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Liquidation Values, Risk and Capital Structure[1]

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Abstract

This paper investigates the interaction between financial structure, liquidation values and product market equilibrium. Liquidation values depend on how many firms are liquidated, and therefore on the industry equilibrium of capital structures and of technology choices.

We show that firms using a technology with high liquidation value issue less debt than those with low liquidation value even if these ones may be inefficiently liquidated. With respect to the equilibrium in the industry, we obtain that even if in equilibrium all firms use the same technology, firms will use widely different capital structures.

JEL classification: G32, G33. Keywords: capital structure, technology choice, industry equilibrium, financial contracts.

1 Introduction

Several papers, notably Williamson (1988) and Shleifer and Vishny (1992), have examined the interaction between capital structure and liquidation values. Shleifer and Vishny (1992) show that a main determinant of asset illiquidity (and therefore a main source of liquidation costs) arises from the *general equilibrium* aspect of assets sales. When a firm is in financial distress, its competitors are likely to be hurting also. Then, to the extent that the firms' assets are specific to the industry, they will have to be sold to a second-best user. Extending this reasoning to a large industry, the magnitude of the bankruptcy costs incurred by a firm will depend on how the rest of the industry is behaving. In particular, it is natural to suppose that as more and more firms are liquidated the assets will have to be sold to firms with ever inferior valuations. We argue then that not only is the resale price of industry-specific assets lower than their going-concern value, but it will decline when there is an industry downturn.[1] Williamson (1988) argues that specific assets should be financed with equity because they will require further investments in the future to keep their value. With debt financing, the firm may not be able to finance these investments, and, given the specificity of the assets, it will incur large costs.

However, one can argue that capital structure choices are generally prior to investment decisions. A firm decides regularly on new investment projects, while debt-equity ratios do not often experience large swings. This has been the approach taken by a large literature starting with Myers (1977) and Jensen and Meckling (1976), where it is shown that shareholders' attitudes towards new investments are affected by capital structure.

The first purpose of this paper is to examine this last issue when the available investments differ in their risk characteristics and in their liquidation values. In particular, one of the available technologies is specific in the sense described above, while the other one is standard (in that the firm's liquidation costs are independent

[1] Strömberg (1997), using data from Swedish bankrupt firms, finds support for the theory developed by Shleifer & Vishny (1992). In particular, he finds that the realized liquidation values decrease with the indebtedness of the industry, which is the source of (resale) market illiquidity they identify

of the situation in the rest of the industry). The two technologies also differ in their operating cost: the low liquidation-value technology is more cost-efficient (if not, it would always be dominated by the other technology and therefore never chosen[2]). This makes them differ also in their riskiness: the expected payoff from the technology with a low liquidation value ranges over a wider support than the other one, and thus this technology is riskier. The second purpose is to conduct this analysis in an 'industry equilibrium model' as first developed by Maksimovic and Zechner (1991), in which a firm's capital structure is determined in the context of the industry in which the firm operates. This is the natural way to approach the problem, given that the liquidation value of the risky technology depends on the rest of the firms in the industry.

With respect to the first goal, our main results are as follows. Firstly, we show that, as in Maksimovic and Zechner (1991), *if* the risky investment is the value maximizing strategy, shareholders have to be given the right incentives by using a properly leveraged financial structure. However, in contrast with their model, we show that risk-free debt will also induce this choice if this technology is sufficiently profitable. The difference arises because debt is not neutral in our model, i.e. issuing (risky) debt changes pre-tax cash flows because it creates bankruptcy costs. Hence, for low debt levels firms are *not* indifferent between both technologies because the risk of bankruptcy is removed, and the most cost-efficient technology is preferred. *Vice versa, if* the less risky strategy is optimal, low leverage ratios will be needed. Notice that by reversing the timing assumed by Williamson, we also -at least partially- reverse his conclusions. Our result is related to (although stronger than) the U-shaped relationship between risk and capital structure found by Kale *et al.* (1991). Risky technologies are used when debt is either risk-free or high, while less risky projects

[2] Notice though that this argument holds only for competitive industries. Elsewhere we have shown that in a duopoly setting an entrant firm may be willing to use a technology with low liquidation values because this provokes a softer reaction from its rival, and that an incumbent firm could use such technology too, if that depresses its potential rival's liquidation value (see Rosellón 1998).

are chosen in between.[3]

Secondly, we show that two kinds of equilibria may arise. First, as in Maksimovic and Zechner (1991) both technologies can coexist in equilibrium, but the capital structures will differ. In this case all firms issue risky debt, but according to the intuition above, the firms using the less risky technology issue *less* debt, foregoing tax shields in exchange for a more risk-seeking strategy. However a second equilibrium arises in our model where the less efficient technology (in the non-bankruptcy states) is not used at all. In this case, some firms use high debt equity ratios, while the rest will not issue any risky debt. The first group incurs higher liquidation costs with some probability and enjoys high tax benefits of debt, while the opposite holds for the second group. In this equilibrium we find *identical* firms using widely different debt equity ratios.

A further insight that can be drawn from the two equilibria is that a firm can use capital structure and technology choice as substitute devices to reduce the riskiness of its total payoff. As more and more firms choose the risky technology it becomes too risky. At some point firms have to reduce the riskiness of their cash flows, and this is done in one of two alternative ways. Either the remaining firms choose this same technology but issue no risky debt, or they just choose the other technology.

As mentioned above, the second contribution of this paper is to incorporate the problem of non-verifiability of cash flows into an industry equilibrium model. Maksimovic and Zechner (1991), Zechner (1996) and Williams (1995) have investigated in industry equilibrium settings issues that had been usually analysed in a single-firm framework. They show that some of the results that hold for a single firm are then reversed. In the literature on incomplete financial contracts, it is assumed that a cash-constrained entrepreneur seeks financing for an investment project, and that the cash flows of the project are not verifiable. The problem is to design the optimal financial contract that will reward the financiers sufficiently for their investment despite that non-verifiability. A central result is that inefficient liquidation of the firm is

[3] Jaffe and Westerfield (1987) among others have also investigated the relationship between capital structure and business risk.

necessary as a disciplining device. When we analyse this problem in a context where firms have to design their capital structure, it is natural to drop the assumption that shareholders are wealth-constrained (since they could choose to issue no debt in the first place, and to finance the firm completely with equity). Therefore, the main issue that arises is when shareholders will be *willing* to repay their debt and when they will default. In our model there is a second problem that capital structure has to deal with, which is the technology choice. If the technology choice is not contractible, shareholders have to be given appropriate incentives.

Two main results arise from the capital structure design problem. First, we show that issuing too much debt creates a debt overhang problem, and inefficient liquidation still occurs when the liquidation value of the assets is less than their continuation value. Second, we show that as a result of the technology choice problem, firms using the technology with the highest liquidation value issue *less* debt than their more risky peers. The intuition is that a technology with a low liquidation value is riskier for the shareholders. As shareholders become more risk-loving the more debt the firm issues, they will choose the safe technology only if leverage is low enough.

Notice that the analysis above can be applied to many of the main decisions that firms have to undertake, not only to technological ones. For example, the decision to start an ambitious research program to develop a new project or a big advertising campaign, a change in the product image (or even name) has the features that characterize the specific assets as we have defined them. More generally, we can think of industries where this kind of 'risky' decisions plays a fundamental role (such as IT) and other less dynamic ones where more conservative attitudes with respect to the product market are optimal.

With respect to the empirical evidence, other than the literature on business risk and capital structure mentioned above, we should mention the literature on liquidation costs and capital structure. This literature mainly finds that firms with high liquidation costs will tend to have low leverage, because this reduces the probability of bankruptcy (see e.g. Anderson and Betker (1995)). These papers are direct tests of Williamson's theory. These results may be seen as contradicting our theory; however, our result does not depend on the effect of debt on the probability of bankruptcy, but on how capital structure determines the choices shareholders make (in particular, the degree of specificity of the technology they choose to produce). In this sense we are analysing another side of the interaction between capital structure and liquidation values. As far as we know there are no tests that control for the liquidation probability to investigate the incentive effects of capital structure.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 analyses shareholders' incentives to repay the debt, and section 4 their technology choice. Sections 5 and 6 close the model determining the optimal capital structure from a firm's perspective, and the equilibrium in the industry respectively. Section 7 summarizes some empirical implications and the last section concludes.

2 The Model

We have a continuum of identical firms on the $[0, l]$ interval. There is no discounting and everyone is risk neutral. There are four time points.

At $t = 0$, firms choose capital structures, consisting of debt and equity. Capital structure is chosen to maximize equity value, which, given that debt is fairly priced, amounts to maximizing firm value. We use taxes as the justification for the use of leverage. Firms profits are taxed at a constant marginal rate, τ. Moreover, debt is tax-deductible, so that for a debt level, D, firms deduct from their tax bill the amount τD.[4]

At $t = 1$, the *shareholders* of each firm have to choose which technology to use. There are two alternatives available to the firms: standard and risky (or specific) technologies[5]. Each allows the firms to produce up to one unit of a homogeneous

[4] We treat tax shields in the same way as Maksimovic and Zechner (1991) do. As they point out, it would be more realistic to assume that the tax benefit is realised only on the interest payments; however, it has been shown that this simplification is not relevant unless tax shields can be lost due to some non-cash charges such as depreciation (see Barnea, Haugen and Talmor (1985)).

[5] We will often call them 'S' (standard) and 'R' (risky) technologies respectively, and will use these superscripts to refer to them.

good, each exhibits constant returns to scale and requires an investment I[6]. The costs functions are: $C_S(q) = (\lambda + \delta)q$ and $C_R(q) = \delta q$, where q is the quantity produced and λ and δ are positive numbers. The standard technology thus involves higher operating costs.

At $t = 2$, firms compete in the product market. Demand is given by $P = a - Q$, where Q is the aggregate quantity produced, and a is a random variable which takes only two values, $a \in \{a^H, a^L\}$, with probabilities θ and $1 - \theta$, and $a^H > a^L$. Firms compete only after they observe the realization of the random variable, act like price takers, and, given constant returns to scale, will produce up to capacity if they produce at all. Hence, aggregate production equals l. There are two possible resulting prices: if the market is large the price will be $p^H = a^H - l$; if it is small, $p^L = a^L - l$[7]. Combining the states of demand with technologies, there are four possible profits, denoted by π_h^r where r denotes the state and h the technology chosen: $\pi_R^L = p^L - \delta$, $\pi_S^L = p^L - \lambda - \delta$, $\pi_R^H = p^H - \delta$ and $\pi_S^H = p^H - \lambda - \delta$.

In the third stage, firms repay their debt (if any) and liquidation decisions are taken. At this point shareholders can decide to raise new equity to repay the debt if the profit obtained is not sufficient. Given that we are allowing them to choose freely the capital structure, they are sufficiently wealthy to generate enough equity to repay any outstanding debt. In the fourth and last stage, the firms remaining in the market obtain a (non-contractible) profit, which depends on the size of the market. If the market turns out to be large (i.e. $a = a^H$) they get X^H and X^L otherwise.

The two technologies differ also in their liquidation values. If the safe technology is liquidated, the liquidation value is L_S, with $X^H > L_S > X^L$. For the firms using the specific (risky) technology, the liquidation value is: $L_R(i) = \alpha - \beta i$, where α and β are exogenous (positive) parameters, and i is the measure of firms choosing the risky technology which is liquidated. This technology always presents a lower liquidation value, i.e. $\alpha < L_S$. We assume that $(1 - \theta)(X^H - L_S) - \lambda > 0$, which guarantees

[6] None of the results below is altered if we assume different investment costs, I_R and I_S as long as $\lambda > I_R - I_S$, i.e. as long as the standard technology remains overall more costly.

[7] Obviously we are assuming that $p_L \geq \delta + \lambda$, i.e. $a_L - l \geq \delta + \lambda$.

that a firm using the risky technology has a larger debt capacity than a firm with the standard one (see below). We also assume throughout that l is 'large enough', to avoid boundary solutions (i.e. we assume all our solutions for i are interior in $[0, l]$). Hence, the risky technology is more efficient in non-bankruptcy states, but it has a lower liquidation value, which incorporates a component of industry-specific risk. This means that if there is an industry downturn and these firms must be liquidated they will experience greater losses than the ones with the alternative technology; moreover, these losses will be related to the industry distribution of technologies. In contrast, the safe technology is less efficient in non-bankruptcy states, but the firms using it provide themselves with a technological hedge against adverse industry-wide conditions.

2.1 The financial structure

At the initial date, firms choose their capital structure (debt and equity) to maximize their value, as argued above. In doing so, they have to cope with two problems: first, we assume that the state of demand is not verifiable for the creditors, so that we obtain the usual contract incompleteness (see e.g. Bolton and Scharfstein (1996)), and the firm has to pledge its assets as collateral. (Of course, it is common knowledge that π_S^L is the least the firm can obtain, and logically we assume that a payment equal to this amount can always be claimed in case of default.[8]) The fact that demand is not verifiable allows the shareholders to divert the profits they obtain to themselves reducing the actual profit that remains available to pay back debt holders (i.e. they 'milk' the company).[9]

Second, the technology choice is not enforceable, and this creates a moral hazard problem that also has to be solved.

We restrict attention to standard debt contracts, where debt holders get control of

[8] This follows Bolton and Scharfstein (1990).

[9] We assume, however, that this is verifiable by the tax authorities, so that diverting profits is not a tax-avoidance device.

the assets if debt is not repaid.[10] Hence, shareholders are residual claimants in both bankruptcy and non-bankruptcy states. Given that cash flows are not verifiable, shareholders cannot commit to make any repayment at the final date and therefore all debt must have maturity one period. Debt is fairly priced (debt holders break even) given the future incentives of shareholders to pay it back or not, which are rationally anticipated.

3 Debt

In this section we analyze shareholders' incentives to repay or not the outstanding debt, depending on the state of nature, on the magnitude of the debt and on the technology choice.

3.1 S technology

Suppose a firm is using the standard technology, and there is some outstanding debt, D. Consider first that the realization of demand is a^H. The question is whether shareholders will be willing to pay back D. Notice that the profit obtained in the first period is not a constraint, for we assume shareholders are not cash-constrained. This is an important difference with respect to the standard framework where the entrepreneur seeks financing for a project because either he has no wealth or his wealth is not sufficient. Although the threat of liquidation is still needed as a means for the debtors to get any repayment at all, this threat is only carried out if shareholders wish to.

If shareholders choose to pay back the debt they obtain $\pi_S^H + X^H - D$, while if they default they get $\pi_S^H - \pi_S^L + Max\{0, L_S + \pi_S^L - D\}$. (Recall that they always have to hand over π_S^L even if they default.) They will repay the debt iff:

$$X^H - D \geq -\pi_S^L + Max\{0, L_S + \pi_S^L - D\} \tag{1}$$

[10] i.e. we do not consider random liquidation devices.

which, given that $X^H > L_S$ is true as long as $D \leq X^H + \pi_S^L$. Observe that shareholders will never pay back any amount larger than $X^H + \pi_S^L$, which is an upper bound for the debt level. In what follows, we directly assume that this upper bound is always respected (i.e. we will ignore the case $D > X^H + \pi_S^L$).

If demand is low, shareholders obtain $\pi_S^L + X^L - D$ if they repay the debt (this amount can be negative), or $Max\{0, \pi_S^L + L_S - D\}$ if they do not. They repay iff

$$\pi_S^L + X^L - D \geq Max\{0, L_S + \pi_S^L - D\} \tag{2}$$

which is never true.

Therefore, shareholders will repay the debt only if demand is high (provided debt is less than $X^H + \pi_S^L$). Hence the optimal decision is taken (the liquidation decision is always efficient).

Given a debt level D, shareholders' expected payoff (at date 1) from choosing this technology is given by

$$\theta(\pi_S^H + X^H - D) + (1 - \theta) Max\{0, L_S + \pi_S^L - D\} \tag{3}$$

Finally, the value of the firm at the initial date is

$$\theta(\pi_S^H + X^H) + (1 - \theta)(\pi_S^L + L_S) + \tau D - I \tag{4}$$

3.2 R technology

Following the same steps as above, when demand is high, shareholders repay the debt if

$$\pi_R^H + X^H - D \geq \pi_R^H - \pi_S^L + Max\{0, L_R(i) + \pi_S^L - D\} \tag{5}$$

which implies that they will repay as long as $D \leq X^H + \pi_S^L$. Henceforth we assume this condition is met.

If demand is low, they repay if

$$\pi_R^L + X^L - D \geq \pi_R^L - \pi_S^L + Max\{0, L_R(i) + \pi_S^L - D\} \tag{6}$$

If $D < L_R(i)+\pi_S^L$, condition (6) becomes: $X^L \geq L_R(i)$. If $D \geq L_R(i)+\pi_S^L$, it becomes if $\pi_S^L + X^L \geq D$.

There are two cases to consider: $X^L \geq L$ and $X^L < L$.

If $X^L < L_R(i)$ shareholders always default on the debt, because $D \geq L_R(i) + \pi_R^L$ implies that $D \geq X^L + \pi_S^L$.

If $X^L \geq L_R(i)$, combining the two cases $(D \lesseqgtr L_R(i) + \pi_S^L)$ we get that debt is repaid if it is less than $X^L + \pi_S^L$.

Therefore, if $D > X^L + \pi_S^L$ (which roughly means if debt is risky) shareholders will default if the liquidation value is less than the continuation value, i.e. inefficient liquidation takes place. This is the counterpart of the standard result when contracts are incomplete and the manager (or the shareholders he represents) is wealth constrained. In that setting, inefficient liquidation arises as a necessary device to discipline the manager (Bolton and Scharfstein (1996), Hart and Moore (1998)). The new feature of our result is that even if the manager is not wealth-constrained, there may be inefficient liquidation. So, we show that the inability to commit future cash flows implies inefficient liquidation even if the manager is wealthy (if debt holders could claim future cash flows they would not seize the assets and would obtain the future profit instead). The reason is that high debt creates a debt overhang problem: the repayment of the debt is the price the manager has to pay for obtaining the second period profit. If this price is larger than the profit itself, shareholders will choose not to repay, regardless the liquidation value, as in this case the liquidation costs are fully born by the debt holders.[11]

As before, we report here the shareholders' expected payoff at date one:

$$\theta(\pi_R^H + X^H - D) + (1-\theta)Max\{\lambda, \pi_R^L + X^L - D, \pi_R^L + L_R(i) - D\} \tag{7}$$

It is useful to write out expression (7) distinguishing the cases $X^L \geq L_R(i)$[12] and

[11]Notice that this result depends on the assumption that there is a 'tough' liquidation procedure in place (such chapter 9 in the US). If some renegotiation were possible, inefficient liquidation could be avoided. This can be ruled out e.g. by assuming that debt is widely held.

[12]Notice that the condition $L_R(i) > X_L$ is equivalent to $i < \frac{\alpha - X_L}{\beta}$, i.e. it is a condition on the number of firms choosing R with high debt.

$X^L < L_R(i)$. If $X^L \geq L_R(i)$, expression (7) equals:

$$= \begin{cases} \theta(\pi_R^H + X^H) + (1-\theta)(\pi_R^L + X^L) - D, & if \quad D \leq \pi_S^L + X^L \\ \theta(\pi_R^H + X^H - D), & if \ D > \pi_S^L + X^L \end{cases} \tag{8}$$

and if $X^L < L_R(i)$:

$$= \begin{cases} \theta(\pi_R^H + X^H) + (1-\theta)(\pi_R^L + L) - D, & if \quad D \leq \pi_S^L + L \\ \theta(\pi_R^H + X^H - D) & if \ D > \pi_S^L + L \end{cases} \tag{9}$$

Finally, the expected value of the firm at the initial date is given as follows. If $X^L \geq L$:

$$\theta(\pi_R^H + X^H) + (1-\theta)(\pi_R^L + X^L) + \tau D - I, \ if \quad D \quad \leq \quad \pi_S^L + X^L \tag{10}$$

$$\theta(\pi_R^H + X^H) + (1-\theta)(\pi_R^L + L) + \tau D - I, \quad if \quad D \quad > \quad \pi_S^L + X^L \tag{11}$$

and by

$$\theta(\pi_R^H + X^H) + (1-\theta)(\pi_R^L + L) + \tau D - I \tag{12}$$

otherwise.

3.3 Debt holders return

We determine now the expected payment debt holders can expect, given a technology choice and a debt level.

From the discussion in section 3.1, if the firm uses the safe technology, this payment equals:

$$\theta D + (1-\theta) Min\{D, L_S + \pi_S^L\} \tag{13}$$

The maximum expected payment is obtained when $D = X + \pi_S^H$, which is therefore the maximum value of debt feasible. The face value corresponding to this debt repayment is $d = \theta(X + \pi_S^H) + (1-\theta)(L_S + \pi_S^L)$. Moreover, debt is risk-free if it does not exceed $X + \pi_S^L$.

If the firm uses the risky technology, and if $X^L > L_R(i)$ ($X^L \leq L_R(i)$), debt is risk-free below $X^L + \pi_S^L$ ($L_R + \pi_S^L$). Otherwise their expected payoff is

$$\theta D + (1-\theta) Min\{D, L_R + \pi_S^L\} \tag{14}$$

The maximum debt repayment is $X^H + \pi_S^L$.

4 Technology Choice

We analyse now the shareholders' incentives to choose one or the other technology at date one, once capital structure is determined. To do this, we only have to compare the expressions obtained above for shareholders' expected payoff from each choice (expressions (7) and (3)). We obtain the following result.

Proposition 1 *(i) If* $(1-\theta)(X^L - L_S) + \lambda \geq 0$*, shareholders always choose the R technology.*
(ii) If $(1-\theta)(X^L - L_S) + \lambda < 0$*, shareholders choose the S technology if* $D < \bar{D}$ *and* $i > \bar{\imath}$ *and the R technology otherwise.* $\bar{D}$ *and* $\bar{\imath}$ *are given by:*

$$\bar{\imath} = \frac{\alpha - L_S}{\beta} + \frac{\lambda}{(1-\theta)\beta} \tag{15}$$

and

$$\bar{D} = X^L + \pi_S^L - \frac{\lambda}{(1-\theta)}.$$

Proof. See Appendix ■

An important observation we draw from Proposition 1 is that giving the right incentives to the shareholders to choose S imposes an upper bound on the firm's leverage. If debt levels are very high, shareholders -residual claimants- become sufficiently risk-loving and they choose the most risky technology. Moreover, for low debt levels debt holders get repaid in full, and therefore all liquidation costs are born by shareholders. Hence, there is no risk-shifting problem and shareholders take the optimal decision, which, depending on $(1-\theta)(L_S - X^L) + \lambda$ being positive or negative, involves the risky or the safe technology. This result agrees with intuition: if debt levels are low, the debt overhang problem is removed, and the most efficient technology with respect to the product market is used.

Notice that these results contrasts with Williamson's conjecture that non-redeployable assets will always be financed with equity and debt will be used for highly redeployable ones. The different result is due to the different timing of the models. In our paper leverage is designed to give incentives to shareholders -hence it is prior to the technology choice, while in Williamson's work, leverage is determined after the choice of the riskiness of the assets. If these are highly specific the firm should not design a risky capital structure.

With respect to the measure of firms that may be liquidated, i, if there are too few firms in this situation, the potential liquidation costs are negligible compared to the benefits in terms of lower operating cost, and shareholders prefer it for any debt level.

5 Capital Structure

Combining the results in the previous section with the maximum debt levels described in section 3.3, we can find the optimal debt level for a firm with a given technology, given i. Due to the tax benefits of debt, a firm will issue as much debt as is compatible with the constraints derived above. In particular, when $(1-\theta)(L_S - X^L) + \lambda < 0$, a firm that is to invest in the safe technology will issue $D_S = \bar{D}$ while if a firm decides to invest in the risky technology it will issue $D_R = \pi_S^L + X^H$ which is the upper bound found above. Similarly, when $(1-\theta)(L_S - X^L) + \lambda \geq 0$ (and therefore all firms will use the R technology), firms have two options. They can choose to issue a very high debt level $(\pi_S^L + X^H)$, at the cost of being (inefficiently) liquidated if demand is low, or a smaller debt $(\pi_S^L + Max\{X^L, L(i)\})$, giving up tax benefits of debt but being efficiently liquidated.

Notice that this result points at a non-linear relation between riskiness and capital structure as suggested by Kale *et al.* (1991): low and high leverage levels are associated with high risk, while low risk corresponds to risky but not too high debt levels, and therefore there is no linear relation between both.

6 Industry Equilibrium

At $t=0$ firms choose capital structures to maximize their value. In doing so, they have to consider the effect the capital structure choice will have on the subsequent shareholders behavior. As we have seen, there are only three possible debt levels: $\pi_S^L + Max\{X^L, L_R(i)\}$, $\pi_S^L + X^H$ and $\bar{D}$. The value of the firm for each of them is given in the following expressions:

$$
\begin{aligned}
V(\bar{D}) &= (\theta(\pi_S^H + X^H) + (1-\theta)(\pi_S^L + L_S))(1-\tau) + \tau\bar{D} \\
&= (\theta(\pi_S^H + X^H) + (1-\theta)(\pi_S^L + L_S))(1-\tau) \\
&\quad +\tau\left(\pi_S^L + L_S - \frac{\lambda}{(1-\theta)}\right) \qquad (16)\\
V(\pi_S^L + Max\{X^L, L_R(i)\}) &= (\theta(\pi_R^H + X^H) + (1-\theta)(\pi_R^L + Max\{X^L, L_R(i)\}))(1-\tau) \qquad (17)\\
&\quad +\tau(\pi_S^L + Max\{X^L, L_R(i)\}) \qquad (18)\\
V(\pi_S^L + X^H) &= (\theta(\pi_R^H + X^H) + (1-\theta)\left(\pi_R^L + L_R(i)\right)(1-\tau) \\
&\quad +\tau(\pi_S^L + X^H) \qquad (19)
\end{aligned}
$$

Observe that $V(\pi_S^L + Max\{X^L, L(i)\}) < V(\pi_S^L + X^H)$ as long as $X^L < L_R(i)$, therefore as long as $i < \frac{\alpha - X_L}{\beta}$ no firm will issue $D = \pi_S^L + Max\{X^L, L_R(i)\}$ and we can restrict attention to $V(\pi_S^L + X^L)$.

From section 4 it is clear that there are two possible equilibria, corresponding to the cases $(1-\theta)(L_S - X^L) + \lambda \leq 0$ and $(1-\theta)(L_S - X^L) + \lambda > 0$.[13] Proposition 2 analyses both possibilities. In the first case, we will obtain an equilibrium where both technologies are used in equilibrium, and the expected firm values from each of them are equal: $V(\pi_S^L + X^H) = V(\bar{D})$. In the second one, technology S is dominated by the other one, in the sense that any firm obtaining $V(\bar{D})$ can increase its profit up to $V(\pi_S^L + X^L)$ regardless what other firms do. We then obtain an equilibrium where all firms choose the same technology, and choose different capital structures so that the expected values are equal ($V(\pi_S^L + X^H) = V(\pi_S^L + X^L)$).

[13] These two cases also correspond to $V(\pi_S^L + X^L) < V(\bar{D})$ and $V(\pi_S^L + X^L) \geq V(\bar{D})$.

Before stating Proposition 2, we define $\tilde{\imath}$ such that $V(\pi_S^L + X^H) \gtrless V(\pi_S^L + X^L) \Leftrightarrow i \lesseqgtr \tilde{\imath} \equiv \frac{\alpha - X_L}{\beta} + \frac{\tau(X^H - X^L)}{(1-\theta)(1-\tau)\beta}$. Similarly, we call $\hat{\imath}$ the point where $V(\pi_L^S + X^H) = V(\bar{D})$, so that

$$V(\pi_S^L + X^H) \gtrless V(\bar{D}) \Leftrightarrow i \lesseqgtr \hat{\imath} \equiv \frac{\alpha - L_S}{\beta} + \frac{\lambda}{(1-\theta)\beta} + \frac{\tau(X^H - L_S - \lambda/(1-\theta))}{(1-\tau)(1-\theta)\beta} \quad (20)$$

Finally, we will call i_S, i_{RN} and i_{RD} the measures of firms issuing $\bar{D}$, $\pi_L^S + X^L$ and $\pi_S^L + X^H$ respectively. With this notation, we can state our results.

Proposition 2 *(i) If $(1-\theta)(L_S - X^L) + \lambda \leq 0$, the equilibrium distribution of firms is given by:*

$$\begin{aligned} i_{RD} &= \hat{\imath} \\ i_S &= l - i_{RD} \\ i_{RN} &= 0 \end{aligned} \quad (21)$$

(ii) If $(1-\theta)(L_S - X^L) + \lambda > 0$, all firms choose the R technology, but they may differ in their financial structure:

$$\begin{aligned} i_{RD} &= \tilde{\imath} \\ i_S &= 0 \\ i_{RN} &= l - i_{RD} \end{aligned} \quad (22)$$

Proof. For part (i) the only thing we have to check is that $i_S \geq \bar{\imath}$, which is immediate from our initial assumption that $(1-\theta)(X^H - L_S - \lambda) > 0$. The second part follows from the previous discussion. ■

In the equilibrium described in Proposition 2(i) each technology is chosen by a fraction of the firms. Interestingly, the firms which have *higher* expected liquidation costs issue *more* debt than other ones. This of course is just a consequence of the discussion in section 3. This equilibrium just described is second best[14], given $(1-\theta)(L_S - X^L) + \lambda \leq 0$. The second best would not be attainable if $\hat{\imath} < \bar{\imath}$. However this is never the case as can be easily seen comparing expressions (15) and (20):

$$\hat{\imath} > \bar{\imath} \Leftrightarrow X^H + \pi_S^L > \bar{D} \Leftrightarrow \frac{\tau(X^H - L_S - \lambda/(1-\theta))}{(1-\tau)(1-\theta)\beta} > 0 \tag{23}$$

which is true by assumption. Notice that the difference between $\hat{\imath}$ and $\bar{\imath}$ resides only in the different tax shields achieved with each debt level, and a firm using the risky technology and issuing risky debt issues the maximum debt possible, which is naturally larger than any debt level an S firm can issue. The reason why this comparison turns out to be so simple can be easily explained looking at the expressions defining the two values. When shareholders face the technology choice, their choice depends on the difference between the liquidation values of the two technologies, as reflected in the first term defining $\bar{\imath}$ (expression (15)). But this same term appears in the comparison between $V(\pi_S^H + X)$ and $V(\bar{D})$, as in these two expressions the two different technologies are also considered. Similarly, the second term in both expressions reflects the cost advantage of the risky technology in both cases. Hence, these two effects appear in the same way in $\bar{\imath}$ and $\hat{\imath}$ and cancel out when comparing them. This means that shareholders' incentives are perfectly aligned with firm value maximization with respect to these two elements. The only remaining term is the third one in (20) that arises from the tax advantage of the R technology. This last term does not appear in the shareholders problem (which defines $\bar{\imath}$), as they decide which technology to operate $after$ the debt level has been decided upon, while firm value, by definition, is defined *ex ante*. As the risky technology has a bigger debt capacity, when maximizing firm value this technology tends to be chosen in a larger region than when maximizing shareholders value.

The second possible scenario is analyzed in Proposition 2(ii). In this equilibrium we find a justification for intra-industry variations in capital structures. Even if firms play a symmetric equilibrium in their real activity, some of them choose highly

[14] We refer to the second best as the optimal distribution of firms given the shareholders technology choices, i.e. taking as given the firm values as defined above.

leveraged capital structures while the rest issue only risk-free debt. Notice that the second best can be achieved again.

In a first best world liquidation decisions would always be efficient, independently of leverage. Given this, the first best measure of firms being liquidated depends again on the sign of $(1-\theta)(L_S - X^L) + \lambda$. If this is positive, all firms should use the risky technology, and $\frac{\alpha - X_L}{\beta}$ firms should be liquidated if demand is low. This value is smaller than $\tilde{\imath}$, by a factor that represents the tax advantage of issuing debt. In order to profit from tax shields, firms issue high debt levels, but this translates into these firms being inefficiently liquidated. The equilibrium given by $\tilde{\imath}$ trades off these two elements. Similarly, if $(1-\theta)(L_S - X^L) + \lambda < 0$ an amount $\frac{\alpha - L_S}{\beta} + \frac{\lambda}{(1-\theta)}$ of firms should be liquidated, which again is smaller than $\hat{\imath}$, and the difference depends again on the tax shields, for the same reasons as above. Hence, the debt-overhang problem created by issuing too much debt leads to second best equilibria always, with too many firms being liquidated. Contrary the results of Maksimovic and Zechner (1991), where risk shifting problems are reduced when the equilibrium in the industry is considered, this debt overhang problem created by the non-contractibility of cash flows is not solved nor softened by looking at the equilibrium in the industry. Moreover, the fact that firms individually take inefficient liquidation decisions implies that the total measure of firms choosing the risky technology with a risky capital structure is too large. Our result is closer to Williams (1995) where there exist parameter configurations for which second best outcomes arise. As in our model, in Williams (1995) there are two moral hazard problems to solve: first, the shareholders/manager have to be given incentives to choose the right technology; second, shareholders can *divert* the funds they obtain to invest consuming them as perks. He shows that there are parameter configurations where firms are not able to solve both problems and a suboptimal result arises (while the first best is attained otherwise). In his model though contracts are complete, in that both problems are dealt with in the initial contract. In our model contracts are incomplete, because profits are not verifiable, and this *always* implies that the risky technology will be liquidated inefficiently if debt is high enough. Therefore, the first best is never attainable in our setting.

7 Discussion and implications

We divide the discussion of the model in two sections, concerning the firm and the industry-wide levels.

7.1 Implications at the firm level

When the firm's shareholders have to make decisions after capital structure is determined, there may exist *moral hazard* problems in that they have to be given the right incentives to undertake the optimal actions (i.e. those which maximize firm value). Usually these actions have implications both for the firm value and for its riskiness. In our particular case, shareholders have to choose which technology to use to produce. We have reasoned that technologies with low liquidation values are likely to be riskier than those with high liquidation values. Hence, when shareholders have to be induced to choose for the former, debt will have to be high (and vice versa). If we abstract from (or control for) the impact that each choice has on liquidation decisions , we should observe that firms required to invest in very specific, risky assets are characterized by high leverage. Further, we can extend our argument to elements other than 'technology choices'. For example, in dynamic industries like IT a great deal or innovation, R&D and risky investments is required from a firm to be successful. These are typically activities with low liquidation values (e.g. R&D costs are 'sunk' after they have been incurred, meaning they have zero liquidation value) and nevertheless have positive NPV (since they are indeed undertaken). In order for shareholders to seek this kind of risky activity, high leverage is called for. This may be an argument explaining the recent success of venture capital firms in new industries. In this kind of firms the manager obtains virtually all his funds from an external investor, the venture capitalist. Arguably this very leveraged financial structure allows -induces- the entrepreneur to take all necessary risks to make a successful firm.

7.2 Implications at the industry level

These are contained in Proposition 2. Observe that the two parts of the proposition together mean that there must be some 'mixing' in the industry in equilibrium. We could restate both results in one by considering that as the S technology becomes too costly with respect to the risky one, the industry shifts from mixing technologies to mixing capital structures. Recall that the condition to have the first equilibrium is $(1-\theta)(L_S - X^L) + \lambda \leq 0$. Therefore, if the cost advantage of the risky technology is low enough compared with its higher potential liquidation costs both technologies are used in equilibrium. At $(1-\theta)(L_S - X^L) + \lambda = 0$ the equilibrium switches and the safe technology is never used. In both equilibria, in order to 'arbitrage' the decreasing liquidation value of the risky technology, a sufficiently high amount of firms needs to get away from the possibility of being liquidated with the risky technology, and this is achieved by either issuing no risky debt or by choosing the alternative technology, whichever possibility is more profitable. This implies that capital structure and technology choice are *ex ante* substitutes in the firm profit as means to reduce expected bankruptcy costs. In order to reduce the potential costs of bankruptcy a firm can either choose safe assets, or else choose risky assets but combined with a less risky capital structure.

$2(i)$ can be seen as a justification of the existence of different production technologies across firms in the same industry (e.g., labor intensive and capital intensive). In this sense, the result is similar to that obtained by Maksimovic and Zechner (1994). One of the technologies may be optimal from a single-firm point of view, but when the whole industry is considered, it turns out that both are used in equilibrium. More interestingly, we show that the firms using one or the other technology have different financial structures. Thus, we find a new justification for the observed existence of different capital structures across firms in the same industry based on the market (liquidation) value of the firms' assets. The empirical prediction would be that when firms use different technologies, or when the behavior of firms with respect to risky actions is different, this difference will be reflected in their capital structure.

This result also justifies why firms may be operating with apparently inefficient technologies. Observe that the only advantage of what we called S technology dwells in its liquidation value. Apparently then, a firm operating this technology is inefficient and actually its operating costs are higher than those of other firms in the industry. Only if we consider the whole value of the firm, including the market value of its assets -and hence the probability of having to sell them out-, is this technology efficient. This may be relevant for 'unstable' industries, like new industries with a lot of future uncertainty, or even declining industries with a decreasing number of firms.

In part (*ii*) of Proposition 2 all firms choose the same technology, but they choose different capital structures. Some firms choose risky capital structures and the rest issue no risky debt. When the firms' assets are specific (firm- or industry-specific) they will have to be sold to inferior users when the firm is liquidated. We argued that, as more and more firms fall into financial distress, that sale will involve a buyer with an ever decreasing valuation, and therefore liquidation costs will be increasing in the number of firms in financial distress. If several firms are involved in a risky dynamic business, the liquidation value of their assets will be very small if all of them simultaneously fall into financial distress. As a consequence, at some point firms will decide that the liquidation value of the typical industry assets has become too small and they will avoid the possibility of financial distress. We should then observe that when it is optimal to operate risky technologies, or more in general, when firms are involved in a business characterized by its innovation, large R&D expenses and so on, so that there is some uniformity across all firms in the industry (in the kind of assets and activities they engage in), some firms will find it optimal not to issue debt at all, forgoing tax shields, but also reducing the risk of bankruptcy. Hence, in this kind of industry large variabilities in capital structure should be observed.

8 Conclusion

A theory of the financial and industry-wide effects of liquidation values in large markets is presented. We investigate the impact of having multiple technologies with different and endogenous liquidation values on the optimal firm and industry-wide equilibrium capital structure. For each of two technologies, we derive optimal capital structures, based on the non-contractibility of both the profit level and the technology choice. We show that the debt level of a firm using assets with high liquidation value is bounded, while firms using more risky assets will issue either very high or risk-free debt levels. The distribution of firms between both technologies turns out to be a key variable, because it determines the equilibrium resale price of the risky assets. In the industry equilibrium, the expected value of all firms has to be equal. This is achieved through using different capital structures and/or different technologies; technology choice and capital structure are alternative ways to reduce expected bankruptcy costs.

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9 Appendix

Proof of Proposition 1:

(i) $(1-\theta)(X^L - L_S) + \lambda \geq 0:$

For the risky technology the relevant intervals are defined by $D \lesseqgtr \pi_S^L + Max\{X^L, L_R(i)\}$, while for the safe one by $D \lesseqgtr L_S + \pi_S^L$. This gives us three regions to look at:

$D < \pi_S^L + Max\{X^L, L_R(i)\}$: the risky technology is chosen iff:

$$\theta(\pi_R^H + X^H) + (1-\theta)(\pi_R^L + Max\{X^L, L_R(i)\}) - D \geq \theta(\pi_S^H + X^H) + (1-\theta)(L_S + \pi_S^L) - D \tag{24}$$

or:

$$(1-\theta)(Max\{L_R(i), X^L\} - L_S) + \lambda \geq 0 \tag{25}$$

which is always true, as $(1-\theta)(Max\{L_R(i), X^L\} - L_S) + \lambda \geq (1-\theta)(X^L - L_S) + \lambda$, and the latter is non negative by assumption.

$\pi_S^L + Max\{X^L, L_R(i)\} \leq D < L_S + \pi_S^L$: R is chosen if

$$\theta(\pi_R^H + X^H - D) + (1-\theta)\lambda \geq \theta(\pi_S^H + X^H) + (1-\theta)(L_S + \pi_S^L) - D \tag{26}$$

which, evaluated at the lower end of the interval $(\pi_S^L + Max\{X^L, L_R(i)\})$ reduces to expression (25), which we know is always true. Obviously for higher debt levels (26) holds *a fortiori.*

Finally, if $L_S + \pi_S^L \leq D$, the safe technology is never chosen, as:

$$\theta(\pi_S^H + X^H - D) > \theta(\pi_R^H + X^H - D) + (1-\theta)\lambda \tag{27}$$

(ii) $(1-\theta)(X^L - L_S) + \lambda < 0:$

Looking at the sames regions as above:

$D < \pi_S^L + Max\{X^L, L_R(i)\}$: the risky technology is chosen iff (25) holds. This is true if and only if

$$i < \frac{\alpha - L_S}{\beta} + \frac{\lambda}{(1-\theta)} \equiv i_1$$

$\pi_S^L + Max\{X^L, L_R(i)\} \leq D < L_S + \pi_S^L$: the risky technology is chosen iff (26) holds. This reduces to:

$$D \leq X^L + \pi_S^L \ - \frac{\lambda}{(1-\theta)} \equiv \bar{D}$$

However, this condition is meaningless unless $\bar{D} \geq \pi_S^L + Max\{X^L, L_R(i)\}$, which is equivalent to $i < i_1$.

The two previous cases together mean that below i_1 R is always chosen, while above i_1 R is chosen if $D > \bar{D}$.

Finally, if $L_S + \pi_S^L \leq D$, the safe technology is, as before, never chosen.

■