left[(1-t_c)(R_i - rB) + (1-E-B)\right] + E}{1+r} \right\} \tag{16}$$
$$\text{s.t. } B \leq \frac{1+a}{1+r},$$

with $\frac{1+a}{1+r} \in [0,1]$ (see Assumption 2). It is thus easy to show that:

Lemma 1 *NPV (16) is increasing in B and decreasing in E for any admissible value of parameters r, t_c and t_d.*

Proof. See Appendix A.1. ■

The above result hinges upon the deductibility of interest expenses, which makes debt less costly than other sources in absence of default. Accordingly, the firm is induced to maximize B and minimize equity issues. This means that:

$$B^* = \frac{1+a}{1+r} \leq 1. \tag{17}$$

and

$$M^* = \min\left\{\bar{M}, 1 - \frac{1+a}{1+r}\right\}. \tag{18}$$

Substituting B^* and M^* into (3) gives optimal equity

$$E^* = 1 - \frac{1+a}{1+r} - M^*. \tag{19}$$

Since E^* depends on the amount $\bar{M}$, according to (18), the firm can be:

(i) either rich, if $\bar{M} \geq 1 - \frac{1+a}{1+r}$,

(ii) or poor, otherwise.

In the former case, the firm sets $M^* = 1 - \frac{1+a}{1+r}$ according to (18), pays out dividends $D^* = \bar{M} - M^*$ and issues no equity. Substituting $B^* = \frac{1+a}{1+r}$ and $E^* = 0$ into (16) and rearranging gives the default-free NPV:

$$NPV_{B,M,i} \equiv \frac{(1-t_d)(1-t_c)}{1+r}\left[(R_i - r) - \frac{rt_c}{1-t_c}\left(1 - \frac{1+a}{1+r}\right)\right]. \tag{20}$$

In the latter case ($\bar{M} < 1 - \frac{1+a}{1+r}$), the firm sets $M^* = \bar{M}$ and $D^* = 0$. Due to cash constraint, it must issue equity, i.e., it sets $E^* = 1 - \frac{1+a}{1+r} - \bar{M}$. Therefore, (16) reduces to:

$$NPV_{B,M,E,i} \equiv NPV_{B,M,i} - \frac{rt_d}{1+r}\left(1 - \frac{1+a}{1+r} - \bar{M}\right). \tag{21}$$

Given Lemma 1, the inequality $NPV_{B,M,i} > NPV_{B,M,E,i}$ holds.

3.2.2 Default scenario

Let us now focus on the interval $\frac{1+a}{1+r} < B \leq 1$. Since $1 + a < (1+r)B$ and $\rho > r$, the firm goes bankrupt with probability $(1 - p_i)$. It is worth noting that we assume for simplicity that the probability of default does not depend on leverage.[8]

Under default risk, the interest rate on debt is $\rho_{0,i}$ and depends the amount of borrowing. Using (12) it is easy to show that

$$\frac{\partial \rho_{0,i}}{\partial B} = \frac{(1-p_i)(1+a)}{pB^2} > 0. \tag{22}$$

In other words, the higher the debt $B \in (\frac{1+a}{1+r}, 1]$, the higher the break-even interest rate $\rho_{0,i}$.

Under debt finance, using (10) and substituting $M = 1 - E - B$ (from (3)) into (9) gives the firm's problem:

$$\max_{E,B}\left\{-(1-t_d)(1-E-B) - E + p_i\frac{(1-t_d)\left[(1-t_c)\left(A - \rho_{0,i}B\right) + (1-E-B)\right] + E}{1+r}\right\} \tag{23}$$

$$\text{s.t. } \frac{1+a}{1+r} < B \leq 1,$$

Solving (23) gives the following:

[8] In doing so we depart from the standard Trade-Off Theory (see, e.g., Kraus and Litzenberger, 1973, and Leland, 1994). This extension is left for further reasearch.

Lemma 2 *NPV (23) is increasing in B and decreasing in E for any r, t_c and t_d.*

Proof. See Appendix A.2. ■

Lemma 2 implies that the firm finances the entire investment with debt, $B^* = 1$. Hence, equity and self-finance are nil (and the dividend payout is $D^* = \bar{M}$). Substituting $B^* = 1$, $M^* = 0$ and $E^* = 0$ into (12) gives

$$\rho_i^* \equiv \frac{r - (1 - p_i)\, a}{p_i}, \tag{24}$$

where $\rho_i^* > r$ under Assumption 2. Substituting $E^* = 0$, $B^* = 1$ and ρ_i^* into (23), the optimal firm's NPV under default risk reduces to:

$$NPV_{B,i} \equiv p_i \frac{(1 - t_d)(1 - t_c)(A - \rho_i^*)}{1 + r}. \tag{25}$$

It is worth noting that, given Assumption **??**, $\rho_i^* = \underline{A}$ and thus $NPV_{B,i} \geq 0$. This means that $A \geq \rho_i^*$.

Finally, since the $NPVs$ of eq. (16) and (23) are decreasing in E. We can therefore say that:

Lemma 3 *Only cash-poor firms issues equity.*

This well-known result is due to the tax advantage of retained profit over equity issues.

3.3 First-best financial policy

When debt finance is allowed, a firm chooses its optimal financial policy by comparing the optimal NPV in the default-free scenario with the one obtained under default risk. Since the former depends on the amount of firm's cash holdings, there are two cases: if the firm is cash-rich, the optimal NPV without default is given by $NPV_{B,M,i}$; otherwise, the optimal NPV without default is equal to $NPV_{B,M,E,i}$.

As shown in Appendix A.3, the inequality $NPV_{B,M,i} \leq NPV_{B,i}$ holds under Assumption 2. Moreover, we have $NPV_{B,M,i} = NPV_{B,i} \Leftrightarrow a = r$. As a consequence, the optimal financial policy for a cash-rich firm is $B^* = 1$. In this case, the optimal NPV is equal to $NPV_{B,i}$.[9] Similarly, when firms are cash-poor firm, it is sufficient to recall that $NPV_{B,M,E,i} < NPV_{B,M,i}$ to conclude that $NPV_{B,M,E,i} < NPV_{B,i}$. Therefore we can state that:

Lemma 4 *Under symmetric information, a firm always prefers full debt finance, i.e.,*

$$\{\rho_i^*, B^*\} = \left\{ \frac{r - (1 - p_i)\, a}{p_i}, 1 \right\}, \ E^* = M^* = 0 \text{ and } D^* = \bar{M}.$$

According to this Lemma, the amount of cash holdings does not affect a firm's financial policy. It is worth noting that full debt finance is always the optimal choice because we have assumed that the bad-state probability does not depend on leverage. As we have pointed out, this simplifying assumption will allow us to focus on tax effects under asymmetric information with a tractable framework.

[9] Recall that Assumption 2 ensures that NPV_B is non-negative.

4 Asymmetric Information

Let us next turn to asymmetric information. In this case, we assume that probability p_i is firm i's private information and lenders only know that a proportion $\lambda \in (0,1)$ of firms is bad and that remaining firms (i.e., $1-\lambda$) are good.

It is worth noting that the asymmetry of information matters only in the default area, i.e., for $B \in \left(\frac{1+a}{1+r}, 1\right]$ (and $\rho > r$). Otherwise, both types of firms would repay with probability 1 and the equilibrium would be trivial because the probability of success is 1 for each type. For this reason, we deal with the default area and study the pure-strategy subgame perfect Nash equilibria (SPNEs) of the following three-stage game, where:

1. there are $N \geq 2$ lenders who compete à la Bertrand by simultaneously offering contracts to the firms. Each contract is a triple $\{\rho; B; k\}$, with $\rho > r$, $B \in \left(\frac{1+a}{1+r}, 1\right]$ and $k \in \{0,1\}$ specifying whether the lenders are committed to the contract, $k=1$, or not, $k=0$. Since there are only two types of firms, the lenders offer at most a pair of contracts.

2. Afterward, both types of firms decide whether to accept a contract and, if so, which one.

3. Finally, 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 decide whether to withdraw the contract or not. If a contract is withdrawn, the firms which chose it obtain their reservation utility, consisting in the NPV with $B=0$. All the other agreements, i.e., contracts with or without commitment, that were not withdrawn, are signed by the parties.

In principle, three types of equilibria may exist:

(i) Separating equilibria, when the two types of firms sign different contracts.

(ii) Pooling equilibria, when both bad and good firms accept the same contract.

(iii) Rationing equilibria, when one type of firms signs a contract, while the other type signs no contract.

As we have shown in the previous Section, under symmetric information, a separating equilibrium would exist where the lenders would earn zero profit by offering first-best type-dependent contracts with or without commitment to firms, i.e.,

$$\left\{\rho_i^* \equiv \frac{r-(1-p_i)\,a}{p_i}; B_i^* \equiv 1; k\right\},$$

with $\rho_L^* > \rho_H^*$ by (24) and (1). When however p_i is private information, the above pair of contracts cannot be an equilibrium. Indeed, L-type firms would prefer contract $\{\rho_H^*; 1; k\}$, given $\rho_L^* > \rho_H^*$, and in this case lenders would probably face a loss.

Invoking a Bertrand argument we can state the following:

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

In the next two sub-sections, we will analyze both cash-rich and cash-poor case introducing, for simplicity, the following:

Assumption 4 *A cash-rich (cash-poor) firm is endowed with* $\bar{M} = 1$ $(\bar{M} = 0)$.

The quality of results would not change if we focused on intermediate cases, with $\bar{M} \in (0, 1)$.

4.1 Cash-rich firms

In order to analyze all possible equilibria, we apply a graphical approach. In this subsection, we focus on cash-rich firms.

Let us our analysis by depicting five curves in the (ρ, b) plane of Figure 1.[10] Curves OH, OL, and OP are the lenders' zero-profit conditions for H-firms, L-firms and for pooling contracts that attract both types of firms, respectively. These curves are increasing in (ρ, b) plane. Therefore lenders are better-off (worse-off) when moving south-east (north-west). To see this let us rearrange the lenders' break-even condition (11) under default. We obtain:

$$[p_i (1 + \rho) - (1 + r)] B + (1 - p_i) (1 + a) = 0. \tag{26}$$

We can see that Eq. (26) increases with ρ and decreases with B since maximum value of $p_i (1 + \rho) - (1 + r)$ is for $\rho_i^* = \frac{r-(1-p)a}{p_i}$ and equal to $-(1 - p_i)(1 + a) < 0$. Solving (26) for B gives

$$B_i = \frac{(1 - p_i)(1 + a)}{1 + r - p_i (1 + \rho)}. \tag{27}$$

Substituting p_H (p_L) into (27) gives OH (OL). The two curves are equal to $\frac{1+a}{1+r}$ when $\rho = r$ (contract O) and to 1 when $\rho_i^* = \frac{r-(1-p_i)a}{pi}$ (contract H when $p_i = p_H$ and contract L when $p_i = p_L$). In Appendix B.1, we show that both first and second derivative of (27) w.r.t. ρ are positive. This implies that OH is steeper than OL. The underlying intuition is as follows. Remember that lenders' profit is positively (negatively) affected by ρ (B). Thus an increase in ρ raises lenders' profit when the borrower is a good firm since $p_H > p_L$, see (26). **This makes OH steeper than OL.**

Let us next turn to the pooling indifference curve OP, which is given by the following weighted average:

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

[10] In Figure 1 and all subsequent ones parameters take the following values: $p_L = .95$; $p_H = .99$; $r = .05$; $a = -.1$; $t_c = .3$; $\lambda = 0.5$.

Solving by B gives

$$B=\frac{\lambda\left(1-p_L\right)\left(1+a\right)+\left(1-\lambda\right)\left(1-p_H\right)\left(1+a\right)}{\lambda\left[\left(1+r\right)-p_L\left(1+\rho\right)\right]+\left(1-\lambda\right)\left[\left(1+r\right)-p_H\left(1+\rho\right)\right]}. \tag{28}$$

Intuitively, OP boils down to OH when all firms are good, $\lambda=0$, and to OL when all firms are bad, $\lambda=1$. Since OP is a linear combination between OH and OL, it is increasing in ρ, flatter (steeper) than OH (OL), equal to $\frac{1+a}{1+r}$ for $\rho=r$, i.e., contract $O\equiv\left(r,\frac{1+a}{1+r},k\right)$, and to 1 for

$$\rho_P=\frac{1+r-\lambda p_L-\left(1-\lambda\right)p_H-\left(1+a\right)\left[\lambda\left(1-p_L\right)+\left(1-\lambda\right)\left(1-p_H\right)\right]}{\lambda p_L+\left(1-\lambda\right)p_H}, \tag{29}$$

i.e., contract $P\equiv\left(\rho_P,1,k\right)$.

Let us finally calculate the equation of i-firms' indifference curve, by equating its the NPV as in (13), with $E=0$ and $M=1-B$, to the one obtained with any contract $X\equiv\left(\rho_X,B_X\right)$:

$$-\left(1-t_d\right)\left(1-B\right)+p_i\frac{\left(1-t_d\right)\left[\left(1-t_c\right)\left(A-\rho B\right)+\left(1-B\right)\right]}{1+r}= \tag{30}$$
$$-\left(1-t_d\right)\left(1-B_X\right)+p_i\frac{\left(1-t_d\right)\left[\left(1-t_c\right)\left(A-\rho_X B_X\right)+1-B_X\right]}{1+r}.$$

Notice that the LHS is increasing in B and decreasing in ρ. Accordingly, the firms' indifference curves are increasing in (ρ,b) plane and firms are better-off (worse-off) when moving south-east (north-west). To see this we solve (30) for B thus obtaining

$$B=\frac{B_X\left[1+r-p_i\left(1+\left(1-t_c\right)\rho_X\right)\right]}{1+r-p_i\left[1+\rho\left(1-t_c\right)\right]}. \tag{31}$$

In Appendix B.1, we have shown that both the first and second derivative of (31) w.r.t. ρ are positive. This entails that H-firms' indifference curves are steeper. The reasoning is the same as that on curves OH and OL. Namely, an increase in ρ causes higher costs for good firms since $p_H>p_L$ (see the LHS of (30)). As a result, good firms must borrow a larger amount of money B in order to be indifferent.

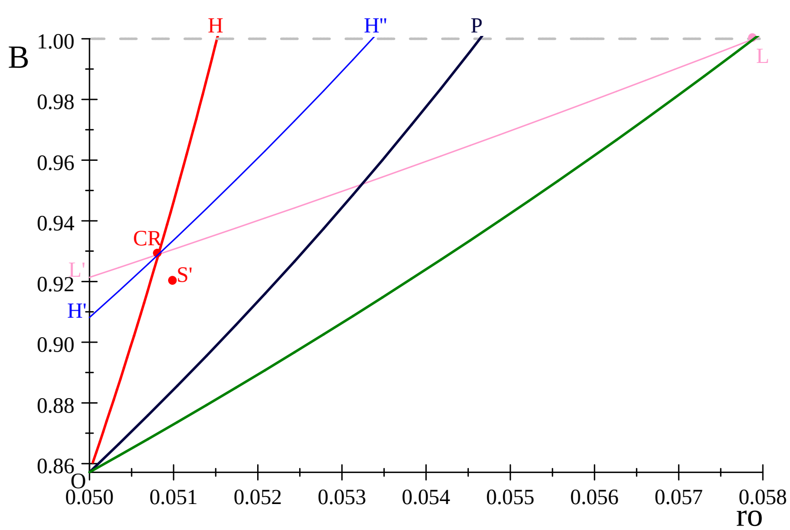

FIGURE 1. SEPARATING EQUILIBRIUM

Let us next analyze equilibria.

Separating equilibrium. As a first step, we demonstrate that an equilibrium where separating contracts (with or without commitment) are signed exists only if the share λ of bad firms is high enough. Recall that when first-best separating contracts $L \equiv \{\rho_L^*; 1; k\}$ and $H \equiv \{\rho_H^*; 1; k\}$ are offered, our competing lenders face a loss since L-firms choose contract H instead oh L. To prevent this deviation, lenders have three alternatives. They might offer (i) L to bad firms and a worse contract than H to good firms, (ii) a better contract than L to bad firms and H to good firms (iii) a worse contract than H to good firms and a better contract than L to bad firms. However, options (ii) and (iii) are not viable since L is bad firms' first-best contract. Moreover, in a separating equilibrium (if any) lenders earn zero profit on each per-type contract according to Claim 1. As a consequence, the unique separating equilibrium is the pair of contracts $L \equiv (\rho_L^*; 1; k)$ to bad firms and $CR \equiv (\rho_{CR}; B_{CR}; k)$ to good firms, with commitment, where CR is given by the intersection between $L'L$, the L-firms' indifference curve through L, and OH, the lenders' zero-profit curve for H-firms.

Contract CR derives from the solution of the following two-equation system

$$\begin{cases} B = \frac{1+r-p_L\left[1+\rho_L^*(1-t_c)\right]}{1+r-p_L[1+\rho(1-t_c)]} & (L'L), \\ B = \frac{(1-p_H)(1+a)}{1+r-p_H(1+\rho)} & (OH). \end{cases}$$

Solutions are equal to

$$\rho_{CR} = \frac{r\left(p_H - p_L\right)(1+a) + t_c\left(1+r-p_H\right)\left(r-a+ap_L\right)}{\left(p_H - p_L\right)(1+a) + t_c\left[p_H\left(r-a\right) + p_L\left(1+a-p_H\right)\right]} < \rho_H^* \tag{32}$$

and

$$B_{CR} = \frac{\left(1-p_H\right)(1+a)}{1+r-p_H\left(1+\rho_{CR}\right)} < 1, \tag{33}$$

where subscript CR stands for cash-rich; see Appendix B.1 for computations.

Notice that contract L is unique because of Bertrand competition. Similarly, contract CR is unique because any contract lying on O, CR would be undercut by other lenders and any contract lying on CR, H would be chosen also by L-firms. Notice that there is no profitable pooling contract lying at south-east of the pooled break-even and preferred by H-firms to CR.

Let us denote $H'H''$ as H-firms' indifference curve through CR. This indifference curve is necessary to prove that both types of firms' participation constraints are not active at the separating equilibrium (L, CR). Indeed, (cash-rich) firms' outside option coincides with (14), the NPV in case of self-financing, which is preferable to equity. Yet, according to Lemma 1, (14) is less than (20), what they get when signing contract $O \equiv \left\{r; \frac{1+a}{1+r}; 1\right\}$, which, in turn, is less than bad firms' NPV in L and good firms' NPV in CR.

Interestingly, the unique separating equilibrium (L, CR) vanishes if share λ is low enough. The reasoning is as follows. The pooled break-even curve OP rotates leftward as λ diminishes and might intersect curve $H'H''$ at a point M with $B_M < 1$. See Figure 2, where OP is depicted for $\lambda = .2$. In this scenario a profitable deviation is available when all lenders are offering contracts (L, S). At least one lender may propose contract $D \equiv \{\rho_D; B_D; 1\}$, lying in area MPH''. Contract D entails higher benefit to both types. All firms take it because lenders are committed to it and make positive profit.

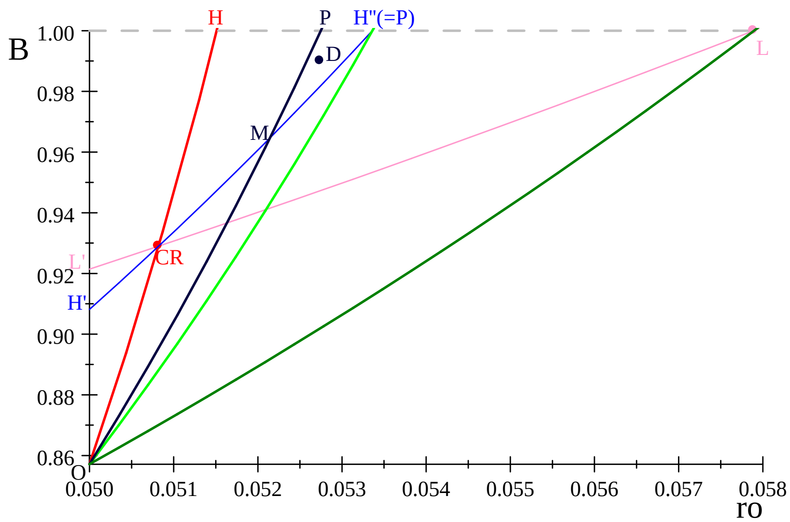

FIGURE 2. NO SEPARATING EQUILIBRIUM WHEN $\lambda < \lambda^{CR}$

To obtain the minimum share λ of L-firms, above which a separating equilibrium (L, CR) exists, it is sufficient to calculate the value of λ such that the pooled break-even line OP intersects $H'H''$ at $B = 1$. As shown in Appendix B.1 it is equal to:

$$\lambda_{CR} = \frac{p_H t_c (1 + r - p_H)}{(1 + r)(p_H - p_L) + p_H t_c (1 + r - p_H)}. \tag{34}$$

Let us finally explain the non-existence of a separating equilibrium with commitment when $\lambda < \lambda_{CR}$. To do so, we must focus on the pooling contract $P \equiv \{\rho_P; 1; k\}$. Since ρ_P is increasing in λ (see (29)), ρ_P is relatively low when few bad firms are operating: in this case, lenders expect that the likelihood of financing a good firm is high enough. Therefore, contract P is particularly appealing and turns out to preferred by good firms to the separating contract CR.

Pooling equilibrium. A pooling equilibrium contract with or without commitment, if any, must lie on the pooled break-even curve OP. As shown in Figure 3, any pooling contract at north-west of the pooled break-even line yields negative profit. Similarly, there is no pooling contract lying at south-east of the pooled break-even line; otherwise banks would earn strictly positive profit. However, this case contradicts Claim 1.

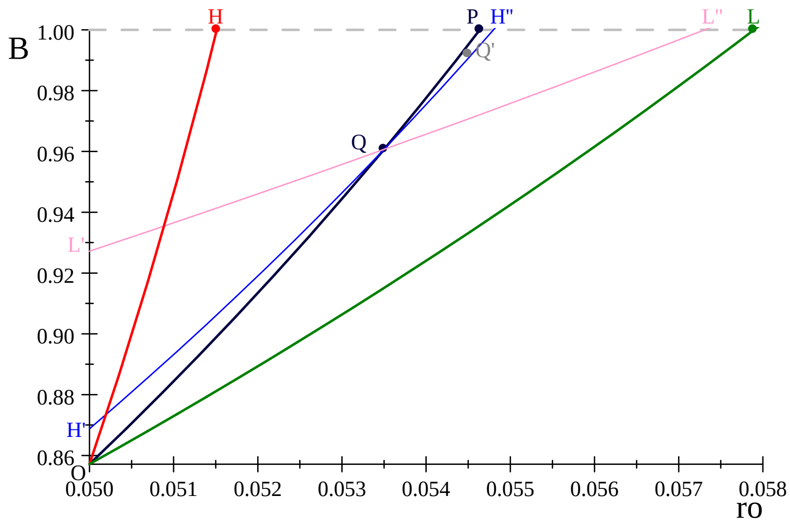

FIGURE 3. NO POOLING EQUILIBRIUM WITH COMMITMENT

Assume now that all lenders offer a pooling contract $Q \equiv (\rho_Q; B_Q; k)$, with or without commitment, lying on the pooled break-even line OP, with $\rho_Q < \rho_P$ and $B_Q < 1$ (see Figure 3). Curves $H'H''$ and $L'L''$ are H- (L-) firms' indifference curve, respectively, through contract Q. Notice that such a contract cannot be an equilibrium, since at least one lender can offer another pooling contract $Q' \equiv (\rho_{Q'}; B_{Q'}; 1)$ placed in the QPP' area, 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 profit to the lender. As a consequence, the only candidate pooling equilibrium contract is $P \equiv (\rho_P; 1; k)$.

Let us next show that when contract CR is dominated by contract D, or equivalently $\lambda < \lambda_{CR}$ as in Figure 2, the agreement P without commitment, i.e., $P \equiv \{\rho_P; 1; 0\}$, is the unique pooling equilibrium. To do so, we draw in Figure 4 (which is based on Figure 2) curves $L'P$ and $H'P$, namely, L-firms' and H- firms' indifference curves through contract P, respectively. First notice that if all lenders offer $P \equiv \{\rho_P; 1; 1\}$ to both types, at least one lender can propose a rationing contract $B \equiv (\rho_B; B_B; k)$. This is a profitable deviation since B lies in the GFP area and is thus accepted only by H-firms. Moreover, the lender offering contract B would earn positive profit. As a result, $P \equiv \{\rho_P; 1; 1\}$ is not an equilibrium. The reasoning is as follows. Good firms' indifference curve is steeper than bad firms' one. This means that good firms prefer to be more credit-rationed, i.e., to have a lower B, than bad firms in order to pay a lower interest rate. Accordingly, it is always possible to find a profitable deviation by moving from P to the south-east GFP triangle.

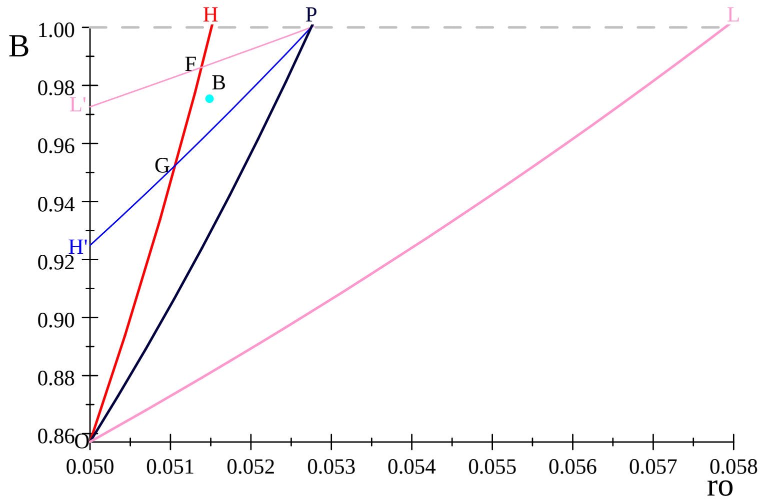

FIGURE 4. POOLING EQUILIBRIUM WITHOUT COMMITMENT WHEN $\lambda < \lambda^{CR}$

Interestingly, any contract with or without commitment in area GFP, such as B, is no longer profitable if all lenders offer $P \equiv \{\rho_P; 1; 0\}$ without commitment. Since the deviant contract B attracts only H-firms, P is only chosen by L-firms and it causes a loss to lenders. As a result, at Stage 3, contract P is withdrawn. This is possible since P is without commitment. By backward induction, at Stage 2 L-firms also choose the deviant contract B since it is the only remaining one and is preferable to a fully self-financed solution (see $NPV_{M,i}$ in (14)). In this case, B causes a loss since it lies to the north-west of the pooled break-even curve OP. We can therefore say that there is no profitable deviation from P. Moreover, one can easily check that contract $P \equiv \{\rho_P; 1; 0\}$ fulfills the participation constraint of both type of firms.

Rationing equilibrium. Let us finally study the existence of rationing equilibrium contract(s), i.e., when only one type of firms signs the agreement. Suppose such an equilibrium contract (if any) is accepted only by H-firms. Then, given Bertrand competition, it must be contract $H \equiv \{\rho_H^*; 1; k\}$, with or without commitment. As we have pointed out however, contract H would also be chosen by L-firms. This means that H cannot be a rationing equilibrium. Suppose now that the rationing equilibrium contract is accepted only by L-firms. Then, given Bertrand competition, it must be contract $L \equiv \{\rho_L^*; 1; k\}$, with or without commitment. If however all lenders offer L, at least one lender has a following profitable deviation. If $\lambda < \lambda_{CR}$, then she can offer the pooling contract with commitment $D \equiv \{\rho_D; B_D; 1\}$. If $\lambda \geq \lambda_{CR}$, she can propose L and a second contract $S' \equiv \{\rho_{S'} \leq \rho_{CR}; B_{S'} \leq B_{CR}; 1\}$ (see Figure 3), which is signed only by H-firms and yields positive profit, thereby contradicting Claim 1. We can therefore say that, irrespective of commitment, no rationing equilibrium contract exists.

Given these results we can now write the following:

Proposition 1 *Suppose all firms are cash-rich. (i) If the share of bad firms in the economy is relatively low, i.e., $\lambda < \lambda_{CR}$ the unique SPNE of the three-stage game played by lenders and cash-rich firms is a pooling equilibrium without commitment, where both H- and L-firms sign contract $P \equiv \{\rho_P; 1; 0\}$. (ii) If the share of bad firms in the economy is high enough, i.e., $\lambda \geq \lambda_{CR}$, the unique*

SPNE is a separating equilibrium with or without commitment, where bad firms sign their first best contract $L \equiv \{\rho_L^*; 1; k\}$, whilst good firms sign contract $CR \equiv \{\rho_{CR}; B_{CR}; k\}$, with $\rho_{CR} < \rho_H^*$ and $B_{CR} < 1$, and use cash holdings $M_{CR} = 1 - B_{CR}$ given Lemma 2 and Assumption 4.

If the fraction of L-firms is low enough, i.e., if λ is below its cut-off level λ_{CR}, banks prefer to offer a single contract to firms. This contract leads to a pooling equilibrium $P \equiv \{\rho_P; 1; 0\}$. Accordingly, debt is equal to $B_P = 1$ and hence no firm is credit rationed. As pointed out, with a low λ the probability of debt repayment is high. Hence, banks offer a contract with a relatively low break-event interest rate ρ_P. As we have shown, the pooling interest rate ρ_P is less than the first best interest paid by bad firms (ρ_L^*). For this reason, in an asymmetric context, bad firms prefer the pooling contract. At the same time, contract $P \equiv \{\rho_P; 1; 0\}$ is also preferred by good firms: though they have to pay a higher interest rate than under separation ($\rho_P > \rho_{CR}$), they are not credit rationed, i.e., $B_P = 1 > B_{CR}$.

Notice that contract P is offered without commitment by lenders: this means that a bank can decide not to sign the agreement after her proposal. If indeed a lender would commit to such an agreement, her competitor would find it profitable to deviate and therefore offer another contract that is strictly preferred by good firms. In this case, the former lender, who decided to commit, would only sign agreements with bad firms, thereby facing an expected loss, while the latter would make profit. For this reason, the lack of commitment is a credible threat against other competitors.

4.2 Cash-poor firms

Let us next focus on cash-poor firms. For simplicity we assume that they have no cash, i.e., $\bar{M} = 0$. If therefore debt is $B < 1$ the remaining amount of resources is ensured by equity, so that $E = 1 - B$.

Following the same procedure adopted for cash-rich firms, let us next calculate firms' indifference curves. To do so, we must equate a i-firm's net present value to the one obtained by signing any $X \equiv (\rho_X, B_X)$, i.e.,

$$\begin{aligned} -(1-B) + p_i \frac{(1-t_d)(1-t_c)(A-\rho B) + 1 - B}{1+r} &= \\ -(1-B_X) + p_i \frac{(1-t_d)(1-t_c)(A-\rho_X B_X) + 1 - B_X}{1+r}&. \end{aligned} \tag{35}$$

The LHS of (35) is equal to the NPV (13) with $M = 0$ and $E = 1 - B$, while the RHS is equal to (13) with $M = 0$ and $E = 1 - B_X$, with $\rho = \rho_X$. Solving (35) for B gives the cash-poor indifference curve of firm $i = L, H$:

$$B = \frac{B_X \{1 + r - p_i [1 + (1-t_c)(1-t_d)\rho_X]\}}{1 + r - p_i [1 + \rho (1-t_c)(1-t_d)]}. \tag{36}$$

It is easy to show that B is increasing in ρ. Moreover, the indifference curves of both kinds of firms are flatter than in the cash-rich case, as can be seen in the following inequalities:

$$MRS_{\rho,B}^{L,cp} = \frac{p_L B (1-t_c)(1-t_d)}{r - p_L \rho (1-t_c)(1-t_d)} < \frac{p_L B (1-t_c)(1-t_d)}{r(1-t_d) - p_L \rho (1-t_c)(1-t_d)} = MRS_{\rho,B}^{L,cr},$$

and

$$MRS^{H,cp}_{\rho,B} = \frac{p_H B}{r - p_H \rho (1-t_c)(1-t_d)} < \frac{p_H B}{r(1-t_d) - p_H \rho (1-t_c)(1-t_d)} = MRS^{H,cr}_{\rho,B}.$$

In Appendix B.2 we show that both the first and second derivative of (36) w.r.t. ρ are positive. Like the cash-rich case therefore, H-firms' indifference curves are steeper. Moreover, we also show that the first derivative of (36) is higher than that of (31): this means that cash-poor i-firms' indifference curves are flatter than cash-rich ones. Finally, the lenders' break-even curves OH, OL and OP are unaffected by the amount of $\bar{M}$ (see (26)).

Following the same reasoning used for cash-rich firms, we can show that a unique pooling equilibrium without commitment exists if the proportion of bad firms is low enough. A unique separating equilibrium, with or without commitment, arises however when λ is high enough. Defining λ_{CP} as the cut-off level below (above) which a pooling (separating) equilibrium is obtained, we will show that $\lambda_{CP} > \lambda_{CR}$. The reasoning is as follows.

The pooling equilibrium contract is equivalent to that in case of cash-rich firms, *i.e.*, $P \equiv \{\rho_P; 1; 0\}$, as can easily be seen. However, the cash-poor separating equilibrium, denoted by the couple (L, CP), is different from the cash-rich one. Contract CP, designed to cash-poor H-firms, is given by the intersection between the unchanged lenders' break-even line for H-firms, OH, and the new cash-poor L-firms' indifference curve through $L \equiv \{\rho_L^*; 1; k\}$, denoted by $l'L$ in Figure 5.

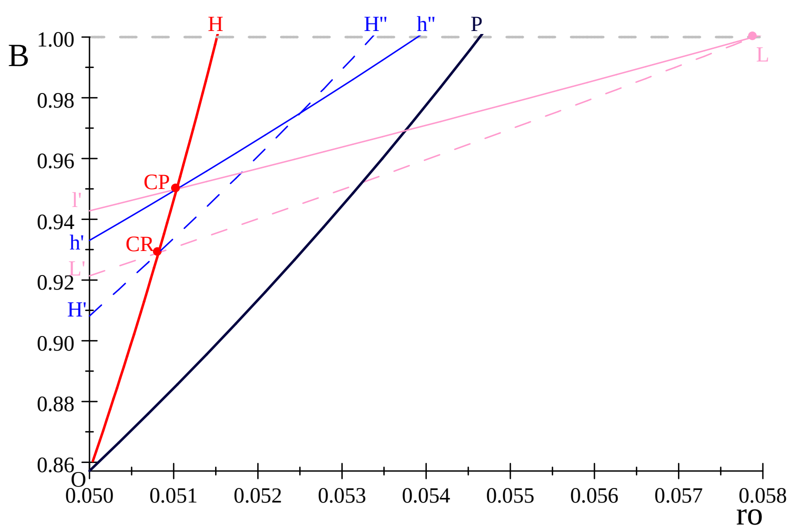

FIGURE 5. SEPARATING EQUILIBRIUM WHEN FIRMS ARE CASH-POOR *vs.* CASH-RICH

Since $l'L$ is flatter than $L'L$, H-firms are less credit rationed than before. To see this, in Appendix B.2 we calculate contract CP by solving the following two-equation system

$$\begin{cases} B = \frac{1+r-p_L\left[1+\rho_L^*(1-t_d)(1-t_c)\right]}{1+r-p_L[1+\rho(1-t_d)(1-t_c)]} & (l''l), \\ B = \frac{(1-p_H)(1+a)}{1+r-p_H(1+\rho)} & (OH), \end{cases}$$

We thus obtain

$$\rho_{CP} \equiv \frac{r(p_H - p_L)(1+a) + (1+r-p_H)(r-a+ap_L)[1-(1-t_c)(1-t_d)]}{(p_H - p_L)(1+a) + [p_H(r-a) + p_L(1+a-p_H)][1-(1-t_c)(1-t_d)]}$$

and

$$B_{CP} \equiv \frac{(1-p_H)(1+a)}{1+r-p_H(1+\rho_{CP})}.$$

The cut-off share λ_{CP} is given by the intersection, at point $B=1$, between the unchanged pooled break-even curve OP and the new cash-poor H-firms' indifference curve through CP, $h'h''$. It is therefore equal to

$$\lambda_{CP} = \frac{p_H(1-(1-t_c)(1-t_d))(1+r-p_H)}{(1+r)(p_H-p_L)+p_H(1-(1-t_c)(1-t_d))(1+r-p_H)}. \tag{37}$$

Given this result it is easy to show that $\lambda_{CP} > \lambda_{CR}$. The reasoning behind this inequality is straightforward. In a cash-poor context, H-firms must issue $E_{CP} = 1 - B_{CP}$ according to the separating contract CP. Since equity is more costly than self-finance, it is now easier to find a pooling contract D' (with both a higher amount of B and a higher tax rate ρ) that lies in the $M'Ph''$ area and is preferred to CP by H-firms. As can be seen in Figure 6, point h'' is to the right of H''.

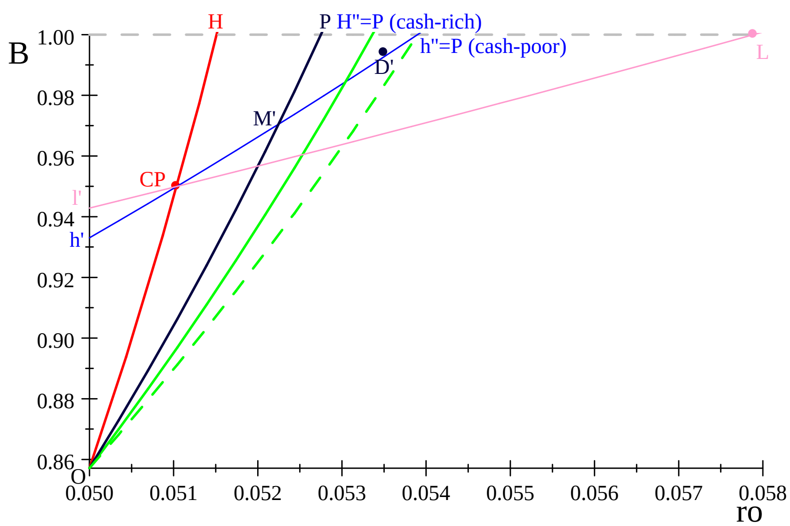

FIGURE 6. CASH-POOR FIRMS: NO SPNE EXISTS

If λ is low enough (i.e., either $\lambda < \lambda_{CR}$ or $\lambda < \lambda_{CP}$), there is one SPNE pooling equilibrium. When firms are poor, it is more likely to obtain such an equilibrium. As pointed out, good firms must issue equity $E = 1 - B_{CP}$ under separation. Since equity is more costly than self-finance (see Lemma), good firms have now a higher propensity to sign pooling contract $P \equiv \{\rho_P; 1; 0\}$, in order to avoid credit rationing.

Given this result we can say that:

Proposition 2 *When all firms are cash-poor, equilibria are as follows. (i) If the proportion of bad firms in the economy is relatively low, i.e., $\lambda < \lambda_{CP}$ the unique SPNE of the three-stage game played by lenders and cash-rich firms is a pooling equilibrium without commitment, where both H- and L-firms sign contract $P \equiv \{\rho_P; 1; 0\}$. (ii) If the share of bad firms in the economy is relatively high, i.e., $\lambda \geq \lambda_{CP}$, the unique SPNE of the three-stage game played by lenders and cash-rich firms is a separating equilibrium with or without commitment, where bad firms sign their first best contract*

$L \equiv \{\rho_L^*; 1; k\}$, whilst good firms sign contract $CP \equiv \{\rho_{CP}; B_{CP}; k\}$, with $\rho_{CP} < \rho_H^*$ and $B_{CP} < 1$, and issue equity $E_{CP} = 1 - B_{CP}$ given Assumption 4.

5 Policy implications and welfare analysis

In the previous Section we have shown that taxation affects equilibrium conditions and that the results depend on whether firms have enough cash to self-finance their investment project or not. In particular we have shown that if the weight of bad firms is low enough, a pooling equilibrium exists. It is worth noting that the threshold percentage of bad firms, below which a pooling equilibrium exists, depends on whether firms are rich or not. In the cash-rich case, the threshold share λ_{CR} is only affected by the corporate taxation. Although our model keeps investment as given, this result echoes the New-View findings according to which dividend taxation is neutral. Similarly, here only corporate taxation affects credit market condition and thus cash-rich company financial decisions. When however cash is not enough to finance investment (or nil, for simplicity), both corporate and dividend taxation affect the optimal financial policy. These tax rates have the same effect: a change in t_c is equivalent to a change in t_d. Again, this result is somehow related to the Old View Theory in terms of financial decisions and credit market conditions.

Moreover, when firms are cash-poor, the cut-off point below which a pooling equilibrium arises is higher. Coeteris paribus, therefore, a separating equilibrium is less likely to occur.

It is worth noting that our framework does not explicitly deal with business cycle. However, our findings suggest that tax effects may depend on market conditions. To give an idea, let the portion of bad firms be $\lambda = \overline{\lambda}$. We expect that inequality $\overline{\lambda} > \lambda_j$ with $j = CP, CR$, is more likely to hold during a recession: in this case a pooling equilibrium arises. The converse is true when economic conditions are better. Similarly, we expect that firms are poorer during a recession and vice versa. This means that a New-View scenario is more likely during a recovery: corporate taxation is expected to affect the credit market equilibrium, while the effect of dividend taxation may vanish. When however, a crisis occurs and profits go down, the probability of equity issues is higher. In this context, an Old View scenario can better describe the economic situation, where both the corporation and dividend tax are expected to affect the credit market equilibrium.

Given these results we can now wonder what are the effects of taxation in terms of welfare.

WELFARE ANALYSIS TO BE DONE

6 Conclusion

To be written.

A Debt finance

A.1 No default

Proof of Lemma 1. NPV (16) can be rewritten as

$$(1-E-B)\left(-(1-t_d)+\frac{(1-t_d)((1-t_c)R_i+1)}{1+r}\right)+ \tag{38}$$
$$E\left(-1+\frac{(1-t_d)(1-t_c)R_i+1}{1+r}\right)+B\left(\frac{(1-t_d)(1-t_c)(R_i-r)}{1+r}\right).$$

Let

$$-(1-t_d)+\frac{(1-t_d)((1-t_c)R_i+1)}{1+r}=x,$$
$$-1+\frac{(1-t_d)(1-t_c)R_i+1}{1+r}=y,$$
$$\frac{(1-t_d)(1-t_c)(R_i-r)}{1+r}=z.$$

One can check that $z-x=\frac{r}{1+r}(1-t_d)t_c>0$ and $x-y=t_d\frac{r}{1+r}>0$. It follows that $z>y$ and (38) rewrites as

$$(1-E-B)x+Ey+Bz, \tag{39}$$

with $y<x<z$. Notice that $\frac{\partial(39)}{\partial E}=y-x<0$ and $\frac{\partial(39)}{\partial B}=z-x>0$: (39) is increasing in B and decreasing in E.

Cash-rich firm. Substituting $B=\frac{1+a}{1+r}$ and $E=0$ into (38) gives

$$\left(1-\frac{1+a}{1+r}\right)\left(-(1-t_d)+\frac{(1-t_d)((1-t_c)R_i+1)}{1+r}\right)+\frac{1+a}{1+r}\left(\frac{(1-t_d)(1-t_c)(R_i-r)}{1+r}\right).$$

After rearrangement:

$$\frac{1-t_d}{1+r}(R_i(1-t_c)-r)+\frac{rt_c(1-t_d)}{(r+1)^2}(1+a),$$

or

$$\frac{(1-t_d)(1-t_c)}{1+r}\left[(R_i-r)-\frac{rt_c}{1-t_c}\left(1-\frac{1+a}{1+r}\right)\right],$$

which is (20) in the text. Taking into account (4), (20) rewrites as

$$\frac{(1-t_d)(1-t_c)}{1+r}\left[(p_iA+(1-p_i)a-r)-\frac{rt_c}{1-t_c}\left(1-\frac{1+a}{1+r}\right)\right]. \tag{40}$$

Solving $NPV_{B,M,i}\geq 0$ for A gives

$$p_iA\geq\frac{rt_c}{1-t_c}\left(1-\frac{1+a}{1+r}\right)-(1-p_i)a+r,$$
$$p_iA\geq\frac{r(1+r-(1+a)t_c)}{(1-t_c)(1+r)}-(1-p_i)a,$$
$$A\geq\frac{r(1+r-t_c)-a(rt_c+(1-t_c)(1+r)(1-p_i))}{p_i(1-t_c)(1+r)}\equiv A_{B,M}.$$

Cash-poor firm. Substituting $B=\frac{1+a}{1+r}$ and $E=1-\frac{1+a}{1+r}-\bar{M}$ into (38) gives

$$\bar{M}\left(-\left(1-t_d\right)+\frac{\left(1-t_d\right)\left(\left(1-t_c\right)R_i+1\right)}{1+r}\right)+$$
$$\left(1-\frac{1+a}{1+r}-\bar{M}\right)\left(-1+\frac{\left(1-t_d\right)\left(1-t_c\right)R_i+1}{1+r}\right)+\frac{1+a}{1+r}\left(\frac{\left(1-t_d\right)\left(1-t_c\right)\left(R_i-r\right)}{1+r}\right)$$

Rearranging gives (21) in the text. Solving $NPV_{B,M,E,i}\geq 0$ by A gives

$$\begin{aligned} p_iA &\geq -\left(1-p_i\right)a+r+\frac{rt_c}{\left(1-t_c\right)}\left(1-\frac{1+a}{1+r}\right)+\frac{rt_d}{\left(1-t_d\right)\left(1-t_c\right)}\left(1-\frac{1+a}{1+r}-\bar{M}\right) \\ A &\geq -\frac{1-p_i}{p_i}a+\frac{r}{p_i}+\frac{rt_c}{p_i\left(1-t_c\right)}\frac{r-a}{1+r}+\frac{rt_d}{p_i\left(\left(1-t_d\right)\left(1-t_c\right)\right)}\frac{r-a}{1+r}-\frac{rt_d}{p_i\left(\left(1-t_d\right)\left(1-t_c\right)\right)}\bar{M} \end{aligned}$$

A.2 Default risk

Proof of Lemma 2. NPV (23) can be rearranged as

$$\left(1-E-B\right)\left(-\left(1-t_d\right)+p_i\frac{\left(1-t_d\right)\left(\left(1-t_c\right)A+1\right)}{1+r}\right)+ \tag{41}$$
$$E\left(-1+p_i\frac{\left(1-t_d\right)\left(1-t_c\right)A+1}{1+r}\right)+B\left(p_i\frac{\left(1-t_d\right)\left(1-t_c\right)\left(A-\rho_{0,i}\right)}{1+r}\right)$$

Let

$$\begin{aligned} -\left(1-t_d\right)+p_i\frac{\left(1-t_d\right)\left(\left(1-t_c\right)A+1\right)}{1+r} &= X \\ -1+p_i\frac{\left(1-t_d\right)\left(1-t_c\right)A+1}{1+r} &= Y \\ p_i\frac{\left(1-t_d\right)\left(1-t_c\right)\left(A-\rho_{0,i}\right)}{1+r} &= Z \end{aligned}$$

We calculate

$$\begin{aligned} X-Y &= \left(1+r-p_i\right)\frac{t_d}{1+r}>0 \\ Z-Y &= \frac{1+r-p_i-p_i\rho_{0,i}\left(1-t_d\right)\left(1-t_c\right)}{1+r} \\ Z-X &= \frac{\left[1+r-p_i-p_i\rho_{0,i}\left(1-t_c\right)\right]\left(1-t_d\right)}{1+r} \end{aligned}$$

We study the sign of $Z-X$, taking into account that $Z-X>0\Rightarrow Z-Y>0$. $Z-X$ is minimum for $\rho=\rho_i^*$, where ρ_i^* is given by (24), and equal to

$$\frac{1-t_d}{1+r}\left\{\frac{1-t_d}{1+r}\left[\left(1+a\left(1-t_c\right)\right)\left(1-p_i\right)+rt_c\right]\right\}>0$$

after rearrangement. We can hence rewrite (41) as

$$\left(1-E-B\right)X+EY+BZ \tag{42}$$

with $Y < X < Z$. We find: $\frac{\partial(42)}{\partial E} = Y - X < 0$ and $\frac{\partial(42)}{\partial B} = Z - X > 0$. The firm's NPV is hence decreasing in E and increasing in B.

We finally calculate

$$\rho_i^* \equiv \frac{r - (1 - p_i)\,a}{p_i} \geq r:$$

this rewrites as $a \leq r$, which holds true under Assumption 2.

A.3 Optimal funding policy

We focus on a cash-rich firm and solve for a inequality $NPV_{B,M,i} \leq NPV_{B,i}$, *i.e.*, (40) $\leq$ (25). Taking into account (4), (25) can be written as

$$\frac{(1 - t_d)(1 - t_c)\left[p_i A + (1 - p_i)\,a - r\right]}{1 + r}. \tag{43}$$

We can write

$$\frac{1 - t_d}{1 + r}\left\{\left[p_i A + (1 - p_i)\,a\right](1 - t_c) - r\right\} + \frac{r t_c (1 - t_d)}{(r + 1)^2}(1 + a) \leq \frac{(1 - t_d)(1 - t_c)\left[p_i A + (1 - p_i)\,a - r\right]}{1 + r}$$

or, equivalently

$$\left[p_i A + (1 - p_i)\,a\right](1 - t_c) - r + \frac{r t_c}{1 + r}(1 + a) \leq (1 - t_c)\left[p_i A + (1 - p_i)\,a - r\right]$$

Rearranging

$$\begin{aligned} -r + \frac{r t_c}{1 + r}(1 + a) &\leq -(1 - t_c)\,r \\ \frac{r t_c}{1 + r}(1 + a) &\leq r t_c \end{aligned}$$

Simplifying, inequality (40) $\leq$ (43) rewrites as $a \leq r$, which is fulfilled under Assumption 2.

B Appendix: asymmetric information

B.1 Cash-rich firms

Curves OH and OL. The first derivative of (27) w.r.t. ρ is

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

which is positive by Assumption 2. The second derivative is

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

To show that the above value is positive it is sufficient to observe that $1+r-p_i(1+\rho)$ is decreasing in ρ, hence minimum for $\rho=\rho_i^*\equiv\frac{r-(1-p_i)a}{p_i}$ and equal to $1+r-p_i\left(1+\frac{r-(1-p_i)a}{p_i}\right)$. Rearranging gives $(1-p_i)(1+a)>0$.

Cash-rich firms' indifference curves. The first derivative of (31) w.r.t. ρ is

$$\frac{\partial\left(\frac{B_X(1+r-p_i(1+(1-t_c)\rho_X))}{1+r-p_i(1+\rho(1-t_c))}\right)}{\partial\rho}=p_i(1-t_c)B_X\frac{1+r-p_i[1+\rho_X(1-t_c)]}{\{1+r-p_i[1+\rho(1-t_c)]\}^2}, \tag{44}$$

which is positive since the numerator is decreasing in ρ, hence minimum for $\rho=\rho_i^*\equiv\frac{r-(1-p_i)a}{p_i}$ and equal to $1-p_i+rt_c+a(1-t_c)(1-p_i)>0$. The second derivative of (31) is

$$\frac{\partial^2\left(\frac{B_X(1+r-p_i(1+(1-t_c)\rho_X))}{1+r-p_i(1+\rho(1-t_c))}\right)}{\partial\rho^2}=2p_i^2(1-t_c)^2B_X\frac{1+r-p_i[1+\rho_X(1-t_c)]}{\{1+r-p_i[1+\rho(1-t_c)]\}^3},$$

where both numerator and denominator are positive according to the above proof.

Contract CR. Solving

$$\frac{1+r-p_L[1+\rho_L^*(1-t_c)]}{1+r-p_L[1+\rho(1-t_c)]}=\frac{(1-p_H)(1+a)}{(1+r)-p_H(1+\rho)}$$

by ρ gives ρ_{CR} in the text. Indeed

$$\frac{1+r-p_L\left(1+\frac{r-(1-p_L)a}{p_L}(1-t_c)\right)}{1+r-p_L\left(1+\frac{r(p_H-p_L)(1+a)+t_c(1+r-p_H)(r-a+ap_L)}{(p_H-p_L)(1+a)+t_c(p_H(r-a)+p_L(1+a-p_H))}(1-t_c)\right)}=$$
$$\frac{(1-p_H)(1+a)}{(1+r)-p_H\left(1+\frac{r(p_H-p_L)(1+a)+t_c(1+r-p_H)(r-a+ap_L)}{(p_H-p_L)(1+a)+t_c(p_H(r-a)+p_L(1+a-p_H))}\right)}$$

is true.

Computation of λ_{CR}. We first calculate contract $H''\equiv(\rho_{H''},1)$, where $\rho_{H''}$ is given by

$$1=\frac{B_{CR}\{1+r-p_H[1+(1-t_c)\rho_{CR}]\}}{1+r-p_H[1+\rho(1-t_c)]}$$

Solving by ρ gives

$$\rho_{H''}=\frac{1+r-p_H-B_{CR}[1+r-p_H(1+(1-t_c)\rho_{CR})]}{p_H(1-t_c)}.$$

Recall that setting $B=1$ into the pooled break-even curve gives (29). We then solve by λ equation $\rho_{H''}=\rho_P$

$$\frac{1+r-p_H-B_{CR}(1+r-p_H(1+(1-t_c)\rho_{CR}))}{p_H(1-t_c)}=$$
$$\frac{(1+r)-(\lambda(1-p_L)+(1-\lambda)(1-p_H))(1+a)-\lambda p_L-(1-\lambda)p_H}{(\lambda p_L+(1-\lambda)p_H)}.$$

We get

$$\lambda = \frac{p_H\left(1+rt_c-p_H+a\left(1-p_H\right)\left(1-t_c\right)-B_{CR}\left(\left(1+r-p_H\right)-\rho_{CR}p_H\left(1-t_c\right)\right)\right)}{\left(p_H-p_L\right)\left(1+r-p_H-ap_H\left(1-t_c\right)-B_{CR}\left(\left(1+r-p_H\right)-\rho_{CR}p_H\left(1-t_c\right)\right)\right)}. \tag{45}$$

Substituting

$$\rho_{CR} = \frac{r\left(p_H-p_L\right)\left(1+a\right)+t_c\left(1+r-p_H\right)\left(r-a+ap_L\right)}{\left(p_H-p_L\right)\left(1+a\right)+t_c\left(p_H\left(r-a\right)+p_L\left(1+a-p_H\right)\right)}$$

and

$$B_{CR} = \frac{\left(1-p_H\right)\left(1+a\right)}{\left(1+r\right)-p_H\left(1+\frac{r(p_H-p_L)(1+a)+t_c(1+r-p_H)(r-a+ap_L)}{(p_H-p_L)(1+a)+t_c(p_H(r-a)+p_L(1+a-p_H))}\right)}$$

into (45) and rearranging, gives $\lambda = \lambda_{CR}$ in the text.

B.2 Cash-poor firms

Cash-poor firms' indifference curves. The first derivative of (36) w.r.t. ρ is

$$\frac{\partial\left(\frac{B_X\{1+r-p_i[1+(1-t_c)(1-t_d)\rho_X]\}}{1+r-p_i[1+\rho(1-t_c)(1-t_d)]}\right)}{\partial\rho} = p_i\left(1-t_c\right)\left(1-t_d\right)B_X\frac{1+r-p_i\left[1+\rho_X\left(1-t_c\right)\left(1-t_d\right)\right]}{\left[1+r-p_i\left(1+\rho\left(1-t_c\right)\left(1-t_d\right)\right)\right]^2}, \tag{46}$$

which is positive since the numerator is decreasing in ρ, hence minimum for $\rho_X = \rho_i^* \equiv \frac{r-(1-p_i)a}{p_i}$ and equal to $1-p_i+rt_c+a\left(1-t_c\right)\left(1-t_d\right)\left(1-p_i\right)>0$. The second derivative of (31) is

$$\frac{\partial^2\left(\frac{B_X(1+r-p_i(1+(1-t_c)(1-t_d)\rho_X))}{1+r-p_i(1+\rho(1-t_c)(1-t_d))}\right)}{\partial\rho^2} = 2p_i^2\left(1-t_c\right)^2\left(1-t_d\right)^2B_X\frac{1+r-p_i\left[1+\rho_X\left(1-t_c\right)\left(1-t_d\right)\right]}{\left\{1+r-p_i\left[1+\rho\left(1-t_c\right)\left(1-t_d\right)\right]\right\}^3},$$

where both numerator and denominator are positive according to the above proof.

Contract CP. Solving

$$\frac{1+r-p_L\left[1+\rho_L^*\left(1-t_d\right)\left(1-t_c\right)\right]}{1+r-p_L\left[1+\rho\left(1-t_d\right)\left(1-t_c\right)\right]} = \frac{\left(1-p_H\right)\left(1+a\right)}{\left(1+r\right)-p_H\left(1+\rho\right)}$$

by λ gives λ_{CP} in the text. Indeed

$$\frac{1+r-p_L\left(1+\frac{r-(1-p_L)a}{p_L}\left(1-t_d\right)\left(1-t_c\right)\right)}{1+r-p_L\left(1+\frac{r(p_H-p_L)(1+a)+(1+r-p_H)(r-a+ap_L)((1-(1-t_c)(1-t_d)))}{(p_H-p_L)(1+a)+(p_H(r-a)+p_L(1+a-p_H))(1-(1-t_c)(1-t_d))}\left(1-t_d\right)\left(1-t_c\right)\right)} =$$

$$\frac{\left(1-p_H\right)\left(1+a\right)}{\left(1+r\right)-p_H\left(1+\frac{r(p_H-p_L)(1+a)+(1+r-p_H)(r-a+ap_L)((1-(1-t_c)(1-t_d)))}{(p_H-p_L)(1+a)+(p_H(r-a)+p_L(1+a-p_H))(1-(1-t_c)(1-t_d))}\right)}$$

holds true.

Computation of λ_{CP}. We first find contract $h'' \equiv (\rho_{h''}, 1)$, where $\rho_{h''}$ is given by

$$1 = \frac{B_{CP}\left\{1+r-p_H\left[1+\left(1-t_c\right)\left(1-t_d\right)\rho_{CP}\right]\right\}}{1+r-p_H\left[1+\rho\left(1-t_c\right)\left(1-t_d\right)\right]}.$$

Solving by ρ gives

$$\rho_{h''} = \frac{1 + r - p_H - B_{CP}\left[1 + r - p_H\left(1 + \left(1 - t_c\right)\left(1 - t_d\right)\rho_{CP}\right)\right]}{p_H\left(1 - t_c\right)\left(1 - t_d\right)}.$$

We then solve by λ equation $\rho_{h''} = \rho_P$

$$\frac{1 + r - p_H - B_{CP}\left[1 + r - p_H\left(1 + \left(1 - t_c\right)\left(1 - t_d\right)\rho_{CP}\right)\right]}{p_H\left(1 - t_c\right)\left(1 - t_d\right)} =$$
$$\frac{(1 + r) - \left(\lambda\left(1 - p_L\right) + (1 - \lambda)\left(1 - p_H\right)\right)(1 + a) - \lambda p_L - (1 - \lambda)p_H}{\left(\lambda p_L + (1 - \lambda)p_H\right)}.$$

We get

$$\lambda = \frac{-r + p_H + \left(1 - p_H\right)(1 + a) - \frac{1}{(1 - t_c)(1 - t_d)}\left(r - p_H - B_{CP}\left(r - p_H\left(1 - \left(1 - t_c\right)\left(1 - t_d\right)\rho_{CP}\right) + 1\right) + 1\right) - 1}{p_H - p_L - \left(p_H - p_L\right)(a + 1) - \frac{p_H - p_L}{p_H(1 - t_c)(1 - t_d)}\left(r - p_H - B_{CP}\left(r - p_H\left(1 - \left(1 - t_c\right)\left(1 - t_d\right)\rho_{CP}\right) + 1\right) + 1\right)}. \tag{47}$$

Substituting

$$\rho_{CP} = \frac{r\left(p_H - p_L\right)(1 + a) + \left(1 + r - p_H\right)\left(r - a + ap_L\right)\left[1 - \left(1 - t_c\right)\left(1 - t_d\right)\right]}{\left(p_H - p_L\right)(1 + a) + \left[p_H(r - a) + p_L\left(1 + a - p_H\right)\right]\left[1 - \left(1 - t_c\right)\left(1 - t_d\right)\right]}$$

and

$$B_{CP} = \frac{\left(1 - p_H\right)(1 + a)}{1 + r - p_H\left(1 + \frac{r(p_H - p_L)(1 + a) + (1 + r - p_H)(r - a + ap_L)[1 - (1 - t_c)(1 - t_d)]}{(p_H - p_L)(1 + a) + [p_H(r - a) + p_L(1 + a - p_H)][1 - (1 - t_c)(1 - t_d)]}\right)}$$

into (47) and rearranging, gives $\lambda = \lambda_{CP}$ in the text.

One can check that $\lambda_{CR} < \lambda_{CP}$. Indeed,

$$\frac{p_H t_c\left(1 + r - p_H\right)}{(1 + r)\left(p_H - p_L\right) + p_H t_c\left(1 + r - p_H\right)} < \frac{p_H\left(1 - \left(1 - t_c\right)\left(1 - t_d\right)\right)\left(1 + r - p_H\right)}{(1 + r)\left(p_H - p_L\right) + p_H\left(1 - \left(1 - t_c\right)\left(1 - t_d\right)\right)\left(1 + r - p_H\right)}$$

rewrites as

$$\frac{(1 + r)\left(p_H - p_L\right) + p_H\left(1 + r - p_H\right)t_c}{t_c} > \frac{p_H\left(2p_L - p_H\right) - p_L(1 + r) + p_H\left(1 + r - p_H\right)\left(1 - t_c\right)\left(1 - t_d\right)}{1 + \left(1 - t_c\right)\left(1 - t_d\right)}$$

Notice that $t_c < 1 < 1 + \left(1 - t_c\right)\left(1 - t_d\right)$, whilst

$$(1 + r)\left(p_H - p_L\right) + p_H\left(1 + r - p_H\right)t_c > p_H\left(2p_L - p_H\right) - p_L(1 + r) + p_H\left(1 + r - p_H\right)\left(1 - t_c\right)\left(1 - t_d\right)$$

rewrites as

$$\frac{1 + r + p_H - 2p_L}{1 + r - p_H} > 1 - 2t_c - t_d + t_c t_d,$$

which holds true. Indeed, the RHS is lower than 1:

$$1 - 2t_c - t_d + t_c t_d < 1,$$

or

$$-t_d\left(1 - t_c\right) < 2t_c.$$

The LHS is higher than 1:

$$\frac{1 + r + p_H - 2p_L}{1 + r - p_H} > 1$$

or

$$1 + r + p_H - 2p_L > 1 + r - p_H,\ 2p_H > 2p_L.$$

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