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Measuring Agency Costs over the Business Cycle*

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March 30, 2017

ABSTRACT

This paper investigates the joint effects of manager-shareholder agency conflicts and macroeconomic risk on corporate policies and firm value. I first derive the implications of a structural model of a firm with assets in place and an investment opportunity, run by a self-interested manager who captures part of the firm's net income as private benefits. The model implies that dynamic aggregate agency costs are driven by firms in the upper half of the distribution of private benefits. The managers of those firms capture 0.8% of firms' net income on average, thereby decreasing aggregate firm value by 1.7%. These agency costs are procyclical (1.9% in booms and 1.4% in recessions) because managerial underleverage decreases default costs particularly in recessions. Further, the model can explain empirical regularities, including the joint level and cyclicality of leverage.

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1. Introduction

The agency costs of corporate managers acting in their own interest (rather than that of shareholders) have received much attention from financial economists since the seminal papers by Jensen and Meckling (1976) and Jensen (1986). In particular, manager-shareholder agency conflicts constitute a crucial determinant of financing and investment policies in the cross section (Smith and Watts, 1992, Rajan and Zingales, 1995). A separate, and equally important, determinant of corporate policy choices is the state of the macroeconomy (Hackbarth, Miao, and Morellec, 2006, Bhamra, Kuehn, and Strebulaev, 2010a, Halling, Yu, and Zechner, 2016). Despite the striking importance of both manager-shareholder agency conflicts and macroeconomic conditions for corporate policies, little is known about how these interact. This paper contributes to the literature by analyzing the joint impact of manager-shareholder agency conflicts and macroeconomic risk on corporate policy choices as well as agency costs for heterogeneous firms.

Specifically, I show that macroeconomic conditions are a key determinant of agency costs of managerial discretion and that the dynamics of these agency costs are procyclical. This result is driven by the following interaction effects between manager-shareholder agency conflicts and macroeconomic risk: On the one hand, managerial discretion over financing choices leads to a debt level lower than the optimal one ("underleverage," Jensen, 1986, Morellec, 2004). Underleverage decreases the expected default costs at the expense of a loss in tax shield. On the other hand, when the economy switches from a boom to a recession, firm value declines. One effect leading to this decline is that a firm's expected default costs increase, as both the distance to default and the recovery rate decrease. Importantly, this effect is weaker for underlevered firms because of their relatively smaller default risk. Combining these two insights, manager-shareholder agency conflicts alleviate the drop in firm value upon a regime switch to a recession by way of underleverage. Thus, agency costs of managerial discretion, driven by underleverage costs, are lower in recessions, when distances to default are smaller.

While qualitative implications of agency conflicts have been analyzed extensively, the quantification of agency costs has received less attention. Earlier contributions on quantifications in dynamic continuous-time models include Mello and Parsons (1992), Mauer and Ott (2000), and Morellec (2004). These papers analyze agency conflicts due to risk-shifting (Mello and Parsons, 1992), underinvestment (Mauer and Ott, 2000), and managerial discretion (Morellec, 2004). More recently, Parrino, Poteshman, and Weisbach (2005) measure agency costs of managerial risk aversion and show that these agency costs vary according to firm and project characteristics, whereas Habib and Ljungqvist (2005) use a stochastic frontier approach to empirically quantify the loss in Tobin's q due to manager-shareholder agency conflicts. My paper adds to this growing literature by measuring the agency costs of managerial discretion over the business cycle. I quantify these agency costs not only for a representative firm, but also for a cross section of firms.

To assess the magnitude of the agency costs of managerial discretion, I develop a structural tradeoff model with macroeconomic risk, explicitly taking into account manager-shareholder agency conflicts.[1] In the model, firms consists of assets in place and an investment opportunity. Assets in place generate cash flows that are driven not only by an idiosyncratic component, but also by an aggregate shock that reflects the state of the economy. The stochastic discount factor, which can be derived endogenously in a

[1]Existing structural tradeoff models include, to my knowledge, only one of these two crucial features. For models on manager-shareholder agency conflicts, but without macroeconomic conditions, see, for example, Stulz (1990), John and John (1993), Hart and Moore (1995), Zwiebel (1996), Morellec (2004), Malmendier and Tate (2005), Hackbarth (2008), as well as Lambrecht and Myers (forthcoming). Corporate models with macroeconomic conditions, but not taking into account manager-shareholder agency conflicts include Hackbarth, Miao, and Morellec (2006), Bhamra, Kuehn, and Strebulaev (2010a), Bhamra, Kuehn, and Strebulaev (2010b), Chen (2010), and Arnold, Wagner, and Westermann (2013).

consumption-based framework with a representative agent, prices both firm-specific shocks and economy-wide shocks. Each firm is run by a self-interested manager who controls financing and investment decisions. Agency conflicts arise because managers capture part of the firm's net income as private benefits. Hence, managerial investment and financing choices additionally reflect the disciplining effect of debt on the manager, and, therefore, differ from optimal policies as determined by the standard tradeoff between the tax benefits of debt and costly default. In this framework, I analyze the impact on firm value and the resulting agency costs in the dynamics and at issuance.

Managerial policies and hence, agency costs, depend explicitly on both macroeconomic conditions and the investment opportunity. Agency costs are reported as the percentage loss in firm value compared to a firm in which the manager does not derive private benefits of control. Hence, agency costs comprise both the direct costs of private benefits and the costs of managerial discretion. The costs of private benefits are defined as the expected value of the diverted funds; the costs of managerial discretion represent the loss in firm value due to manager-selected suboptimal investment and financing policies. I show that the agency costs of managerial discretion are quantitatively important. For instance, they correspond to more than half of the total agency costs in the baseline case. Further, agency costs are increasing in the importance of a firm's investment opportunity. At issuance in a boom [recession], agency costs in the baseline firm rise from 1.20% [1.17%] to 1.67% [1.64%] and to 1.81% [2.06%] as Tobin's q increases from about 1.15 to 1.55 and to 1.90, respectively. Finally, agency costs at issuance are roughly acyclical for low and moderate values of q, but slightly countercyclical for high values of q. This countercyclicality is primarily due to higher costs of overinvestment in recessions for high-q firms.

Agency costs vary in a non-linear way with firm characteristics such as investment opportunities and leverage. Hence, the agency costs of a baseline firm do not necessarily reflect average agency costs in the economy. To address this issue, I use data on firm fundamentals and executive compensation to match the empirical cross section with model-implied firms. The resulting sample closely reflects the empirical sample in terms of ownership structure, leverage ratios, and investment opportunities. The average implied private benefits of control amount to 0.43% of the firm's net income. Private benefits vary substantially across firms, ranging between 0% and more than 10%. The distribution of the corresponding parameter is right skewed. In particular, firms with private benefits below the median typically exhibit agency costs close to zero. For firms with private benefits above median, the average implied private benefits correspond to 0.81% of net income.

To investigate the cyclicality of agency costs over time, I simulate a dynamic aggregate economy based on the cross section of firms. Aggregate agency costs are defined as the percentage loss in aggregate firm value due to private benefits of control. In the full cross section, aggregate agency costs correspond to 0.87% in booms and 0.48% in recession, with an overall average of 0.72%. Quantitatively, these aggregate agency costs are driven by firms in the upper half of the distribution of private benefits. Agency costs of firms in the upper half amount to 1.70% on average with a strong procyclicality of 1.89% in booms and 1.37% in recessions. The strong procyclicality emphasizes that the little researched question of how macroeconomic conditions impact agency costs is indeed a first-order effect. Interestingly, for firms close to default, the underleverage effect dominates and the overall effect of manager-shareholder agency conflicts on firm value is positive due to reduced default risk. Hence, ex-post, firms potentially enjoy "agency benefits." Similarly, Hackbarth (2008) finds a possible positive role of manager-shareholder agency conflicts for single firms arising from managerial traits. Additionally, I show that agency benefits may persist even in the aggregate economy, typically during prolonged recessions.

The relevance of manager-shareholder agency conflicts depends not only on the magnitude of the resulting agency costs, but also on their ability to explain empirical regularities. Morellec (2004) shows that manager-shareholder agency conflicts can explain the conservative debt levels observed in practice (Graham, 2000). My model not only addresses the underleverage puzzle, but also simultaneously explains the countercyclicality of leverage as empirically documented by Korajczyk and Levy (2003) and Halling, Yu, and Zechner (2016). The model also helps explaining the relatively low portion of debt financing of investments as documented by Elsas, Flannery, and Garfinkel (2013). Finally, the model is consistent with stylized facts concerning the relation between leverage and growth opportunities, the cyclicality of credit spreads, and the procyclicality of investment.

Literature review. This paper relates to different strands of literature. First, it belongs to the field of research that investigates manager-shareholder conflicts, their impact on firms' financing and investment decisions, and the implications for the value of the firm.[2] Dynamic capital structure under managerial entrenchment is addressed by Zwiebel (1996). Morellec (2004) shows that an empire-building manager has an incentive to choose low debt levels. Conversely, in a real options model with investment and disinvestment, Lambrecht and Myers (2008) find that firms with weaker investor protection choose higher debt levels. Empirically, Agrawal and Mandelker (1987) document a positive relationship between managerial security holdings and changes in financial leverage. The authors conclude that executive security holdings reduce agency conflicts, a feature that is captured in my model as well. Similarly, Amihud, Lev, and Travlos (1990) present evidence consistent with the hypothesis that managers value control. Jung, Kim, and Stulz (1996) provide

[2]In addition to those cited above, important theoretical contributions include Myers (1977), Harris and Raviv (1990), Stulz (1990), Chang (1993), John and John (1993), and Hart and Moore (1995). For a survey on early models of agency problems as well as early empirical evidence, see Harris and Raviv (1991).

strong support for the agency model with respect to a firm's financing decisions. Furthermore, Berger, Ofek, and Yermack (1997) document that entrenched managers choose lower debt levels, a finding that is in line with the results in my model. On the contrary, the empirical study by Graham and Harvey (2001) finds only little evidence of relations between managerial discretion and free cash flow or asset substitution.

The closest paper to mine is Morellec, Nikolov, and Schürhoff (2012), which uses a dynamic tradeoff model with manager-shareholder agency conflicts to investigate the impact on the dynamics of leverage. My paper complements their work by introducing macroeconomic risk and investment. These model features allow me to analyze the dynamics of agency costs in different economic regimes and to address cross sectional features of agency costs. Two related papers by Levy and Hennessy (2007) and Chen and Manso (forthcoming) also investigate agency costs and macroeconomic regimes. Levy and Hennessy (2007) propose a general equilibrium model in discrete time to analyze the relation between financial flexibility and cyclical variation in leverage. In their model, single-period financial contracts are issued and the authors show that no managerial diversion takes place in equilibrium. My paper differs in that it considers long-term financial contracts and investigates agency costs over the business cycle stemming from exogenously given private benefits. Further, Chen and Manso (forthcoming) find that the agency costs of debt overhang are substantially higher in the presence of macroeconomic regimes, and they quantify the costs of debt overhang depending on the value of a firm's growth option. My paper focuses on the agency costs of managerial discretion based on a free cash flow problem, and not exclusively on debt overhang. Finally, Glover and Levine (2015) use a neoclassical model to analyze the impact of manager-shareholder agency conflicts on investment decisions. In contrast to my paper, the authors restrict the time horizon of managers to one period and do not focus on capital structure decisions. My paper constitutes a relevant complement because manager-selected debt levels result in substantial agency costs and exhibit important interaction effects with macroeconomic conditions.

Second, this paper relates to the macroeconomic literature that investigates agency costs defined as the loss in aggregate productivity. Traditionally, this literature emphasizes countercyclical agency costs (see, for example, Bernanke and Gertler, 1986, or Eisfeldt and Rampini, 2008). In my paper, the focus is on agency costs measured as the loss in firm value due to private benefits of control and the resulting suboptimal managerial behavior. In particular, these agency costs are fundamentally different from agency costs capturing a loss in aggregate productivity, and are, hence, not directly comparable.

Third, this study belongs to the field of structural corporate finance. In detail, the proposed model is in the spirit of Mello and Parsons (1992), as extended by Hackbarth, Miao, and Morellec (2006) for macroeconomic regimes. Manager-shareholder agency conflicts are introduced by way of assuming private benefits, as in La Porta, de Silanes, Shleifer, and Vishny (2002) and Morellec, Nikolov, and Schürhoff (2012).

2. The model

I consider agency conflicts between managers and shareholders within the framework of a structural model for financing and investment decisions of firms with assets in place and an investment opportunity. The economy is subject to intertemporal macroeconomic shocks. The structural tradeoff model is similar to that in Arnold, Wagner, and Westermann (2013); additionally, agency conflicts are introduced as in Morellec, Nikolov, and Schürhoff (2012). Assets are continuously traded in complete and arbitrage-free markets. I first describe the economy, then the firms and finally, I address manager-shareholder agency conflicts.

2.1. Assumptions

The economy. The economy includes a large number N of infinitely lived firms, a large number of identical infinitely lived households, and a government collecting taxes. Macroeconomic uncertainty is modeled by a time-homogeneous Markov chain I_t with state space $\{B, R\}$, in which the two states correspond to boom (B) and recession (R), and $\lambda_i \in (0,1)$, $i = B, R$, denotes the rate of leaving state i. The realization of the Markov chain I_t at time t, i.e., boom or recession, constitutes an economy-wide state variable at time t. As in Hackbarth, Miao, and Morellec (2006), I assume that the regime boom is more persistent than the regime recession, i.e., $\lambda_B < \lambda_R$.[3]

Following Chen and Manso (forthcoming), I specify an exogenous stochastic discount factor, which is determined by the regime-dependent risk free rate and the risk prices for firm-level shocks and regime shifts, respectively. The stochastic discount factor implies the risk-neutral probability measure $\mathbb{Q}$ that is used to price assets in this economy. Chen (2010) and Bhamra, Kuehn, and Strebulaev (2010b) show that this pricing kernel is the solution of a representative agent problem, in which the agent has the continuous-time analog of Epstein-Zin-Weil preferences (Epstein and Zin, 1989 and Weil, 1990), given that the expected growth rate and volatility of aggregate output is regime-dependent. Technical details of the derivation and the resulting stochastic discount factor can be found in Appendix 1.[4]

[3] The following properties hold: The probability that the regime switches from state i to state j during an infinitesimal time interval $\mathrm{d}t$ corresponds to $\lambda_i \mathrm{d}t$, and the probability that the duration of state i is larger than $t \geq 0$ is given by $e^{-\lambda_i t}$. The expected duration of regime i is $\frac{1}{\lambda_i}$, and the expected fraction of time spent in regime i is calculated by $\frac{\lambda_j}{\lambda_i + \lambda_j}$.

[4] The main limitations of this approach in my framework are as follows. First, I assume that aggregate output is given exogenously, in particular, I abstract away from the impacts of firm-specific default and investment on the aggregate output. This assumption may be justified by considering a large number of firms in the economy, such that each firm's contribution to aggregate output is minor. Second, the model ignores the impact of agency conflicts on the state-price density. While this feedback effect is potentially interesting, solving the corresponding model is beyond the scope of this work.

The firm. A firm f consists of assets in place and an investment opportunity. At each time, assets in place generate a nominal stream of operating cash flow X_t^f, which constitutes the firm-specific state variable in the model.[5] For the sake of a parsimonious exposition, I suppress the firm dependence on the cash flow. The cash flow X_t of the firm follows a regime dependent Brownian motion under the physical measure $\mathbb{P}$,

$$\frac{\mathrm{d}X_t}{X_t} = \mu_i \mathrm{d}t + \sigma_i \mathrm{d}Z_t, \tag{1}$$

in which μ_i and σ_i are the regime-dependent drift and volatility, respectively, and Z_t is a Brownian motion under $\mathbb{P}$. As in Chen (2010), the drift and the volatility of the nominal cash flow process are determined by the dynamics of the real cash flow process and a stochastic price index. The real cash flow process, in turn, depends on the realization of aggregate consumption and a firm specific idiosyncratic component. Details regarding the setup, the derivation of the cash flow dynamics, and the derivation of risk neutral parameters are presented in Appendix 1. Because the part of volatility that is connected to the evolution of aggregate consumption is smaller in booms than in recessions (Ang and Bekaert, 2004), I obtain that the total volatility, σ_i, is also smaller in booms, i.e., $\sigma_B < \sigma_R$. Following Bhamra, Kuehn, and Strebulaev (2010b), I assume that the regime-dependent drift is higher in booms than in recessions, i.e., $\mu_B > \mu_R$. Formally, the state variable in the model is given by the vector $[X_t, I_t]$, in which the first component corresponds to the firm-specific cash flow level realization, and the second component constitutes the economy-wide realization of the regime.

An investment opportunity of the firm is modeled as an American call option on the cash flows. Specifically, if the firm decides to invest at time $\bar{t}$, it pays exercise costs K

[5] The cash flows X_t^f contain both a systematic and an idiosyncratic component, see Appendix 1.

and achieves an additional future cash flow of $(s-1)\,X_t$ for some firm-specific factor $s>1$ for all future times $t \geq \bar{t}$. This model specification is a simplification of real firms in that the firm's investment opportunities are assumed to be concentrated in only one growth option, whereas actual firms can have several investment opportunities. After investment, the firm consists of only invested assets. The investment decision is irreversible. As in Morellec and Wang (2004), financing of the exercise price K takes place by issuing a mix of equity and debt. Fixed financing of the investment opportunity (e.g., debt or equity only) introduces distortions in investment policies. To obtain a closed-form solution of the model, I assume that at the time of investment, first, debt is called at par value P and second, new debt with coupon c_n is issued.[6] This setup is similar to Goldstein, Ju, and Leland (2001), Chen (2010), and Morellec, Valta, and Zhdanov (2015). Further, Hackbarth and Mauer (2012) show that it is, in general, suboptimal to separate investment and financing decisions. Dudley (2012) provides empirical evidence that firms adjust their capital structure in periods of investment.

The firm is financed by issuing equity and debt. To facilitate the analysis, I consider the case of infinite maturity debt. After debt has been issued, a firm pays a total coupon c_o to debt holders until the firm defaults or invests. Subsequently to paying the coupon, the firm pays corporate taxes at a constant rate τ, under the assumption of full loss offset corporate taxation. Hence, after paying debt service and taxes, net income is given by $(1-\tau)\,(X-c)$, in which $c=c_o$ (before investment) or $c=c_n$ (after investment).[7] Following the standard in the literature, I assume that in case the required debt service exceeds the cash flows, shareholders may inject funds to finance the coupons. Alternatively, shareholders have the possibility to default on their debt obligations (Leland, 1994). If shareholders decide to

[6] The firm's motivation may be justified by existing debt covenants concerning investment or financing.

[7] In the model, free cash flow to equity differs from net income only at the time of investment, when investment costs and debt repayment occur.

default, the firm is immediately liquidated and bondholders enjoy absolute priority of debt claims, resulting in a payment worth the unlevered asset value times the regime-dependent recovery rate $\alpha_i \in (0,1]$. Following Acharya, Bharath, and Srinivasan (2007), recovery rates are assumed to be lower in recessions than in booms, i.e., $\alpha_R < \alpha_B$. This setup implies that default costs are a regime-dependent fraction $1-\alpha_i$ of the unlevered value of the assets in place and the full value of the investment opportunity. While tax benefits encourage debt financing by way of shielding part of the firm's cash flow from taxation, costly default reduces the incentive for issuing debt.

The manager. Agency conflicts are introduced by assuming that a firm is run by a self-interested manager. The manager captures a fraction ϕ of net income as private benefits (as in La Porta, de Silanes, Shleifer, and Vishny, 2002, Lambrecht and Myers, 2008, Albuquerque and Wang, 2008, and Morellec, Nikolov, and Schürhoff, 2012). Examples for managerial private benefits include perquisites, excessive salary, or employing relatives and friends who are not qualified.[8] The fraction of net income that the manager appropriates, ϕ, is exogenous and captures the severity of manager-shareholder agency conflicts. Because the manager receives a fraction ϕ of net income, i.e., $\phi(1-\tau)(X_t-c_o)$, equityholders receive only a fraction $(1-\phi)$ of net income as free cash flows to equity, i.e., $(1-\phi)(1-\tau)(X_t-c_o)$. Further, as in Morellec, Nikolov, and Schürhoff (2012) and Nikolov and Whited (2014), the manager owns a fraction $\psi > 0$ of the firm's equity. Hence, the total cash flow to the manager is given by the sum of his equity share and the value of managerial private benefits, i.e., $\psi(1-\phi)(1-\tau)(X_t-c_o)+\phi(1-\tau)(X_t-c_o) = (\psi-\psi\phi+\phi)(1-\tau)(X_t-c_o)$. The larger the private benefits ϕ, the more important is the agency conflict; the larger the equity share ψ, the smaller is the agency conflict. In

[8]For evidence of private benefits of control, see Barclay and Holderness (1989) or La Porta, de Silanes, Shleifer, and Vishny (2000). For a catalog of legal and illegal forms of managerial tunneling, see Johnson, La Porta, de Silanes, and Shleifer (2000).

the model, the fraction ψ of managerial ownership represents the managerial incentive alignment with shareholders. As in Nikolov and Whited (2014) and Morellec, Nikolov, and Schürhoff (2012), this setup of private benefits and compensation aims to capture agency problems in reality to analyze their implications. The setup is not suitable for explaining private benefits and the choice of managerial compensation contracts. In the analysis, I consider a cross section of model-implied firms that closely reflects the empirical cross section and therefore exhibits firm-specific values of ϕ and ψ. Subsequently, I analyze a baseline firm with agency conflicts to investigate the magnitude of agency costs at issuance.

In the model, agency costs arise due the allocation of control rights within the firm. Specifically, I presume that the manager controls investment and capital structure decisions, whereas shareholders decide about default.[9,10] Assuming managerial control rights on investment policies follows, e.g., Zwiebel (1996), Morellec (2004) or Nikolov and Whited (2014). Managers' control rights on capital structure decisions are in line with Morellec (2004), Hackbarth (2008) and Morellec, Nikolov, and Schürhoff (2012). When making financial and investment decisions, the manager acts in his own interest to maximize the present value of total cash flows from managerial rents and equity stake. In particular, at issuance, the manager chooses the coupon that maximizes his objective function, anticipating his own investment policy, equityholders' default policy, as well as his preferred financing policy at the time of investment. This specification of the model entails two sources of agency costs, namely, the direct value loss due to private benefits and the agency costs of

[9] Alternatively, it could be assumed that the manager controls the default decision as in Lambrecht and Myers (2008). The manager-selected default boundaries are typically close to the shareholder-selected default boundaries, such that the impact on the valuation and results is minor.

[10] Since the manager controls the investment decision, this setup implies that the manager can issue equity to finance a suboptimal investment decision from the point of view of shareholders. To justify this assumption, I suppose that it is costly for shareholders to act collectively and hence, they cannot directly influence decisions taken by managers (Hackbarth, 2008). Alternatively, Morellec (2004) takes into account the market for corporate takeover, presuming that the incumbent manager has specific skills in administering the firm's assets and that control challenges are costly. As a consequence, the manager has some discretion over policy choices.

managerial discretion. The agency costs of managerial discretion arise due to the choice of suboptimal investment and financing policies selected by the self-interested manager.

2.2. Model solution

The model is solved by backward induction. I begin with the calculation of the value functions after investment. Subsequently, the value functions prior to investment and the capital structure chosen by the manager are presented. Finally, I define agency costs.

Value functions and capital structure after investment. The value functions of interest are corporate debt, $\hat{d}_i$, equity, $\hat{e}_i$, and the manager's claim to cash flows, $\hat{m}_i$, in booms and recessions. Suppose that $\hat{D}_B, \hat{D}_R$ are the default boundaries after investment in booms and recessions, respectively. c_n^* is the manager-selected coupon after investment, and its dependence on the cash flow at issuance, X, is omitted for brevity. I consider the case in which the default boundary in booms is lower than the one in recessions, i.e., $\hat{D}_B < \hat{D}_R$.[11] The derivation of the value functions after investment follows the standard approach for the valuation of corporate securities in a regime-switching model as in Hackbarth, Miao, and Morellec (2006). The value functions are presented in the Internet Appendix 1. Notably, the solution exhibits a scaling property: conditional on the current state, the manager-selected coupon, the default boundaries, the values of debt and equity, the value of the firm's net income, and the manager's claim to cash flows are all homogenous of degree one in cash flows. This scaling property is based on Fischer, Heinkel, and Zechner (1989) and Goldstein, Ju, and Leland (2001) for the case of only one regime, and first extended by Hackbarth, Miao, and Morellec (2006) for regime-switching models.

[11]Optimal default boundaries for reasonable parameter values satisfy this inequality (Hackbarth, Miao, and Morellec, 2006, Bhamra, Kuehn, and Strebulaev, 2010a, Chen, 2010, and Arnold, Wagner, and Westermann, 2013).

Value functions, corporate policies, and capital structure before investment. Next, I show how to derive the value functions for equity before investment in booms and recessions, denoted by $e_i(X)$. The valuation of the firm's net income $n_i(X)$ (required to calculate the value of the manager's claim to cash flows) and the valuation of corporate debt $d_i(X)$ are similar and are presented in Appendix 2, Proposition 1 (iii) and (i), respectively.

Consider a set of default and investment boundaries, D_B, D_R, X_B, and X_R. I present the case in which default and investment boundaries are lower in booms than in recessions ($D_B < D_R$, $X_B < X_R$). Optimal policies fulfill these inequalities for reasonable parameter values.[12] Define $c^*_{n,i}$ as the manager-selected coupon at the investment boundary X_i.

The value of equity. Equity requires an instantaneous return equal to the nominal risk-free rate r^n_i. An application of Ito's lemma with regime switches shows that the Hamilton-Jacobi-Bellman equation for equity is:

For $0 \leq X \leq D_B$:

$$\begin{cases} e_B(X) = 0 \\ e_R(X) = 0. \end{cases} \tag{2}$$

For $D_B < X \leq D_R$:

$$\begin{cases} r^n_B e_B(X) = (1-\phi)(1-\tau)(X-c_o) + \tilde{\mu}_B X e'_B(X) + \frac{1}{2}\tilde{\sigma}^2_B X^2 e''_B(X) \\ \qquad\qquad + \tilde{\lambda}_B(0 - e_B(X)) \\ e_R(X) = 0. \end{cases} \tag{3}$$

[12] Chen and Manso (forthcoming) and Arnold, Wagner, and Westermann (2013) also find these relations to hold.

For $D_R < X < X_B$:

$$\begin{cases} r_B^n e_B(X) &= (1-\phi)(1-\tau)(X-c_o) + \tilde{\mu}_B X e_B'(X) + \frac{1}{2}\tilde{\sigma}_B^2 X^2 e_B''(X) \\ & \quad + \tilde{\lambda}_B (e_R(X) - e_B(X)) \\ r_R^n e_R(X) &= (1-\phi)(1-\tau)(X-c_o) + \tilde{\mu}_R X e_R'(X) + \frac{1}{2}\tilde{\sigma}_R^2 X^2 e_R''(X) \\ & \quad + \tilde{\lambda}_R (e_B(X) - e_R(X)). \end{cases} \tag{4}$$

For $X_B \leq X < X_R$:

$$\begin{cases} e_B(X) &= \hat{e}_B\left(sX; c_{n,B}^*\right) - K - P + \hat{d}_B\left(sX; c_{n,B}^*\right) \\ r_R^n e_R(X) &= (1-\phi)(1-\tau)(X-c_o) + \tilde{\mu}_R X e_R'(X) + \frac{1}{2}\tilde{\sigma}_R^2 X^2 e_R''(X) \\ & \quad + \tilde{\lambda}_R \left(\hat{e}_B(sX; c_n^*) - K - P + \hat{d}_B(sX; c_n^*) - e_R(X)\right). \end{cases} \tag{5}$$

For $X \geq X_R$:

$$\begin{cases} e_B(X) &= \hat{e}_B\left(sX; c_{n,B}^*\right) - K - P + \hat{d}_B\left(sX; c_{n,B}^*\right) \\ e_R(X) &= \hat{e}_R\left(sX; c_{n,R}^*\right) - K - P + \hat{d}_R\left(sX; c_{n,R}^*\right). \end{cases} \tag{6}$$

This system of ordinary differential equations (ODEs) is intuitive. Whenever the firm defaults, equityholders receive zero due to absolute priority of debt claims (Eqs. (2), second line of Eqs. (3)). As long as the firm takes no action (first line of Eqs. (3), Eqs. (4), first line of Eqs. (5)), the left-hand side of the equations shows the required rate of return. The right-hand side corresponds to the expected rate of return, consisting of the cash flow to equity and the expected change in the value of equity as given by Ito's lemma. The final term captures the change in the value of equity in case of a regime switch. When investment takes place (first line of Eqs. (5) and Eqs. (6)), equity value is given by the value of equity after investment, $\hat{e}_i(sX; c_n^*)$, less the investment costs, K, and the principal, P, plus the issue proceeds from new debt, $\hat{d}_i(sX; c_n^*)$. The boundary conditions read:

$$\lim_{X \searrow D_R} e_B(X) = \lim_{X \nearrow D_R} e_B(X), \qquad \lim_{X \searrow D_R} e'_B(X) = \lim_{X \nearrow D_R} e'_B(X), \tag{7}$$

$$\lim_{X \searrow X_B} e_R(X) = \lim_{X \nearrow X_B} e_R(X), \qquad \lim_{X \searrow X_B} e'_R(X) = \lim_{X \nearrow X_B} e'_R(X), \tag{8}$$

$$e_B(D_B) = 0, \qquad e_B(X_B) = \hat{e}_B\left(sX_B; c_{n,B}^*\right) - K - P + \hat{d}_B\left(sX_B; c_{n,B}^*\right), \tag{9}$$

$$e_R(D_R) = 0, \qquad e_R(X_R) = \hat{e}_B\left(sX_R; c_{n,R}^*\right) - K - P + \hat{d}_R\left(sX_R; c_{n,R}^*\right). \tag{10}$$

Eqs. (7) [Eqs. (8)] correspond to the value-matching and smoothness conditions for the equity value function in a boom [recession] at the default [investment] boundary in a recession [boom]. Eqs. (9) [Eqs. (10)] present the value-matching conditions in a boom [recession] at the default and investment threshold. The solution to the system (2)–(6) subject to its boundary conditions (7)–(10) is given in Appendix 2, Proposition 1 (ii).

The valuation of a claim to the firm's net income. For the firm's net income, the system of ODEs and its boundary conditions are similar to the one for equity. The main difference is that upon investment, equity holders are concerned with the financing of the investment as well as the principal payment to existing debt holders, whereas these actions do not impact the firm's net income. Therefore, upon investment, the value of a claim to the firm's net income is given as the value of a claim to the firm's net income after investment. The corresponding system of ODEs, its boundary conditions, and the resulting value functions are presented in Appendix 2, Proposition 1 (iii).

The manager's claim to cash flows. Because the manager owns a fraction ψ of equity and diverts a fraction ϕ of net income, his claim to cash flows $m_i(X)$ is given as

$$m_i(X) = \psi e_i(X) + \phi n_i(X). \tag{11}$$

Default, investment and financing policies. To determine the default and investment policies, I first derive the value matching conditions of the value of the manager's claim to cash flows. I denote shareholders' default policy simultaneously chosen with the manager's investment boundaries by D_i^*, and the investment policy chosen by the manager by X_i^*. Simultaneously, the manager and shareholders solve, respectively,

$$D_i^* = \arg\max_{D_i} e_i(X), \qquad X_i^* = \arg\max_{X_i} m_i(X). \tag{12}$$

I assume that the solutions to Eqs. (12) exist and are unique, and verify this conjecture in the quantitative analysis and in the simulations. The smooth-pasting conditions that determine these policies are given by the derivatives of the corresponding value matching conditions. The value matching conditions of equity at default are stated in Eqs. (9)–(10). The value matching conditions of the manager's expected cash flow at investment are implied by the value-matching conditions of both equity (cf. Eqs. (9)–(10)) and the firm's net income (cf. Appendix 2, Eqs. (74)–(77)), and read

$$\begin{aligned} m_i(X_i) &= \psi\left(\hat{e}_i\left(sX_i; c_{n,i}^*\right) - K - P + \hat{d}_i\left(sX_i; c_{n,i}^*\right)\right) + \phi\hat{n}_i\left(sX_i; c_{n,i}^*\right) && (13)\\ &= \hat{m}_i\left(sX_i; c_{n,i}^*\right) + \psi\hat{d}_i\left(sX_i; c_{n,i}^*\right) - \psi(K+P). && (14)\end{aligned}$$

The four optimality conditions (Eqs. (12)) translate into smooth-pasting conditions at the respective boundaries:

$$\begin{cases} e_B'(D_B^*) = 0 \\ e_R'(D_R^*) = 0 \\ m_B'(X_B^*) = \hat{m}_B'\left(sX_B^*; c_{n,B}^*\right) + \psi\hat{d}_B'\left(sX_B^*; c_{n,B}^*\right) \\ m_R'(X_R^*) = \hat{m}_R'\left(sX_B^*; c_{n,R}^*\right) + \psi\hat{d}_R'\left(sX_R^*; c_{n,R}^*\right), \end{cases} \tag{15}$$

in which derivatives are taken with respect to the first argument. Next, the manager determines his preferred coupon level by maximizing the value of his objective function ex-ante. A fraction ψ of the issue proceeds of debt accrues to the manager due to his equity share. Hence, the manager solves:

$$c_o^* = \arg\max_{c_o} \left(m_i \left(X; c_o \right) + \psi d_i \left(X; c_o \right) \right). \tag{16}$$

The problem of the manager thus consists of solving Eq. (16) subject to Eqs. (12). A closed-form solution does not exist and standard numerical procedures are used.

2.3. Agency costs

In the absence of private benefits, i.e., $\phi = 0$, the manager's only source of income is his equity share. Therefore, the manager's and equityholders' incentives are perfectly aligned and manager-shareholder agency conflicts do not exist. Thus, I consider the case without private benefits as the benchmark and define agency costs AC_i as the loss in firm value due to private benefits expressed as the percentage of the firm value without private benefits:

$$AC_i \left(X \right) = 100 \left(1 - \frac{v_i^* \left(X \left| \phi \right. \right)}{v_i \left(X \left| \phi = 0 \right. \right)} \right). \tag{17}$$

$v_i^* \left(X \left| \phi \right. \right)$ denotes the firm value given private benefits ϕ and manager-selected financing and investment policies. $v_i \left(X \left| \phi = 0 \right. \right)$ is the firm value without agency conflicts. Agency costs in the model stem from two sources. First, private benefits directly reduce firm value by the expected value of diverted funds. These costs are denoted by PB_i and are defined as the value of diverted funds, expressed as a fraction of firm value without agency conflicts:

$$PB_i(X) = 100 \frac{\phi n_i^*(X|\phi)}{v_i(X|\phi = 0)}. \tag{18}$$

$n_i^*(X|\phi)$ is the value of a claim to the firm's net income given private benefits ϕ and manager-selected financing and investment policies. Second, the agency costs of managerial discretion, AC_i^{MD}, are defined as the total value loss less the direct costs of private benefits:

$$AC_i^{MD}(X) = AC_i(X) - PB_i(X). \tag{19}$$

Agency costs of managerial discretion arise due to the separation of ownership and control. Specifically, manager-selected investment and financing policies differ from the policies that maximize equity value.[13] This deviation from equity holders' preferred policies entails a further loss in firm value.

The agency costs of managerial discretion can further be decomposed into costs due to suboptimal initial leverage, costs due to investment distortions, and costs due to suboptimal financing of the investment costs. The disciplining effect of debt leads to managerial underleverage (Jensen, 1986); in my model, this disciplining effect of debt gives rise to underleverage both initially and upon investment. Empirical evidence of underleverage can be found in Berger, Ofek, and Yermack (1997), while further theoretical work includes Morellec (2004), Morellec and Wang (2004), and Morellec, Nikolov, and Schürhoff (2012). Further, private benefits incentivize the manager to invest earlier (overinvestment). The reason is that the manager benefits from the increased cash flows after investment but does

[13] Equity-value maximizing policies are typically similar (but not equal) to firm-value maximizing policies. As a result, the agency costs of debt are negligible (cf. Childs, Mauer, and Ott, 2005).

not fully internalize the costs. In fact, he contributes to the investment costs and debt repayment only via his equity share. Managerial overinvestment is in line with Morellec (2004) or Hackbarth (2008). Thus, agency costs of managerial discretion comprise costs due to underleverage as well as overinvestment.

In the dynamic economy, I define aggregate agency costs $AC_{i,t}^{agg}$ at time t as the total loss in firm value due to private benefits:[14]

$$AC_{i,t}^{agg} = 100\left(1 - \frac{\sum_f v_i^*\left(X_t^f\,|\phi^f\right)}{\sum_f v_i\left(X_t^f\,|\phi = 0\right)}\right), \tag{20}$$

in which the nominator of the fraction is the sum of all firm values and the denominator corresponds to the sum of all firm values of hypothetical firms without private benefits. This definition extends the one for single-firm agency costs (Eq. (17)).

3. Aggregate dynamics of agency costs

I first present the calibration and explain how I construct the cross section of model-implied firms. Subsequently, dynamic aggregate agency costs and their cyclicality are analyzed. Finally, I discuss the model's implications for leverage, investment, and default.

3.1. Parameter choice

Table I presents the calibration of model parameters. The firm characteristics, presented in Panel B, are selected as follows. The initial cash flow is normalized to $X_0 = 1$. Following

[14]Alternative definitions such as the sum of value-weighted single-firm agency costs with firm-value weights or equity-value weights yield similar results.

the literature, the tax advantage of debt is $\tau = 0.15$ (Hackbarth, Miao, and Morellec, 2006). The nominal cash flow growth rates and systematic volatilities correspond to the estimates by Bhamra, Kuehn, and Strebulaev (2010b) in a two regime-model. The idiosyncratic volatility is chosen as in Arnold, Wagner, and Westermann (2013) to reflect the average asset volatility. Further, recovery rates are set as $\alpha_B = 0.7$ and $\alpha_R = 0.5$. These quantities are motivated by Acharya, Bharath, and Srinivasan (2007), who report a procyclicality of 20 cents on a dollar difference. Further, the average is close to the average recovery rate in Hackbarth, Miao, and Morellec (2006) and Chen (2010).[15]

The parameters related to the economy are presented in Panel D. The transition rates, consumption growth rates, and their volatilities are estimated in Bhamra, Kuehn, and Strebulaev (2010b). In particular, the estimates imply that the mean sojourn time in booms is 64%. The parameters related to inflation and the parameters determining the stochastic discount factor are as in Arnold, Wagner, and Westermann (2013).

3.2. Construction of the cross section

I construct a cross section of model-implied firms that is structurally similar to the empirical cross section. The approach builds on the work by Bhamra, Kuehn, and Strebulaev (2010b) as extended by Arnold, Wagner, and Westermann (2013). While my model yields tractable solutions in closed form, its non-stationarity impedes a full-blown simulated method of moments (SMM) estimation.[16]

[15]The implied bond recovery rate corresponds to 41% [40%] in booms and 28% [27%] in recessions for the baseline firm initiated in a boom [recession]. These values are within the bond recovery range of 24–63% in booms and 21%–37% in recessions, as reported by Moody's in Cantor, Emery, Matos, Ou, and Tennant (2009) and Chiu, Metz, and Ou (2011).

[16]Examples of SMM estimation of structural models in discrete time are Hennessy and Whited (2007) and Nikolov and Whited (2014). Hennessy and Whited (2007) consider endogenous investment, payout, and default, and use this model to estimate the magnitude of financing frictions. The model of Nikolov and

Specifically, I consider a cross section of model-implied firms that closely reflects the empirical cross section with respect to leverage ratios, ownership structure, and q. To obtain this cross section, I match simulated model-implied firms with actual firms from the empirical cross section. A limitation of the approach is that model firms cannot reflect multiple investment and restructuring options of actual firms. Instead, matching with model-implied data implicitly simplifies the structure of the firms' investment and restructuring options to one investment opportunity that, upon exercise, entails an adjustment of the capital structure. While my model allows for a first cross sectional analysis of agency costs under these assumptions, using a richer model in future research could provide additional insights. Examples of richer models on related topics include Hennessy and Whited (2007), Kuehn and Schmid (2014), and Nikolov and Whited (2014).

Data. I merge data on executive ownership available in ExecuComp as provided by Coles, Daniel, and Naveen (2013) and yearly balance sheet data from Compustat. I consider the time period 1992–2010. As is standard in the literature, all regulated (SIC 4900–4999) and financial (SIC 6000–6999) firms are omitted. I also exclude observations with missing SIC code, total assets, market value, or book value of equity. Following Morellec, Nikolov, and Schürhoff (2012), I restrict the sample to firms that have total assets over $10 million.

Each firm in the cross-section is characterized by the time-average of its quasi-market leverage, book leverage, q, and managerial delta. The exact definitions of these variables are given in Appendix 3.1. In the cross section, I delete the firms below the 1% quantile and above the 99% quantile of quasi-market leverage, book leverage, q, and managerial delta. I finally obtain a cross section of 2,058 firms. Panel A of Table II provides descriptive statistics of the cross sectional data. Managerial incentive alignment parameters vary

Whited (2014) features manager-shareholder agency conflicts, corporate liquidity management, investment, and default. The complexity of these models, however, impedes closed-form solutions.

between 0.23% and 40.27%, with a mean of 6.36% and a median of 4.15%. In particular, these statistics are comparable to the ones in Morellec, Nikolov, and Schürhoff (2012).

Matching the empirical cross section and simulation. The approach consists of two steps. First, I simulate a large universe of firms with a wide range of asset, capital, and ownership structures for ten years ("pre-simulation"). In particular, the simulated universe reflects that real firms are typically not at the time of issuance (Strebulaev, 2007). Second, I match each firm in the empirical cross section with the model-implied firm from the simulation that is closest in asset, capital, and ownership structures ("matching"). I consider 1,000 pre-simulations. Details can be found in Appendix 3.2

Characteristics of the matched cross section. Panel B of Table II shows descriptive statistics of the model-implied firms at the time of matching. Comparison of Panels A and B yields that the matched cross section reflects the characteristics of the empirical cross section quite well. An exception is the right tail of the empirical distribution of q because the model cannot replicate large values of q.[17] The distributions of market and book leverage are matched well.

To investigate the sample of matched firms further, Table III presents the statistics of the matching-implied private benefits parameter, both in absolute terms (first line) and relative to the managerial incentive alignment (second line). Panel A shows the results for the full sample. The average matching-implied private benefits ϕ are 0.43% of net income. Both the standard deviation of 0.81% as well as the quantiles document that the cross-sectional variation is substantial. The results conform to Morellec, Nikolov, and Schürhoff (2012), who estimate private benefits in a model with dynamic capital structure, but

[17]The model-implied q increases with the value of the investment opportunity relative to invested assets, but is bounded from above. A more valuable investment opportunity entails a lower investment threshold, implying immediate investment and a q of one for sufficiently valuable investment opportunities.

without investment and without business cycle risk. Specifically, while the distributional properties such as standard deviation and skewness of private benefits are comparable, the percentage magnitude of diversion is somewhat smaller with my approach, potentially because of the larger net income due to the absence of dynamic restructuring in my model.

The second line of Panel A in Table III shows statistics of the private-benefits-to-incentive-alignment ratio $\frac{\phi}{\psi}$ in percent. The mean ratio is 5.46%, with a substantial standard deviation of 4.78%. The corresponding histogram is further depicted in Fig. 1.

INSERT FIGURE 1 HERE

Panel B of Table III presents the results for firms in the upper half of the distribution of private benefits, i.e., the sub-sample of firms with matching-implied private benefits larger than the median. In this sub-sample, the average private benefits amount to 0.81% of net income. Remarkably, the private-benefits-to-incentive-alignment ratio is also considerably higher than in the full sample (9.40% vs. 6.36% in the full sample). Both the substantial cross-sectional variation as well as the right-skewness of the distribution are preserved.

The baseline firm. The baseline firm is chosen to represent firms in the upper 50% quantile of private benefits ("upper half"). Specifically, this baseline firm is characterized by private benefits of $\phi = 0.8\%$, a managerial incentive alignment parameter $\psi = 9.4\%$, and an investment scale parameter of $s = 2.6$, assuming an investment cost of $K = 20$. Panels A and C of Table I present these parameters for the representative managerial characteristics and investment opportunity, respectively. The parameters results in a model-implied q of approximately 1.55 at initiation, closely mirroring the average q of firms in the upper half. That is, this firm derives about one third of its value from the investment opportunity, while the remaining roughly two thirds stem from the assets in place. To capture different growth potentials of firms in the model, I vary the investment scale parameter s.[18] The baseline firm is used to investigate the agency costs at issuance in Section 4. The qualitative results do not depend on these parameters.

3.3. Aggregate dynamics

In this subsection, I explore the implications of manager-shareholder agency conflicts at the level of the aggregate economy. By simulating a cross section of firms, I take into account dynamic time-series and non-linear cross sectional effects. Strebulaev (2007) highlights the importance of considering the time-series evolution instead of drawing conclusions based on a model's implications at the time of issuance. The main reason is that firms' cash flows deviate from the initial ones, and these deviations impact firm values and, hence, agency costs in a non-linear way. Additionally, cash flow deviations in the aggregate economy are not symmetric and do not cancel each other out. In the cross section, the non-linear relations between capital, asset, and ownership structure and agency costs imply that average agency costs in the cross-section are typically different from the agency costs of a firm with average observable characteristics.[19] The analysis reveals that aggregate agency costs are strongly procyclical, thereby emphasizing the first-order importance of macroeconomic conditions for agency costs.

Simulation. The simulation uses the cross section of 2,058 model-implied firms. The simulation is conducted on a quarterly basis. All firms are subject to the same macroeconomic, consumption, and inflation shocks, but differ with respect to their idiosyncratic

[18] Model-implied q and investment costs K exhibit a negative relation. However, a variation in K intuitively reflects varying investment costs for a fixed investment payoff. To capture different growth potentials of firms, I instead vary the investment scale parameter s.

[19] Qualitatively, the main results such as the procyclicality of agency costs remain valid when considering an aggregate economy that is populated by copies of an average firm only instead of considering the constructed cross section.

shocks. Each quarter, each firm observes its current cash flow, as well as the current regime and behaves optimally: if the current cash flow is below its firm-specific default threshold given the current regime, the firm defaults; if the current cash flow is above its firm-specific investment boundary in the current regime, the firm invests; otherwise, the firm takes no action. To ensure a balanced sample over the time evolution of the dynamic economy, a firm that defaults or invests is replaced with a new firm that has not defaulted or invested yet (but is otherwise identical), using the cash flows of this firm at the time of matching. Details on the replacement procedures can be found in Appendix 3.2.

First, this dynamic economy is simulated for fifty years. This pre-simulation diminishes the impact of the initial distribution on the inter-firm distribution of cash flows and initial regimes. Next, the dynamic economy is simulated for fifty years more, which constitute the time window of the presented aggregate dynamics. I consider 500 simulations.

Panel C of Table II presents the descriptive statistics of firm characteristics in the dynamics, as implied by the simulation. The time-series averages of firm characteristics are similar to the characteristics at the time of matching and reflect the empirical cross section quite well. In particular, cross sectional averages of these statistics correspond to 31% market leverage, 45% book leverage, and a q of 1.51, the empirical counterparts being 30% market leverage, 44% book leverage, and a q of 1.97. However, the dynamics do not fully account for the right tail of the distribution of market leverage. The main reason for this deviation is that disregarding simulated firm-quarter observations with a book leverage greater than one also cuts large values of market leverage.

Results. Fig. 2 shows a time-series of 50 years of aggregate agency costs, where the shaded areas correspond to recessions. Fig. 2 suggests that aggregate agency costs are procyclical. When the economy switches from recession to boom, both overinvestment and underleverage increase a firm's agency costs. First, overinvestment becomes more severe because the firm's distance to suboptimal investment decreases due to lower investment boundaries in booms than in recessions. Second, underleverage entails an increase in agency costs upon regime switch to a boom mainly because the greater distance to default renders foregone tax savings relatively more important compared to lower bankruptcy costs.

Further, the sample path documents that aggregate agency costs can be negative in the dynamics. The reason is that initial underleverage results in a lower distance to default, which may become beneficial in case the firm's cash flows deteriorate strongly. As a result, aggregate agency costs are more prone to turn negative in times of prolonged recession due to systematically deteriorating cash flows (see, e.g., the spike in Fig. 2 around year 15).

INSERT FIGURE 2 HERE

To illustrate the model's implication for macroeconomic conditions observed in reality, Fig. 3 plots a sample path of simulated aggregate agency costs given NBER booms and recessions between 1992 and 2010. First, this sample path is consistent with the procyclicality of aggregate agency costs. Further, the graph displays that during the relatively long NBER recession between 12/07 and 06/09, aggregate agency costs decline, and, in particular, do become negative during the last quarter of the recession.[20] These considerations also suggest that negative aggregate agency costs may arise during prolonged recession.

INSERT FIGURE 3 HERE

To formally explore the dynamics of aggregate agency costs, Panel A of Table IV presents statistics over simulations with simulated macroeconomic conditions and cash flow paths of aggregate agency costs (columns 2–7) as well as the corresponding aggregate agency costs at issuance (column 1). The table confirms the strong procyclicality of aggre-

[20] Aggregate agency costs are negative during this recession for about 9% of simulated sample paths.

gate agency costs. Specifically, agency costs in booms amount to 0.87%, i.e., almost twice as large as agency costs in recessions (0.48%). Further, inspection of the quantiles suggests that aggregate agency costs exhibit substantial variation over the simulated economies. Finally, Table IV confirms that average dynamic agency costs (0.72%) differ from average agency costs at issuance (1.47%).

In Panel B of Table IV, I present the results for the upper half of firms with respect to private benefits. In the lower half, aggregate agency costs are close to zero (–0.09%, not in the table). Panel B shows that the simulation-implied magnitude of agency costs in this subsample amounts to 1.70%. These results suggest that aggregate agency costs are substantial for firms with private benefits above median. It further confirms the strong procyclicality of agency costs. Specifically, aggregate agency costs in recession (1.37%) are only about two thirds of the agency costs in booms (1.89%), which corresponds to a difference of 0.52%. Given the magnitude of these numbers, the simulation approach confirms that both agency conflicts and macroeconomic risk matter in powerful ways for corporate policies and, in particular, lead to substantial agency costs.

These results are complementary to the macroeconomic literature, which typically emphasizes countercyclical agency costs (e.g., Bernanke and Gertler, 1986, Rampini, 2004, Eisfeldt and Rampini, 2008). The reason is that the definition of agency costs is fundamentally different in the macroeconomic literature compared to the corporate finance literature. Specifically, the macroeconomic literature usually measures agency costs as costs due to a loss in productivity, whereas the corporate finance literature considers losses in firm values or equity values. For example, the agency costs due to private benefits and the choice of suboptimal lumpy investment and financing as analyzed in this paper are unaccounted for in macroeconomic models, which typically do not consider the interplay between private benefits and corporate policies (e.g., Carlstrom and Fuerst, 1998, or

Eisfeldt and Rampini, 2008). Conversely, the structural corporate model does not speak to agency costs as defined in the macroeconomic literature. There are two main reasons: First, in the model, a firm's productivity is not continuously affected by a manager, but only through lumpy investment decisions or through financing decisions by way of default. Second, the aggregate output process is given exogenously (see Eq. (21) in Appendix 1).

3.4. Time patterns of leverage, investment, and default

I explore the model's joint implications for the level and the dynamics of market leverage. Bhamra, Kuehn, and Strebulaev (2010a) show that macroeconomic risk entails countercyclical leverage in a dynamic economy, while Morellec (2004) argues that manager-shareholder agency conflicts can resolve the low-leverage puzzle. My analysis further complements the paper by Levy and Hennessy (2007), who focus on the dynamics of book leverage in the presence of agency conflicts. Figure 4 plots a sample path of aggregate market leverage implied by a simulation over 50 years.[21]

INSERT FIGURE 4 HERE

Panel C of Table IV confirms that the simulation-implied aggregate leverage is countercyclical (on average, 21% in booms and 26% in recessions). The countercyclicality of market leverage ratios conforms to the empirical results of Korajczyk and Levy (2003) and Halling, Yu, and Zechner (2016). The simulation-implied unconditional mean leverage of 23% is also comparable to the magnitudes documented in these empirical studies. Hence, the results suggest that manager-shareholder agency conflicts and macroeconomic risk can explain jointly the low debt levels and the countercyclicality of leverage.

[21] I define aggregate market leverage as the sum of the values of debt of all firms in the economy divided by the sum of the firm values of all firms in the economy (cf. Bhamra, Kuehn, and Strebulaev, 2010a).

Next, Panel D of Table IV presents the dynamics of average credit spreads in the economy, in which credit spreads are defined as the coupon divided by the value of debt less the perpetual risk-free rate. The model is consistent with countercyclical credit spreads as first reported by Fama and French (1989). The reason is that debt values are smaller in recessions, when default becomes more costly and more likely due to increased default thresholds, lower drift, and higher volatility. The overall magnitude of credit spreads (131 bps) conforms to the empirical literature (Duffee, 1998; Davydenko and Strebulaev, 2007; assuming a non-default component in credit spreads as documented by Longstaff, Mithal, and Neis, 2005). Finally, Panels D and E report the fraction of firms that invest and default in each regime, respectively. Panel D reveals that about 72% of the investments take place during booms. Comparison of investment rates in booms with the unconditional sojourn time of 64% in booms suggests that the model is consistent with a procyclical investment pattern reported by the empirical literature (Barro, 1990; Cooper, Haltiwanger, and Power, 1999). Further, as in Bhamra, Kuehn, and Strebulaev (2010a), default rates are strongly countercyclical, with 29% of the defaults occurring in booms and 71% in recessions. This finding reflects the higher probability of default during recessions.

One of the key findings of empirical research on capital structure is the inverse relation between leverage and growth opportunities (e.g., Rajan and Zingales, 1995; Barclay, Marx, and Smith, 2003; Johnson, 2003; Billett, King, and Mauer, 2007). Theoretical work explaining this inverse relation started with Myers (1977) and Jensen and Meckling (1976). To investigate my model's implications, I consider a regression of the simulation-implied quasi-market leverage on q and find a negative regression coefficient of -0.165 on average over simulations. In Subsection 4.2, I show that the inverse relation implied by the model also holds at the time of issuance. I conclude that my model is consistent with the inverse relation between market leverage and q.

4. Agency costs at issuance

First, I quantify total agency costs for the baseline firm depending on the investment opportunity and on the current economic regime. I subsequently discuss empirical predictions.

4.1. Quantifying agency costs at issuance

The impact of manager-shareholder agency conflicts on corporate policies, value functions, and agency costs are presented in Tables V. Each panel displays the results for the baseline firm with positive private benefits ($\phi = 0.8\%$) and the case without private benefits ($\phi = 0\%$), for both initiation in a boom and in a recession.

I start by investigating the baseline firm with a q of about 1.55, presented in Panel A. Table V shows that manager-shareholder agency conflicts generate strong underleverage in booms and recessions, and both at investment and at issuance. For instance, in the absence of agency conflicts, an initial leverage of 28% in booms is chosen; however, with private benefits of 0.8%, the manager-selected leverage at initiation corresponds to only 19% in booms. Further, the decline in investment boundaries documents overinvestment. For instance, for a firm initiated in a recession, private benefits lead to a decline of the investment thresholds from 1.55 (1.58) in booms (recessions) to 1.49 (1.51).

Panel A of Table VI shows that total agency costs are substantial and amount to 1.67% (1.64%) for firms initiated in booms (recessions). Table VI further decomposes total agency costs AC_i into the direct costs of private benefits, PB_i, and the agency costs of managerial discretion, AC_i^{MD} (see Subsection 2.3 for the definitions). Less than one half of total agency costs corresponds to the direct cost of private benefits (0.72% in booms and 0.70% in recessions). The agency costs of managerial discretion, AC_i^{MD} are quantitatively important: 0.95% in booms and 0.94% in recessions. These magnitudes are particularly striking given that the baseline firm exhibits private benefits of only 0.8% of net income.

Agency costs of managerial discretion can further be decomposed into agency costs due to the initial financing decision, agency costs due to the timing of investment, and agency costs due to the financing of investment.[22] Table VI shows that for the baseline firm initiated in a boom, agency costs due to the initial financing decision amount to 0.19%, agency costs due to investment timing correspond to 0.17%, and agency costs due to the financing of investment are 0.54%. In the baseline case, the agency costs of managerial discretion slightly exceed the sum of these three agency costs due to interaction effects.

Panels B and C of Table V report corporate policies and value functions for firms with lower and higher scale parameters of $s = 1.7$ and $s = 3.1$, respectively.[23] Table V shows that total agency costs are increasing in q and rise from 1.20% (1.17%) for a firm with a lower scale parameter of $s = 1.7$ to 1.67% (1.64%) for a baseline firm to 1.81% (2.06%) for a firm with a higher scale parameter of $s = 3.1$ in booms (recessions). The columns PB and AC^{MD} of Table VI reveal that the reason is that both the direct costs of private benefits as well as the agency costs of managerial discretion are increasing in q. The Internet Appendix 2 provides further comparative statics with respect to managerial and firm characteristics.

The cyclicality of agency costs at issuance depends on q. Total agency costs are roughly acyclical for firms with low and intermediate q, but countercyclical for firms with high q. For example, agency costs in booms (recessions) are 1.20% (1.17%) for a firm with a q

[22]To calculate agency costs due to the the initial financing decision, I first consider the firm value of a firm in which the manager controls the initial financing decision, while equity holders control the timing and the financing of investment. To isolate the effect of managerial discretion, I add the present value of private benefits to this firm value. This sum is then compared to the firm value of a corresponding firm without private benefits. The agency costs due to the timing and the agency costs due to the financing of investment are calculated analogously.

[23]These values of s are chosen as the 10% and 90% quantiles of the implied scale parameters in the upper 50% quantile of private benefits in the matched cross section.

of about 1.15 (Panel B of Table VI), but 1.81% (2.06%) for a firm with a q of about 1.8 (Panel C). Quantitatively, the countercyclicality remains moderate, with a difference of 0.25%. This difference in percentage points corresponds to agency costs that are about 12% higher in a recession than in a boom. Columns PB and AC^{MD} reveal that the result is driven by the countercyclicality of the agency costs of managerial discretion, while the value of the private benefits is roughly acyclical. The decomposition of the agency costs of managerial discretion shows that the countercyclicality of agency costs for high-q firms is primarily due to the higher costs of overinvestment in recessions.

4.2. Empirical predictions

Empirically, the median debt financing proportion of large investments is between 37% and 41% of the investment costs (Elsas, Flannery, and Garfinkel, 2013). Models without manager-shareholder agency conflicts typically overpredict debt amounts used for financing investment. For example, Table V shows that without private benefits, the primary source of financing the investment costs is debt (between 94% and 119% in the base case).[24] My model implies lower net debt financing with values that are closer to the empirically observed magnitude. For the baseline firm, the percentage of debt financing of the investment costs varies between 65% and 82% (depending on the macroeconomic regimes at issuance and at investment). These results suggest that manager-shareholder agency conflicts can help explain financing of investments in practice.

Additionally, Table V shows that initial leverage is also decreasing in q, consistent with Barclay, Smith, and Morellec (2006) and Korteweg (2010). Further, Table V suggests that underleverage should be more pronounced for hiqh-q firms. Finally, the Internet Appendix

[24] In the model, net debt financing of more than 100% implies a debt-financed dividend to equityholders.

3 presents net benefits of debt implied by my model, as analyzed in Korteweg (2010), van Binsbergen, Graham, and Yang (2010), and Morellec, Nikolov, and Schürhoff (2012).

5. Conclusion

This paper quantifies the costs of manager-shareholder agency conflicts in the presence of macroeconomic risk and investigates their evolution and implications using a dynamic approach. To do so, I develop a structural tradeoff model with intertemporal macroeconomic risk, explicitly taking into account manager-shareholder agency conflicts. Firms are heterogeneous in their asset composition, a feature included by modeling both assets in place and an investment opportunity. Each firm is run by a manager who controls financing and investment decisions. Agency conflicts arise because managers capture part of net income as private benefits and exercise control rights on financing and investment in their own best interest.

In this framework, I investigate manager-selected investment and financing policies and the implied effects on the loss in firm value. I find that, at issuance, agency costs are substantial (1.67% in booms and 1.64% in recessions for the baseline firm) and increasing in a firm's q. Based on a model-implied cross section of firms that closely resembles the empirical one, I find that aggregate agency costs stem from firms in the upper half of the distribution of private benefits. In this subsample, aggregate agency costs amount to 1.7% of aggregate firm value. In recessions, when default is particularly likely and costly, firms may benefit from the larger distance to default due to underleverage. This mechanism results in procyclical aggregate agency costs (1.9% in booms and 1.4% in recessions).

6. Tables

Table I
Calibration.

This table presents the calibration of parameters. Panel A shows the parameters of managerial characteristics of a baseline firm. Parameters defining firm characteristics are reported in Panel B. Panels C and D contain the parameter values for the investment opportunity and the macroeconomy, respectively.

Parameter	Parameter value	
	Boom	Recession
Panel A. Managerial characteristics of a baseline firm		
Private benefits of control ϕ	0.8%	
Managerial incentives ψ	9.4%	
Panel B. Firm characteristics		
Initial value of cash flows (X_0)	1	
Tax advantage of debt (τ)	0.15	
Nominal cash flow growth rate (μ_i)	0.0782	−0.0401
Systematic cash flow volatility ($\sigma_i^{X,C}$)	0.0834	0.1334
Idiosyncratic cash flow volatility ($\sigma^{X,id}$)	0.168	
Recovery rate (α_i)	0.7	0.5
Panel C. Investment parameters of a baseline firm		
Investment costs (K)	20	
Scale parameter of the investment opportunity (s)	2.6	
Panel D. Economy		
Rate of leaving regime i (λ_i)	0.2718	0.4928
Consumption growth rate (θ_i)	0.0420	0.0141
Consumption growth volatility (σ_i^C)	0.0094	0.0114
Expected inflation rate (π)	0.0342	
Systematic price index volatility ($-\sigma^{P,C}$)	0.0035	
Idiosyncratic price index volatility ($\sigma^{P,id}$)	0.0132	
Rate of time preference (ρ)	0.015	
Relative risk aversion (γ)	10	
Elasticity of intertemporal substitution (Φ)	1.5	

Table II
Statistics of the cross section.

This table presents statistics for the variables that characterize a firm in the cross section. Panel A displays descriptive statistics of the empirical cross section. The sample is based on Compustat yearly data and ExecuComp, and consists of 2,058 firms. All variables are defined in Appendix 3.1. Panel B shows statistics for the model-implied variables that characterize a firm in the matched cross section (see Subsection 3.2 for details on the construction of the cross section). Panel C presents statistics implied by the dynamic aggregate economy (see Subsection 3.3 for details). The statistics are based on the cross section calculated as averages over time and over simulations. Observations for which book leverage exceeds one are omitted. ψ is the manager's equity share in the model.

	Mean	SD	Min	Max	5%	25%	50%	75%	95%
Panel A. Empirical cross section.									
Quasi-market leverage	0.30	0.18	0.02	0.80	0.08	0.15	0.28	0.42	0.55
Book leverage	0.44	0.18	0.07	0.87	0.20	0.30	0.44	0.58	0.68
q	1.97	0.99	0.80	6.36	1.08	1.29	1.67	2.33	3.27
Managerial incentives (%)	6.36	6.68	0.23	40.27	1.14	2.16	4.15	7.70	14.67
Panel B. Matched cross section.									
Quasi-market leverage	0.30	0.16	0.03	0.74	0.09	0.16	0.27	0.42	0.54
Book leverage	0.43	0.19	0.04	0.86	0.17	0.28	0.44	0.57	0.67
q	1.58	0.34	0.98	2.13	1.10	1.26	1.62	1.87	2.03
ψ (%)	6.36	6.67	0.50	40.50	1.00	2.00	4.00	7.50	14.50
Panel C. Dynamics based on the matched cross section.									
Quasi-market leverage	0.31	0.08	0.04	0.45	0.13	0.27	0.32	0.36	0.41
Book leverage	0.45	0.14	0.05	0.70	0.18	0.34	0.48	0.57	0.64
q	1.51	0.26	0.99	1.89	1.05	1.32	1.57	1.74	1.85
ψ (%)	6.36	6.67	0.50	40.50	1.00	2.00	4.00	7.50	14.50

Table III
Matching-implied private benefits.

This table presents statistics of private benefits implied by the cross-sectional matching (see Subsection 3.2 for details on the procedure). Statistics are reported for the matching-implied private benefits ϕ, as well as the private-benefits-to-incentive-alignment ratio $\frac{\phi}{\psi}$, both in percent. The second column ("SD") presents the cross-sectional standard deviation of the firm-level matching-implied averages. Panel A presents the full sample, whereas Panel B considers only firms in the the upper 50% quantile of the distribution of model-implied private benefits.

	Mean	SD	Min	Max	Quantiles				
					10%	25%	50%	75%	90%
Panel A. Full sample.									
ϕ in %	0.43	0.81	0.00	10.41	0.00	0.04	0.15	0.45	1.83
$\frac{\phi}{\psi}$ in %	5.46	4.78	0.06	27.76	0.15	1.52	4.50	7.70	15.33
Panel B. Upper 50% quantile.									
ϕ in %	0.81	1.00	0.16	10.41	0.19	0.26	0.45	0.91	1.83
$\frac{\phi}{\psi}$ in %	8.56	4.56	0.71	27.76	3.76	4.93	7.34	11.87	15.31

Table IV
Impact of agency conflicts on agency costs in the aggregate economy.

This table presents time series statistics of aggregate agency costs both in the economy (Panel A) and for the subsample of firms with private benefits above median (upper half, Panel B). Panel C shows aggregate leverage, Panel D credit spreads, and Panel E (F) the fraction of investments (defaults) in each regime. Unconditional statistics are reported in the first line of Panels A–D. The second (third) line in Panels A–D and the first (second) line in Panels E–F show the statistics in booms (recessions) only. The first column presents the values at issuance. The unconditional value is calculated as the weighted sum of the values, in which the weights correspond to the average time spent in each regime. Columns 2–8 display mean, standard deviation, and quantiles. The statistics are based on 500 simulations, each containing 50 years of quarterly data for 2,058 firms in the cross section. For each data set, aggregate statistics are calculated for each time. These statistics are averaged over data sets; columns 3–8 show statistics of the aggregate time-series averages.

	At issuance	Dynamics						
		Moments		Quantiles				
		Mean	SD	10%	25%	50%	75%	90%
Panel A. Agency costs, full sample								
Unconditional	1.47	0.72	0.16	0.50	0.62	0.74	0.84	0.91
Boom	1.41	0.87	0.09	0.74	0.81	0.88	0.93	0.98
Recession	1.58	0.48	0.25	0.15	0.29	0.47	0.67	0.80
Panel B. Agency costs, upper half of the distribution of private benefits								
Unconditional	2.74	1.70	0.25	1.35	1.53	1.73	1.90	2.01
Boom	2.62	1.89	0.16	1.67	1.79	1.91	2.01	2.08
Recession	2.96	1.37	0.39	0.87	1.10	1.36	1.68	1.89
Panel C. Leverage								
Unconditional	0.22	0.23	0.03	0.20	0.21	0.22	0.25	0.27
Boom	0.22	0.21	0.03	0.18	0.19	0.21	0.23	0.25
Recession	0.23	0.26	0.03	0.22	0.24	0.26	0.28	0.30
Panel D. Credit spreads								
Unconditional	79	131	18	109	118	129	142	156
Boom	84	115	13	100	106	113	122	131
Recession	70	158	24	128	140	157	175	190
Panel E. Investment								
Boom		0.72	0.11	0.57	0.66	0.73	0.80	0.85
Recession		0.28	0.11	0.15	0.20	0.27	0.34	0.43
Panel F. Default								
Boom		0.29	0.15	0.12	0.18	0.27	0.38	0.49
Recession		0.71	0.15	0.51	0.62	0.73	0.82	0.88

Table V

The impact of manager-shareholder agency conflicts on corporate policies and value functions.

This table displays the impact of manager-shareholder agency conflicts on corporate policies, value functions and agency costs for firms with varying importance of the investment opportunity. Standard parameters from Table I are used. Panel A shows the results for a baseline firm with a scale parameter of $s = 2.6$. Panel B (C) displays the results for a firm with a lower (higher) scale parameter of $s = 1.7$ ($s = 3.1$). X_i is the investment threshold in regime i. q is calculated as firm value divided by the value of invested assets. c_o is the initial coupon, l_0 initial leverage, l_i^I leverage at investment boundary X_i, and df_i is the percentage of debt financing of the exercise cost at investment boundary X_i, calculated as the difference between the value of new debt issued and the principal as a percentage of the total exercise costs K. d, e, fv and m are the value functions of debt, equity, firm value and the manager, respectively. AC are total agency costs defined as the percentage loss in firm value compared to the case without private benefits. Each panel reports the results for a firm initiated in a boom ($i_0 = B$, lines 1–2) and in a recession ($i_0 = R$, lines 3–4) for a firm with private benefits of $\phi = 0.8\%$ and the benchmark of no private benefits ($\phi = 0\%$).

		X_B	X_R	q	c_o	l_0	l_B^I	l_R^I	df_B	df_R	d	e	fv	m	AC
Panel A: Baseline firm ($s = 2.6$)															
$i_0 = B$	$\phi = 0.8\%$	1.48	1.50	1.58	0.34	0.19	0.33	0.32	79.33	65.35	4.71	20.14	24.86	2.08	1.67
	$\phi = 0\%$	1.54	1.57	1.61	0.55	0.28	0.45	0.44	114.55	94.29	7.07	18.21	25.28	1.71	
$i_0 = R$	$\phi = 0.8\%$	1.49	1.51	1.50	0.29	0.20	0.33	0.32	82.44	68.42	4.19	16.42	20.61	1.69	1.64
	$\phi = 0\%$	1.55	1.58	1.53	0.46	0.30	0.45	0.44	119.48	99.18	6.19	14.76	20.96	1.39	
Panel B: Lower scale parameter ($s = 1.7$)															
$i_0 = B$	$\phi = 0.8\%$	3.44	3.57	1.15	0.38	0.29	0.33	0.32	130.50	112.11	5.21	12.85	18.05	1.31	1.20
	$\phi = 0\%$	3.49	3.62	1.16	0.57	0.40	0.45	0.44	184.61	158.49	7.37	10.90	18.27	1.02	
$i_0 = R$	$\phi = 0.8\%$	3.45	3.58	1.13	0.32	0.29	0.33	0.32	134.70	116.27	4.48	11.06	15.54	1.13	1.17
	$\phi = 0\%$	3.50	3.63	1.14	0.47	0.40	0.45	0.44	190.52	164.37	6.32	9.40	15.72	0.88	
Panel C: Higher scale parameter ($s = 3.1$)															
$i_0 = B$	$\phi = 0.8\%$	1.12	1.14	1.96	0.34	0.15	0.33	0.32	70.58	57.35	4.55	26.34	30.89	2.73	1.81
	$\phi = 0\%$	1.18	1.20	2.00	0.56	0.22	0.45	0.44	101.67	82.44	7.03	24.43	31.46	2.30	
$i_0 = R$	$\phi = 0.8\%$	1.13	1.14	1.82	0.29	0.17	0.33	0.32	73.30	60.00	4.14	20.94	25.08	2.18	2.06
	$\phi = 0\%$	1.19	1.20	1.86	0.46	0.24	0.45	0.44	107.17	87.85	6.08	19.52	25.60	1.83	

Table VI

The impact of manager-shareholder agency conflicts on various agency costs.

This table displays the impact of manager-shareholder agency conflicts on agency costs for firms with varying importance of the investment opportunity. Standard parameters from Table I are used. In particular, private benefits are set to $\phi = 0.8\%$. Panel A shows the results for a baseline firm with a scale parameter of $s = 2.6$. Panel B [C] displays the results for a firm with a lower [higher] scale parameter of $s = 1.7$ [$s = 3.1$]. AC are total agency costs defined as the percentage loss in firm value compared to the case without private benefits ($\phi = 0$), the value of private benefits, PB, is the expected value of diverted cash flows as a percentage of firm value without private benefits, and AC^{MD} corresponds to the agency costs of managerial discretion given as the difference between total agency costs and the expected cash flow due to private benefits, i.e., $AC^{MD} = AC - PB$. AC^F are agency costs due to managerial control rights of the initial financing decision only, AC^I are agency costs due managerial control rights of the investment timing decision only, and AC_I^F are agency costs due to the choice of investment financing only. Each Panel reports the results for a firm initiated in a boom (line 1) and in a recession (line 2).

	AC	PB	AC^{MD}	AC_0^F	AC^I	AC_I^F
Panel A: Baseline firm ($s = 2.6$)						
$i_0 = B$	1.67	0.72	0.95	0.19	0.17	0.54
$i_0 = R$	1.64	0.70	0.94	0.24	0.16	0.48
Panel B: Lower scale parameter ($s = 1.7$)						
$i_0 = B$	1.20	0.55	0.66	0.42	0.01	0.23
$i_0 = R$	1.17	0.55	0.63	0.43	0.01	0.20
Panel C: Higher scale parameter ($s = 3.1$)						
$i_0 = B$	1.81	0.81	1.00	0.10	0.19	0.68
$i_0 = R$	2.06	0.82	1.24	0.11	0.38	0.60

7. Figures

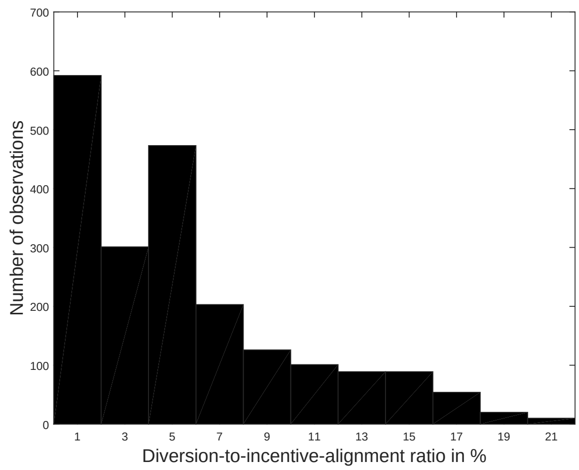

Figure 1. *Histogram of matching-implied private-benefits-to-incentive-alignment ratios.* The histogram shows the cross-sectional distribution of the average matching-implied private-benefits-to-incentive-alignment ratios in percent. For each firm, the ratio is calculated as the average over simulations. The right-most bin contains all firms that exhibit a ratio of 20% or larger.

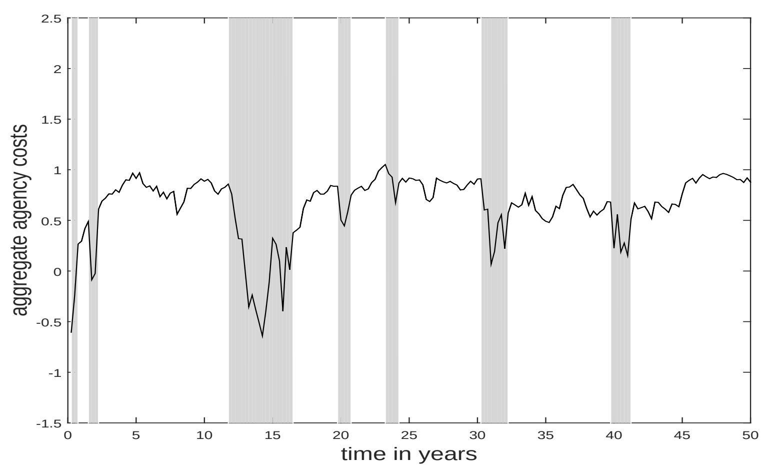

Figure 2. *Time series of aggregate agency costs.* The solid line shows the aggregate agency costs during 50 years in a simulated economy. The shaded areas represent times of recession. Standard parameters from Table I are used as well as the cross section of firms as constructed in Subsection 3.2.

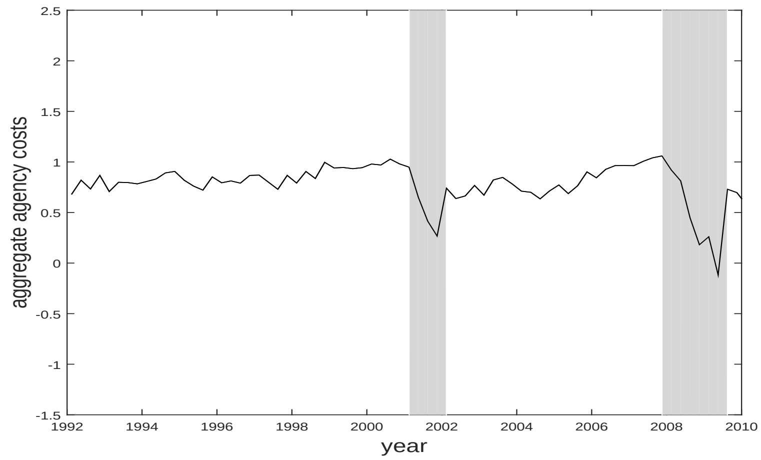

Figure 3. *Time series of aggregate agency costs.* The solid line shows the aggregate agency costs in a simulated economy using NBER recessions (shaded areas) between 1992 and 2010. Standard parameters from Table I are used as well as the cross section of firms as constructed in Subsection 3.2.

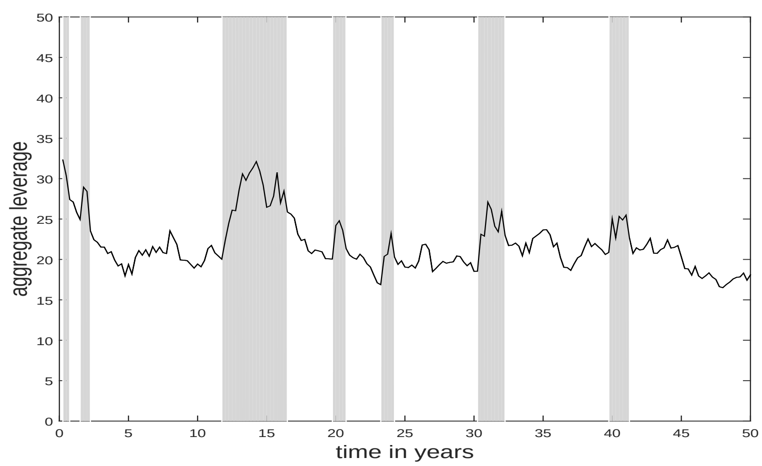

Figure 4. *Time series of aggregate market leverage.* The solid line shows aggregate market leverage during 50 years in a simulated economy. The shaded areas represent times of recession. Standard parameters from Table I are used as well as the cross section of firms as constructed in Subsection 3.2.

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Appendix

1. The model

In this section of the appendix, I present the technical model components that are not directly connected to agency conflicts, and are, therefore, omitted in the main text. The technical results stem from Bhamra, Kuehn, and Strebulaev (2010b) and Chen (2010), who also provide proofs of the formulas. Further, the model components presented here are analogous to Arnold, Wagner, and Westermann (2013), who also build on the results of Bhamra, Kuehn, and Strebulaev (2010b) and Chen (2010); hence, this section is analogous to the corresponding parts in the main text and appendix of Arnold, Wagner, and Westermann (2013). For completeness and the convenience of the reader, the assumptions and main results are presented here as well.

The dynamics of the aggregate output C_t are given by a regime-switching geometric Brownian motion:

$$\frac{\mathrm{d}C_t}{C_t} = \theta_i \mathrm{d}t + \sigma_i^C \mathrm{d}W_t^C, \ \ i = B, R, \tag{21}$$

in which W_t^C is a Brownian motion independent of the Markov chain and θ_i, σ_i^C correspond to the regime-dependent growth-rates and volatilities of the aggregate output, respectively. The partial equilibrium model is solved by postulating the equality of aggregate consumption and aggregate output. Hence, in equilibrium, the aggregate consumption dynamics are driven by a regime-switching geometric Brownian motion as well.

Preferences are defined as the continuous-time analog of Epstein-Zin-Weil preferences (Epstein and Zin, 1989; Weil, 1990), which belong to the class of stochastic differential utility (Duffie and Epstein, 1992a,b). The Epstein-Zin-Weil preferences are non time-separable and hence, take into account the impact of the intertemporal distribution of consumption risk on the representative household's utility. Specifically, for any consumption path $(C_s)_{0\leq s\leq t}$, the utility index U_t is given by

$$U_t = \mathbb{E}^{\mathbb{P}} \left[\int_t^{\infty} \frac{\rho}{1-\delta} \frac{C_s^{1-\delta} - ((1-\gamma)\, U_s)^{\frac{1-\delta}{1-\gamma}}}{((1-\gamma)\, U_s)^{\frac{1-\delta}{1-\gamma}} - 1} \mathrm{d}s \, | \mathcal{F}_t \right], \tag{22}$$

in which ρ represents the rate of time preference, γ is the coefficient of relative risk aversion for a timeless gamble, and $\Phi := \frac{1}{\delta}$ corresponds to the elasticity of intertemporal substitution for deterministic consumption paths. Chen (2010) solves the Bellman equation associated with the consumption problem of the representative agent and finds that the real stochastic discount factor sdf_t follows the dynamics

$$\frac{\mathrm{d}sdf_t}{sdf_t} = -r_{i,real}\mathrm{d}t - \eta_i \mathrm{d}W_t^C + \left(e^{\kappa_i} - 1\right)\mathrm{d}M_t, \tag{23}$$

in which M_t is the compensated process associated with the Markov chain and

$$\begin{aligned} r_{i,real} &= \bar{r}_i + \lambda_i \left[\frac{\gamma-\delta}{\gamma-1}\left(w^{-\frac{\gamma-1}{\gamma-\delta}} - 1\right) - \left(w^{-1} - 1\right)\right], & (24)\\ \eta_i &= \gamma \sigma_i^C, & (25)\\ \kappa_i &= (\delta - \gamma)\log\left(\frac{h_j}{h_i}\right). & (26) \end{aligned}$$

The parameters h_B, h_R solve the non-linear equation

$$0 = \rho\frac{1-\gamma}{1-\delta}h_i^{\delta-\gamma} + \left((1-\gamma)\theta_i - \frac{1}{2}\gamma(1-\gamma)\left(\sigma_i^C\right)^2 - \rho\frac{1-\gamma}{1-\delta}\right)h_i^{1-\gamma} + \lambda_i\left(h_j^{1-\gamma} - h_i^{1-\gamma}\right). \tag{27}$$

r_i are the regime-dependent real risk-free interest rates. Here, $\bar{r}_i$ is defined as

$$\bar{r}_i = \rho + \delta\theta_i - \frac{1}{2}\gamma(1+\delta)\left(\sigma_i^C\right)^2, \tag{28}$$

and w is defined as

$$w := e^{\kappa_R} = e^{-\kappa_B}. \tag{29}$$

The stochastic price index is assumed to follow the dynamics

$$\frac{\mathrm{d}P_t}{P_t} = \pi\mathrm{d}t + \sigma^{P,C}\mathrm{d}W_t^C + \sigma^{P,id}\mathrm{d}W_t^P, \tag{30}$$

in which W_t^P is a Brownian motion driving the idiosyncratic price index shock, independent of the consumption shock Brownian W_t^C and the Markov chain. The expected inflation rate is denoted by π and $-\sigma^{P,C} > 0, \sigma^{P,id} > 0$ are the volatilities of the stochastic price index associated with the consumption shock and the idiosyncratic price index shock, respectively. It can be shown that the nominal interest rates r_i^n are determined as

$$r_i^n = r_{i,real} + \pi - \sigma_P^2 - \sigma^{P,C}\eta_i, \tag{31}$$

in which $\sigma_P := \sqrt{\left(\sigma^{P,C}\right)^2 + \left(\sigma^{P,id}\right)^2}$ is the total volatility of the stochastic price index.

The dynamics of the real cash flow process X are given by

$$\frac{\mathrm{d}X_{t,real}}{X_{t,real}} = \mu_{i,real}\mathrm{d}t + \sigma_{i,real}^{X,C}\mathrm{d}W_t^C + \sigma^{X,id}\mathrm{d}W_t^f, \quad i = B, R, \tag{32}$$

in which W_t^f is a standard Brownian motion corresponding to an idiosyncratic shock, independent of the aggregate output shock W_t^C, the consumption price index shock W_t^P, and the Markov chain. $\mu_{i,real}$ represent the real regime-dependent drifts, $\sigma_{i,real}^{X,C} > 0$ the real firm-specific regime-dependent volatilities associated with the aggregate output process, and $\sigma^{X,id} > 0$ the firm-specific volatility associated with the idiosyncratic Brownian shock. The idiosyncratic shocks W_t^f are assumed to be independent across firms.

Next, the dynamics of the nominal cash flow process are given by

$$\frac{\mathrm{d}X_t}{X_t} = \mu_i\mathrm{d}t + \sigma_i^{X,C}\mathrm{d}W_t^C + \sigma^{P,id}\mathrm{d}W_t^P + \sigma^{X,id}\mathrm{d}W_t^f, \quad i = B, R, \tag{33}$$

in which $\mu_i = \mu_{i,real} + \pi + \sigma^{P,C}\sigma_{i,real}^{X,C}$ represent the nominal regime-dependent drifts, and $\sigma_i^{X,C} = \sigma_{i,real}^{X,C} + \sigma^{P,C} > 0$ the nominal firm-specific regime-dependent volatilities associated with the aggregate output process. As suggested by Ang and Bekaert (2004), I assume that these volatilities are larger in recessions than in booms, i.e., $\sigma_B^{X,C} < \sigma_R^{X,C}$. Finally, defining

$$\sigma_i = \sqrt{\left(\sigma_i^{X,C}\right)^2 + \left(\sigma^{P,id}\right)^2 + \left(\sigma^{X,id}\right)^2}, \tag{34}$$

and a $\mathbb{P}$-Brownian Z_t yields the cash flow dynamics as stated in (1).

Let $\tilde{\mu}_i, \tilde{\sigma}_i$, and $\tilde{\lambda}_i$ denote the expected growth rates of the firm's nominal cash flow, the total volatility, and the transition densities under the risk-neutral measure $\mathbb{Q}$, respectively.

Chen (2010) shows that the risk-neutral dynamics are characterized by the following drift, volatility, and transition densities:

$$\tilde{\mu}_i = \mu_i - \sigma_i^{X,C}\left(\eta_i + \sigma^{P,C}\right) - \left(\sigma^{P,id}\right)^2, \tag{35}$$

$$\tilde{\sigma}_i = \sqrt{\left(\sigma_i^{X,C}\right)^2 + \left(\sigma^{P,id}\right)^2 + \left(\sigma^{X,id}\right)^2}, \tag{36}$$

$$\tilde{\lambda}_i = e^{\kappa_i}\lambda_i. \tag{37}$$

Next, the unlevered asset value V_t is determined by

$$V_t = (1-\tau)\,X_t y_i \quad \text{for } I_t = i, \tag{38}$$

in which y_i is the price-cash flow ratio in state i defined as

$$y_i^{-1} = r_i^n - \tilde{\mu}_i + \frac{\left(r_j^n - \tilde{\mu}_j\right) - \left(r_i^n - \tilde{\mu}_i\right)}{r_j^n - \tilde{\mu}_j + \tilde{p}}\tilde{p}\tilde{f}_j. \tag{39}$$

$\tilde{p} := \tilde{\lambda}_i + \tilde{\lambda}_j$ represents the risk-neutral rate of news arrival and $\left(\tilde{f}_B, \tilde{f}_R\right) = \left(\frac{\tilde{\lambda}_R}{\tilde{p}}, \frac{\tilde{\lambda}_B}{\tilde{p}}\right)$ corresponds to the long-run risk-neutral distribution. For reasonable parameter values, the price-cash flow ratio in booms exceeds the one in recessions, i.e., $y_B > y_R$ (cf. Bhamra, Kuehn, and Strebulaev, 2010b). Finally, I define r_i^p as the perpetual risk-free rate given by

$$r_i^p = r_i^n + \frac{r_j^n - r_i^n}{\tilde{p} + r_j^n}\tilde{p}\tilde{f}_j. \tag{40}$$

2. The value functions before investment

For the value functions after investment, see Internet Appendix 1.

The value functions before investment. The following Proposition 1 displays the value functions of interest. I first state the general functional form of the value functions of interest (equity, debt, manager's claim to cash flows) and then present the parameters of the general functional form for each value function.

Proposition 1. *For any given set of default and exercise boundaries D_B, D_R, X_B, X_R, the general functional form for the value function of interest in regime i is given by*

$$f_i(X) = \begin{cases} E_{i1}X & X \le D_i, & i = B, R, \\ C_1 X^{\beta_1^B} + C_2 X^{\beta_2^B} + C_3 X + C_4 & D_B < X \le D_R, & i = B \\ A_{i1}X^{\gamma_1} + A_{i2}X^{\gamma_2} + A_{i3}X^{\gamma_3} & & \\ +A_{i4}X^{\gamma_4} + A_{i5}X + A_{i6} & D_R < X \le X_B, & i = B, R \\ B_1 X^{\beta_1^R} + B_2 X^{\beta_2^R} + B_3 X + B_4 & X_B < X \le X_R, & i = R \\ F_{i1}X + F_{i2} & X > X_i, & i = B, R, \end{cases} \tag{41}$$

in which

$$\beta_{1,2}^i = \frac{1}{2} - \frac{\tilde{\mu}_i}{\tilde{\sigma}_i^2} \pm \sqrt{\left(\frac{1}{2} - \frac{\tilde{\mu}_i}{\tilde{\sigma}_i^2}\right)^2 + \frac{2\left(r_i^n + \tilde{\lambda}_i\right)}{\tilde{\sigma}_i^2}}. \tag{42}$$

$\gamma_k, k = 1, 2, 3, 4$ *are the roots of the quartic equation*[25]

$$\left(\tilde{\mu}_R\gamma + \frac{1}{2}\tilde{\sigma}_R^2\gamma(\gamma-1) - \tilde{\lambda}_R - r_R^n\right)\left(\tilde{\mu}_B\gamma + \frac{1}{2}\tilde{\sigma}_B^2\gamma(\gamma-1) - \tilde{\lambda}_B - r_B^n\right) = \tilde{\lambda}_R\tilde{\lambda}_B. \tag{43}$$

A_{Rk}, $k = 1, 2, 3, 4$, *is a multiple of* A_{Bk} *with the factor*

$$l_k := \frac{1}{\tilde{\lambda}_B}(r_B^n + \tilde{\lambda}_B - \tilde{\mu}_B\gamma_k - \frac{1}{2}\tilde{\sigma}_B^2\gamma_k(\gamma_k - 1)). \tag{44}$$

$[A_{B1}\ A_{B2}\ A_{B3}\ A_{B4}\ C_1\ C_2\ B_1\ B_2]^T$ *solve a linear system*

$$M\begin{bmatrix} A_{B1} & A_{B2} & A_{B3} & A_{B4} & C_1 & C_2 & B_1 & B_2 \end{bmatrix}^T = b, \tag{45}$$

in which

$$M = \begin{bmatrix} D_R^{\gamma_1} & D_R^{\gamma_2} & D_R^{\gamma_3} & D_R^{\gamma_4} & -D_R^{\beta_1^B} & -D_R^{\beta_2^B} & 0 & 0 \\ \gamma_1 D_R^{\gamma_1} & \gamma_2 D_R^{\gamma_2} & \gamma_3 D_R^{\gamma_3} & \gamma_4 D_R^{\gamma_4} & -\beta_1^B D_R^{\beta_1^B} & -\beta_2^B D_R^{\beta_2^B} & 0 & 0 \\ 0 & 0 & 0 & 0 & D_B^{\beta_1^B} & D_B^{\beta_2^B} & 0 & 0 \\ l_1 D_R^{\gamma_1} & l_2 D_R^{\gamma_2} & l_3 D_R^{\gamma_3} & l_4 D_R^{\gamma_4} & 0 & 0 & 0 & 0 \\ l_1 X_B^{\gamma_1} & l_2 X_B^{\gamma_2} & l_3 X_B^{\gamma_3} & l_4 X_B^{\gamma_4} & 0 & 0 & -X_B^{\beta_1^R} & -X_B^{\beta_2^R} \\ l_1\gamma_1 X_B^{\gamma_1} & l_2\gamma_2 X_B^{\gamma_2} & l_3\gamma_3 X_B^{\gamma_3} & l_4\gamma_4 X_B^{\gamma_4} & 0 & 0 & -\beta_1^R X_B^{\beta_1^R} & -\beta_2^R X_B^{\beta_2^R} \\ X_B^{\gamma_1} & X_B^{\gamma_2} & X_B^{\gamma_3} & X_B^{\gamma_4} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & X_R^{\beta_1^R} & X_R^{\beta_2^R} \end{bmatrix}, \tag{46}$$

[25] The equation has two distinct positive and two distinct negative real roots, see Guo (2001).

$$
b = \begin{bmatrix} -A_{B5}D_R - A_{B6} + C_3 D_R + C_4 \\ -A_{B5}D_R + C_3 D_R \\ -C_3 D_B - C_4 + E_{B1} D_B \\ -A_{R5}D_R - A_{R6} + E_{R1}D_R \\ -A_{R5}X_B - A_{R6} + B_3 X_B + B_4 \\ -A_{R5}X_B + B_3 X_B \\ -A_{B5}X_B - A_{B6} + F_{B1}X_B + F_{B2} \\ -B_3 X_R - B_4 + F_{R1}X_R + F_{R2} \end{bmatrix}. \tag{47}
$$

(i) The value of corporate debt, $d_i(X)$, is determined by the following parameters.

$$
E_{i1} = \alpha_i y_i (1-\tau), \qquad C_3 = \tilde{\lambda}_B \frac{\alpha_R (1-\tau) y_R}{r_B^n - \tilde{\mu}_B + \tilde{\lambda}_B}, \qquad C_4 = \frac{c_o}{r_B^n + \tilde{\lambda}_B}, \tag{48}
$$

$$
A_{i5} = 0, \qquad A_{i6} = \frac{c_o}{r_i^p}, \qquad B_3 = 0, \tag{49}
$$

$$
B_4 = \frac{\tilde{\lambda}_R P + c_o}{r_R^n + \tilde{\lambda}_R}, \qquad F_{i1} = 0, \qquad F_{i2} = P. \tag{50}
$$

P is the par value of debt.

(ii) The value function of equity, $e_i(X)$, is determined by the following parameters.

$$
E_{i1} = 0, \qquad C_3 = \frac{(1-\tau)(1-\phi)}{r_B^n - \tilde{\mu}_B + \tilde{\lambda}_B}, \tag{51}
$$

$$
C_4 = -\frac{(1-\tau)(1-\phi) c_o}{r_B^n + \tilde{\lambda}_B}, \qquad A_{i5} = (1-\tau)(1-\phi) y_i, \tag{52}
$$

$$
A_{i6} = -\frac{(1-\tau)(1-\phi) c_o}{r_i^p} \qquad B_3 = \frac{(1-\tau)(1-\phi) + \tilde{\lambda}_R s f_i^v}{r_R^n - \tilde{\mu}_R + \tilde{\lambda}_R}, \tag{53}
$$

$$
B_4 = -\frac{(1-\tau)(1-\phi) c_o + \tilde{\lambda}_R (P+K)}{r_R^n + \tilde{\lambda}_R}, \qquad F_{i1} = s f_i^v, \tag{54}
$$

$$
F_{i2} = -P - K. \tag{55}
$$

f_i^v is the factor for calculating the value of a firm with only invested assets given the manager-selected coupon c_n. P is the par value of debt.

(iii) The value of the firm's net income, $n_i(X)$, is determined by the following parameters.

$$E_{i1} = 0, \qquad C_3 = \frac{(1-\tau)}{r_B^n - \tilde{\mu}_B + \tilde{\lambda}_B}, \qquad C_4 = -\frac{(1-\tau)\, c_o}{r_B^n + \tilde{\lambda}_B}, \tag{56}$$

$$A_{i5} = (1-\tau)\, y_i, \qquad A_{i6} = -\frac{(1-\tau)\, c_o}{r_i^p}, \qquad B_3 = \frac{(1-\tau) + \tilde{\lambda}_R s f_i^n}{r_R^n - \tilde{\mu}_R + \tilde{\lambda}_R}, \tag{57}$$

$$B_4 = -\frac{(1-\tau)\, c_o}{r_R^n + \tilde{\lambda}_R}, \qquad F_{i1} = s f_i^n, \qquad F_{i2} = 0. \tag{58}$$

f_i^n is the factor for calculating the value of the firm's net income of a firm with only invested assets given the manager-selected coupon c_n.

(iv) The value of the managers claim to cash flows, $m_i(X)$, is given by

$$m_i(X) = \psi e_i(X) + \phi n_i(X). \tag{59}$$

Proof.

(i) The system of ODEs for corporate debt, $d_i(X)$, is given by:

For $0 \leq X \leq D_B$:

$$\begin{cases} d_B(X) &= \alpha_B (1-\tau) X y_B \\ d_R(X) &= \alpha_R (1-\tau) X y_R. \end{cases} \tag{60}$$

For $D_B < X \leq D_R$:

$$\begin{cases} r_B^n d_B(X) &= c_o + \tilde{\mu}_B X d_B'(X) + \frac{1}{2}\tilde{\sigma}_B^2 X^2 d_B''(X) + \tilde{\lambda}_B \left(\alpha_R (1-\tau) X y_R - d_B(X)\right) \\ d_R(X) &= \alpha_R (1-\tau)(X y_R). \end{cases} \tag{61}$$

For $D_R < X < X_B$:

$$\begin{cases} r_B^n d_B(X) &= c_o + \tilde{\mu}_B X d_B'(X) + \frac{1}{2}\tilde{\sigma}_B^2 X^2 d_B''(X) + \tilde{\lambda}_B \left(d_R(X) - d_B(X)\right) \\ r_R^n d_R(X) &= c_o + \tilde{\mu}_R X d_R'(X) + \frac{1}{2}\tilde{\sigma}_R^2 X^2 d_R''(X) + \tilde{\lambda}_R \left(d_B(X) - d_R(X)\right). \end{cases} \tag{62}$$

For $X_B \leq X < X_R$:

$$\begin{cases} d_B(X) &= P \\ r_R^n d_R(X) &= c_o + \tilde{\mu}_R X d_R'(X) + \frac{1}{2}\tilde{\sigma}_R^2 X^2 d_R''(X) + \tilde{\lambda}_R \left(P - d_R(X)\right). \end{cases} \tag{63}$$

For $X \geq X_R$:

$$\begin{cases} d_B(X) &= P \\ d_R(X) &= P. \end{cases} \tag{64}$$

The boundary conditions are

$$\lim_{X \searrow D_R} d_B(X) = \lim_{X \nearrow D_R} d_B(X), \qquad \lim_{X \searrow D_R} d'_B(X) = \lim_{X \nearrow D_R} d'_B(X), \tag{65}$$

$$\lim_{X \searrow D_B} d_B(X) = \alpha_B (1-\tau) D_B y_B, \qquad \lim_{X \searrow D_R} d_R(X) = \alpha_R (1-\tau) D_R y_R, \tag{66}$$

$$\lim_{X \searrow X_B} d_R(X) = \lim_{X \nearrow X_B} d_R(X), \qquad \lim_{X \searrow X_B} d'_R(X) = \lim_{X \nearrow X_B} d'_R(X), \tag{67}$$

$$\lim_{X \nearrow X_B} d_B(X) = P, \qquad \lim_{X \nearrow X_R} d_R(X_R) = P. \tag{68}$$

The functional form of the system of ODEs (60)–(64) and its boundary conditions (65)–(68) is given in (41). Employing standard techniques, I find that the parameters correspond to those in (48)–(50). The linear system determining the remaining unknowns $A_{B1}, A_{B2}, A_{B3}, A_{B4}, C_1, C_2, B_1, B_2$, (45)–(46), is given by the boundary conditions (65)–(68).

(ii) The system of ODEs and boundary conditions for equity is stated in the main text, Eqs. (2)–(6) (ODEs) and Eqs. (7)–(10) (boundary conditions). The functional form of the solution corresponds to the one presented in (41). Employing standard techniques, I find that the parameters correspond to those in (51)–(55). The linear system determining the remaining unknowns $A_{B1}, A_{B2}, A_{B3}, A_{B4}, C_1, C_2, B_1, B_2$, (45)–(46), is given by the boundary conditions (7)–(10).

(iii) The system of ODEs for a claim to the firm's net income is given by

For $0 \leq X \leq D_B$:

$$\begin{cases} n_B(X) &= 0 \\ n_R(X) &= 0. \end{cases} \tag{69}$$

For $D_B < X \leq D_R$:

$$\begin{cases} r_B^n n_B(X) &= (1-\tau)(X - c_o) + \tilde{\mu}_B X n'_B(X) + \frac{1}{2}\tilde{\sigma}_B^2 X^2 n''_B(X) + \tilde{\lambda}_B (0 - n_B(X)) \\ n_R(X) &= 0. \end{cases} \tag{70}$$

For $D_R < X < X_B$:

$$\left\{ \begin{array}{rcl} r_B^n n_B(X) & = & (1-\tau)(X-c_o) + \tilde{\mu}_B X n_B'(X) + \frac{1}{2}\tilde{\sigma}_B^2 X^2 n_B''(X) \\ & & +\tilde{\lambda}_B (n_R(X) - n_B(X)) \\ r_R^n n_R(X) & = & (1-\tau)(X-c_o) + \tilde{\mu}_R X n_R'(X) + \frac{1}{2}\tilde{\sigma}_R^2 X^2 n_R''(X) \\ & & +\tilde{\lambda}_R (n_B(X) - n_R(X)). \end{array} \right. \tag{71}$$

For $X_B \leq X < X_R$:

$$\left\{ \begin{array}{rcl} n_B(X) & = & \hat{n}_B\left(sX; c_{n,B}^*\right) \\ r_R^n n_R(X) & = & (1-\tau)(X-c_o) + \tilde{\mu}_R X n_R'(X) + \frac{1}{2}\tilde{\sigma}_R^2 X^2 n_R''(X) \\ & & +\tilde{\lambda}_R (\hat{n}_B(sX; c_n^*) - n_R(X)). \end{array} \right. \tag{72}$$

For $X \geq X_R$:

$$\left\{ \begin{array}{rcl} n_B(X) & = & \hat{n}_B\left(sX; c_{n,B}^*\right) \\ n_R(X) & = & \hat{n}_R\left(sX; c_{n,R}^*\right) \end{array} \right. \tag{73}$$

The boundary conditions are

$$\lim_{X \searrow D_R} n_B(X) = \lim_{X \nearrow D_R} n_B(X), \qquad \lim_{X \searrow D_R} n_B'(X) = \lim_{X \nearrow D_R} n_B'(X), \tag{74}$$

$$n_B(D_B) = 0, \qquad n_R(D_R) = 0, \tag{75}$$

$$\lim_{X \searrow X_B} n_R(X) = \lim_{X \nearrow X_B} n_R(X), \qquad \lim_{X \searrow X_B} n_R'(X) = \lim_{X \nearrow X_B} n_R'(X), \tag{76}$$

$$n_B(X_B) = \hat{n}_B\left(sX_B; c_{n,B}^*\right), \qquad n_R(X_R) = \hat{n}_B\left(sX_R; c_{n,R}^*\right). \tag{77}$$

The functional form of the system of ODE (69)–(73) and its boundary conditions (74)–(77) is given in (41). Employing standard techniques, I find that the parameters correspond to those in (56)–(58). The linear system determining the remaining unknowns $A_{B1}, A_{B2}, A_{B3}, A_{B4}, C_1, C_2, B_1, B_2$, (45)–(46), is given by the boundary conditions (74)–(77).

(iv) The equality follows immediately from the fact that the manager owns a fraction ψ of equity value and captures a fraction ϕ of the firm's net income as private benefits. $\square$

3. Details on the construction of the cross section

I first describe the construction of variables in the data and subsequently present details on the simulations.

3.1. Construction of variables

The calculations and selection criteria presented in the main text (Subsection 3.2) lead to 15,233 firm-year observations, which are used to construct the cross section. To calculate book leverage, market leverage and q, I follow Fama and French (2002) and Baker and Wurgler (2002). Specifically, book equity is defined as total assets (AT) minus total liabilities (LT) and preferred stock ($PSTKL$) plus deferred taxes ($TXDITC$) and convertible debt ($DCVT$). Preferred stock is replaced with its redemption value ($PSTKRV$) when missing. Book debt is defined as total assets minus book equity. The market value of equity is calculated as the closing price ($PRCCF$) times the number of common shares outstanding ($CSHO$). Using these definitions, the quasi-market leverage is given as book debt divided by the sum of book debt and market value of equity. Book leverage is defined as book debt divided by total assets. Finally, q is total assets minus book equity plus market equity all divided by total assets. Following Baker and Wurgler (2002), I delete firm-year observations for which the book leverage exceeds one or for which q exceeds ten. Next, managerial deltas are provided by Coles, Daniel, and Naveen (2013) based on Coles, Daniel, and Naveen (2006) and Core and Guay (2002). The managerial delta is the dollar change in total managerial wealth (including shares) for a 1% change in market value (cf. Core and Guay, 2002). To compute the managerial incentive alignment ψ^m for a manager m, 100·delta is scaled by the market value of equity. Because managerial delta includes both shares and option sensitivities, the estimated managerial incentive alignment comprises both a direct component (managerial share ownership) and an indirect component (driven by pay-performance sensitivity of option awards), as in Morellec, Nikolov, and Schürhoff (2012). Finally, the managerial incentive alignment parameter ψ in a given firm-year is calculated as the sum of the managerial incentive alignment parameters ψ^m for the five highest paid executives as ranked by ExecuComp according to salary and bonus. Firm-year observations with an estimated ψ greater than one are excluded, resulting in an exclusion of 0.01% of firm-years. I consider only firm-year observations for which data for the highest paid five executives is available.

3.2. Simulations

I start the pre-simulation with a large universe of firms. Specifically, I consider firms with managerial incentive alignment parameters between $\psi = 0.5\%$ and $\psi = 40.5\%$ using a grid size of 0.5%. For each managerial incentive alignment, I consider ten levels of private benefits ϕ, ranging from no private benefits ($\phi = 0$) to the highest value of ϕ that implies a levered capital structure chosen by the manager in both regimes. Next, for each combination of managerial incentive alignment and private benefits, I use scale parameters of the investment opportunity between $s = 1.1$ and the largest possible value for s such that the investment boundaries are at cash flow levels of 1.1 or above, again for initiation in both regimes. This criterion prevents that the investment opportunity is exercised immediately. Depending on the incentive alignment and private benefits, the maximal s varies between $s = 2.9$ and $s = 3.2$. The step size for the grid of s is 0.1. These procedures lead to 16,848 different firms, all of which can be initiated either in boom or in recession. For each firm, I calculate the manager-selected capital structure in each regime. Finally, each firm is replicated 50 times, resulting in a universe of firms that contains 842,400 firms in total.

This universe of firms is then simulated forward for ten years. For each firm, a cash flow path is simulated that, according to the model setup, contains both an economy-wide as well as an idiosyncratic component and that depends on the current macroeconomic condition. In the dynamics, each firm invests if the cash flows exceed the manager-selected regime-dependent investment boundary; the firm defaults if cash flows fall below the regime-dependent default boundary selected by equity holders; otherwise, the firm takes no action. To ensure a balanced sample over time and valid comparisons of firm values, I implement the following replacements: a firm is replaced by an identical firm with respect to ownership, private benefits, and investment opportunity once its cash flows exceed the investment threshold or once its cash flows fall below the default threshold of the corresponding firm without private benefits.[26] At the end of the pre-simulation, I calculate market leverage,

[26] For scale parameters close to 1, i.e., in case the growth option is almost worthless, the manager optimally chooses to slightly underinvest to defer refinancing. In that case, a firm is substituted once its cash flows reach its investment boundary of the corresponding firm without private benefits.

book leverage and q for each firm.[27] Analogously to the empirical sample, I disregard firms with a book leverage larger than one (Baker and Wurgler, 2002). I obtain a model-implied economy of firms with a broad range of asset, capital, and ownership structures. Specifically, the range of quasi-market leverages of the model-implied firms is 0.05% to 81%, book leverage varies between 0.04% and 100%, and q covers the range of 0.88 to 2.23.

Each firm in the empirical cross section is matched with a model-implied firm at the end of the pre-simulation as follows. First, I winsorize the empirical sample with respect to q such that the values are consistent with the model-implied range for each variable (i.e., at q ratios of 0.85 and 2.25). For each empirical firm, I consider only model-implied firms with the managerial incentive alignment equal to the empirical managerial delta (rounded to the nearest full or half percentage).[28] The firm-specific sample of model-implied firms to match one empirical firm consists of more than 10,000 model-implied firms in all cases. Next, each firm is matched with the model-implied firm that exhibits the corresponding ownership structure and the shortest distance. The distance is defined as the sum of the squared percentage errors with respect to quasi-market leverage, book leverage, and q, i.e., $distance = \left(\frac{mlev_{emp}-mlev_{t,mi}}{ml_{emp}}\right)^2 + \left(\frac{blev_{emp}-blev_{t,mi}}{bl_{emp}}\right)^2 + \left(\frac{q_{emp}-q_{t,mi}}{q_{emp}}\right)^2$, with $mlev$ denoting market leverage, $blev$ book leverage, and the subscripts $_{emp}$ and $_{t,mi}$ refer to time-averages of empirical statistics and the model-implied statistic at time t, respectively. In particular, as in Bhamra, Kuehn, and Strebulaev (2010b), model-implied statistics are considered at one date only, whereas empirical moments are time-averages. This consideration respects the non-stationarity of the model and constitutes the main difference to a SMM estimation.

When simulating the cross section of matched firms, I implement the analogous replacement procedures as in the pre-simulation. These replacements guarantee a balanced sample over time as well as valid comparisons of model-firms with hypothetical firms without private benefits.

[27]For a model-implied firm, the quasi-market leverage is calculated as the value of debt at issuance (i.e., the principal) divided by the sum of the value of debt at issuance and the market value of equity (as in Bhamra, Kuehn, and Strebulaev, 2010b); book leverage is given as the value of debt at issuance divided by the value of assets in place, and q corresponds to the value of debt at issuance plus the market value of equity all divided by the value of assets in place.

[28]Three empirical firms with managerial deltas of 0.23% and 0.24% are matched with an incentive alignment parameter of 0.5% to guarantee a levered capital structure of the model-implied firm.