Why Does Capital Structure Choice Vary With Macroeconomic Conditions?

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Abstract

This paper develops a calibrated model that explains the pronounced counter-cyclical leverage patterns observed for firms that access public capital markets, and relates these patters to debt and equity issues. Moreover, it explains why leverage and debt issues do not exhibit this pronounced behavior for firms that face more severe constraints when accessing capital markets. In the model, managers issue a combination of debt and equity to finance investment by weighing the trade-off between agency problems and risk sharing. During contractions, leveraged managers receive a relatively small share of wealth, resulting in a relative increase in household demand for securities. Securities markets clear as managers that are not up against their borrowing constraints increase leverage while satisfying the agency condition that they maintain a large enough portion of their firm's equity.

Whether measured in levels or flows, there is substantial time variation in the debt-equity financing choice that differs with the degree of capital market access. In general, firms that exhibit low degrees of financial constraints have pronounced counter-cyclical leverage with much of the variation attributed to varying macroeconomic conditions. It is also well documented that debt issues are counter-cyclical and equity issues are pro-cyclical for firms that access public capital markets. Meanwhile, firms that exhibit higher degrees of financial constraints do not exhibit these pronounced counter-cyclical leverage or debt issue patterns.[1] These observations suggest that financing choices vary systematically with macroeconomic conditions, and this response differs with the degree of capital market access. It is natural to ask why such patterns are observed, and what are their implications for investment and growth. In this paper, a model is developed where the fundamental reasons for these patterns are agency problems whose severity is determined by the distribution of aggregate wealth, which varies endogenously over the cycle. The model predicts that target debt ratios will be relatively high when corporate profits are low or following poor performance in the equity market for firms that are not constrained from increasing leverage. For reasonable parameter values, managers adjust their capital structure and issue securities in patterns similar to those observed in the data.

The link between access to capital markets, investment and the macroeconomy has traditionally

[1] Specifically, Choe, Masulis and Nanda (1993) document that seasoned primary equity issues are pro-cyclical and debt issues are counter-cyclical. Korajczyk, Lucas and McDonald (1990) document that equity issues are positively related with equity market performance. Gertler and Gilchrist (1993) document that debt (public and private) increases for large firms but remains flat for small firms following recessions associated with a monetary contraction. Gertler and Gilchrist (1994) document that net short term debt issues are flatter over the business cycle for small firms. After correcting for time-variation in firm characteristics, Korajczyk and Levy (2000) document that: (1) macroeconomic conditions account for a substantial portion of the observed counter-cyclical leverage patterns for firms that they classify as financially unconstrained, (2) their constrained sample does not exhibit counter-cyclical leverage patterns, (3) deviations from estimated target leverage is economically and statistically significant in explaining time series variations in issue choice for both samples.

been analyzed in the credit channel literature.[2] This literature generally focuses on firms that rely on debt financing and face severe agency problems in accessing external capital.[3] It explains how agency problems in accessing external capital at the firm level result in exaggerated swings in economic activity as feedback effects propagate and magnify aggregate shocks. This is consistent with evidence in Kashyap, Stein and Wilcox (1993) (hereinafter KSW), Gertler and Gilchrist (1993), (1994) and Bernanke, Gertler and Gilchrist (1996) (hereinafter BGG) who relate debt issue patterns of firms that have deferential capital market access, using size or bank-dependence as proxies, with aggregate and cohort investment following Federal Reserve monetary contractions or at the onset of recessions.[4] Theoretically, this paper adds to the credit cycle literature by simultaneously considering how differential access to capital markets and investment across firms interacts with the choice of financing (capital structure) and the macroeconomy.

The link between security issues and macroeconomic conditions has been analyzed in several empirical and theoretical studies.[5] In general, these studies are motivated in a Myers and Majluf

[2]See for example Bernanke and Gertler (1989), Bernanke, Gertler and Gilchrist (1998), Carlstrom and Fuerst (1997), Cooley and Quadrini (1999), Fisher (1998), Greenwald and Stiglitz (1993) and Kiyotaki and Moore (1997). For a review and a distinction between the different channels see Bernanke and Gertler (1995). For a review of the literature which addresses the relation between financial structure and aggregate activity see Gertler (1988).

[3]In the case of Bernanke, Gertler and Gilchrist (1998) and Biais and Casamatta (1999) both debt and outside equity is issued. However, equity risk can be completely diversified since there is no aggregate uncertainty. In Bernanke, Gertler and Gilchrist (1998) dynamics are achieved by considering an unexpected perturbation from the steady state. The focus of the macroeconomic analysis in Biais and Casamatta (1999) is on the relation between capital structure and exogenous shocks to the severity of agency problems. Cooley and Quadrini (1998), (1999) do consider heterogeneous firms that issue both debt and risky equity. However, the model imposes restrictions on the types and timing of security issues. Furthermore, their model has a different set of predictions regarding the effects of productivity shocks on capital structure across firms.

[4]Specifically, KSW provide evidence supporting the view that capital market imperfections result in inefficient reductions in investments following a Federal Reserve monetary tightening. BGG also relate the shift in inventory investment away from small (or bank-dependent) firms following a Federal Reserve monetary tightening with the asymmetry in access to capital markets across firms. This is consistent with Chirinko and Schaller(1995), Fazzari, Hubbard and Peterson(1988), Gilchrist and Himmelberg(1995), Hubbard, Kashyap and Whited(1995) and Whited(1992), who present firm level evidence suggesting that cash flows, and therefore access to capital markets, affect investment decisions.

[5]As discussed in Korajczyk and Levy (2000), the arguments used to explain cross-sectional variation in capital

(1984) setting where privately informed managers have current equity owners interest in mind and avoid issuing equity when they believe their shares are underpriced. This adverse selection results in an equity issue announcement conveying unfavorable news about the firm's prospects, resulting in a negative price reaction.[6] Lucas and McDonald (1990) extend Myers and Majluf's (1984) theory to a dynamic setting where managers, with private information about their company's value, cannot issue debt and delay equity issues until their stock price rises to or above its true value. Since market prices are correlated across firms, equity issues cluster around market peaks. Choe, Masulis and Nanda (1993) argue that adverse selection costs vary counter-cyclically to explain the general increase in equity issues during expansions. Bayless and Chaplinsky (1996) argue that "windows of opportunity" in which capital can be raised at favorable terms result in observed periods of extreme equity issue volume (or "hot" equity markets) as firms time their equity issues. Both Choe, Masulis and Nanda (1993) and Bayless and Chaplinsky (1996) show that, in general, the price reaction to equity issue announcements is less negative during these periods. Although these papers are helpful in describing some of the regularities in the data, they are not complete. For example, during both expansions of the 1970s, the equity market preformed poorly and the average price drop upon an equity issue announcement was relatively large, yet equity issues as a fraction of total external financing was relatively high.[7] Moreover, Korajczyk and Levy (2000) document that after correcting

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structure, such as variations in debt tax shields, deadweight bankruptcy costs, the debt overhand problem (Myers (1977)), or the risk shifting problem (Jensen and Meckling (1976)), have a difficult time explaining the observed counter-cyclical variation in leverage for firms that do not face severe capital constraints. During contractions profits are low, resulting in lower debt tax shields and higher expected bankruptcy costs, both of which reduce the benefits of debt. Moreover, debt overhand and risk shifting problems are generally associated with firms that are close to their debt capacity, suggesting that these problems are not binding.

[6]To explain the negative price reaction to equity issue announcements observed in the data, Jensen (1986) uses a moral hazard argument, as apposed to adverse selection, where managers indulge themselves when they are not forced to make debt interest payments.

[7]Bayless and Chaplinsky (1996) document that the average price reaction to an equity issue announcement was

for the run-up in the equity market and the variation in the expected price reaction to an equity issue announcement, deviations from target leverage ratios that vary with macroeconomic conditions account for a significant amount of the variation in issue choice.[8] Theoretically, this paper adds to this literature by linking variations in financing choices with macroeconomic conditions using arguments that do not rely on the variation in the price reaction to equity issues in a setting where managers, that face various degrees of financial constraints, can issue either equity or debt securities.

As discussed in Zwiebel (1996), the notion that agency conflicts between managers and outside owners of the firm are important determinants of capital structure, as proposed by Jensen and Meckling (1976) or Jensen (1986), is now widely accepted. Moreover, the notion that capital structure is voluntarily chosen by mangers is also recognized and discussed in Zwiebel (1996). In this spirit, I model two firm level factors that affect managers' capital structure choice, the inability to write state-contingent contracts due to agency problems and managerial risk aversion (the setting of Modigliani and Miller (1958) does not apply). Based on Levy (1999), and similar to Lacker and Weinberg (1989), a conflict between the manager and outside shareholders arises from the assumption that managers can misreport output or extract private benefits, but at a deadweight cost. Since the manager bears only a fraction of these costs, his portion of the equity must be large enough to offset the incentive to misreport. As a result, holding the manager's absolute investment in the firm fixed, increases in the fraction of the firm financed by outside debt increase the manager's

-3.6% between 1976 and 1979 and -2.0% during their classified "normal" markets. Meanwhile, Choe, Masulis and Nanda (1993) document that the dollar amount of equity issues as a fraction of the sum of equity and straight debt issues for companies listed in the NYSE, AMEX and NASDAQ was 40% between April 1975 and January 1980 and 18% for their entire sample period between January 1971 and December 1991.

[8]Korajczyk and Levy (2000) also document that the unusually high leverage during the expansion in the 1980s (see Bernanke and Blinder (1988)) was a result of variations in firm characteristics, with high growth in aggregate corporate profits and high returns on the equity market driving leverage lower.

share of the equity and mitigates the conflict. However, increased leverage increases the risk of the manager's equity, resulting in inefficient risk sharing. Moreover, a second assumed agency problem places an upper bound on leverage. Specifically, a manager may liquidate his firm or use assets to his private benefit, but at a deadweight cost. Since the manager does not own the entire firm, he bears only a fraction of these costs. It is shown that the condition ensuring a manager will not liquidate is equivalent to placing an upper bound on leverage. Resolving the tension between the manager's incentives to misreport or liquidate his firm and his desire to share risk results in a constrained-optimal capital structure.[9]

At the macroeconomic level, the fraction of wealth held by managers varies over the business cycle and is the driving force in the model. Consider a two period economy where households can only save by investing with managers that face lax leverage constraints. When managers have most of the wealth, they have no incentive to misreport since they own most of their equity. The agency problem does not bind, so perfect risk sharing can be achieved and no debt is issued. Alternatively, suppose households have most of the wealth and therefore have a high demand for securities. Since each manager must hold a large enough fraction of his firm's equity to discourage misreporting, the fraction of the firm financed by debt must be high. However, to induce managers to take such levered positions, the return households require on debt must be low enough so that the benefits of leverage to managers offset the cost of inefficient risk sharing. In equilibrium, managers hold levered equity in their firms while households hold levered equity and debt.

[9] For a review of the literate that relates these sorts of conflicts to capital structure choice see Harris and Raviv (1991), (1992) and references therein. Others have also analyzed financing choices in dynamic frameworks but have not simultaneously linked the choice of financial contracts, investment and macroeconomic conditions as this paper does (e.g. Leland (1998)).

In a multi-period setting, the relative wealth of managers and households is endogenous, since savings are carried forward from the previous period. Relative wealth is affected by the realized productivity of capital since managers hold leveraged positions in their firms. A low realization of aggregate output results in leveraged managers receiving a relatively small portion of aggregate wealth. When managers have a small proportion of aggregate wealth, they increase leverage if they are not up against their leverage constraint. Since manager compensation is positively related with corporate profits (e.g. bonuses) as well as equity performance (e.g. equity or option compensation), the model predicts that during periods of low corporate profits or poor equity performance target debt ratios will be relatively high.

In the paper I consider a stochastic, general equilibrium model with three classes of risk-averse agents: households and two classes of managers. Managers are distinguished by their stochastic constant returns to scale production technologies and the degree of their agency problems. Due to its complexity, the model must be solved numerically. The production technology and agency parameters are the key features distinguishing firms in the model. In the calibration, these features are identified using dividend-payout ratios and firm size as proxies, and are based on COMPUSTAT data and statistics reported in Holderness, Krozner and Sheehan (1999).

In simulating the calibrated model, I find that low agency cost firms have a pronounced counter-cyclical variation in leverage and outstanding debt as well as pro-cyclical variation in outstanding equity. Meanwhile, high agency cost firms exhibit no variation in leverage, but pro-cyclical variation in outstanding debt and equity. Investment and expected future growth are pro-cyclical despite independent productivity shocks. Moreover, since high agency cost firms are up against their borrowing constraints, there is an inefficient reduction in their investment relative to the aggregate during contractions.

The rest of this paper is organized as follows: Section 1 presents a two period model with a single class of managers to develop the basic intuition behind the agency problems. Section 2 solves the full, infinite horizon model and presents the calibrated parameter choices. Section 3 discusses and interprets the results from simulating the economies of Section 2. Section 4 concludes with direction for future research.

1 A Two Period Model

I begin by describing the economic environment and contracting problem in the context of a two period model. Examples are presented to illustrate how agency problems affect capital structure.

1.1 The Economic Environment

There are two periods $t \in \{0, 1\}$, a single consumption good, and two classes of agents: households and managers. Agents begin period 0 with an exogenous endowment of consumption good wealth. Households receive an additional exogenous endowment of the consumption good at the beginning of period 1. Each manager has private access to a random, inter-temporal production technology, $f(\omega, i) = \omega i$, where i is the amount of the consumption good invested at period 0 and ω is a common random variable with support $[\underline{\omega}, \overline{\omega}]$, $\underline{\omega} > 0$ (see Section 3.2 for a discussion). Let Ω denote the common period 0 information set. At period 0, each manager chooses how much to consume and how much to invest in the production technology. The manager can raise additional capital by issuing securities. Similarly, each household must choose between consumption and investing in securities.

All agents have CRRA utility, with coefficient of risk aversion α. The discount rates for the households and managers are β and βx respectively. The expected utility of a manager and a household with respective consumptions, c^m and c^h, and period 0 expectations, E_Ω, are:

$$U_m(c_0, c_1) = \frac{(c_0^m)^{1-\alpha}}{1-\alpha} + E_\Omega \beta x \frac{(c_1^m)^{1-\alpha}}{1-\alpha}; 0 < x \leq 1 \tag{1}$$

and

$$U_h(c_0, c_1) = \frac{(c_0^h)^{1-\alpha}}{1-\alpha} + E_\Omega \beta \frac{(c_1^h)^{1-\alpha}}{1-\alpha} \tag{2}$$

Assumption 1 *Managers are weakly less patient than households:* $0 < x \leq 1$

Assumption 1 is necessary in the infinite horizon setting to ensure managers do not accumulate wealth to the point where the agency problem is not binding (see footnote 20).

1.1.1 The contracting environment

It is assumed that only managers can issue securities.

Assumption 2 *Only managers can issue securities.*

However, conflicts between manager j and outside security holders (households) arise because period 1 output (ωi^j) is not contractible. Security payoffs can be functions of the total amount invested in the manager's firm (i^j), period 0 transfers from households to the manager (i_h^j) and the manager's report (if one is made) about the realization of output ($\hat{\omega} i^j$).

Assumption 3 is the basis of the conflict between outside security holders and managers.

Assumption 3 *After production output ωi^j is realized, the manager can **(A)** take an action to (mis)report output $\hat{\omega} i^j$ at the deadweight cost $(1-\psi)\times(\omega i^j - \hat{\omega} i^j)$ for $\omega \geq \hat{\omega}$, keeping $\psi \times (\omega i^j - \hat{\omega} i^j)$ in addition to his contractual payoff OR **(B)** make no report and liquidate the entire firm at a deadweight cost $(1-\psi)\omega i^j + \psi\gamma i^j$, keeping $\psi\omega i^j - \psi\gamma i^j$ for himself.*

$(1-\psi)$ should be thought of as a measure of transparency. A high $(1-\psi)$ implies a manager incurs a maximal cost (minimal benefit) to misreport/embezzle. $(1-\psi)$ can represent the cost of falsifying records, or ψ can represent the fraction of benefits a manager can attain from inappropriate use of funds. If the manager liquidates the entire firm, he runs off with $\psi\omega i^j - \psi\gamma i^j$ and outside security holders get nothing. $(1-\psi)\omega i^j + \psi\gamma i^j$ can be thought of as a liquidation cost, $\psi\gamma i^j$, in addition to the cost of reporting $\hat{\omega} = 0$, which is not on the support of ω.[10] γ should be thought of as a measure of illiquidity associated with a specialized asset. A high γ implies a manager incurs maximal cost (minimal benefit) to liquidate. γ can represent the cost of selling an illiquid asset, or $(1-\gamma)$ can represent the fraction of benefits a manger can attain from inappropriately using a specialized asset.[11]

[10] Although the notation $\psi\omega i^j - \hat{\gamma} i^j$ (where $\hat{\gamma} = \psi\gamma$) is more intuitive, $\psi\omega i^j - \psi\gamma i^j$ allows for simpler expressions in the remaining analysis.

[11] Although quite general, the functional form of the liquidation option is chosen to place an upper bound on leverage (see below). However, I expect alternative functional forms, as well as a variety of agency problems that limit borrowing, such as asset substitution or debt overhang, will result in similar leverage patterns obtained in this paper for firms that are far from their borrowing constraints. The credit channel literature (see the introduction) has recognized and explored the subtleties of alternative binding borrowing constraints.

Assumption 4 restricts managers to issuing debt and equity securities and receiving equity compensation (see Sections 2.2.3 and 3.2 for discussions).[12]

Assumption 4 *Manager j can only issue two types of securities: debt and equity. Specifically, the manager can issue debt whose payoff, b^j, is independent of the report $\hat{\omega} i^j$, as well as a share $(1-s^j)$ of equity with payoff, $(1-s^j)(\hat{\omega} i^j - b^j)$. The manager's contractual compensation is the remaining share s^j of the equity payoff, $s^j(\hat{\omega} i^j - b^j)$.*

Figure 1-1 summarizes the timing of actions and payoffs.

Figure 1-1 - Timing & Payoffs

period 0

- agents receive their endowments
- securities are issued and households transfer a total of i_h^j to manager j
- a total of i^j is invested by manager j
- consumption takes place

period 1

- agents receive their endowments
- manager j liquidates his firm **or** reports $\hat{\omega} i^j$
  - if the firm is liquidated:
    households are paid nothing,
    the manager gets $\psi \omega i^j - \psi \gamma i^j$
  - if the manager reports $\hat{\omega} i^j$:
    outside equity holders are paid $(1-s^j)(\hat{\omega} i^j - b^j)$,
    debt holders are paid b^j,
    the manager gets $s^j(\hat{\omega} i^j - b^j) + \psi \times (\omega i^j - \hat{\omega} i^j)$
- consumption takes place

Proposition 1 describes how Assumption 3 relates to capital structure choice.

[12] Given the assumed agency problems, the restriction to contracts whose payoffs are linear in the manager's output report is not necessary in a slightly different setting, such as Levy (1999) or Lacker and Weinberg (1989). A general class of agency problems that achieves similar qualitative results is discussed in Section 3.2 (also see footnote 19).

Proposition 1 *(A) Manager j always reports truthfully iff $s^j \geq \psi$. (B) When $s^j \geq \psi$ manager j never liquidates iff leverage is bounded by $\frac{(s^j-\psi)\underline{\omega}+\psi\gamma}{s^j}$: $\frac{(s^j-\psi)\underline{\omega}+\psi\gamma}{s^j} \geq \frac{b^j}{i^j}$.*

Proof. See Appendix 1 ■

Proposition 1 (A) relates the marginal cost to misreport, $(1-\psi)$, to the slope (equity share) of managerial payoffs. If the cost to misreport $(1-\psi)$ is high, managers do not have to hold much of the equity (ψ) to ensure truthful reporting. Proposition 1 (B) presents the condition that ensures managers will never liquidate and always make a report of output. The liquidation option introduces a lower bound on managers' compensation that is translated to a restriction on leverage.[13]

As shown in Proposition 2, securities that result in truth telling and no liquidation dominate securities that result in non-truth telling or liquidation.

Proposition 2 *(A) Securities that result in truth telling strictly dominate securities that result in false reports. (B) Securities that result in no liquidation strictly dominate securities that result in liquidation if for every state $\breve{\omega} > \underline{\omega}$ the price-density of a contingent unit claim in state ω, $\hat{p}_\omega$, satisfies either (i) $\int_{\breve{\omega}}^{\overline{\omega}} \hat{p}_\omega \partial\omega - \breve{\omega}\hat{p}_{\breve{\omega}} \leq 0$ OR (ii) $\frac{\partial \hat{p}_\omega}{\partial \omega} \leq 0$ and $(\overline{\omega} - 2\breve{\omega}) \leq 0$.*

Proof. See Appendix 1 ■

Since all of the economies I consider satisfy either condition (i) or (ii) of Proposition 2 (B), I restrict attention to securities with truth telling and no liquidation without loss of generality. Since payoffs from debt securities are assumed to be independent of the report (Assumption 4), no

[13] A manager that is indifferent between liquidating and reporting is assumed to report. A manger that is indifferent between reporting truthfully and falsifying is assumed to report truthfully.

liquidation implies that debt is risk-free in equilibrium.[14]

1.1.2 Manager j's problem

At period 0, manager j begins with wealth w_0^j and information Ω. A manager must choose the total amount invested in his firm, i^j, as well as the face value of debt, b^j, and the share of outside equity, $1 - s^j$, to issue. Since it will be verified that internal returns are higher than equilibrium market returns, and since production shocks are assumed to be common, it is clear that a manager will never invest with a different manager. Moreover, by Assumption 4 managers can not short-sell shares of different managers.[15] The manager maximizes utility, equation (1), with respect to c_0^j, c_1^j, i^j, b^j and s^j subject to the budget constraints

$$\begin{aligned} c_0^j &\leq w_0^j - (i^j - (1 - s^j)(pi^j - p^b b^j) - p^b b^j), \\ c_1^j &\leq s^j(\omega i^j - b^j), \end{aligned} \tag{3}$$

and the no liquidation (leverage γ) and truthful reporting (equity ψ) constraints

$$\begin{aligned} \frac{(s^j - \psi)\underline{\omega} + \psi\gamma}{s^j} &\geq \frac{b^j}{i^j}, \\ s^j &\geq \psi, \end{aligned}$$

where p^b and p are period 0 market prices of a risk-free claim to one unit of consumption and a unit of production output ω (unlevered equity) at period 1; the return on levered equity will be reported

[14] The restriction on state prices in Proposition 2 is similar to a requirement that a firm's return covary positively with the market/consumption; in a CAPM setting this is similar to having a positive beta. To see when liquidation may be optimal, consider the case where a firm's return covaries negatively with the market. This implies that when the market preforms well and state prices are low, the firm preforms poorly and the undiversified manager's consumption is low. When state prices are sufficiently low, the manager may do better by smoothing consumption through liquidation since the market does not place much value on the resulting losses.

[15] If managers can short sell, the assumption of identical shocks would allow them to completely undo the problem of inefficient risk sharing (also see Section 3.2).

with the results. Notice that the manager's technology is constant returns to scale, implying that a world with no agency problem will have $p = 1$; the cost of a security with payoff ω is 1. It is not surprising, as Proposition 3 shows, that the equity constraint generically binds when the return on the technology exceeds market returns.

Proposition 3 *When* $\frac{(s^j-\psi)\underline{\omega}+\psi\gamma}{s^j} > \frac{b^j}{i^j}$*, it is sufficient for* $p > 1$ *to ensure* $s^j = \psi$*. When* $\frac{(s^j-\psi)\underline{\omega}+\psi\gamma}{s^j} = \frac{b^j}{i^j}$ *it is sufficient for* $p > 1$ *and* $3\gamma \geq \underline{\omega}$ *to ensure* $s^j = \psi$*.*

The condition that $3\gamma \geq \underline{\omega}$ ensures the equity constraint binds whenever the borrowing constraint binds. Since parameters are such that $s^j = \psi$ in all the equilibria considered, it is taken as given for the remainder of the discussion. Moreover, the restriction on leverage reduces to $\gamma \geq \frac{b^j}{i^j}$ when $s^j = \psi$.

1.1.3 Household k's problem

At period 0, household k begins with wealth w_0^k and information Ω. In addition, household k receives an exogenous endowment of l_1^k, at the beginning of period 1. At period 0, the household chooses the shares of equity, s^k and the face value of bond holdings, b^k. They are restricted from short-selling any securities by Assumption 2. The household maximizes utility, equation (2), with respect to c_0^k, c_1^k, b^k and s^k subject to the budget constraints

$$\begin{aligned} c_0^k &\leq w_0^k - s^k(pi - p^b b) + p^b b^k, \qquad (4) \\ c_1^k &\leq l_1^k + s^k(\omega i - b) - b^k, \end{aligned}$$

and the borrowing and short-sales constraints

$$-b^k \geq 0,$$

$$s^k \geq 0,$$

where b and i denote the total face value of debt issued and the total invested by managers at period 0.

1.1.4 Equilibrium

Aggregate disposable wealth consists of output from investment as well as the endowment process. Market clearing requires

$$\begin{aligned} s^m + s^h &= 1, \qquad (5) \\ b^m + b^h &= 0, \end{aligned}$$

and

$$\begin{aligned} c_0^h + c_0^m + i &= w_0^h + w_0^m, \qquad (6) \\ c_1^h + c_1^m &= \omega i + l_1^h, \end{aligned}$$

where superscripts m and h denote manager and household aggregates.

When the borrowing constraint does not bind, the first order necessary conditions from each manager's optimization problem imply that

$$p = \frac{1}{1-\psi} - \frac{\psi E_\Omega[\beta x \omega (c_1^m)^{-\alpha}]}{(1-\psi)(c_0^m)^{-\alpha}}, \qquad (7)$$

and

$$p^b = \frac{E_\Omega[\beta x (c_1^m)^{-\alpha}]}{(c_0^m)^{-\alpha}}. \qquad (8)$$

When the borrowing constraint binds, equation (8) is replaced by

$$\frac{b^m}{i} = \gamma. \tag{9}$$

Similarly, when the borrowing and short selling conditions do not bind, the first order necessary conditions from each household's optimization problem imply that

$$p = \frac{p^b b^m}{i} + \frac{E_\Omega[\beta(\omega i - b^m)(c_1^h)^{-\alpha}]}{i(c_0^h)^{-\alpha}}, \tag{10}$$

and

$$p^b = \frac{E_\Omega[\beta(c_1^h)^{-\alpha}]}{(c_0^h)^{-\alpha}}. \tag{11}$$

Notice that equation (10) is equivalent to the standard FOC for equity holdings, but is represented differently because the price for unlevered equity is used.

When the short sales or borrowing constraints bind, equations (10) or (11) are respectively replaced by

$$s^h = 0, \tag{12}$$

and

$$b^h = 0. \tag{13}$$

At period 0, the unknowns are p, p^b, c_0^m, c_0^h, and b^m. The equilibrium is defined by the consumption constraints in equations (3) and (4), the market-clearing conditions in equations (5) and (6), asset equations (7), (8)or (9), (10) or (12) and (11) or (13).

1.2 Discussion and Equilibrium

This subsection illustrates how the relative distribution of wealth between managers and households affects capital structure choice. I consider the relative initial wealth for managers $\frac{w_0^m}{W} \in [2.5\%, 12.5\%]$ to demonstrate a range of economies where the agency problem is severe (when managers have little wealth) to less severe (when managers have more wealth), where total initial wealth $W = w_0^m + w_0^h = 1$.[16]

In this model, as wealth shifts between managers and households, capital structure changes are due to general equilibrium conditions alone, rather than individual wealth effects. The manager's capital structure choice can be interpreted as a portfolio choice problem where the manager chooses the proportion of debt and equity. Since managers have CRRA preferences and face technologies with constant returns to scale, changes in wealth do not affect portfolio weights. Therefore, capital structure is invariant to the wealth of any single manager. The change in capital structure is the result of relative aggregate wealth on agency problems, and hence on required market returns.

Table 1-1, below, presents results for the base parameter choices where $x = 1$ (the utility functions for managers and households are identical), $\beta = 0.95$, $\alpha = 2.5$, $\psi = 0.35$, $\gamma = 0.75$, $\omega \in \{1.1, 1.3\}$, $\Pr[\omega = 1.3] = 0.5$ and $l_1^h = 0.6$.

Firstly, look at the effect of wealth changes on leverage and returns. The negative relationship observed in Table 1-1 between leverage, $\frac{b}{i}$, and managers' endowment, w_0^m, follows from the argument that leverage increases when w_0^m decreases in order to maintain the manager's fraction, ψ of the

[16] The equilibrium is solved numerically using a modified version of the "auctioneer algorithm" developed in Lucas (1994). We discuss the modifications as well as approximation errors in Appendix 2.

equity and allow demand for securities by households to equal supply. Notice that the leverage constraint $\gamma = 0.75$ binds when $\frac{w_0^m}{W} \in \{2.5, 5\}$. Market returns on unlevered equity, $E[r] = \frac{E[\omega]}{p} - 1$ and risk free debt, r_f, adjust so that leverage is chosen optimally. The difference between $E[r]$ and the expected return on the production technology, $E[\omega] - 1 = 20\%$ is a measure of the rents appropriated by managers as the result of agency problems, and is monotonically decreasing with the manager's endowment, w_0^m. When $\frac{w_0^m}{W} \in \{2.5, 5\}$, low market returns, $E[r]$ and r_f, reflect household desire to save across periods when financial instruments are scarce; managers are restricted in issuing both equity and debt. As managers' endowment increase, the economy can achieve appropriate incentives at lower costs through better risk sharing.

Increases in leverage, and therefore risk, drive the negative relationship between the equity premium, $E[r_e - r_f] = \frac{E[\omega i - b]}{pi - p^b b} - (1 + r_f)$, and managers' endowment, w_0^m up to the case $\frac{w_0^m}{W} = 5\%$. The reduction in the equity premium from the case $\frac{w_0^m}{W} = 5\%$ to $\frac{w_0^m}{W} = 2.5\%$ is a result of decreased risk (leverage is constant). Although payoffs are constant, higher prices result in market returns having a lower standard deviation.

A wealth change also affects equilibrium investment. The differences in investment across economies (the row labeled $\frac{i}{W}$) is due to the relative savings rates of managers and households which is affected by three factors: risk, return, and period 1 endowment (l_1^h). Managers' positions are riskier, which increases their savings since $\alpha > 1$. At the same time,managers receive higher expected returns, which lowers their savings since $\alpha > 1$. Finally, since managers do not have period 1 endowment, they must rely on investment for period 1 income, which increases their savings. Since total investment is increasing with w_0^m, the higher managerial savings dominates lower household savings.[17,18]

Table 1 − 1 : equilibrium under various initial relative *managerial* wealth levels (*percent*)

manager wealth $\frac{\mathbf{w}_0^m}{W}$	**2.5**	**5**	**7.5**	**10**	**12.5**
leverage $\frac{b}{i}$	75.0	75.0	57.3	38.1	18.7
unlevered equity $E[r]$	5.5	17.7	18.8	19.1	19.3
risk free r_f	5.2	17.3	18.4	18.7	18.9
equity premium $E[r_e - r_f]$	0.9	1.1	0.8	0.6	0.5
investment $\frac{i}{W}$	18.47	19.93	20.04	20.05	20.07

β=0.95,x=1,α=2.5,ψ=0.35,γ=0.75,$\omega\in\{1.1,1.3\}$,Pr[ω=1.3]=0.5,l_1^h=0.6

2 The Full Model

In this section the model is generalized to an infinite horizon setting with two classes of managers.

2.1 The Economic Environment

There are now households as well as two classes of managers distinguished by agency parameters ψ and γ as well as the stochastic process for their investment outcomes. Due to the complexity of the problem, two period securities are taken as given. Periods are linked only by the relative wealth of each class of agent carried forward from the previous period. Every period output is realized, securities are paid and new securities are issued. Implicitly, the degree of anonymity in the market is high enough that upon deviation, the manager can raise funds with no discrimination. I expect that the qualitative results remain if securities are generalized to be history dependent as argued

[17] It is possible for the relation between i and w_0^m to be non monotonic, although not for the chosen parameters.

[18] The result that managers have a higher savings rate is consistent with empirical findings in Gentry and Hubbard (1998). Although Gentry and Hubbard attribute high savings rates to high external finance costs and high internal returns, they do recognize that entrepreneurs face greater income risk and therefore might save more for precautionary reasons.

in Section 3.2.

2.1.1 Manager j of class z's problem

At each period, t, manager j of class z begins with wealth w_t^j and information Ω_t. Wealth at period t includes income from his investments at period $t-1$, as well as an exogenous endowment stream, l_t^j. The manager must choose how much his firm will invest, i_t^j, the face value of debt, b_t^j, and the share of outside equity, $1 - s_{t,z}^j$, to issue. Moreover, he must choose the share of the other firm class' equity, $s_{t,-z}^j$, to hold on his own account, where $-z$ denotes the other class of managers; $s_{t,-z}^j$ must be non-negative by Assumption 4.[19] Since it will be verified that internal returns are higher than equilibrium market returns, and since production shocks are assumed to be common, it is clear that a manager will never invest with a different manager in the same class. The higher returns for managers also result in higher wealth accumulation. To avoid the unrealistic scenario where the economy converges to a steady state with no agency problems, the managerial sector is now assumed to be less patient, $x < 1$ (Assumption 1).[20] The manager has following maximization problem:

[19] With more structure Assumption 4 can be relaxed to allow $s_{t,-z}^j$ to be purchased on the firm's account without changing the manager's problem. Specifically, if the return on traded securities cannot be falsified and if managers incur no cost upon liquidating financial assets (due to their liquid nature), the equity constraint would not be affected and the borrowing constraint would be tighter. This is excluded for brevity.

[20] This can potentially be endognized by introducing random project destruction. Formally, if managers are restricted from diversifying project destruction shocks and project destruction occurs after contracts are paid off with probability $(1-x)$, we can simply augment the discount factor for managers by x. The desired result follows from manager j's first order necessary conditions as he maximizes utility with respect to i_j (in order for utility to be well defined when projects pay 0, give managers a small endowment in the following period). Also see Blanchard (1985). Alternatively, a model where agents have finite lives (e.g. an overlapping generations model) can achieve the desired result as each generation starts with limited wealth. Kyotaki and Moore (1997) achieve an equivalent result by assuming farmers must consume at least an exogenous fraction of output; effectively, they are less patient. Carlstrom and Furst (1997) also assume entrepreneurs (managers) are less patient.

$$\max_{\{c^j, i^j, b^j, s^j_z, s^j_{-z}\}_t} E_{\Omega_t} \sum_{\tau=0}^{\infty} (x_z \beta)^t \frac{(c^j_{t+\tau})^{1-\alpha}}{1-\alpha},$$

with budget and wealth constraints

$$\begin{aligned} c^j_t &\leq w^j_t - (i^j_{t,z} - (1-s^j_z)(p_{t,z} i^j_{t,z} - p^b_t b^j_t) - p^b_t b^j_t) - s^j_{t,-z}(p_{t,-z} i_{t,-z} - p^b_t b_{t,-z}), \\ w^j_t &= s^j_z(\omega_{t,z} i^j_{t-1,z} - b^j_{t-1}) + s^j_{t-1,-z}(\omega_{t,-z} i_{t-1,-z} - b_{t-1,-z}) + l^j_t, \end{aligned} \tag{14}$$

and the borrowing, equity and short-sales constraints

$$\begin{aligned} \frac{(s^j_{t,j} - \psi_z)\underline{\omega}_z + \psi_z \gamma_z}{s^j_{t,j}} &\geq \frac{b^j_t}{i^j_t}, \\ s^j_{t,-z} &\geq 0, \\ s^j_{t,j} &\geq \psi_z, \end{aligned}$$

where p^b_t and $p_{t,z}$ are the period t market prices of a risk-free claim to one unit of consumption and a unit of production output $\omega_{t,z}$ (unlevered equity) at period 1; the return on levered equity will be reported with the results. $b_{t,-z}$ and $i_{t,-z}$ denote the total face value of debt issued and the total invested by managers of class $-z$ at period t. Since parameters are such that $s^j_{t,j} = \psi_z$ in almost all of the realized states in the simulations considered, it is taken as given for the discussion (the borrowing constraint reduces to $\gamma_z \geq \frac{b^j_t}{i^j_t}$).

2.1.2 Household k's problem

At each period, t, household k begins with wealth w^k_t and information Ω_t. Wealth at period t includes income from investments at period $t-1$, as well as an exogenous endowment stream,

l_t^k. The household chooses the shares of equity, $s_{t,1}^k$ and $s_{t,2}^k$ as well as the face value of debt, b_t^k. Households are restricted from short-selling any securities by Assumption 2. Household i faces the following problem:

$$\max_{\{c^k, s_1^k, s_2^k, b^k\}_t} E_{\Omega_t} \sum_{\tau=0}^{\infty} \beta^t \frac{(c_{t+\tau}^k)^{1-\alpha}}{1-\alpha},$$

with budget and wealth constraints

$$\begin{aligned} c_t^k &\leq w_t^k - s_{t,1}^k (p_{t,1} i_{t,1} - p_t^b b_{t,1}) - s_{t,2}^k (p_{t,2} i_{t,2} - p_t^b b_{t,2}) + p_t^b b_t^k, \\ w_t^k &= s_{t-1,1}^k (\omega_{t,1} i_{t-1,1} - b_{t-1,1}) + s_{t-1,2}^k (\omega_{t,2} i_{t-1,2} - b_{t-1,2}) - b_{t-1}^k + l_t^k, \end{aligned} \tag{15}$$

and the borrowing and short-sales constraints

$$-b_t^k \geq 0,$$

$$s_{t,z}^k \geq 0 \text{ for all } z.$$

2.1.3 Equilibrium

At period t, aggregate disposable wealth consists of output from each class, $\omega_{t,1} i_{t-1,1}$ and $\omega_{t,2} i_{t-1,2}$,as well as the endowment process for households and managers, l_t^h, $l_t^{m_1}$ and $l_t^{m_2}$. The market clearing requires

$$\begin{aligned} s_{t,1}^h + s_{t,1}^{m_1} + s_{t,1}^{m_2} &= 1, \\ s_{t,2}^h + s_{t,2}^{m_1} + s_{t,2}^{m_2} &= 1, \\ b_t^{m_1} + b_t^{m_2} + b_t^h &= 0, \end{aligned} \tag{16}$$

and

$$y_t = c_t^h + c_t^{m_1} + c_t^{m_2} + i_{t,1} + i_{t,2} = \omega_{t,1} i_{t-1,1} + \omega_{t,2} i_{t-1,1} + l_t^h + l_t^{m_1} + l_t^{m_2}, \tag{17}$$

where superscripts m_z and h denote class z manager and household aggregates.

When the borrowing constraint does not bind, the first order necessary conditions from each manager's optimization problem imply that, for all t and z,

$$p_{t,z} = \frac{1}{1-\psi_z} - \frac{\psi_z x_z \beta E_{\Omega_t}[\omega_z (c_{t+1}^{m_z})^{-\alpha}]}{(1-\psi_z)(c_t^{m_z})^{-\alpha}}, \tag{18}$$

$$p_{t,-z} = -\frac{p^b b_{t,-z}}{i_{t,-z}} + \frac{x_z \beta E_{\Omega_t}[(\omega_{t,-z} i_{t,-z} - b_{t,-z})(c_{t+1}^{m_z})^{-\alpha}]}{i_{t,-z}(c_t^{m_z})^{-\alpha}}, \tag{19}$$

and

$$p_t^b = \frac{x_z \beta E_{\Omega_t}[(c_{t+1}^{m_z})^{-\alpha}]}{(c_t^{m_z})^{-\alpha}}. \tag{20}$$

When the short sales or borrowing constraints bind equations (19) or (20) are respectively replaced by

$$s_{t,-z}^{m_z} = 0, \tag{21}$$

or

$$b_t^{m_z} = \gamma_z i_t^j. \tag{22}$$

Similarly, when the borrowing and short selling conditions do not bind, the first order necessary conditions from each household's optimization problem imply that, for all t and z,

$$p_{t,z} = -\frac{p^b b_{t,z}}{i_{t,z}} + \frac{\beta E_{\Omega_t}[(\omega_{t,z} i_{t,z} - b_{t,z})(c_{t+1}^h)^{-\alpha}]}{i_{t,z}(c_t^h)^{-\alpha}} \tag{23}$$

and

$$p_t^b = \frac{\beta E_{\Omega_t}[(c_{t+1}^h)^{-\alpha}]}{(c_t^h)^{-\alpha}}. \tag{24}$$

When the short sales or borrowing constraints bind, equations (23) or (24) are respectively replaced by

$$s_{t,z}^h = 0 \tag{25}$$

or

$$b_t^h = 0. \tag{26}$$

At period t, the unknowns are $p_{t,z}$, p_t^b, $c_t^{m_z}$, c_t^h, $b_t^{m_z}$, b_t^h, and $s_{t,z}^h$ for $z = \{1, 2\}$. The equilibrium is defined by the budget constraints in equations (14) and (15), the market-clearing conditions in equations (16) and (17) and asset equations (18), (19) or (21) (for $z = \{1, 2\}$), (20) or (22) (for $z = \{1, 2\}$), (23) or (25) (for $z = \{1, 2\}$) and (24) or (26). I only consider stationary equilibria in which the consumption growth rate, investment rules, security issue rules, security purchase rules and equilibrium prices are functions of the period t state, Ω_t.

2.2 State Variables and Parameter Calibration

The exogenous state is described by a Markov chain that gives the dynamics of the stochastic production outcomes, $\omega_{t,1}$ and $\omega_{t,2}$. The state Ω_t includes these exogenous variables as well as the endogenous distribution of wealth.

2.2.1 Class 1 and class 2 firms

Managers and production technologies are parameterized to firms that face low (class 1) and high (class 2) agency costs associated with accessing capital markets. Absent a direct measure of agency problems and motivated by a variety sources, dividend-payout ratios and firm size are used as proxies. In the model, only two period securities are considered resulting in a dividend-payout ratio of unity. However, theoretical arguments as well as empirical evidence (e.g. Fazzari, Hubbard and Petersen (1988)) support the view that firms in need of cash (and therefore constrained in accessing capital markets) pay lower dividends. When dividend-payout ratios are unavailable, firm size is used as the proxy and is motivated by the credit channel literature.[21] Papers such as BGG obtain similar results regarding the relation between inventory investment and macroeconomic conditions when using size or a firm's reliance on bank loans versus public financial markets as a proxy for agency costs in accessing external capital. Moreover, as seen in Table 2-2 there is a strong relationship between firm size and the dividend-payout ratio.

2.2.2 Calibration of the Markov chain

Ideally, the Markov chain should capture the uncertainty managers face when making investment decisions as well as uncertainty households face when saving in the market. In the model, managers face the stochastic return ω on investment i: $f(\omega, i) = \omega i$. The analogue measure in the world is the stochastic value of a firm for a given level of investment in assets: $\text{Market Value of Firm}_t + \widetilde{\text{Dividends}}_t + \text{Interest Payments}_t = \omega_t \times \text{Book Value of Assets}_{t-1}$. This assumes one period represents one year, marginal returns equal average returns and the present value of growth opportunities can be realized immediately. Following this logic, the Markov chain is calibrated so that each firm receives a stochastic return on investment, $\omega_t = \frac{\text{Market Value of Firm}_t + \widetilde{\text{Dividends}}_t + \text{Interest Payments}_t}{\text{Book Value of Assets}_{t-1}}$, whose dynamics are described by

$$\log \omega_{z,t} = \mu_z + \sigma_z \tilde{u}_{z,t}, \tag{27}$$

[21] In the model, due to aggregation, the measure of agents in each class is somewhat nebulous as we can assume that there are B managers of class 1 and S managers of class 2, where $S >> B$.

where $\tilde{u}_{z,t}$ represents white noise with unit variance.[22,23] The parameters of equation (27) are estimated for each firm in a sample from COMPUSTAT.[24] Appendix 2 describes the data in more detail. Table 2-1 describes the Markov chains implied from descretizing the state space using the techniques developed in Tauchen and Hussey (1991).

The Markov chain is set to capture heterogeneous firm level dynamics as well as equity market dynamics. This is done by decomposing $\omega_{z,t}$ so that $\omega_{z,t} = \omega_{aggregate,t} \times \omega_{idiosyncratic\ z,t}$. $\omega_{aggregate,t}$ is calibrated so the standard deviation of the equity market approximately matches the data (Heaton and Lucas (1996) Table 3 cites 17.3%). Following the discussion in Section 2.2.1, $\omega_{idiosyncratic\ z,t}$ is set so that $\log \omega_{z,t}$ has a mean μ_z and standard deviation σ_z, the cross-sectional medians from estimating equation (27) conditional on the firm having a dividend-payout ratio in the top two-thirds of the sample when $z = 1$, and the bottom third of the sample when $z = 2$. For a more complete description of the procedure and results see Appendix 2.

[22] Since the model is driven by the distribution of wealth, it is calibrated to capture innovations that have market value, that include realized production. Since market values tend to be more volatile than output (see the literature on the equity premium puzzle) it is taken as given that some market friction(s) other than those modeled here produce this "excess" volatility.

[23] By using a stochastic constant returns to scale technology with innovations that are independent and identically distributed across time, variations in leverage ratios and expected market returns can be attributed to the distribution of wealth in the economy.

[24] Since μ_i represents average return, not the marginal return it is overstated. This results in managers issuing more debt in the model. Since managers tend to know more about future returns than the unconditional mean, σ_i is probably overstated. This results in managers issuing less debt in the model.

Table 2 − 1
Markov chain for exogenous state variables:
Combined idiosyncratic and aggregate components

State number	ω_1	ω_2
1	1.580	0.827
2	0.897	1.716
3	1.243	0.651
4	0.706	1.350

The transition probability matrix is equally weighted and independent across states

2.2.3 Other parameters

I now describe the motivation behind the other parameter choices. The truth telling agency parameter (ψ), that can be measured by managerial equity stake, is calibrated using statistics reported in Holderness, Krozner and Sheehan (1999). Median (mean) managerial equity ownership, adjusted for option compensation, across deciles of the market value of equity (dividend-payout ratios are not reported) for firms in their 1995 sample ranges from 30.6% (33.3%) in the smallest decile to 1.5% (5.4%) in the largest decile, with an overall median (mean) of 14.4% (21.1%). ψ_1 is set at 0.04, the median ownership of the second largest equity value decile, the decile whose midpoint is closest to the median equity market value from my sample of high dividend payout firms (see Table 2-2). ψ_2 is then set at 0.20, approximately the median ownership of the seven smallest deciles.

To adjust for the variety of other incentive contracts, I use statistics reported in Holderness, Krozner and Sheehan (1999). They report the ratio of median (mean) dollar value of managerial equity ownership to median (mean) compensation, defined as salary plus bonus, for the five highest paid executives in firms included in the S&P 500, S&P MidCap, and S&P SmallCap 500 was 4 (20) in 1932 and 12 (32) in 1995. I use a conservative approach by treating this compensation as low risk and provide managers an endowment stream that is proportional to the entire economy, $l_t^{m_z} = l^{m_z} y_t$. l^{m_z} is then set to 0.005 for both classes so that $\frac{E[\sum_z \psi(\omega_{t,z} i_{t-1,z}^j - b_{t-1}^j)]}{E[\sum_z l_t^{m_z}]}$ equals 8, the average of the two medians.[25]

The parameter γ places an upper bound on leverage. γ_1 and γ_2 are respectively set at 0.25 and 0.2 so that leverage in the simulated economy is close to that observed in the data and reported in Table 2-2.

Table 2 − 2
Medians [means] from COMPUSTAT sample

	High dividend payout firms	Low dividend payout firms
$\frac{\text{Dividend}}{\text{Net Income}}$	0.163 [0.203]	0.054 [0.043]
Market Value of Equity in 1995	\$1,397 Million [\$5,503 Million]	\$328 Million [\$2,328 Million]
Book Value of Assets in 1995	\$1,613 Million [\$5,461 Million]	\$317 Million [\$2,539 Million]
$\frac{\text{Book Value of Debt}}{\text{Book Value of Assets}}$	0.242 [0.245]	0.206 [0.206]

The household endowment, l_t^h, is set to be a constant proportion, of the economy at period $t-1$, $l_t^h = l^h y_{t-1}$. l^h is set at 0.65 so that the standard deviation of growth in the simulated economy is approximately 4.5%, the standard deviation of real net worth growth of households and nonprofit organizations reported in the Flow of Funds.[26,27]

[25] Giving managers a small endowment also places a lower bound on their wealth. This allows for computational ease since the representative manager's problem is only defined when his wealth is strictly positive. Since this is an open interval it is computationally difficult to deal with. I found that varying l^{m_z} within [0.0025,0.0075] did not substantially change the statistics reported in Table 3-1.

[26] As discussed in footnote 22, it seems natural to concentrate on market value and calibrate the model to wealth dynamics.

[27] From a modeling perspective, endowments can be interpreted as labor income by augmenting the production function to achieve the desired wage rate, labor demand, and labor supply; this is excluded for the sake of brevity. Endogenizing labor should not affect the basic results on capital structure which are driven by the distribution of

The preference parameters β and α are chosen to be standard at 0.95 and 2.5 respectively. To ensure no class of managers accumulates wealth to the point where agency problems do not bind $x_1 = x_2 = 0.87$.[28]

3 Simulation

3.1 Simulation results

This section reports the results of a Monte Carlo simulation for the economy with the parameters described in Section 2.2.2. The equilibrium is solved numerically using a modified version of the "auctioneer algorithm" developed in Lucas (1994).[29]

Managers face technology dynamics described by the Markov chain in Table 2-1. Table 3-1 presents key endogenous variables conditioned on the realized aggregate state. These statistics are computed under the assumption that initially each manager has 7.5% of the wealth. The economy evolves for 5,000 years, driven by realizations of the exogenous technology process. The reported statistics are based on averages for years 5,001 to 25,000.

Aside from leverage $(\frac{b_{t,z}}{i_{t,z}})$, a number of summary statistics are reported across the aggregate state. Although expected returns on the underlying technologies do not change over time, expected market returns on unlevered equity $(E[r_{t+1,z}|\omega_{aggregate,t}] = \frac{E[\omega_{t+1,z}|\omega_{aggregate,t}]}{p_{t,z}} - 1)$ and risk free debt (r^f_{t+1}) vary with the severity of agency problems and are reported. Equity premia $(E[r^{e_z}_{t+1} - r^f_{t+1}|\omega_{aggregate,t}] = \frac{E[\omega_{t+1,z}i_{t,z} - b_{t,z}|\omega_{aggregate,t}]}{p_{t,z}i_{t,z} - p^b_t b_{t,z}} - (1 + r^f_{t+1}))$, investment growth $(\frac{i_{t,1}+i_{t,2}}{i_{t-1,1}+i_{t-1,2}} - 1)$,

wealth across the economy.

[28] The solution technique maps current relative wealth of each manager class $(\frac{w_{t,1}}{y_t}, \frac{w_{t,2}}{y_t})$ to the next period $(\frac{w_{t+1,1}}{y_{t+1}}, \frac{w_{t+1,2}}{y_{t+1}})$. The technique only works when the space of relative wealth gets mapped onto itself; managers cannot get too rich or too poor. In general, there is a range for x_1 and x_2 that will work.

[29] Modifications as well as approximation errors are discussed in Appendix 2.

expected future growth ($E[\frac{y_{t+2}}{y_{t+1}}|\omega_{aggregate,t}] - 1$) and the change in debt and equity as a fraction of the economy ($E[\frac{b_{t,z}-b_{t-1,z}}{y_{t-1}}|\omega_{aggregate,t}] - 1$ and $E[\frac{(p_{t,z}i_{t,z}-p^b_t b_{t,z})-(p_{t-1,z}i_{t-1,z}-p^b_{t-1}b_{t-1,z})}{y_{t-1}}|\omega_{aggregate,t}] - 1$) are reported and related to leverage and the severity of agency problems.

The intuition from the two period economy follows in this infinite horizon setting. In any period, a low realization of production results in a relative wealth shift away from that class of managers due to their levered positions. Since periods are linked by the relative wealth of each agent, class 1 (low agency cost) firms have counter-cyclical leverage, whereas class 2 (high agency cost) firms do not; class 2 firms are up against their borrowing constraint. Expected market returns on unlevered equity and risk free debt, are pro-cyclical despite the constant expected return on technology; $E[\omega_1] = 1.1065$ and $E[\omega_2] = 1.1360$. The difference between $E[r_{t+1,z}|\omega_{aggregate,t}]$ and $E[\omega_z]$ is a measure of the rents appropriated by managers as a result of the agency problems. Despite higher technology returns, class 2 market returns are not uniformly higher due to the severity of their agency problems. The inefficiency in investment is evident by the relative investment of class 1 firms across the aggregate state, $\frac{i_1}{i_1+i_2}$, that is counter-cyclical. It is not surprising that contractions reduce i_2 by more than i_1; firms that face more severe restrictions on capital structure choice cannot invest optimally. The counter-cyclical equity premium for class 1 firms is due to counter-cyclical leverage as well as the risk premium households require for holding a less diversified portfolio in contractions; the unlevered equity premium is counter-cyclical for class 1 firms. The pro-cyclical equity premium for class 2 firms is in part due to their flat leverage over the cycle as well as the diversification premium households pay in contractions; the unlevered equity premium is pro-cyclical for class 2 firms. The expected growth in the economy one period after the aggregate state is realized is approximately 0.12% lower when the economy realizes the low aggregate state, indicating the endogenous persistence of bad outcome realizations. The change in equity financing is pro-cyclical for both classes of firms and the change in debt is counter-cyclical for class 1 firms. The pro-cyclical change in debt for class 2 firms is due to flat leverage coupled pro-cyclical investment; the decrease in investment during contractions force debt to decrease due to the binding borrowing constraint. Finally, the standard deviation of investment growth is 4.7%.

Table 3 − 1 : endogenous variables from simulations when managers are heterogeneous (*percent*)

	Expansions	*Contractions*
$leverage_1$ $(\frac{b_1}{i_1})$	21.56	24.65
$leverage_2$ $(\frac{b_2}{i_2})$	20.00	20.00
$unlevered\ equity_1$ (r_1)	10.17	9.81
$unlevered\ equity_2$ (r_2)	10.38	9.38
$risk\ free\ rate$ (r_f)	8.91	8.31
$equity\ premium_1$	0.96	2.03
$equity\ premium_2$	1.78	1.30
$investment\ growth_1$	4.66	−1.11
$investment\ growth_2$	9.10	−4.41
$\frac{i_1}{i_1+i_2}$	55.34	57.07
$y_{t+1}\ growth$	1.62	1.50
$change\ in\ equity_1$	0.90	−0.43
$change\ in\ debt_1$	−0.12	0.22
$change\ in\ equity_2$	0.95	−056
$change\ in\ debt_2$	0.22	−0.11

3.2 Discussion and interpretation

For reasonable parameter values, I have demonstrated that the model can achieve capital structure dynamics similar to those observed in the data. Class 1 (low agency cost) firms have counter-cyclical leverage ratios, but class 2 (high agency cost) firms do not. This is consistent with Korajczyk and Levy (2000) who find that after correcting for variations in firm characteristics, target leverage was approximately 2-3% higher for their classified unconstrained firms during the 1990/91 recession when compared to the rest of their sample period. Results from the calibrated model also show that the change in debt due to the variation in target leverage is counter-cyclical for class 1 firms, but not for class 2 firms, and the change in equity is substantially pro-cyclical for both classes. This is qualitatively consistent with Korajczyk and Levy (2000) who find that deviations from target leverage account for a substantial portion of time-series variation in the security issue or repurchase choice.[30]

The reduction in investment and future growth, and the model's prediction that investment growth is more volatile than the economy is qualitatively consistent with empirical results on aggregate investment found in the macroeconomic literature (e.g. Kydland and Prescott (1982). However, the model does not differentiate between investment and the capital stock, so it is difficult to compare magnitudes to any single series in the data. The inefficient shift away from class 2 investment in contractions is consistent with BGG who present evidence that inventory investment growth for small (or bank-dependent) firms is more susceptible to recessions associated with Federal Reserve monetary tightening. This result is also consistent with the literature that relates cash flows (and

[30]Since the model does not differentiate between security issues, security repurchases or payout policies, the magnitudes are difficult to compare to any single series in the data.

access to capital markets) with investment (see the introduction).[31]

The calibration of γ_1 is open to question since low agency cost firms can issue bonds with a face value of at most 25% of investment. However, sensitivity analysis for γ (not reported in this paper) indicate that relaxing this constraint increases average leverage and magnifies the variance of leverage and issues across the aggregate state; the qualitative results on leverage or the change in debt and equity remain unchanged.

Moreover, two assumptions on the space of contracts, the restriction on aggregate state and single period contracts, are used for tractability and require justification. First, there is empirical evidence and theoretical arguments that justify why manager compensation should be tied to aggregate risk (see Aggarwal and Samwick (1999) or Bertrand and Mullainathan (2000)).[32] Others have used alternative modeling techniques in general equilibrium settings, such as aggregate constraints on financial intermediaries, to achieve amplification and propagation of aggregate shocks while allowing for aggregate state contingent securities (see for example Bernanke, Gertler and Gilchrist (1998), Krishnamurthy (2000), Rampini (1999) and Suarez and Sussman (1997)). In such settings, when output is high, managers receive a higher level of wealth which reduces moral hazard problems and allows for better risk sharing (lower leverage), maintaining the qualitative counter-cyclical nature of leverage.

[31] The relative size of our two classes is similar to that cited in BGG. They estimate that $\frac{1}{3}$ of manufacturing, $\frac{3}{4}$ of wholesale and retail, $\frac{8}{9}$ of services and $\frac{9}{10}$ of construction sales is done by small firms.

[32] Aggarwal and Samwick (1999) develop a model where strategic interactions among firms can explain the lack of relative performance-based incentives. Bertrand and Mullainathan (2000) argue that boards may want their CEOs to respond to aggregate shocks for two reasons. First, in the context of the oil industry, the board may want the CEO to "keep his eyes open" for an oil shock. Second, the "value" of a CEO's human capital rises and falls with industry fortunes. Since a CEO's pay rises and falls with his outside wage, his pay will rise and fall with aggregate shocks.

Second, models that relate risk sharing with agency problems, in settings that allow for dynamic contracts, generally find that agents (managers) receive a riskier compensation stream (hold riskier positions in their firm) than they would with no agency problems (see Atkeson and Lucas (1992) or Green (1987)). As above, in such a setting, when output is high, managers in my model receive a higher share of wealth which reduces moral hazard problems and allows for better risk sharing (lower leverage). In this sense the qualitative counter-cyclical nature of leverage is robust to expanding the space of contracts or alternative agency problems.

4 Conclusion

This paper began by asking how the choice of financial instruments (capital structure) varies with macroeconomic conditions in presence of agency problems, and how this choice relates to investment decisions and future growth. I have provided a calibrated model of capital structure choice that explains observed systematic financing patterns across firms. The model predicts a resulting inefficient shift of investment away from high agency cost firms as well as lower aggregate investment and expected growth in downturns.

There are several natural directions to extend this work. The model can be calibrated to help explain some of the capital structure regularities across countries (see Rajan and Zingales (1998) for example). It would be interesting to embed a more developed production technology that can differentiate between changes in agency costs and the marginal product of investment, allowing for more accurate inference. The model also has implications for how asset prices, managerial compensation and managerial ownership of other firms vary predictably with macroeconomic conditions that has not been emphasized and could be explored.

Furthermore, the model can be extended to multiple periods. Adding more structure can incorporate price reactions to issue choices. Another extension can include a distinction between retained earnings and capital markets as sources financing as well as a payout policy decision.

1 Appendix

Proof of Proposition 1

Truthful reporting and no liquidation follow from the following incentive constraint:

$$s^j(\omega i^j - b) \geq \max[s^j(\hat{\omega} i^j - b) + \psi(\omega i^j - \hat{\omega} i^j), \psi\omega i^j - \psi\gamma i^j] \ \forall\omega, \, \hat{\omega} < \omega$$

(A) Truthful reporting requires:

$$s^j(\omega i^j - b^j) \geq s^j(\hat{\omega} i^j - b^j) + \psi(\omega i^j - \hat{\omega} i^j) \ \forall\omega, \, \hat{\omega} < \omega$$

$$\Leftrightarrow s^j(\omega - \hat{\omega}) \geq \psi(\omega - \hat{\omega}) \ \forall\omega, \, \hat{\omega} < \omega$$

$$\Leftrightarrow s^j \geq \psi$$

(B) When $s^j \geq \psi$, no liquidation requires:

$$s^j(\omega i^j - b^j) \geq \psi\omega i^j - \psi\gamma i^j \ \forall\omega$$

$$\Leftrightarrow \frac{(s^j - \psi)\omega + \psi\gamma}{s^j} \geq \frac{b^j}{i^j} \ \forall\omega$$

since $s^j \geq \psi$

$$\Leftrightarrow \frac{(s^j - \psi)\underline{\omega} + \psi\gamma}{s^j} \geq \frac{b^j}{i^j}$$

■

Proof of Proposition 2:

I prove the proposition in 4 steps. Lemma 1 shows that a manager only liquidate if $s^j > \psi$. This allows us to rule out liquidation securities when $s^j \leq \psi$ and prove that truth telling securities strictly dominate securities with false reports in Lemma 2. Lemma 3 describes the set of ω where the manager liquidates. Finally, Lemma 4 proves that securities with no liquidation strictly dominate securities with liquidation.

Lemma 1 *A manager only liquidates if* $s^j > \psi$.

Proof. When $s^j = \psi$, the manager always reports the truth by Proposition 1 (A). He liquidates if his contractual payoff is lower than liquidation, $\psi(\omega i^j - b) < \psi\omega i^j - \psi\gamma i^j$, which reduces to $\psi\gamma i^j < b\psi$. Since this is independent of ω, the manager will always or never liquidate. If he always liquidates, no outside funding can be obtained since no household would accept this security.

When $s^j < \psi$, the manager's payoff from reporting, $s^j(\hat{\omega} i^j - b^j) + \psi(\omega i^j - \hat{\omega} i^j) = (s^j - \psi)\hat{\omega} i^j - s^j b + \psi\omega i^j$, is decreasing in $\hat{\omega}$ and he always reports $\min\{\hat{\omega}\} = \underline{\omega}$. Therefore, the manager liquidates if the following incentive constraint holds: $s^j(\underline{\omega} i^j - b^j) + \psi(\omega i^j - \underline{\omega} i^j) < \psi\omega i^j - \psi\gamma i^j \Leftrightarrow s^j(\underline{\omega} i^j - b^j) - \psi\underline{\omega} i^j < -\psi\gamma i^j$ which is independent of ω. Once again, the manager will always or never liquidate. ■

Lemma 2 *Truth telling securities dominate securities with false reports.*

Proof. By Proposition 1 (A) consider a strategy with misreporting: i^j, b^j and $s^j < \psi$. I show that an alternative strategy i^j, $b^{j\prime} = \frac{(\psi - s^j)\underline{\omega} i^j}{\psi} + \frac{s^j}{\psi} b^j$ and $s^{j\prime} = \psi$ provides the manager with the same payoffs, but allows him to raise strictly more capital for the given level of investment.

Under the original strategy $s^j < \psi$ and there is no liquidation by Lemma 1. Therefore, the manager's payoff, $s^j(\hat{\omega} i^j - b^j) + \psi(\omega i^j - \hat{\omega} i^j) = (s^j - \psi)\hat{\omega} i^j - s^j b + \psi\omega i^j$, is decreasing in $\hat{\omega}$ and he always reports $\min\{\hat{\omega}\} = \underline{\omega}$. As a result, his payoff is $s^j(\underline{\omega} i^j - b^j) + \psi(\omega i^j - \underline{\omega} i^j)$ and the household's payoff is $(1 - s^j)(\underline{\omega} i^j - b^j) + b^j$.

Under the alternative strategy, there is no liquidation since $b^{j\prime} = \frac{(\psi - s^j)\underline{\omega} i^j}{\psi} + \frac{s^j}{\psi} b^j \leq \frac{(\psi - s^j)\underline{\omega} i^j}{\psi} + \frac{s^j}{\psi}\frac{(s^j-\psi)\underline{\omega}+\psi\gamma}{s^j} i^j = \gamma i^j$, where the inequality follows from no liquidation in the original strategy: $b^j \leq \frac{(s^j-\psi)\omega+\psi\gamma}{s^j} i^j \; \forall \omega$. The manager's payoff in each state, $\psi(\omega i^j - b^{j\prime})$ is the same as the original strategy:

$$\psi(\omega i^j - b^{j\prime}) = \psi(\omega i^j - \frac{(\psi - s^j)\underline{\omega} i^j + s^j b}{\psi}) = \psi \omega i^j - (\psi - s^j)\underline{\omega} i^j - s^j b^j = s^j(\underline{\omega} i^j - b^j) + \psi(\omega i^j - \underline{\omega} i^j)$$

Moreover, the household's payoff, $(1-\psi)(\omega i^j - b^{j\prime}) + b^{j\prime}$ is weakly higher in all states, and strictly higher in some states, when compared to the original strategy:

$$\begin{aligned} & (1-\psi)(\omega i^j - b^{j\prime}) + b^{j\prime} \\ = \; & (1-\psi)\omega i^j + (\psi - s^j)\underline{\omega} i^j + s^j b^j \\ & \quad = \quad \text{for } \omega = \underline{\omega} \\ & \quad > \quad \text{for } \omega > \underline{\omega} \\ & (1-\psi)\underline{\omega} i^j + (\psi - s^j)\underline{\omega} i^j + s^j b^j \\ = \; & (1-s^j)(\underline{\omega} i^j - b^j) + b^j \end{aligned}$$

implying the manager can raise strictly more capital for the given level of investment. ■

Lemma 3 *If $s^j > \psi$ and the manager liquidates in state $\breve{\omega}$, then the manager liquidate in states $\omega < \breve{\omega}$.*

Proof. Since $s^j > \psi$, the manager reports truthfully by Proposition 1 (A). Therefore, if the manager liquidates in state $\breve{\omega}$, it must be that his contractual payoff is less than liquidation: $s(\breve{\omega} i^j - b^j) < \psi \breve{\omega} i^j - \psi \gamma i^j$. Since $s^j > \psi$ it must be the case that $s^j(\omega i^j - b^j) < \psi \omega i^j - \psi \gamma i^j$ for $\omega < \breve{\omega}$. ■

Lemma 4 *Securities with no liquidation strictly dominate securities with liquidation.*

Proof. I consider a liquidation strategy, and show an alternative no liquidation strategy that provides the manager a weakly higher payoff in all states, strictly higher in some states, and allows him to raise at least as much capital for the given level of investment. By Lemma 1 attention can be restricted to the case where $s^j > \psi$. Consider liquidation strategy s^j, b^j and i^j, and denote $\breve{\omega} > \underline{\omega}$ to be the minimum state the manager does not liquidate. The manager's payoff is:

$$\begin{aligned} s^j(\omega i^j - b^j) \text{ for } \omega &\geq \breve{\omega} \\ \psi\omega i^j - \psi\gamma i^j \text{ for } \omega &< \breve{\omega} \end{aligned}$$

Furthermore, the amount raised under this strategy is $\int_{\breve{\omega}}^{\overline{\omega}} \{(1 - s^j)(\omega i^j - b^j) + b^j\} \hat{p}_\omega \partial\omega$ where Lemma 3 is used to price securities that only pay in states $\omega \geq \breve{\omega}$.

Consider the alternative no liquidation strategy $i^j, s^{j\prime}$ and $b^{j\prime}$ which is defined to solve:

$$\begin{aligned} s^{j\prime}(\overline{\omega} i^j - b^{j\prime}) &= s^j(\overline{\omega} i^j - b^j) \\ b^{j\prime} &= \frac{(s^{j\prime} - \psi)\underline{\omega} + \psi\gamma}{s^{j\prime}} i^j \end{aligned}$$

Under the alternative strategy, the manager's payoff is the same as in the original strategy in state $\overline{\omega}$, by the definition of $s^{j\prime}(\overline{\omega} i^j - b^{j\prime})$, and in state $\underline{\omega}$, since $s^{j\prime}(\underline{\omega} i^j - b^{j\prime}) = (s^{j\prime}\underline{\omega} - (s^{j\prime} - \psi)\underline{\omega} - \psi\gamma) i^j = (\psi\underline{\omega} - \psi\gamma) i^j$. Moreover, his payoff in intermediate states, $\underline{\omega} > \omega > \overline{\omega}$, is strictly higher than the original strategy. This follows since the alternative payoff is a linear combination of the two extreme points of the original convex payoff (recall the slopes, s^j and ψ, of the original payoff form a kink at $\breve{\omega}$). It follows that $s^{j\prime} > \psi$ and $s^{j\prime} < s^j$. Since $s^{j\prime}$ and $\frac{b^{j\prime}}{i^j}$ satisfy the conditions of Proposition 1 (B), there is no liquidation. The amount raised under the alternative strategy is $\int_{\underline{\omega}}^{\overline{\omega}} \left\{(1-s^{j\prime})(\omega i^j - b^{j\prime}) + b^{j\prime}\right\} \hat{p}_\omega \partial\omega$.

To complete the proof, it is sufficient to show the manager raises at least as much capital, for the given level of investment, under the alternative strategy:

$$\int_{\breve{\omega}}^{\overline{\omega}} \left\{(1-s^j)(\omega i^j - b^j) + b^j\right\} \hat{p}_\omega \partial\omega \leq \int_{\underline{\omega}}^{\overline{\omega}} \left\{(1-s^{j\prime})(\omega i^j - b^{j\prime}) + b^{j\prime}\right\} \hat{p}_\omega \partial\omega$$

$$\Leftrightarrow \int_{\breve{\omega}}^{\overline{\omega}} \left\{(1-s)\omega i^j + s b^j\right\} \hat{p}_\omega \partial\omega \leq \int_{\underline{\omega}}^{\overline{\omega}} \left\{(1-s^{j\prime})\omega i^j + s^{j\prime} b^{j\prime}\right\} \hat{p}_\omega \partial\omega$$

since there is no liquidation with the original strategy in state $\breve{\omega}$, it must be true that $\psi\breve{\omega}i^j - \psi\gamma i^j \leq s^j(\breve{\omega}i^j - b^j) \Leftrightarrow b^j \leq \frac{(s^j-\psi)\breve{\omega}+\psi\gamma}{s^j} i^j$. Moreover, since $b^{j\prime} = \frac{(s^{j\prime}-\psi)\underline{\omega}+\psi\gamma}{s^{j\prime}} i^j$ it is sufficient to replace both b^j and $b^{j\prime}$ and show:

$$\int_{\breve{\omega}}^{\overline{\omega}} \left\{(1-s^j)\omega i^j + (s^j-\psi)\breve{\omega}i^j + \psi\gamma i^j\right\} \hat{p}_\omega \partial\omega \leq \int_{\underline{\omega}}^{\overline{\omega}} \left\{(1-s^{j\prime})\omega i^j + (s^{j\prime}-\psi)\underline{\omega}i^j + \psi\gamma i^j)\right\} \hat{p}_\omega \partial\omega$$

since $\breve{\omega} > \underline{\omega}$

$$\int_{\breve{\omega}}^{\overline{\omega}} \left\{(1-s^j)\omega + (s^j-\psi)\breve{\omega}\right\} \hat{p}_\omega \partial\omega \leq \int_{\underline{\omega}}^{\overline{\omega}} \left\{(1-s^{j\prime})\omega + (s^{j\prime}-\psi)\underline{\omega})\right\} \hat{p}_\omega \partial\omega$$

$$\Leftrightarrow \int_{\breve{\omega}}^{\overline{\omega}} \left\{s^j(\breve{\omega}-\omega) + \omega - \psi\breve{\omega}\right\} \hat{p}_\omega \partial\omega \leq \int_{\underline{\omega}}^{\overline{\omega}} \left\{s^{j\prime}(\underline{\omega}-\omega) + \omega - \psi\underline{\omega}\right\} \hat{p}_\omega \partial\omega$$

since $s^j > s^{j\prime}$ and $\underline{\omega} \leq \omega$ it is sufficient to replace $s^{j\prime}$ with s^j on the right hand side and show:

$$\Leftrightarrow \int_{\breve{\omega}}^{\overline{\omega}} \left\{s^j(\breve{\omega}-\omega) + \omega - \psi\breve{\omega}\right\} \hat{p}_\omega \partial\omega \leq \int_{\underline{\omega}}^{\overline{\omega}} \left\{s^j(\underline{\omega}-\omega) + \omega - \psi\underline{\omega}\right\} \hat{p}_\omega \partial\omega$$

since the inequality is linear in s^j, it is sufficient to consider $\max[s^j]$; the condition is trivially satisfied at $s^j = \psi$ since $\underline{\omega} < \breve{\omega}$. By Assumption 2, $\max[s^j] = 1$:

$$\frac{\breve{\omega}\int_{\breve{\omega}}^{\overline{\omega}} \hat{p}_\omega \partial\omega}{\underline{\omega}\int_{\underline{\omega}}^{\overline{\omega}} \hat{p}_\omega \partial\omega} \leq 1$$

Since $\frac{\breve{\omega}\int_{\breve{\omega}}^{\overline{\omega}}\hat{p}_\omega\partial\omega}{\underline{\omega}\int_{\underline{\omega}}^{\overline{\omega}}\hat{p}_\omega\partial\omega}\mid_{\breve{\omega}=\underline{\omega}}= 1$, it is sufficient to show that at each point $\breve{\omega}\in(\underline{\omega},\overline{\omega}]$, $\frac{\partial}{\partial\breve{\omega}}\breve{\omega}\int_{\breve{\omega}}^{\overline{\omega}}\hat{p}_\omega\partial\omega\leq 0$: $\frac{\partial}{\partial\breve{\omega}}\breve{\omega}\int_{\breve{\omega}}^{\overline{\omega}}\hat{p}_\omega\partial\omega=\int_{\breve{\omega}}^{\overline{\omega}}\hat{p}_\omega\partial\omega-\breve{\omega}\hat{p}_{\breve{\omega}}\leq 0$ which is true by condition (i).

When $\frac{\partial\hat{p}_\omega}{\partial\omega}\leq 0$, $\int_{\breve{\omega}}^{\overline{\omega}}\hat{p}_\omega\partial\omega-\breve{\omega}\hat{p}_{\breve{\omega}}<\hat{p}_{\breve{\omega}}\int_{\breve{\omega}}^{\overline{\omega}}\partial\omega-\breve{\omega}\hat{p}_{\breve{\omega}}=\hat{p}_{\breve{\omega}}(\overline{\omega}-2\breve{\omega})\leq 0$ which is true by condition (ii). ■■

Proof of Proposition 3:

By Propositions 1 and 2 it is sufficient to consider securities where $s^j\geq\psi$ and $s^j(\underline{\omega}i^j-b^j)\geq\psi\underline{\omega}i^j-\psi\gamma i^j$. This proposition shows the truth telling constraint binds, $s^j=\psi$. The manager's maximization problem is:

$$\max_{i^j,b^j,s^j} U_m(c_0^j,c_1^j)$$

$$\begin{aligned} s.t.\ c_0^j &\leq w_0^m-(i^j-(1-s^j)(pi^j-p^bb^j)-p^bb^j)\\ c_1^j &\leq s^j(\omega i^j-b^j)\\ s^j &\geq \psi\\ s^j(\underline{\omega}i^j-b) &\geq \psi\underline{\omega}i^j-\psi\gamma i^j \end{aligned}$$

Recognizing that by nonsatiation the first two constraints hold with equality, the following Lagrangian follows (suppressing the notation for c_0^j and c_1^j):

$$\max_{i^j,b^j,s^j,\mu_1,\mu_2}\Upsilon=\frac{(c_0^j)^{1-\alpha}}{1-\alpha}+x\beta E\frac{(c_1^j)^{1-\alpha}}{1-\alpha}-\mu_1(\psi-s^j)-\mu_2(\psi\underline{\omega}i^j-\psi\gamma i^j-s^j(\underline{\omega}i^j-b^j)).$$

Necessary conditions imply the following FOCs

$$\frac{\partial\Upsilon}{\partial i^j}=-(1-p(1-s^j))(c_0^j)^{-\alpha}+x\beta E[s^j\omega(c_1^j)^{-\alpha}]-\mu_2(\psi\underline{\omega}-\psi\gamma-s^j\underline{\omega})=0 \tag{28}$$

and

$$\frac{\partial \Upsilon}{\partial b^j} = p^b s^j (c_0^j)^{-\alpha} - x\beta E[s^j (c_1^j)^{-\alpha}] + \mu_2 s^j = 0 \tag{29}$$

Case 1: $s^j(\underline{\omega} i^j - b^j) > \psi\underline{\omega} i^j - \psi\gamma i^j \Rightarrow \mu_2 = 0$ and the following necessary FOC

$$\begin{aligned}\frac{\partial \Upsilon}{\partial s^j} &= -(pi^j - p^b b^j)(c_0^j)^{-\alpha} + x\beta E[(\omega i^j - b^j)(c_1^j)^{-\alpha}] + \mu_1 = 0 \\ &= -(pi^j - p^b b^j)(c_0^j)^{-\alpha} + x\beta E[\omega(c_1^j)^{-\alpha}]i^j - \beta E[(c_1^j)^{-\alpha}]b^j + \mu_1\end{aligned}$$

using equations (28) and (29)

$$\begin{aligned} &= -(pi^j - p^b b^j)(c_0^j)^{-\alpha} + i^j \frac{(1-(1-s^j)p)}{s^j}(c_0^j)^{-\alpha} - p^b b^j (c_0^j)^{-\alpha} + \mu_1 \\ &= \left\{-(pi^j - p^b b^j) + i^j \frac{1-p+s^j p}{s^j} - p^b b^j\right\}(c_0^j)^{-\alpha} + \mu_1 \\ &= i^j \frac{1-p}{s^j}(c_0^j)^{-\alpha} + \mu_1 \\ &\Leftrightarrow \ \mu_1 = i^j \frac{p-1}{s^j}(c_0^j)^{-\alpha} \\ &\Rightarrow \ \mu_1 > 0 \text{ when } p > 1\end{aligned}$$

furthermore, the condition $\mu_1(\psi - s^j) = 0 \Rightarrow \psi = s^j$.

Case 2: When $s^j(\underline{\omega} i^j - b^j) = \psi\underline{\omega} i^j - \psi\gamma i^j$ the necessary FOC implies

$$\begin{aligned}\frac{\partial \Upsilon}{\partial s^j} &= -(pi^j - p^b b^j)(c_0^j)^{-\alpha} + x\beta E[(\omega i^j - b^j)(c_1^j)^{-\alpha}] + \mu_1 + \mu_2(\underline{\omega} i^j - b^j) = 0 \\ &= -(pi^j - p^b b^j)(c_0^j)^{-\alpha} + x\beta E[\omega(c_1^j)^{-\alpha}]i^j - x\beta E[(c_1^j)^{-\alpha}]b^j + \mu_1 + \mu_2(\underline{\omega} i^j - b^j)\end{aligned}$$

using equations (28) and (29),

$$\begin{aligned} = \ & -(pi^j - p^b b^j)(c_0^j)^{-\alpha} + \left\{\frac{(1-(1-s^j)p)}{s^j}(c_0^j)^{-\alpha} + \mu_2 \frac{(\psi\underline{\omega} - \psi\gamma - s^j\underline{\omega})}{s^j}\right\} i^j - (p^b(c_0^j)^{-\alpha} + \mu_2)b^j \\ & + \mu_1 + \mu_2(\underline{\omega} i^j - b^j)\end{aligned}$$

$$
\begin{aligned}
&= \left\{ -(pi^j - p^b b^j) + i^j \frac{1-p+s^j p}{s^j} - p^b b^j \right\} (c_0^j)^{-\alpha} + \mu_1 + \mu_2 (i^j \frac{(\psi \underline{\omega} - \psi\gamma - s^j \underline{\omega})}{s^j} - b^j + \underline{\omega} i^j - b^j) \\
&= i^j \frac{1-p}{s^j} (c_0^j)^{-\alpha} + \mu_1 + \mu_2 (i^j \frac{\psi\underline{\omega} - \psi\gamma}{s^j} - 2b^j) \\
&\Leftrightarrow \mu_1 = i^j \frac{p-1}{s^j} (c_0^j)^{-\alpha} - \mu_2 i^j (\frac{\psi\underline{\omega} - \psi\gamma}{s^j} + 2\frac{(\psi - s^j)\underline{\omega} - \psi\gamma}{s^j}) \\
&= i^j \frac{p-1}{s^j} (c_0^j)^{-\alpha} - \mu_2 \frac{i^j}{s^j} (3\psi\underline{\omega} - 2s^j\underline{\omega} - 3\psi\gamma) \\
&\geq i^j \frac{p-1}{s^j} (c_0^j)^{-\alpha} \text{ since } \psi \leq s^j,\ \mu_2 \geq 0 \text{ and } \underline{\omega} \leq 3\gamma \\
&\Rightarrow \mu_1 > 0 \text{ when } p > 1
\end{aligned}
$$

furthermore, the condition $\mu_1(\psi - s^j) = 0 \Rightarrow \psi = s^j$.■

2 Appendix

This appendix describes the procedure used to calibrate the Markov chain. Annual firm level COMPUSTAT data from 1974 to 1997 is used. Firms from the financial, insurance and real estate sector (SIC codes in the 6000s) are precluded. Firms are required to have all data items except for data on convertible and preferred securities, share repurchases and share issues for the entire sample period. The resulting data set contains 899 firms from which 267 are deleted due to extreme values.[33] As discussed in the text, two different calibration cases for the Markov chain are considered. In all cases equation (27) is estimated for each firm where Book Value of Assets$_{t-1}$ and Market Value of Firm$_t$+Intrst$_t$+Div$_t$ are defined using the following data:

[33] I require each firm to have (i) Book Value of Assets>0 for all periods, (ii) the Market Value of Firm must be greater than the Book Value of Assets for at least one period, and (iii) the Debt-to-Equity ratio over the period must be less than 4.

Data Definitions[34]
Equity_t=shares outstanding_t × Price per share_t
Div_t=amount of dividends paid_t
Debt_t=book value of long term and short term debt_t
Interest_t=interest expense_t
Issue_t=value of shares issued_t
NPPE_{t-1}=book value of property plant and equipment_{t-1}
PPE_{t-1}=market value of property plant and equipment_{t-1}
$\text{Conv\&Pref}_t$=value of convertible and preferred stock_t
Rep_t=value of shares repurchased_t
Book Value of Assets_{t-1}=book value of assets_{t-1}-NPPE_{t-1}+PPE_{t-1}
Market Value of Firm_t=Equity_t+Debt_t+$\text{Conv\&Pref}_t$+Intrst_t+Div_t+Rep_t-Issue_t

Dynamics of the production technology for the two classes of managers, $\omega_{z,t}$, match those of the median estimates of equation (27) for firms that pay high and low dividends (Table A2-1) and the simulated economy exhibits approximately the same standard deviation for the equity market observed in the data (Heaton and Lucas(1996) Table 3 cites 17.3%). A firm is classified as paying high dividends if it's average dividend-to-income ratio over the sample period is in the top two thirds of the sample.[35]

Table A2 – 1
Sample medians [means] and (cross sectional standard errors)

	High dividend payout firms			Low dividend payout firms		
μ	0.0547	[0.0755]	(0.3517)	0.0547	[0.1090]	(0.3400)
σ	0.3073	[0.3271]	(0.1433)	0.3843	[0.4182]	(0.1882)

The aggregate standard deviation and individual dynamics are matched by placing the following restrictions:

1. $\omega_{z,t} = \omega_{aggregate,t} \times \omega_{idiosyncratic\ z,t}$

2. $\omega_{z,t}$ must match the idiosyncratic dynamics of Table A2-2

[34] Market value of property plant and equipment is estimated using procedures developed in Salanger and Summers (1983) where capital expenditures are made at the beginning of a period. Following this logic, book value of assets are measured at the beginning of the period.

[35] Alternative classifications such as the $250 million assets (measured in 1991) cutoff used in BGG yield very similar results.

3. the standard deviation of aggregate equity returns approximately matches the data

4. investment across the classes of firms is assumed to be the same

   (only the stochastic portion of output can be calibrated)

5. $\omega_{idiosyncratic\ 1,t}$ is perfectly negatively correlated with $\omega_{idiosyncratic\ 2,t}$

6. $\omega_{aggregate,t}$ and $\omega_{idiosyncratic\ z,t}$ are independent and can each take on values $\pm\varpi_{agg}$ and $\pm\varpi_z$

These restrictions imply the following three equations with three unknowns (ϖ_{agg}, ϖ_1 and ϖ_2):

$$\begin{aligned}
\sigma_1^2 &= \frac{1}{4}\{(\varpi_{agg}-\varpi_1)^2+(\varpi_{agg}+\varpi_1)^2+(-\varpi_{agg}-\varpi_1)^2+(-\varpi_{agg}+\varpi_1)^2\} \\
\sigma_2^2 &= \frac{1}{4}\{(\varpi_{agg}+\varpi_2)^2+(\varpi_{agg}-\varpi_2)^2+(-\varpi_{agg}+\varpi_2)^2+(-\varpi_{agg}-\varpi_2)^2\} \\
\sigma_{aggregate}^2 &= \frac{1}{4}\{(\varpi_{agg}+\frac{\varpi_2-\varpi_1}{2})^2+(\varpi_{agg}+\frac{\varpi_2-\varpi_1}{2})^2+ \\
&\quad (-\varpi_{agg}+\frac{\varpi_2-\varpi_1}{2})^2+(-\varpi_{agg}+\frac{\varpi_2-\varpi_1}{2})^2\}
\end{aligned}$$

The restrictions imply $\varpi_{agg}=0.12$, $\varpi_1=0.283$, $\varpi_2=0.365$ and the Markov chain described in Table A2-2 with a transition probability matrix that is equally weighted and independent across states.

Table A2 – 2
Markov chain

State Number	ω_1	ω_2
1	$\exp(\mu+\varpi_{agg}+\varpi_1)=1.580$	$\exp(\mu+\varpi_{agg}-\varpi_2)=0.827$
2	$\exp(\mu+\varpi_{agg}-\varpi_1)=0.897$	$\exp(\mu+\varpi_{agg}+\varpi_2)=1.716$
3	$\exp(\mu-\varpi_{agg}+\varpi_1)=1.243$	$\exp(\mu-\varpi_{agg}-\varpi_2)=0.651$
4	$\exp(\mu-\varpi_{agg}-\varpi_1)=0.706$	$\exp(\mu-\varpi_{agg}+\varpi_2)=1.350$

2.1 Equilibrium Accuracy

Model equilibria in both the two period and infinite horizon setting are computed using a version of the "auctioneer" algorithm of Lucas (1994) and is similar to that found in Heaton and Lucas (1996). This algorithm searches for investment(s), stock holdings and bond holdings between all agents that clears markets in every state of the world and implies agreement on the price of investment(s) and bonds.

In the two period setting, the Euler equations of the unconstrained agents define prices of investment and bonds as functions of the exogenous and endogenous variables. A fixed point to the equations is found by iterating until the difference in solution for each asset price is less than 10^{-10}.

In the infinite horizon setting, for a given level of investment and allocation of securities, the Euler equations of the unconstrained agents define functional equations in the prices of investment and bonds as functions of the exogenous and endogenous state variables (the distribution of wealth across managers). These equations are estimated over a grid of 30 equally spaced points for managers of class 1's wealth and managers of class 2's wealth (both for the range 0.003 to 0.15). The resulting discrete state space is $30 \times 30 \times 4$ since the exogenous state variables take on 4 different values. A fixed point to the equations is found by iterating until there is less than a 0.05 percent difference in the (uniformly weighted) average asset price solution across the grid space. Owing to the discrete approximation, it is not possible to set the prices quoted by the three agents exactly equal to one another.

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