A structural econometric investigation of the agency theory of financial structure

Bruno Biais[1] Christophe Bisière[2] Jean-Paul Décamps[3]

April 26, 1999

[1]Toulouse University, GREMAQ, IDEI
[2]Perpignan University, GREMAQ, IDEI
[3]Toulouse University, GREMAQ, IDEI.

Many thanks to Francesca Cornelli, Jacques Cremer, Didier Davydoff, Jean Pierre Florens, Michel Habib, Gildas de Nercy, Dimitri Vayanos and participants to the NYSE–Paris Bourse conference on Global Equity Markets in Paris, the London Business School TMR workshop and the IDEI lunch seminar, for helpful discussions.We gratefully acknowledge the financial support of the Société des Bourses Françaises.

Abstract

A structural econometric investigation of the agency theory of financial structure

We estimate a structural model of financing choices in presence of managerial moral hazard, financial distress costs and taxes. In the theoretical model, firms with low cost of managerial effort, and high financial distress costs and non–debt tax shields, find it optimal to issue equity. Correspondingly the likelihood that a given firm issues equity is the probability that its managerial cost of effort is below an upper bound, reflecting its financial distress cost and non debt tax shields, as well as the other deep parameters of the model. Similarly we characterize the likelihood of issues of debt and convertible bonds. Using maximum likelihood analysis, we confront this theoretical model to data on financing choices by French firms in 1996. We find large costs of financial distress, equal on average to 41.2% of the value of the firm when it is in distress. We also find large agency costs, equal to 40.26% of the value of the investment project. In contrast, we find that tax shields do not play a significant role in the financing decision.

JEL codes: G32.

1 Introduction

One of the central paradigms in corporate finance, stemming from the seminal work of Modigliani and Miller (1958 and 1963), emphasizes the tax shield value of debt, and compares it to the potential costs of financial distress induced by leverage.[1] A competing paradigm is offered by the agency theory of financial structure, analyzing information asymmetries and conflicts of interests between managers and outside financiers, in the line of the seminal works of Jensen and Meckling (1976),[2] emphasizing moral hazard, and Ross (1977), Leland and Pyle (1977) and Myers and Majluf (1984), emphasizing adverse selection.[3] A rich body of empirical work has shed light on the relevance of these two paradigms.[4] Complementing this literature, which has mainly relied on reduced forms regressions, the present paper proposes a structural econometric approach. The goal is to conduct a direct test of the implications of the theory and to estimate the deep parameters of the model, thus generating measures of financial distress costs and agency costs.

In the next section we present a simple theoretical model of financing choices with financial distress costs, tax shields and moral hazard. Consider a manager, facing an investment project with positive net present value if he exerts sufficient effort. Internal cash is available to the firm to contribute to the financing of the project. But additional outside financing must be obtained. The financing alternatives available include straight debt, convertible debt, and outside equity. Each of these give claims to the outside investors on the cash flows generated by the project. These claims cannot be too high, lest they should destroy the incentives of the manager to exert costly effort, by reducing his stake in the cash flows. In addition to this moral hazard problem, the model features financial distress costs

[1] This classical tradeoff theory of financial structure is presented, for example, in the textbooks of Brealey and Myers (1991, p 434) and Ross, Westerfield and Jaffe (1988, p 427). Heinkel and Zechnner (1993) study capital structure adjustment with financial distress costs.

[2] One could in fact trace this line of literature back to Adam Smith, as illustrated by the following sentences from the Wealth of Nations (1776), quoted by Jensen and Meckling (1976): “The directors of such [joint stock] companies, however, being the managers rather of other people’s money than of their own, it cannot well be expected that they should watch over it with the same anxious vigilance with which the partners in a copartnery frequently watch over their own.”

[3] An insightful survey of more recent works in this field is presented by Harris and Raviv (1991).

[4] See e.g. Miller and Modigliani (1966), Long and Malitz (1985), Mackie–Mason (1990), Lucas and MacDonald (1990), Titman and Wessels (1988), Jung, Kim and Stulz (1996), Shyam–Sunder and Myers (1999), and Lewis, Rogalski and Seward (1998).

and corporate taxes. We find that, if the cost of financial distress, the disutility of effort, and the amount of outside financing needed are too high, the project cannot be funded, and there is credit rationing. On the other hand, if the cost of effort is relatively low, the project can be undertaken and financed by equity. In intermediary situations, where both the cost of effort and the cost of financial distress are significant, convertible debt can offer a better financing tool than both debt and equity, and thus enable the project to be undertaken.[5]

To confront this theoretical model to the data, we rely on a sample of 379 French firms listed on the Bourse in 1996. This dataset is presented in Section III. Along with information on balance sheets and income statements, our data includes information about equity and convertible debts issues, as well as on increases in debt financing for these companies. In our sample, 16 firms issued equity, 9 issued convertible bonds, 75 issued straight debt, and 279 did not issue any outside financial claim.

In section IV we present our econometric approach. The cost of effort is assumed to differ across firms. While the manager and the financier observe it, for the econometrician it is a random variable, i.e., an unobservable heterogeneity component. We estimate the distribution of this cost of effort as well as the other deep parameters of the model, using maximum likelihood estimation. The idea underlying our econometric approach is the following. Our theoretical analysis implies that firms can rely on equity financing only if their cost of effort is lower than a threshold value, which is a function of the deep parameters of the model and the observable variables for that firm. When equity financing is thus feasible, firms choose to issue equity if this generates less taxes and bankruptcy costs than other feasible financing schemes. Consequently the likelihood that a given firm issues equity is the probability that these conditions are met, implying in particular that its cost of effort be lower than its threshold value. Similarly, we write the likelihood of convertible bonds and straight debt issues, as well as the likelihood that firms do not issue any outside financial claim. We then search for the parameter values maximizing the likelihood of the observed financial choices.

Section V presents our econometric results. In this preliminary draft, we have not analyzed the convertible bonds issues. Our findings suggest that financial

[5]Our theoretical analysis of the incentive properties of convertible debt is related to Green (1984), Harris and Raviv (1985), Stein (1992), Décamps and Faure Grimaud (1997) and Biais and Casamatta (1998). The main difference with Green (1984), Décamps and Faure Grimaud (1997) and Biais and Casamatta (1998) is that we focus on managerial effort and not on risk shifting. Similarly to Stein (1992), we analyze the trade–off between asymmetric information and financial distress costs, but we focus on moral hazard while Stein (1992) considers a signalling model.

distress costs and agency issues play an important role, while tax considerations do not. Our estimate of the average cost of financial distress: 41.2 % of the value of the firm when it is in distress, is rather large. So is our estimate of agency costs, which we find on average equal to 40.26% of the value of the investment project. In contrast, we find that tax shields do not play a significant role in the financing decision.

Section VI offers a brief conclusion. Some technical aspects of our analysis are in Appendices 1 and 2.

2 Theoretical model

2.1 The investment project

For simplicity, we focus on a simple one–period model, with risk–neutral agents.[6] Consider a manager–owned firm. Assume its assets in place pay X with certainty at the end of the period. Also, debt in place d must be serviced to senior debtholders at the end of the period. We assume that $X > d$, i.e., the firm is not currently in financial distress,[7] and that the assets in place are currently illiquid, i.e., they generate X only at the end of the period. In addition to these illiquid assets, the firm has cash A. It also faces an investment opportunity, requiring initial investment $I > A$. Since assets in place other than A are illiquid, the investment can be undertaken only if the firm can raise outside financing $I - A$.

The manager can decide to exert unobservable effort, to enhance the profitability of the project, or not to exert effort. The disutility of effort for the manager is e. Effort improves the distribution of the cash–flow obtained at the end of the period, in the sense of first order stochastic dominance. If the manager decides to exert effort, the distribution of the cash flow R is given by the density $f(.)$ with support $[0, T]$, and c.d.f $F(.)$. If the manager decides not to exert effort, the density of the cash flow is $g(.)$, with the same support but with a dominated distribution. The corresponding c.d.f is denoted $G(.)$. Denote $E_f(.)$ the expectation operator with respect to the density f, and $E_g(.)$ the expectation taken with respect to g.

Assume effort is socially optimal, i.e., $E_f(R) - e > E_g(R)$, and that under

[6]Our moral hazard model is in the same spirit as Holmstrom and Tirole (1997) and Innes (1990). Differences between our theoretical model and theirs include our focus on equity, debt and convertible debt and on bankruptcy costs and taxes.

[7]Hence there are no issues associated with gambling for resurrection, see Décamps and Faure Grimaud (1998).

effort, the project has positive net present value:

$$E_f(R) - e > \rho I,$$

where ρ is the social discount rate, while without effort it has negative net present value:

$$E_g(R) < \rho I.$$

Hence, the issue at stake is wether it is possible to finance the project while ensuring that the manager will indeed exert effort. For simplicity we hereafter normalize the discount rate ρ to 1.

At the end of the period, corporate income tax at rate τ must be paid. Debt provides tax shields since interest expenses are tax deductible.

2.2 Financing the project

2.2.1 Equity

One possibility is for the manager to issue equity. In this case, when the project is undertaken, cash–flow from operations, minus interest expenses equals:

$$X + R - kd,$$

where k is the fraction of debt service d corresponding to interest payments. Consequently, taxes equal:

$$(X + R - kd)(\tau),$$

and the total cash flow to equity holders is:

$$(X + R - kd)(1 - \tau) - (1 - k)d,$$

which can be rewritten as:

$$(X + R)(1 - \tau) - d + k\tau d,$$

i.e., after tax cash flow from unlevered firm, minus cash flow to debtholders, plus tax shields from debt.[8]

[8] The firm would benefit from increasing the fraction of the debt service corresponding to interests (k), but we assume that this fraction is exogenous, and reflects legal constraints, and thus cannot be manipulated by the firm.

Denote δ the share of the ownership over the cash flows allocated to the outside financier, $i.e.$ the dilution. At the end of the period outside financiers obtain:

$$\delta[(X+R)(1-\tau)-d+k\tau d],$$

while the manager obtains:

$$(1-\delta)[(X+R)(1-\tau)-d+k\tau d].$$

2.2.2 Debt financing

Alternatively, the manager can issue debt. Denote D the service of the new debt. kD corresponds to interests payments, while $(1-k)D$ corresponds to reimbursement. We assume that the debt in place d is senior and the new debt D is junior.

Leverage can generate financial distress. Financial distress, and the corresponding costs, can arise before the firm effectively defaults on its debt. For simplicity, in the present one–period model, we collapse both events (financial distress and default) into a single event, which happens when $R+X<D+d$, i.e., when earnings before interests and taxes are not sufficient to service the debt. In that case, the cost of financial distress, borne by the junior debtholders, is assumed to be equal to: $c(R+X-d)$, where c is a constant between 0 and 1. In spite of our simplifying assumption, it is important to bear in mind that in addition to direct bankruptcy costs, such as legal fees, c reflects indirect, economic costs, related to the fact that financially distressed firms must face problems reducing their value. Examples of such indirect costs are the fact that customers and suppliers are reluctant to engage in relationships with distressed firms, that the employees of such firms are less encline towards investing in firm specific human capital, and that competitors are likely to engage in predatory price wars to drive the distressed firm out of business.[9]

In this context, when the project is financed by debt, at the end of the period the manager obtains:

$$Max[0,(R+X)(1-\tau)-(D+d)+\tau k(D+d)],$$

i.e., the manager obtains the after tax cash flow from the unlevered firm, minus the service of debt, and plus the tax shields from debt. The outside financier obtains:

$$Min[R+X-d,D]-c(R+X-d)1(R<D+d-X),$$

[9]The latter concern is emphasized in the Harvard Business School case “MCI communications Corp., 1983”, which studies issues of convertible bonds. See for example the discussion on page 4 of the Teaching Note by Bruce Greenwald (1986). See also Chevalier (1995).

where $1(R < D + d - X)$ is the indicator variable taking the value one when $R < D + d - X$, i.e., when the firm is in financial distress.

2.2.3 Convertible debt

Another possible financing scheme is to issue convertible debt. In this case the outside financiers hold debt, promising repayment D, and in addition have the option to convert this debt into a fraction γ of the equity. The maturity of the option is at the end of the period, when the cash flow R is realized. The outside financiers exercise this option if the value of the fraction γ of the equity is worth more than the repayment on the debt, i.e., if:

$$\gamma((R + X)(1 - \tau) - d + k\tau d) > D.$$

Hence, with convertible bonds, the outside financier obtains:

$$Min[R+X-d, Max[D, \gamma((R+X)(1-\tau)-d+k\tau d)]]-c(R+X-d)1(R < D+d-X),$$

while the manager obtains:

$$Max[0, Min[(R+X)(1-\tau)-(D+d)+k\tau(D+d), (1-\gamma)((R+X)(1-\tau)-d+k\tau d)]].$$

Of course, equity is a particular case of convertible bond, for $D = 0$, while debt is a particular case for $\gamma T > D$, i.e., for values of D and γ such that it is never optimal to convert the bond into equity.

In the present paper, we do not search for optimal contracts which could well be more general than debt, convertible bonds or equity. Rather, we take a positive approach, taking as given the contracts or securities actually observed in financial markets. This is because the goal of the present theoretical model is to provide a framework for our econometric analysis of the existing financing tools observed in the data: equity, debt and convertible bonds.

Issuing securities, such as equity or convertible bonds entails transactions costs, including the commissions paid to the financial intermediaries in charge of the placement of the securities. Denote: F_C the cost incurred in the case of convertible debt, and F_E the cost incurred in the case of equity. The presence of these fixed costs justifies the reliance of the firm on one of the three financing alternatives (equity, debt or convertible debt) rather than a mix of the three.[10] Because convertible debt is a more sophisticated product than equity, it is likely to entail larger commissions, i.e., $F_C > F_E$. For simplicity we normalize F_E to 0.

[10] This corresponds to the situation described in the above mentioned Harvard Business School case: "MCI communications corp., 1983". See for example the discussion on page 7 of the Teaching Note by Bruce Greenwald (1992).

2.3 The moral hazard problem

2.3.1 Moral hazard with equity

First consider the case of equity financing. Since the project has positive net present value only if effort is undertaken, it can be financed with equity, with dilution δ, only if the following incentive compatibility condition holds:

$$(1-\tau)(1-\delta)E_f(R+X-\frac{1-k\tau}{1-\tau}d)-e \geq (1-\tau)(1-\delta)E_g(R+X-\frac{1-k\tau}{1-\tau}d),$$

i.e., if the manager finds it in his interest to exert effort. On the other hand, if the investors anticipate that the manager will exert effort, they are willing to provide equity financing if and only if the following individual rationality constraint holds:

$$(1-\tau)\delta E_f(R+X-\frac{1-k\tau}{1-\tau}d) \geq I-A.$$

Hence, the project can be financed with equity if and only if there exists $\delta \in [0,1]$ such that the two conditions above hold.[11]

The incentive compatibility condition of the manager can be rewritten as:

$$\delta \leq 1-\frac{e}{(1-\tau)(E_f(R)-E_g(R))}.$$

The manager is not willing to work hard if his inside equity claim on the cash flow of the firm is too diluted because δ is too large.[12] Note that this problem is more severe if the cost of effort e is large.

On the other hand, the individual rationality condition of the investors amounts to:

$$\delta \geq \frac{I-A}{E_f(R+X-\sigma d)(1-\tau)},$$

where $\sigma = \frac{1-k\tau}{1-\tau}$. This inequality means that the investors are willing to finance the project only if their claim on the cash flow of the firm is large enough that they

[11] It is straightforward to show that if the incentive compatibility condition of the manager and the individual rationality condition of the financier are consistent, then there exists a value of δ, satisfying both of these conditions and the individual rationality condition of the manager (for example set δ to saturate the individual rationality condition of the financier). The same remark also applies to the cases of straight debt and convertible bonds.

[12] This is the sense in which we interpret the statement by the CEO of MCI (in the HBS case: “MCI communications corp. 1983”) that too much dilution could undermine the performance of the firm.

can recoup from their initial cash outflow. This rewriting of the two conditions shows that there is a potential conflict between them. Yet, if the cost of effort is not too large, the upper bound on the dilution imposed by the incentive compatibility condition of the manager is relatively high, hence it can be consistent with the participation constraint of the outside financier. Consequently, financing the investment with equity is feasible if the cost of effort is not too large, as stated in the following proposition.

Proposition 1 *Investment can take place and be financed with equity if and only if the cost of effort of the manager is lower than the following threshold:*

$$e_E = \frac{(1-\tau)(E_f(R+X-\sigma d)) - (I-A)}{1 + \frac{E_g(R+X-\sigma d)}{E_f(R)-E_g(R)}}.$$

Note that the larger the outside financing need ($I-A$) the lower the threshold for the cost of effort (e_E). This is because if the outside financing need is large, a large amount must be pledged to the outside financier, i.e., dilution is large, which reduces the compensation to the manager, and weakens his incentives.

2.3.2 Moral hazard with debt

Denote $\hat{\varphi}(D)$ the difference between the expected cash flow to the manager under effort and his expected cash flow without effort.

$$\begin{aligned}\hat{\varphi}(D) \quad &= \quad E_f(Max[(R+X)(1-\tau) - (D+d) + k\tau(D+d), 0]) \\ &\quad\quad -E_g(Max[(R+X)(1-\tau) - (D+d) + k\tau(D+d), 0]).\end{aligned}$$

The incentive compatibility condition of the manager is:

$$\hat{\varphi}(D) \geq e.$$

Note that $\hat{\varphi}(D)$ can be rewritten as:

$$\hat{\varphi}(D) = \int_{Max[(D+d)\sigma - X, 0]}^{T} (1-\tau)[(R+X) - \sigma(D+d)](f(R) - g(R))dR.$$

Integrating by parts we obtain:

$$\hat{\varphi}(D) = \int_{Max[(D+d)\sigma - X, 0]}^{T} (G(R) - F(R))dR,$$

which is decreasing with D. Consistent with intuition, the larger the debt service, the lower the incentives of the manager to exert effort. Relying on this monotonicity property, the incentive compatibility condition of the manager is equivalent to:

$$D \leq \hat{\varphi}^{-1}(e).$$

Consistent with the debt–overhang effect analyzed by Myers (1977), the manager is not willing to exert effort if the service of debt is too large.

Denote $\varphi(D)$ the expected cash flow earned by the debt–holders if the promised repayment is D and if the manager exerts effort, i.e.,

$$\varphi(D) = E_f(Min[R + X - d, D] - c(R + X - d)1(R < D + d - X)).$$

The participation constraint of the outside financier holds iff:

$$\varphi(D) \geq I - A.$$

Similarly to $\hat{\varphi}$, it can be shown that, for the relevant values of D, $\varphi(D)$ is increasing in D. This has a natural interpretation: the larger the amount D promised to the debt holders, the larger their expected cash–flow (provided the manager exerts effort). Relying on this monotonicity property, the participation constraint of the outside financier is:

$$D \geq \varphi^{-1}(I - A),$$

i.e., the financier is willing to fund the project only if he is promised a sufficiently large repayment.

Consequently, the project can be undertaken while being funded by debt if there exists a value of $D \in [0, T]$ sufficiently low to incentivize the manager to exert effort, and at the same time sufficiently large to compensate the investors. Similarly to the case of equity, this is possible if and only if the cost of effort is not too large, as stated in the proposition below.

Proposition 2 *Investment can take place and be financed with debt if and only the cost of effort of the manager is lower than the following threshold:*

$$e_D = \hat{\varphi}(\varphi^{-1}(I - A)).$$

2.3.3 Moral hazard with convertible debt

Denote $\hat{\psi}(\gamma, D)$ the difference between the expected cash flow to the manager under effort and his expected cash flow without effort.

$$\begin{aligned}\hat{\psi}(\gamma, D) \quad = \quad & E_f(Max[0, Min[(R+X)(1-\tau)-(D+d)+k\tau(D+d),\\ & (1-\gamma)((R+X)(1-\tau)-d+k\tau d)]])\\ & -E_g(Max[0, Min[(R+X)(1-\tau)-(D+d)+k\tau(D+d),\\ & (1-\gamma)((R+X)(1-\tau)-d+k\tau d)]]).\end{aligned}$$

The incentive compatibility condition of the manager is:

$$\hat{\psi}(\gamma, D) \geq e.$$

It can easily be shown that $\hat{\psi}(\gamma, D)$ is decreasing in γ. This has a natural interpretation: the larger the dilution promised to the bond–holders the lower the incentives of the manager to exert effort. Consequently, the incentive compatibility condition of the manager is equivalent to:

$$\gamma \leq \hat{\psi}_{\gamma}^{-1}(e, D),$$

where $\hat{\psi}_{\gamma}^{-1}$ denotes the inverse of $\hat{\psi}$ with respect to γ. Similarly to the equity financing case, dilution must not be too large, lest it should destroy the incentives of the manager to exert efffort.

Denote $\psi(\gamma, D)$ the expected cash flow earned by the debt–holders if the promised repayment is D, the conversion rate is γ, and the manager exerts effort, i.e.,

$$\psi(\gamma, D) = E_f(Min[R+X-d, Max[D, \gamma((R+X)(1-\tau)-d+k\tau d)]]$$

$$-c(R+X-d)1(R < D+d-X),).$$

The participation constraint of the outside financier holds iff:

$$\psi(\gamma, D) \geq I - A + F_C.$$

It can be checked that, as long as the conversion threshold is below the upper bound of the cash flow, $\psi(\gamma, D)$ is increasing in γ. Again, this conforms to intuition: the larger the conversion rate, the better off the bond–holders (provided the manager exerts effort). Relying on this monotonicity condition, the participation constraint of the outside financier is:

$$\gamma \geq \psi_\gamma^{-1}(I - A + F_C, D),$$

where ψ_γ^{-1} denotes the inverse of ψ with respect to γ. That is, the financier is willing to fund the project with convertible debt only if he is promised a sufficiently large conversion rate.

Note that in the above inequalities ψ_γ^{-1} and $\hat{\psi}$ are evaluated for a certain value of D. The project can be undertaken and funded by convertible debt if there exists a value of $D \in [0, T]$, such that the individual rationality condition of the manager and the participation constraint of the outside financier are consistent. As in the cases of debt and equity, this is possible if and only if the cost of effort is not too large, as stated in the proposition below.

Proposition 3 *Investment can take place and be financed with convertible debt if and only the cost of effort of the manager is lower than the following threshold:*

$$e_C = Max_D[\hat{\psi}(\psi_\gamma^{-1}(I - A + F_C, D), D)].$$

2.4 Financial choices

When the cost of effort is lower than the three thresholds characterized above, i.e., when:

$$e < Min[e_C, e_D, e_E],$$

then the three forms of financing are feasible. In this case, the entrepreneur simply needs to pick the financing tool generating the largest utility for him. To characterize this choice, for simplicity, assume that the particpation constraint of the outside investors is binding (we will subsequently stick to this assumption.) The expected utility of the manager if he issues equity is:

$$U_E = (E_f(R) + X - \sigma d)(1 - \tau) - (I - A) - e,$$

which is equal to the after tax profit of the firm, minus the amount which must be paid back to the outside financiers to ensure that their participation constraint holds, and minus the cost of effort. On the other hand, if the manager issues debt, his expected utility is:

$$U_D = (E_f(R) + X - d) - (I - A) - e - cE_f((R + X - d)1(R < D - X + d))$$

$$-\tau E_f((R+X-k(D+d))1(R>\sigma(D+d)-X)),$$

which is equal to the expected cash–flow, minus the amount to be promised to the financiers, the cost of effort, the expected bankruptcy cost, and the expected tax cost. Similarly, with convertible bond financing, the expected utility of the manager is:

$$U_C = E_f(R)+X-d-(I-A+F_C)-e-cE_f((R+X-d)1(R<D-X+d))$$

$$-\tau[\int_{Max[\sigma(D+d)-X,0]}^{Min[Max[\frac{D}{\gamma(1-\tau)}+\sigma d-X,0],T]}(R+X-k(D+d))f(R)dR]$$
$$-\tau[\int_{Min[Max[\frac{D}{\gamma(1-\tau)}+\sigma d-X,0],T]}^{T}(R+X-k(D+d))f(R)dR],$$

reflecting again the expected cash–flow, the compensation of the outside financiers, the cost of effort, the financial distress costs and the taxes. In this context, the manager will choose the financing tool providing him with the largest expected utility. This choice exactly reflects the trade–off theory, i.e., the manager selects the financing scheme minimizing the sum of financial distress costs, taxes and issuing costs. Indeed, when, for all three financing schemes, incentive compatibility conditions and participation constraints are consistent, agency issues do not constrain financial choices, and the Modigliani and Miller logic applies.

On the other hand, if only equity and convertible bonds are feasible, i.e., if:

$$e_D < e < Min[e_E, e_C],$$

then the manager chooses equity if: $U_E > U_C$, and convertible bonds otherwise. Similarly, if only debt and equity are feasible the manager chooses equity if and only if: $U_E > U_D$, while if only convertible bonds and debt are feasible, the manager chooses debt if and only if: $U_D > U_C$. Finally, if only one financing tool is feasible, it is trivially selected, while if no financing tool is feasible, i.e., if:

$$e > Max[e_E, e_D, e_C],$$

then the firm is credit rationed and investment cannot take place.

2.5 A simple parametrization

To explicitly compute the above characterized quantities in our econometric analysis, we rely on a simple parametrization for the distribution the cash flows. First, we assume that the c.d.f of the cash flow when the manager does not exert effort (G) is equal to: F^p, where F is the c.d.f of the cash flow under effort. $p \in [0, 1]$ quantifies the consequences of managerial effort on output. Since $F < 1$, for $p \in [0, 1]$, $G > F$, as required by first order stochastic dominance. The lower p the more severe the consequences of shirking on output. Second, to simplify computations, we assume F is uniform over $[0, T]$. Under these assumptions, we computed the threshold values of the cost of effort and the managerial expected utility for the different financing schemes. The results are presented in Appendix 1.

3 Data

To confront this theoretical analysis to the data we consider 680 French firms quoted on the Paris Bourse on December 31, 1996.[13] To analyze their investment and financing behavior in 1996 we use as predetermined variables accounting information from 1995. To collect this information, as well as information on the industries to which firms belong, we used data from a French financial statements analyst: DAFSA. We obtained the entire information we needed for 379 firms. For these firms we observe in 1995 the total assets, the book value debt, the tangible assets, corporate income tax, interest expenses and depreciations. In our description of this data, as well as in our econometric analysis below, we will focus on variables normalized by total assets. This facilitates comparability across firms. Summary statistics are presented in Table 1, both across all 379 firms and sorted across four broadly defined industries: manufacturing firms, services, high–tech, and real estate and financial firms.[14] We chose to differentiate high–tech firms from the other industrial firms because they are likely to exhibit different investment and financing patterns. On average, across industries, total assets amounted to 11.15 billion French Francs (i.e. approximately 2 billion dollars). The ratio of debt to total assets was close to 50%, while the ratio of tangible assets to total assets was approximately 23%. While the average total assets of manufacturing

[13] This excludes firms which listed in 1996 and firms which did not list. This limitation is a loss, since some of these firms have issued (privately) equity, convertible debt or bank debt in that period, and would have offered an interesting testing ground for our theory. Unfortunately, data on these issues is not easily available.

[14] Slightly less than one half of the firms in the category “Real estate and finance” are real estate investment funds, with very large tangible to total assets ratios. Investment funds, with very low leverage ratio, represent a large fraction of the other half.

firms were somewhat above the grand–mean, they were lower for the financial and real estate sector, and high–tech firms.

In this sample, in 1996, 16 firms issued equity, and 9 issued convertible bonds. We identified as firms issuing debt those for which total debt on December 31, 1996, was more than 10 % higher than total debt on December 31, 1995.[15] Using this criterion, 75 firms issued debt that year.[16] This left 279 firms in the sample for which there was no outside financing. Summary statistics on these financial choices are presented in Table 2. On average convertible bond issues amount to 1.3 billion French Francs (approximately .2 billion dollars), corresponding to 17.8 % of the total assets of the firms. Debt issues amounted on average to 1.6 billion French Francs, corresponding to 24% of the total assets. Equity issues amounted on average to .19 billion French Francs, corresponding to 20 % of the total assets. Figure 1, Panel A, plots issue size as a fraction of total assets (in 1995) for the 16 firms in our sample which issued equity in 1996. The corresponding plot for firms which raised debt is in Panel B.

The ratio of total debt to total assets was similar for firms issuing equity and for firms issuing convertible bonds (around 57 %). This ratio was lower for firms issuing debt (48%). Also the ratio of tangible assets to total assets is larger for firms issuing debt (24.8 %) than for firms issuing equity (14.7 %) or convertible bonds (16 %). This is consistent with the view that firms which are highly levered or which have low tangible assets ratio are exposed to a larger financial distress risk.

4 Econometric model

4.1 Parameter and variables

We assume that the firms differ with respect to their cost of effort, their cost of financial distress, their financing need, their effective tax rate (reflecting non–debt tax shields), their interest rate, their debt initially in place, and the expected cash flow from their investment opportunity, denoted: $e_i, c_{i,} I_i - A_i, \tau_i, k_i, d_i$, and $E_{f_i}(R)$, respectively, where i is the index of the firm. Otherwise firms are similar. While the agents in the theoretical model (i.e., the manager and the outside

[15] This is similar to Dichev and Piotrovski, 1998.

[16] Note that corporate bond issues by non financial firms are very rare in France, and most of these debt issues corresponded to bank loans.

investor) are assumed to know $e_i, c_{i,} J_i, \tau_i, k_i, d_i, X_i$, and $E_{f_i}(R)$, the econometrician does not observe these directly.

To conduct the econometric analysis, we assume that $c_{i,}\tau_i, k_i, d_i$, and $E_{f_i}(R)$ are functions of observable, predetermined. Financial distress costs are likely to be larger for firms with a large fraction of intangible assets. We assume there exists two constants α_C and β_C such that:

$$c_i = \exp(-[\alpha_C + \beta_C G_i]),$$

where G_i is the ratio of tangible assets to total assets in 1995. For positive values of α_C and β_C, this specification ensures that while the cost of financial distress is always between 0 and 1, it is decreasing in the ratio of tangible assets to total assets. Further we assume that the tax rate for firm i is:

$$\tau_i = \exp(-[\alpha_t + \beta_t \frac{depreciation}{total.assets}]),$$

where total assets as well as depreciation are observed in 1995. We also assume that the interest rate is*:*

$$k_i = \frac{S_i}{debt},$$

where S_i is interest expenses for firm i in 1995 and $debt$ is its debt in 1995. Assets in place are our normalizing variable and in the econometric analysis will be set to one. Debt in place is assumed to be:

$$d_i = \frac{debt}{total.assets}.$$

Finally the upper bound of the distribution of cash–flow is:

$$T_i = \sum_{s=1}^{S} t_s 1(i \in s),$$

where $1(i \in s)$ is the indicator that firm i is in industry s.

Denote $J_i = I_i - A_i$ the outside financing need of firm i. Consistent with the above normalizations, in the econometric analysis, we normalize the observed amounts raised by firms by dividing them by the total assets of the issuing firms. For those firms which do issue debt, convertible debt or equity, we observe the (normalized) value of J_i. For the other firms, J_i is not directly observed. We assume all the outside financing needs are independently drawn from the same distribution with positive support and density and c.d.f. denoted $n(.)$ and $N(.)$ respectively. In the econometric analysis we will use this identifying assumption to back up estimates of the latent outside financing needs of the firms who have not raised funds.

We do not observe the costs of effort. We assume they are independent draws of distributions with positive support with density and c.d.f. denoted $m_i(.)$ and $M_i(.)$ respectively. The distributions of the costs of efforts e_i can vary across individuals only as a function of the predetermined observed variables. The parametric forms we use in our maximum likelihood estimation for the distribution of the cost of effort and the distribution of the outside financing need are presented in Appendix 2.

Denote θ the vector of deep parameters to be estimated. It includes: The parameters of the distributions of J and e. The moral hazard parameter: p. The parameters characterizing the financial distress costs: α_C, β_C, the effective tax rate: α_T, β_T, and the cash flow from the project: $t_s, s = 1, 2, 3, 4,$.

4.2 Likelihood

Denote: $u_l = U_l - e, l = E, C, D$. Note that u_l does not depend on e. Denote I_E the set of firms which issued equity, I_{CD} the set of firms which issued convertible debt, I_D the set of firms which issued debt, I_R is the set of firms which did not issue any claims. The likelihood of the observations is:

$$\mathcal{L} = \mathcal{L}_E \mathcal{L}_D \mathcal{L}_C \mathcal{L}_R,$$

where $\mathcal{L}_E$ is the likelihood of the firms which issued equity:

$$\mathcal{L}_E = \Pi_{i \in I_E} \{[M(\min[e_E, e_C]) - M(e_D)]^+ 1(u_E - u_C > 0)$$

$$+[M(\min[e_E, e_D]) - M(e_C)]^+ 1(u_E - u_D > 0)$$

$$+M(\min[e_E, e_C, e_D]) 1(u_E > \max[u_C, u_D])$$

$$+[M(e_E) - M(\max[e_C, e_D])]^+\} n(J_i),$$

while $\mathcal{L}_C$ is the likelihood of the firms which issued convertible debt:

$$\mathcal{L}_C = \Pi_{i \in I_C}\{[M(\min[e_E, e_C]) - M(e_D)]^+ 1(u_C - u_E > 0)$$

$$+[M(\min[e_C, e_D]) - M(e_E)]^+ 1(u_C - u_D > 0)$$

$$+M(\min[e_E, e_C, e_D])1(u_C > \max[u_E, u_D])$$

$$+[M(e_C) - M(\max[e_E, e_D])]^+\}n(J_i),$$

$\mathcal{L}_D$ is the likelihood of the firms which issued straight debt:

$$\mathcal{L}_D = \Pi_{i \in I_D}\{[M(\min[e_D, e_C]) - M(e_E)]^+ 1(u_D - u_C > 0)$$

$$+[M(\min[e_D, e_E]) - M(e_C)]^+ 1(u_D - u_E > 0)$$

$$+M(\min[e_E, e_C, e_D])1(u_D > \max[u_E, u_C])$$

$$+[M(e_D) - M(\max[e_C, e_E])]^+\}n(J_i),$$

and $\mathcal{L}_R$ is the likelihood of the firms which were rationed and issued no claim:

$$\mathcal{L}_R = \Pi_{i \in I_R}\{\int_0^{J_{\text{sup}}} [1 - M(Max[e_D(z), e_{CD}(z), e_E(z)])]n(z)dz\},$$

where J_{sup} is the upper bound of the support of J.

To conduct the numerical maximization of the loglikelihood we used genetic algorithms.[17] We set the population size, i.e., the number of candidate parameter values in one generation, to 50. We set the total number of trials to 8000. The crossover rate (which characterizes the way in which the characteristics of the individuals in the population are mixed from one iteration to the other) was set to 0.6, while the mutation rate, i.e., the probability that each individual in one generation is affected by a random mutation, was set to 0.1. The ranges of the parameter values we considered while conducting the numerical optimization are in Table 3.

[17] The package we used is GENESIS Version 5.0.

5 Econometric results

In this preliminary version of the paper, we report results obtained relying only on the firms which issued equity or debt and on the firms which did not raise funds, i.e., we have not yet included convertible debt issues. We will do so in a further draft.

The estimates of the deep parameters of the model are in Table 4. They can be interpreted in relation with the driving forces of our theoretical model: agency costs, financial distress costs, and taxes.

- *Agency costs:* The estimates are such that the fraction of the expected cash–flow from the project which is lost if the manager shirks

  $$\frac{E_f(R) - E_g(R)}{E_f(R)} = \frac{1-p}{1+p},$$

  is equal to 43%. Hence, according to our estimates, managerial effort has quite a large impact on profits. Another way to quantify the agency cost is to consider the ratio of the average cost of effort to the expected cash flow from the project:

  $$\frac{E(e)}{E_f(R)}.$$

  Our estimates imply that this ratio is equal to 40.26%. Hence we find rather large agency costs.

- *Financial distress:* Our estimates imply that the average cost of financial distress c amounts to 41.2%. This is rather large. A recent paper by Andrade and Kaplan (1998) offers estimates based on an in depth analysis of LBO cases. Their estimate is of the order of magnitude of 20%. They note that their sample of LBO's is likely to include firms with lower than average financial distress costs, and which consequentlly chose to increase their leverage significantly. Our estimates also imply that, for the 75 firms in or sample which raised debt the probability of financial distress after the issue:

  $$\Pr(R < D + d - X)$$

  is approximately equal to 2.1%.

- *Effective tax rates*: Our estimates imply that the effective tax rate, prevailing after firms have used all ther non debt tax shields, is not significantly different from 0. This suggests rejecting the theory of leverage based on tax shields.

A graphic illustration of our results is presented in Figure 2. Panel A plots, for all the firms which raised funds in our sample, the estimated values of their threshold costs of effort associated with debt (e_D) and with equity (e_E), against the outside financing need (J) of these firms. This figure illustrates that the threshold cost of effort is larger for debt than for equity. This is because debt provides stronger incentives to exert effort than equity does. In spite of this, equity is sometimes chosen by the manager, when their cost of effort is sufficiently low, to avoid financial distress costs. Panel B presents the cumulative density function of the cost of effort: $M(e)$, for our estimate of λ_J and taking as upper bound of e the value above which effort ceases to be optimal:

$$E_f(R) - E_g(R) = \frac{1-p}{1+p}E(\frac{T}{2}).$$

Finaly, Panel C presents the c.d.f of the (normalized) outside financing need: $N(J)$.

What is the robustness of our results ? The estimate of agency costs seems to be rather robust. Figure 3 plots the loglikelihood of the observations, keeping all parameters in θ constant, except p, which varies from 0 to 1. The figure shows that the loglikelihood is well behaved and exhibits a clear extremum around $p = .396$. In a earlier draft of this paper (Biais, Bisière and Décamps, 1998), relying on a somewhat different theoretical model and data–set, we had obtained estimates of the agency costs with the same order of magnitude.[18] Also, as the numerical maximization algorithm we used progressed, it kept generating estimates of p close to $.4$.

Our finding that effective tax rates are not significantly different from 0 is also a pervasive feature of the outputs generated by our numerical maximization procedure at its different steps.

On the other hand, there seems to be some instability in our estimates of the financial distress costs. In the above mentioned previous version of this paper (Biais, Bisière and Décamps, 1998) we had obtained estimates of the order of magnitude of 20%, which is quite lower than our present estimate. In addition, as the numerical maximization algorithm we used to generate the present estimate

[18]The previous draft relied on a more stylized theoretical model, which did not allow for assets in place, prior leverage, or taxes. Also it used a coarser data set. In particular the econometric analysis did not integrate information about leverage, industry, taxes, etc...

progressed, and before it reached the optimum reported in Table 4, it sometimes generated values such that the financial distress costs were much above or below 40%.

6 Conclusion

This paper presents a structural econometrics analysis of an agency theoretic model of financing choices and estimates it on a data set of 370 French firms in 1996. We find that agency costs and costs of financial distress are rather large, while the search for tax shields does not seem to influence financial choices.

By offering estimates of optimal financing choices and agency costs, we take a first step towards using asymmetric information theory to generate quantitative rather than simply qualitative insights into corporate finance decision making. This speaks to the issue raised by Leland (1998) in his presidential address: "The theories fail to offer quantitative advice as to the amount of debt a firm should issue in different environments."[19] Furthermore, our structural econometric approach of the *joint* investment and financing decision provides a bridge between the empirical works studying the impact of financial constraints on investment (in which financial structure variables are on the right–hand–side of the regression, see e.g. Gilchrist and Himmelberg, 1995), and those analyzing the determinants of financial structure (in which financial decisions are on the left–hand–side, see e.g., Barclay, Smith and Watts, 1995).

[19]Obviously, Leland's (1998) own answer predates ours. Still, the trade–off underlined in the theoretical analysis of Leland (1998), between the tax benefits of debt and its risk–shfting agency costs, differs from the trade–off studied in the present paper. Furthermore, while Leland (1998) relies on numerical simulations to implement his analysis, we offer a structural econometrics approach.

Appendix 1:Cost of effort threshold and managerial utility in our simple parametrization of the distribution of the cash–flow.

Under our simple parametrization, after tedious but straightforward computations, we obtain that the functions $\hat{\varphi}$, φ, ψ and $\hat{\psi}$ characterizing incentive compatibility and individual rationality for debt and convertible bonds are as follows:

$$\hat{\varphi}(D) = [\frac{T}{2}\frac{1-p}{1+p} + \frac{1}{2T}(Max[(D+d)\sigma - X, 0]^2 - (\frac{Max[(D+d)\sigma - X, 0]}{T})^{p+1}\frac{2T^2}{p+1})](1-\tau),$$

where: $\sigma = \frac{1-k\tau}{1-\tau}$,

$$\varphi(D) = -\frac{1-c}{2T}(X-d)^2 + D(1+\frac{X-d}{T}) - \frac{1+c}{2T}D^2,$$

$$\begin{aligned}\hat{\psi}(D,\gamma) &= \hat{\varphi}(D) - D\frac{k\tau}{1-\tau}(\frac{h(\gamma)^p}{T^p} - \frac{h(\gamma)}{T}) \\ &\quad -\frac{\gamma T}{2}[\frac{1-p}{1+p} + \frac{1}{T^2}(h(\gamma)^2 - \frac{2}{p+1}(\frac{h(\gamma)}{T})^{p+1})],\end{aligned}$$

where:

$$h(\gamma) = Min[Max[\sigma d + \frac{D}{\gamma(1-\tau)} - X, 0], T],$$

and:

$$\psi(D,\gamma) = \varphi(D) + \frac{\gamma(1-\tau)}{2T}(Min[Max[\sigma d + \frac{D}{\gamma(1-\tau)} - X, 0], T])^2,$$

while the effort thresholds are:

$$e_E(J) = \frac{(1-\tau)(\frac{T}{2} + X - \sigma d) - J}{1 + \frac{\frac{p}{p+1}T + X - \sigma d}{\frac{1-p}{p+1}\frac{T}{2}}},$$

$$e_D(J) = \hat{\varphi}(\varphi^{-1}(J)),$$

where:

$$\varphi^{-1}(J) = \frac{1 + \frac{X-d}{T} - \sqrt{\Delta(J)}}{\frac{1+c}{T}},$$

and:

$$\Delta(J) = (1 + \frac{X-d}{T})^2 - 2\frac{1+c}{T}[\frac{1-c}{2T}(X-d)^2 + J],$$

and finally:

$$e_C(J) = Max_D[\hat{\psi}(D, \psi_\gamma^{-1}(D, J + F_C))],$$

where:

$\psi_\gamma^{-1}(D,J) = \frac{D}{(T+X-\sigma d)(1-\tau)}$
$+\frac{T}{(1-\tau)(\sigma d - X - T)^2}\sqrt{J + F_C - \varphi(D)}$
$[\sqrt{J + F_C - \varphi(D)} + \sqrt{J + F_C - \varphi(D) - \frac{2D}{T}(\sigma d - X - T)}]$.

Furthermore, in this parametrization, managerial expected utility under the different financing schemes is as follows:

$$U_E = (\frac{T}{2} + X - \sigma d)(1-\tau) - J - e.$$

$$\begin{aligned} U_D &= \frac{T}{2} + X - d - J - e - \frac{c}{2T}(\varphi^{-1}(J)^2 - (X-d)^2) \\ &- \frac{\tau}{T}[\frac{T^2}{2} + \frac{X^2}{2} - \frac{\sigma^2(d+\varphi^{-1}(J))^2}{2} + XT - k(\varphi^{-1}(J)+d)(T + X - \sigma(d + \varphi^{-1}(J)))]. \end{aligned}$$

$$\begin{aligned} U_C &= Max_D[\frac{T}{2} + X - d - J - e - \frac{c}{2T}(D^2 - (X-d)^2) \\ &- \frac{\tau}{T}[\frac{T^2}{2} + \frac{X^2}{2} - \frac{\sigma^2(d+D)^2}{2} + XT] \\ &+ \frac{\tau}{T}[kd(T - \sigma(D+d) + X) + kD^2(\frac{1}{\psi_\gamma^{-1}(D, J+F_C)(1-\tau)} - \sigma)]], \end{aligned}$$

s.t.,

$$e < \hat{\psi}(D, \psi_\gamma^{-1}(D, J + F_C)).$$

Appendix 2: Parametrization of the distributions of the cost of effort and the outside financing need.

Distribution of the outside financing need:

We assume that the support of the distribution of J_i is: $[0,1]$.We assume that the density of J_i over this interval is:

$$n(J_i) = k_J \exp(\lambda_J J_i).$$

For $\lambda_J = 0$, this is the uniform distribution, and $k_J = 1$. Else,

$$k_J = \frac{\lambda_J}{\exp(\lambda_J) - 1}.$$

Note that $n(J_i)$ is increasing in J_i iff $\lambda_J > 0$.

Distribution of the cost of effort:

Positive NPV for all projects (provided effort is exerted) implies: $\frac{T_i}{2} - e_i > I_i$, that is: $e_i < \frac{T_i}{2} - I_i$. Since $\forall i, J_i < I_i$, this implies that: $e_i < \frac{T_i}{2} - J_i$, which we impose. Furthermore, social efficiency of effort, which we assume, imposes that: $\forall i, e_i < \frac{1-p}{1+p}\frac{T_i}{2}$.

Hence, we assume that the support of the cost of effort for firm i is:

$$[e_{\inf_i}, e_{\sup_i}] = [0, Min(\frac{T}{2} - J_i, \frac{1-p}{1+p}\frac{T_i}{2})].$$

We assume that the density of e_i over this interval is:

$$m(e_i) = k_{i,e} \exp(\lambda_e e_i).$$

For $\lambda_e = 0$, this is the uniform distribution, and

$$k_{i,e} = \frac{1}{e_{\sup_i} - e_{\inf_i}}.$$

Else,

$$k_{i,e} = \frac{\lambda_e}{\exp(\lambda_e e_{\sup_i}) - \exp(\lambda_e e_{\inf_i})}.$$

Note that $m(e_i)$ is increasing in e_i iff $\lambda_e > 0$.

The cdf of e_i is:

$$M(e_i) = \frac{\exp(\lambda_e e_i) - 1}{\exp(\lambda_e e_{i\,\sup_i}) - 1}.$$

Bibliography

Andrade, G. and S. Kaplan, 1998, How costly is financial (not economic) distress ? Evidence from highly leveraged transactions that became distressed, Journal of Finance, October 1998, 1443–1494.

Barclay, M., C. Smith, and R. Watts, 1995, The determinants of corporate leverage and dividend policies, Journal of Applied Corporate Finance, 4–19.

Biais, B., and C. Casamatta, 1998, Optimal leverage and aggregate investment, forthcoming *Journal of Finance*.

Biais, B., C. Bisière, and J.P. Décamps, 1998, Financing corporate investment with equity, debt, and convertile bonds, Working paper, Toulouse University.

Brealey, R. and S. Myers, 1991, Principles of Corporate Finance, Mac Graw Hill.

Chevalier, J.A., 1995, Do LBO supermarkets charge more ? An empirical analysis of the effects of LBO's on supermarket pricing, Journal of Finance, 1095–1112.

Décamps, J.P. and A. Faure–Grimaud, 1998, Pricing the gambling for resurrection and the consequences of renegotiation and debt design, Working paper, Toulouse University.

Gajewski, J.F., and Ginglinger, E., The information content of equity issues in France, working paper, University of Paris Val de Marne.

Gilchrist, S., and C. Himmelberg, 1995, Evidence on the role of cash flow for investment, Journal of Monetary Economics, 541–572.

Green, R., 1984, Investment incentives, debt and warrants, Journal of Financial Economics, 115–136.

Greenwald, B., 1992, MCI Communications Corporation (1983), Teaching Note, Harvard Business School.

Greenwald, B., 1986, MCI Communications Corporation (1983), Teaching Note, Harvard Business School.

Greenwald, B., 1988, MCI Communications Corporation (1983), Case Study, Harvard Business School.

Harris, M. and A. Raviv, 1985, A sequential signalling model of convertible debt policy, Journal of Finance, 815–830.

Heinkel, R., and J. Zechner, 1993, Financial distress and optimal capital structure adjustments, Journal of Economics and Management Strategy, 4, 531–565.

Holmstrom, B. and J. Tirole, 1997, Financial intermediation, loanable funds and the real sector, Quarterly Journal of Economics.

Innes, R., 1990, Limited liability and incentive contracting with ex–ante action choices, Journal of Economic Theory, 45–67.

Jensen, M., and Meckling, W., 1976, Journal of Financial Economics, Theory of the firm: managerial behaviour, aency costs, and capital structure, 3, 305–360.

Jung, K., Y. Kim, and R. Stulz, 1996, Journal of Financial Economics, Timing, investment opportunities, managerial discretion and the security issue decision, 159–185.

Leland, H., and D. Pyle, 1977, Informational asymmetries, financial structure and financial intermediation, Journal of Finance, 317–387.

Leland, H., Agency costs, risk management, and capital structure, 1998, Journal of Finance.

Lewis, C., Rogalski, R., and Seward, J., 1998, Agency problems, information asymmetries, and convertible debt security design, Journal of Financial Intermediation, 32–59.

Mackie–Mason, J., 1990, Do taxes affect corporate financing decisions ?, Journal of Finance, 1471–1494.

Modigliani, F., and M. Miller, 1958, The cost of capital, corporation finance, and the theory of investment, American Economic Review, 261–297.

Modigliani, F., and M. Miller, 1963, Corporate income taxes and the cost of capital: a correction, American Economic Review, 433–443.

Myers, S., 1977, Determinants of corporate borrowing, Journal of Financial Economics, 147–175.

Myers, S. and N. Majluf, Corporate financing and investment decisions when firms have information that investors do not have, Journal of Financial Economics, 187–221.

Ross, S., 1977, The determination of financial structure: the incentive signalling approach, Bell Journal of Economics, 23–40.

Shyam–Sunder, L. and S. Myers, 1999, Testing static tradeoff against pecking order models of capital structure, Journal of Financial Economics, 219–244.

Stein, J., 1992, Convertible bonds as backdoor equity financing, Journal of Financial Economics, 3–21.

Titman, S., and R. Wessels, 1988, The determinants of capital structure choice, Journal of Finance, 1–19.

Table 1:
Summary statistics on size, leverage and tangible assets in 1995 for the 379 firms in our data set. Amounts are in millions of French Francs.

Variable	N	Mean	Std Dev	Minimum	Maximum
All firms					
Total assets	379	11154.52	35074.04	15.23700	290599.00
debt/assets	379	0.5196524	0.2073228	0.00232	0.965383
tangible/assets	379	0.2263907	0.1800641	0.000564	0.9854510
Finance and real estate					
Total assets	36	3257.99	7010.80	15.237	38090.20
debt/assets	36	0.277872	0.3168160	0.00232	0.965383
tangible/assets	36	0.3585852	0.3436250	0.00056	0.90918
manufacturing					
total assets	215	14537.79	40760.32	50.7260	255675
debt/assets	215	0.53224	0.18115	0.0068	0.965
tangible/assets	215	0.217	0.1159	0.0011	0.666
services					
total assets	96	8249.70	31658.07	23.22	290599
debt/assets	96	0.56168	0.1595	0.093	0.87433
tangible/assets	96	0.239	0.204	0.005	0.985
High tech					
total assets	33	6176.79	15242.77	49.8820	60186.00
debt/assets	33	0.5790985	0.168764	0.15355	0.8416915
tangible/assets	33	0.1023383	0.0668731	0.017	0.2943401

Table 2:
Summary statistics on outside financing for the 379 firms in our sample (amounts are in millions of French Francs)

Variable	N	Mean	Std Dev	Minimum	Maximum
Total assets	379	11154.52	35074.04	15.23700	290599.00
debt/assets	379	0.5196524	0.2073228	0.00232	0.965383
tangible/assets	379	0.2263907	0.1800641	0.000564	0.9854510
no issue					
total assets	279	10934.49	33062.53	31.4130	255675.00
debt/assets	279	0.5249441	0.2132213	0.0023	0.965383
tangible/assets	279	0.2236136	0.1676078	0.000684	0.8921527
equity issue					
issue size	16	192.6847500	221.390	9.7550	31.7130
total assets	16	2476.56	4417.04	89.0100	14244.70
debt/assets	16	0.5793020	0.13512	0.3632	0.7688
issue/assets	16	0.2023289	0.1940427	0.0425	0.80209
tangible/assets	16	0.1469748	0.1137562	0.0127	0.3668
convertible issue					
issue size	9	1311.80	1510.47	36.69	4221.00
total assets	9	33975.50	75267.33	207.115	231812.00
debt/assets	9	0.5772443	0.2178464	0.2456	0.8324885
issue/assets	9	0.1783167	0.1818973	0.0148	0.4549453
tangible/assets	9	0.1605648	0.1477376	0.0005	0.3914218
debt issue					
isssue size	75	1630.52	4859.76	3.6230	32985.00
total assets	75	11088.77	38509.02	15.2370	290599.00
debt/assets	75	0.4802608	0.1924821	0.0257	0.8457512
issue/assets	75	0.2479311	0.1904441	0.1006	0.9535835
tangible/asssets	75	0.2615993	0.2279999	0.0048	0.9854510

Table 3:
Parameter ranges used in the numerical maximization algorithm.

parameter	Min	Max
α_c	0	10
β_c	0	10
α_t	3.32	50
β_t	0	50
λ_e	-50.0	20.0
λ_J	-20.0	0
t_1	1.0	5.0
t_2	1.0	5.0
t_3	1.0	5.0
t_4	1.0	5.0
p	0	1

Table 4:
Estimates of the deep parameters of the model.

Parameter	Estimate
α_C	0.787
β_C	0.450
α_t	22.103
β_t	45.644
t_1	3.688
t_2	3.756
t_3	3.559
t_4	4.060
p	0,396
λ_e	18.221
λ_J	-0.003
Log–likelihood	-468.21

Figure 1, Panel A:
Issue size, as a fraction of total assets in 1995, for the 16 firms in our sample which issued equity in 1996.

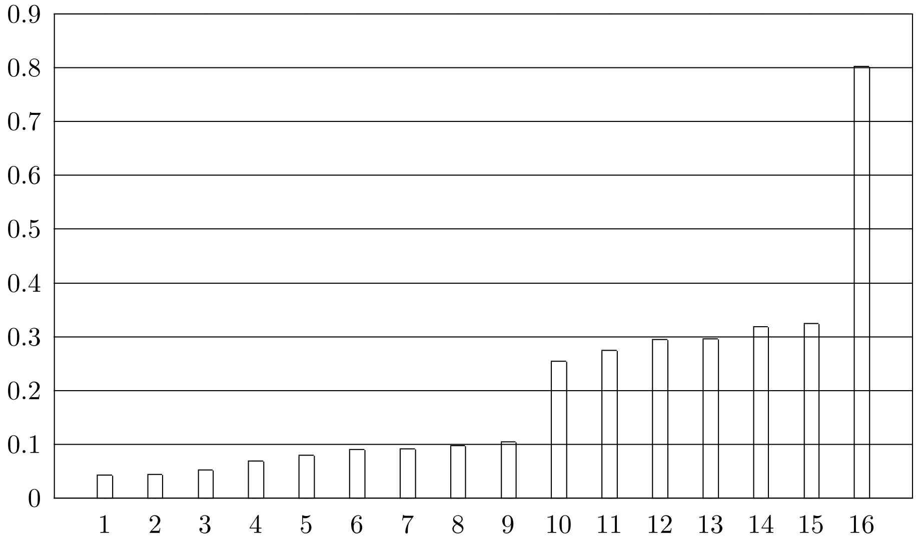

Figure 1, Panel B:
Issue size, as a fraction of total assets in 1995, for the 75 firms in our sample which raised debt in 1996.

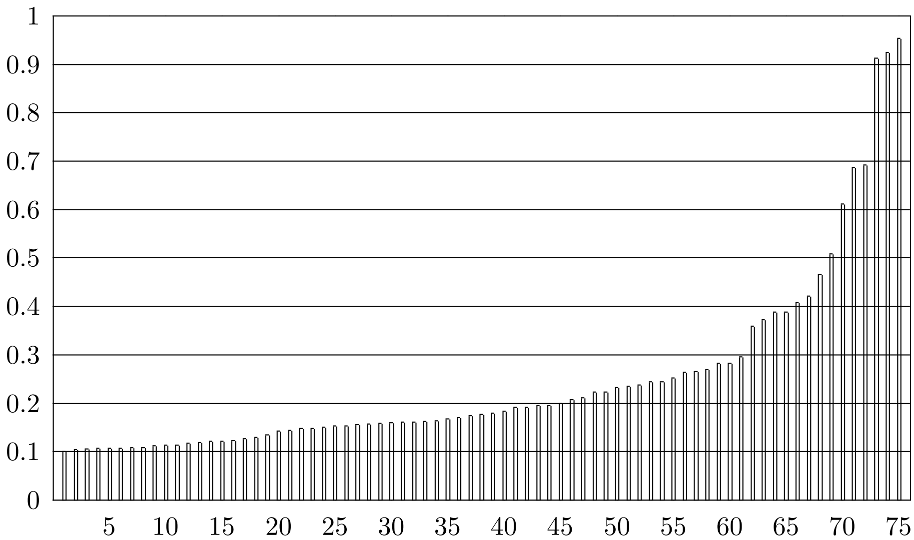

Figure 2, Panel A:
Threshold cost of effort for debt (e_D, depicted by empty circles) and equity (e_E, depicted by solid circles), as a function of outside financing need (J), for the 91 firms which issued debt or equity.

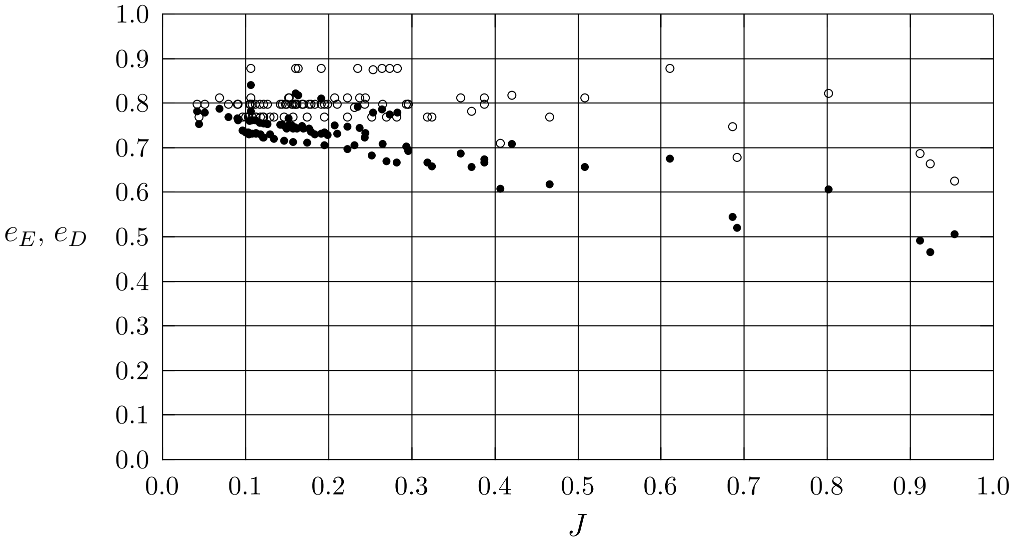

Figure 2, Panel B:
cdf of the cost of effort for the estimated value of λ_e.

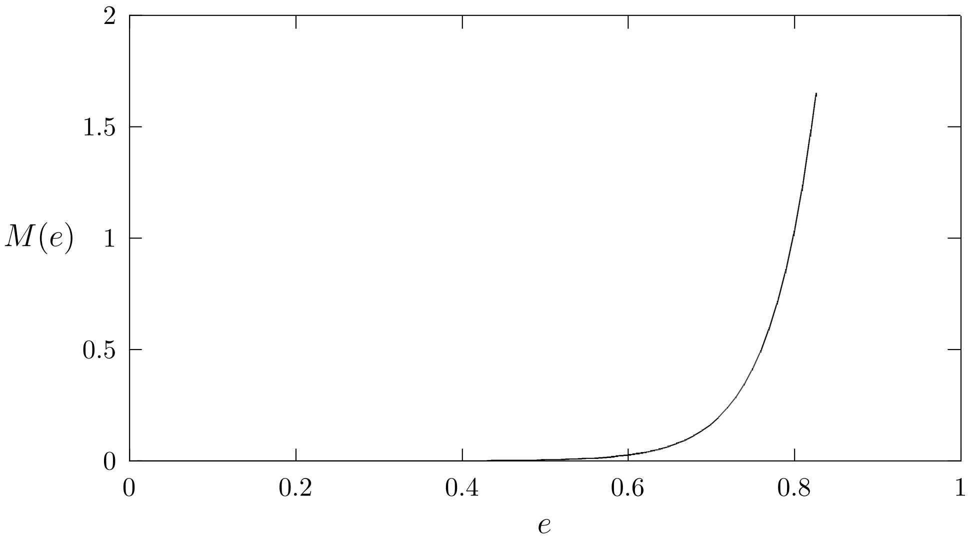

Figure 2, Panel C:
cdf of the outside financing need, for the estimated value of λ_J.

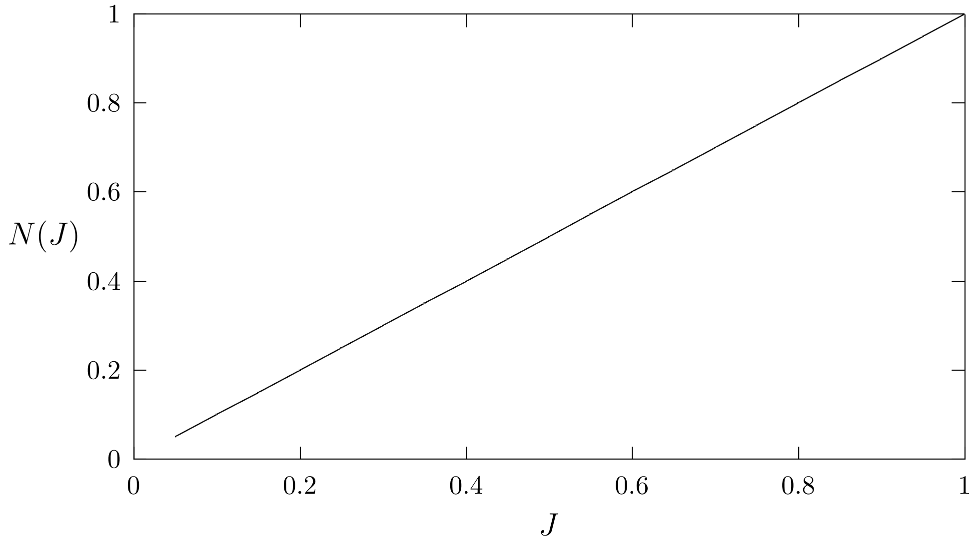

Figure 3:
Loglikelihood of the data, keeping all the parameters fixed at their optimal value, except p, which varies from 0 to 1.