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Capital structure dynamics and transitory debt ☆

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ABSTRACT

Firms deliberately but temporarily deviate from permanent leverage targets by issuing transitory debt to fund investment. Leverage targets conservatively embed the option to issue transitory debt, with the evolution of leverage reflecting the sequence of investment outlays. We estimate a dynamic capital structure model with these features and find that it replicates industry leverage very well, explains debt issuances/repayments better than extant tradeoff models, and accounts for the leverage changes accompanying investment "spikes." It generates leverage ratios with slow average speeds of adjustment to target, which are dampened by intentional temporary movements away from target, not debt issuance costs.

1. Introduction

We estimate a dynamic capital structure model that differs from prior models in which firms have leverage targets because it recognizes that firms sometimes issue transitory debt and deviate deliberately, but temporarily, from target in order to fund investment. The model generates leverage dynamics that differ radically from those of prior tradeoff models and yields a rich set of testable predictions that link capital structure to variation in the volatility of shocks to investment policy, the serial correlation of such shocks, and the marginal profitability of investment, as well as to variation in both fixed and convex costs of adjusting the capital stock. Because firms often borrow and move away from target to fund investment, the model generates leverage ratios with slow average speeds of adjustment (SOA) to target that are close to the estimates reported in empirical SOA studies, with rebalancing toward target largely occurring in states of the world in which firms' investment needs are moderate. We find that the model replicates industry leverage very well, that it explains firms' debt issuance/repayment decisions better than extant tradeoff models of capital structure, and that it can account for the leverage changes that accompany investment "spikes."

In this model, firms' use of transitory debt and their target capital structures are systematically related to the nature of their investment opportunities because (i) borrowing is a cost-efficient means of raising capital when a given shock to investment opportunities dictates a funding need, and (ii) the option to issue debt is a scarce resource whose optimal intertemporal utilization depends on both current and prospective shocks. The

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option to issue debt is valuable in our model because investment is endogenous and because of three assumptions that dictate that all sources of capital (external equity, corporate cash balances, and borrowing) are costly means of funding investment. First, equity issuance entails costs, an assumption intended to reflect the existence of adverse selection problems or security flotation expenses. Second, holding cash incurs costs, which can reflect corporate taxes, agency costs, or an interest rate differential on precautionary liquid asset holdings in the spirit of Keynes (1936). Finally, debt capacity is finite, an assumption that can reflect financial distress costs or asymmetric information problems that prevent creditors from gauging firms' ability to support debt. As a result, when a firm borrows today, the relevant "leverage-related cost" includes the opportunity cost of its consequent future inability to borrow.

This opportunity cost of borrowing implies that target capital structures are more conservative than those produced by otherwise similar tax/distress cost tradeoff models because the cost of borrowing today includes the value lost when a firm fails to preserve the option to borrow later at comparable terms. Intuitively, a firm's long-run target is the theoretically ideal debt level that, when viewed ex ante, optimally balances its tax shield from debt against not only distress costs, but also against the opportunity cost of borrowing now rather than preserving the option to borrow later. More precisely, in our model a firm's target capital structure is the matching of debt and assets to which the firm would converge if it optimized its debt and assets decisions in the face of uncertainty, but then by chance happened to receive only neutral shocks to investment opportunities for many periods in a row. (In this case, the firm has ample resources to pay down any debt in excess of target, and also has no new projects that must be funded externally.) In general, the target debt level is a function of the probability distribution of investment opportunities, taxes, distress costs, external equity financing costs, and the costs of holding cash. We show that the target is a single ratio of debt to assets, except when firms face fixed costs of adjusting their stock of physical capital, in which case firms have a range of target leverage ratios.

Our model yields a variety of specific testable predictions that link firms' investment attributes to their capital structure decisions. For example, average debt outstanding is inversely related to the volatility of unexpected shocks to investment opportunities, and the imposition of corporate taxes induces greater leverage for firms that face low as opposed to high shock volatility. Intuitively, firms that face high shock volatility find it especially valuable to preserve debt capacity to address substantial funding needs associated with future shocks to investment opportunities, and this benefit looms large relative to the interest tax shields they lose by maintaining low debt ratios on average. The more volatile investment outlays of high versus low shock volatility firms also induce the former to rely more on (costly) cash balances to fund investment. For similar reasons, the model also predicts lower average debt ratios and greater reliance on cash balances for firms that face higher (i) serial correlation of shocks to investment opportunities, (ii) marginal profitability of investment, and (iii) fixed (compared to convex) costs of adjusting the stock of physical capital.

We refer to the difference between actual and target debt levels as transitory debt,[1] with actual debt deviating from target because investment policy is endogenous. For example, with no tax or other permanent benefit from corporate debt, firms nevertheless find that issuing debt is sometimes the most efficient source of capital (in a sense made precise below), yet zero debt is the capital structure target. Paying down debt (issued to fund prior investment) frees up debt capacity, which reduces the expected future costs of capital access. Hence managers always have incentives to return their firms to zero debt in the absence of taxes. They may not be able to accomplish this objective quickly, however, since multiple sequential shocks may arrive, requiring additional funds and, perhaps, more borrowing.

Although firms have leverage targets as in static tradeoff models, managers sometimes choose to deviate from target, and subsequently seek to rebalance to target by reducing debt with a lag determined in part by the time path of investment opportunities and earnings realizations. The prediction that firms *deliberately* deviate from target differentiates our analysis from static tradeoff models and from the multi-period contingent claims generalizations thereof, which assume exogenous investment and positive leverage rebalancing costs, e.g., Fischer, Heinkel, and Zechner (1989) and Goldstein, Ju, and Leland (2001). These models predict that all management-initiated changes in capital structure move firms toward target, although as we detail in Section 6 several prior studies and our own evidence indicate that this prediction is not borne out empirically.

A second empirical shortcoming of extant tradeoff theories—and a shortcoming plausibly related to the high observed incidence of deliberate deviations from target —is the slow speed of adjustment (SOA) to target estimated in leverage rebalancing studies. For example, Fama and French (2002) find "suspiciously slow" speeds of adjustment to target, and other studies estimate that firms adjust an average of somewhere between one-third and one-twelfth of the way toward target in a typical year (see, e.g., Flannery and Rangan, 2006; Kayhan and Titman, 2007; Lemmon, Roberts, and Zender, 2008; Parsons and Titman, 2008). With empirical studies uniformly reporting slow SOA estimates, it is difficult to accept the premise of extant tradeoff theories that rebalancing to target is the sole driver of proactive changes in capital structure undertaken by firms.

[1] Transitory debt is not synonymous with short-term debt. Indeed, our model includes only perpetual debt, which managers issue and later retire or perhaps leave outstanding indefinitely as future circumstances dictate. In reality, transitory debt can include bonds, term loans, and borrowing under lines of credit that managers intend to pay off in the short to intermediate term to free up debt capacity. In other words, it is managerial intent (and behavior) that determines whether debt is transitory, and not the stated life or any other contractual feature of a given debt issue.

The leverage ratios implied by our estimated model parameters exhibit slow average speeds of adjustment to target in the neighborhood of the estimates in prior SOA studies. Since our estimation procedure does not match model parameter values to real-world data on the basis of SOA, this finding provides additional empirical support for the model. Perhaps more importantly, the fact that firms exhibit slow speeds of adjustment to target in our model does not imply that they have weak incentives to rebalance leverage. On the contrary, we find that firms in our model rebalance aggressively toward target in some, but not all, states of the world, most notably when optimal investment outlays are low. Our analysis implies that the SOA measures used in earlier rebalancing studies understate the strength of firms' incentives to rebalance leverage because their estimates of the average SOA include financing decisions in which firms choose to move temporarily away from target.

We conduct four tests of our model's ability to explain observed leverage decisions. First, we run simulated method of moments (SMM) estimations for each of 41 two-digit standard industrial classification (SIC) code industries and find that, with the exception of railroads, actual average leverage ratios from Compustat do not differ significantly from the simulated average leverage generated by our industry-level SMM analyses. Second, we regress average industry leverage on the structural parameters from 40 of these estimations (excluding railroads), and find that almost all of the model-specified attributes of investment opportunities exert statistically significant influences on leverage in a manner consistent with the model's predictions. Third, analysis of debt issuance and repayment decisions by Compustat firms reveals that our model does a significantly better job predicting such decisions than is done by extant tradeoff models in which investment policy is exogenous and firms rebalance leverage subject to capital structure adjustment costs. Fourth, we analyze financing decisions associated with investment "spikes," and find that even when leverage is currently above average, large investment outlays are typically accompanied by substantial debt issuances that increase leverage.

Perhaps the most important "carry away" of the paper is that our evidence indicates that a simple dynamic capital structure model in which firms have leverage targets and issue transitory debt to fund investment does a good job explaining industry leverage, and is markedly better than extant tradeoff models at explaining debt issuance and repayment decisions and the financing decisions that accompany investment spikes. At the same time, it is also worth noting that our analysis moves beyond existing dynamic capital structure models in that our approach (i) develops the target capital structure and leverage dynamics implications of the opportunity cost of borrowing, (ii) demonstrates that this opportunity cost induces firms to use debt as a transitory financing vehicle, taking deliberate, but temporary deviations from their target capital structures, (iii) establishes that transitory debt implies radically different leverage dynamics from those of adjustment cost models in which all proactive capital structure decisions move firms toward their leverage targets, (iv) formally operationalizes the notion of—and demonstrates the existence of—capital structure targets in a dynamic model with endogenous investment policy, (v) yields new testable implications that link the time-series and cross-sectional variation in firms' capital structure to variation in the nature of their investment opportunities, (vi) shows that when transitory debt is an important component of capital structure, conventional measures of the speed of adjustment to target leverage markedly understate the strength of firms' actual rebalancing incentives, and (vii) demonstrates that the types of physical capital stock adjustment costs that firms face affect predicted leverage dynamics and determine whether capital structure targets are unique.

Endogeneity of investment policy is critical to our analysis, and variation in investment opportunity attributes is the main driver of our comparative statics predictions. The importance of endogenous investment is also evident in the results of a small but growing literature of dynamic models that explore the interactions of investment policy and capital structure. For example, Tserlukevich (2008), Morellec and Schürhoff (2010), and Sundaresan and Wang (2006) study the leverage impact of real options. Similarly, Brennan and Schwartz (1984), Hennessy and Whited (2005), Titman and Tsyplakov (2007) and Gamba and Triantis (2008) treat investment as endogenous while focusing, respectively, on debt covenants, taxes, agency issues, and cash holdings.[2] Our analysis complements that of these studies by focusing directly on the capital structure impact of variation in investment attributes and, in particular, on the leverage impact of variation in the volatility and serial correlation of investment shocks, the marginal profitability of investment, and the properties of capital stock adjustment costs. (We use the shorthand term "investment shock" to mean a shock to investment opportunities, and not a stochastic shift in the level of investment.)

While our model shares several features with Whited (1992) and Hennessy and Whited (2005), e.g., endogenous investment, there are a number of important differences. For example, while Hennessy and Whited (2005, Abstract) conclude that "there is no target leverage ratio" in their analysis, we recognize that a meaningful leverage target does in fact exist in dynamic models of the general type they employ. Our analysis is also differentiated by its consideration of a more realistic set of investment policy features, which both generate a richer set of leverage predictions and enable our model to do a markedly better job than Hennessy and Whited's model does in matching the empirical volatility of investment. More generally, our

[2] Tserlukevich (2008, Table 1) catalogs the assumptions of 10 dynamic capital structure models, and notes that five treat investment as exogenous (Kane, Marcus, and McDonald, 1984; Fischer, Heinkel, and Zechner, 1989; Goldstein, Ju, and Leland, 2001; Strebulaev, 2007; Leary and Roberts, 2005) and five treat it as endogenous (Brennan and Schwartz, 1984; Mauer and Triantis, 1994; Titman and Tsyplakov, 2007; Hennessy and Whited, 2005; Tserlukevich, 2008). Hennessy and Whited (2007), Gamba and Triantis (2008), and Bolton, Chen, and Wang (2009) also treat investment as endogenous, as do Riddick and Whited (2008), who analyze cash balances (but not leverage decisions) in an analytical framework close in spirit to the one we employ.

analysis is distinctive for the role it assigns to deliberate transitory deviations from target leverage, and for the associated implications it derives for (i) the existence of (and cross-firm variation in) capital structures targets, and (ii) the systematic connections between the nature of investment opportunities and leverage dynamics, including firms' use of transitory debt to fund investment. We posit a simple dynamic model to sharply highlight the capital structure role of transitory debt, but as we show in Section 7, our conclusions generalize to considerably more complex model settings. These extensions illustrate that *any* cost of leverage that is increasing in the debt level implies that borrowing today entails an opportunity cost in terms of reduced future ability to borrow at terms the firm currently faces.

We begin in Section 2 by explaining the model and presenting the estimation results. Sections 3 and 4 present our comparative statics analysis that establishes the predicted connections between leverage and attributes of investment opportunities. Section 5 analyzes the speed of adjustment to target. Section 6 presents evidence on our model's ability to explain industry leverage, firms' debt issuance/repayment decisions, and the leverage changes that accompany investment spikes. Section 7 demonstrates that our conclusions generalize to allow for collateral constraints, endogenous default, and cash holdings simultaneous with outstanding debt. Section 8 summarizes our findings.

2. A simple dynamic model of capital structure

Managers select the firm's investment and financial policies at each date in an infinite-horizon world so that they must always be mindful of the consequences of today's decisions on the feasible set of future decisions. Their decisions include (i) investment in real assets, (ii) changes in cash balances, (iii) equity or debt issuances, and (iv) distributions to debt and equity holders. Debt capacity is finite, an assumption that reflects the view that distress costs and/or asymmetric information problems prevent creditors from gauging with precision the firm's ability to support debt. Equity issuance incurs exogenously given costs, which can be interpreted as flotation or adverse selection costs, as in Myers and Majluf (1984). Cash balances are also costly, an assumption motivated by differential borrowing and lending rates (Cooley and Quadrini, 2001), agency costs (Jensen, 1986; Stulz, 1990), and/or a premium paid for precautionary cash holdings (Keynes, 1936). For simplicity, we refer to such costs as "agency costs" or "costs of maintaining cash balances."

2.1. Model setup

The firm's managers select investment and financing decisions to maximize the wealth of owners, which is determined by risk-neutral security pricing in the capital market. The firm's per period profit function is $\pi(k,z)$, in which k is capital and z is a shock observed by managers each period before making investment and financing decisions. For brevity, we often refer to z as an "investment shock" to capture the idea that variation in z alters the marginal productivity of capital and therefore the firm's investment opportunities. The profit function $\pi(k,z)$ is continuous and concave, with $\pi(0,z)=0$, $\pi_z(k,z)>0$, $\pi_k(k,z)>0$, $\pi_{kk}(k,z)<0$, and $\lim_{k\to\infty}\pi_k(k,z)=0$. We use the standard functional form $\pi(k,z)=zk^{\theta}$, where θ is an index of the curvature of the profit function, with $0<\theta<1$, which satisfies concavity and the Inada condition.

The shock z takes values in the interval $[\underline{z},\overline{z}]$ and follows a first-order Markov process with transition probability $g(z',z)$, where a prime indicates a variable in the next period. The transition probability $g(z',z)$ has the Feller property. A convenient parameterization is an $AR(1)$ in logs,

$$\ln(z')=\rho\ln(z)+\nu', \tag{1}$$

in which ν' has a truncated normal distribution with mean zero and variance σ_ν^2.

Without loss of generality, k lies in a compact set. As in Gomes (2001), define $\overline{k}$ as

$$(1-\tau_c)\pi(\overline{k},\overline{z})-\delta\overline{k}\equiv 0, \tag{2}$$

in which δ is the capital depreciation rate, $0<\delta<1$, and τ_c is the corporate income tax rate. Concavity of $\pi(k,z)$ in k and $\lim_{k\to\infty}\pi_k(k,z)=0$ ensure that $\overline{k}$ is well-defined. Because $k>\overline{k}$ is not economically profitable, k lies in the interval $[0,\overline{k}]$. Compactness of the state space and continuity of $\pi(k,z)$ ensure that $\pi(k,z)$ is bounded.

Investment, I, is defined as

$$I\equiv k'-(1-\delta)k, \tag{3}$$

in which a prime once again indicates a variable in the next period. The firm purchases and sells capital at a price of one and incurs capital stock adjustment costs that are given by

$$A(k,k')=\gamma k\Phi_i+\frac{a}{2}\left(\frac{k'-(1-\delta)k}{k}\right)^2 k. \tag{4}$$

The functional form of (4) is standard in the empirical investment literature, and it encompasses both fixed and smooth adjustment costs. See, for example, Cooper and Haltiwanger (2006). The first term captures the fixed component, $\gamma k\Phi_i$, in which γ is a constant, and Φ_i equals one if investment is nonzero, and zero otherwise. The fixed cost is proportional to the capital stock so that the firm has no incentive to grow out of the fixed cost. The smooth component is captured by the second term, in which a is a constant. We include the quadratic component to isolate the effects of smooth adjustment costs, which turn out to have interesting effects on leverage dynamics.

The firm can finance via debt, internal cash, current profits, and external equity. Define the stock of net debt, p, as the difference between the stock of debt, d, and the stock of cash, c. Given no debt issuance costs and positive agency costs of holding cash, which are formalized below, a firm never simultaneously has positive values of both d and c because using the cash to pay off debt would leave the tax bill unchanged and reduce agency costs. It follows that $d=\max(p,0)$ and $c=-\min(0,p)$, and so we can parsimoniously represent the model with the variable p and then use the definitions of d and c to obtain debt and cash balances at each point in time.

Debt takes the form of a riskless perpetual bond that incurs taxable interest at the after-corporate tax rate $r(1-\tau_c)$, while cash earns the same after-tax rate of return (aside from the incremental cost, s, formalized below). For simplicity, we abstract from the effects of personal taxes and debt covenants, which are treated in Miller (1977), Hennessy and Whited (2005), Smith and Warner (1979) and Brennan and Schwartz (1984).

We motivate the modeling of a riskless bond from the literature that has focused on adverse selection as a mechanism for credit rationing. Jaffee and Russell (1976) discuss the potential for the quality of the credit pool to decline as the amount borrowed increases, and Stiglitz and Weiss (1981) demonstrate that lenders, recognizing the existence of adverse selection and asset substitution problems, may ration credit rather than rely on higher promised interest rates as a device for allocating funds. Based on this consideration, we assume lenders allocate funds on the basis of a screening process that ensures the borrower can repay the loan in all states of the world. This assumption translates into an upper bound, $\overline{p}$, on the stock of net debt:

$$p \le \overline{p}. \tag{5}$$

The estimated value of the parameter $\overline{p}$ leads to a solution for equity value that always exceeds zero, which implies that the firm never defaults. Although the assumption of riskless debt with an exogenously specified upper bound may appear unduly simple and restrictive, we show in Section 7 that relaxing this assumption has no material effect on our results.

A value of p greater than zero indicates a positive net debt position, and a value less than zero indicates a positive net cash position. Bounded savings are ensured by the corporate tax on interest earned on cash balances and by the assumption that firms face what we refer to as "agency costs," as in Eisfeldt and Rampini (2006). For simplicity, we do not bound cash holdings via a stochastic probability of default, as in Carlstrom and Fuerst (1997). The agency cost function is given by

$$s(p) = sp\Phi_c, \tag{6}$$

in which s is a constant and Φ_c is an indicator variable that takes a value of one if $p<0$, and zero otherwise. To make the choice set compact, we assume an arbitrary lower bound on liquid assets, $\underline{p}$. This lower bound is imposed without loss of generality because of our taxation and agency cost assumptions. As in the case of an exogenously specified upper bound on debt, the assumption that cash equals negative debt has no qualitative effects on our results.

The final source of finance is external equity. Equity issuance/distributions are determined simultaneously with investment, debt, and cash, and these decision variables are connected by the familiar identity that stipulates that the sources and uses of funds are equal in each period. To express this identity, we first define $e(k,k',p,p',z)$ as gross equity issuance/distributions. If $e(\cdot)>0$, the firm is making distributions to shareholders, and if $e(\cdot)<0$, the firm is issuing equity. As in Hennessy and Whited (2005, 2007) and Riddick and Whited (2008), we model the cost of external equity finance in a reduced-form fashion that preserves tractability, which is necessary to estimate the model. The external equity-cost function is linear-quadratic and weakly convex:

$$\phi(e(k,k',p,p',z)) \equiv \Phi_e(\lambda_1 e(k,k',p,p',z) - \tfrac{1}{2}\lambda_2 e(k,k',p,p',z)^2)$$

$$\lambda_i \ge 0, \quad i=1,2,$$

in which $\lambda_1>0$ and $\lambda_2 \ge 0$. The indicator function Φ_e equals one if $e(\cdot)<0$, and zero otherwise. Convexity of $\phi(e(\cdot))$ is consistent with the evidence on underwriting fees in Altinkilic and Hansen (2000). Net equity issuance/distributions are then given by $e(\cdot)+\phi(e(\cdot))$. This quantity must be equal to the difference between the firm's sources of funds and uses of funds via the identity:

$$\begin{aligned} e(\cdot)+\phi(e(\cdot)) \equiv\ & (1-\tau_c)\pi(k,z)+p'-p(1+r(1-\tau_c))+\delta k\tau_c \\ & -(k'-(1-\delta)k)-A(k,k')+s(p). \end{aligned} \tag{7}$$

The firm chooses (k',p') each period to maximize the value of expected future cash flows, discounting at the opportunity cost of funds, r. The Bellman equation for the problem is

$$\begin{aligned} V(k,p,z) = \max_{k',p'} \Bigg\{ & e(k,k',p,p',z)+\phi(e(k,k',p,p',z)) \\ & + \frac{1}{1+r}\int V(k',p',z')dg(z',z)\Bigg\}. \end{aligned} \tag{8}$$

The first two terms represent the current equity distribution net of equity infusions and issuance costs and the third term represents the continuation value of equity. The model satisfies the conditions for Theorem 9.6 in Stokey and Lucas (1989), which guarantees a solution for (8). Theorem 9.8 in Stokey and Lucas (1989) ensures a unique optimal policy function, $\{k',p'\}=u(k,p,z)$, if $e(\cdot)+\phi(e(\cdot))$ is weakly concave in its first and third arguments. This requirement puts easily verified restrictions on $\phi(\cdot)$ that are satisfied by the functional forms chosen above. The policy function is essentially a rule that states the best choice of k' and p' in the next period for any (k,p,z) triple in the current period. Intuitively, it tells the firm how much to invest given the tradeoff between the cost of investing and expectations about future productivity. It also positions the firm's capital structure optimally to balance current financing needs with the possible need to raise debt capital once again in response to future shocks that might materialize.

2.2. Optimal financial policy

This subsection develops the intuition behind the model by examining its optimality conditions. For simplicity of exposition, we assume in this subsection that V is once differentiable. This assumption is not necessary for the existence of a solution to (8) or of an optimal policy function. The optimal interior financial policy, obtained by solving the optimization problem (8), satisfies

$$1+(\lambda_1-\lambda_2 e(\cdot))\Phi_e = -\frac{1}{1+r}\int V_2(k',p',z')dg(z',z). \tag{9}$$

The left side represents the marginal cost of equity finance. If the firm is issuing equity, this cost includes issuance costs. If the firm is not issuing equity, then this cost is simply a dollar-for-dollar cost of cutting distributions to shareholders. The right side represents the expected marginal cost of debt next period. At an optimum, the firm is indifferent between issuing equity, which incurs costs today, and issuing debt, which entails costs in the future.

To see precisely what these costs are, we use the envelope condition. Let μ be the Lagrange multiplier on the constraint (5). Then the envelope condition can be written as

$$-V_2(k,p,z) = ((1+(1-\tau_c)r) - s\Phi_c)(1+(\lambda_1 - \tfrac{1}{2}\lambda_2 e(\cdot))\Phi_e) + \mu. \tag{10}$$

This condition clearly illustrates the marginal costs of having debt/cash on the balance sheet. The first term in parentheses represents interest payments (less the tax shield). In the case of cash balances, this term represents the benefit of the interest on the cash (less taxes) minus the extra cost of carrying cash. The second term in parentheses captures the fact that this debt service is all the more costly if the firm has to issue external equity to make the payments. Finally, the third term is the shadow value of relaxing the constraint on debt issuance. This last term captures the intuitive point that a firm may want to preserve debt capacity today in order to avoid bumping up against its constraint in the next period. One clear implication of the value of preserving debt capacity is the intertwining of real and financial decisions. In particular, if a particular firm characteristic increases the probability that the firm will optimally want to make a large future investment, that characteristic also implies that the firm preserves debt capacity now.

2.3. Defining a target

Hennessy and Whited (2005) state that, in this type of model, there is no single optimal capital structure independent of the current state of the world. Indeed, in our model, capital structure choices are made each period and are state-contingent, exhibiting (local) path dependence. One of our main contributions is the observation that even in this type of setting, firms nonetheless have capital structure targets in a long-run sense. Consider the following thought experiment. What if the firm forms an optimal policy in the face of uncertainty but then happens by chance to face an arbitrarily long sequence of shocks, all of which are neutral ($z=1$)? In this case, no new funding requirements arrive randomly, and the firm eventually receives enough internally generated resources to enable it to reach its desired debt level without having to incur the costs of issuing equity. Would its optimal policy converge under this sequence of neutral shocks, and, if so, to a single $\{k,p\}$ pair or to a range of $\{k,p\}$ pairs?[3]

To answer the first part of this question, we define $u_1(k,p,1)$ as the first element of the policy function, evaluated at $z=1$, and we define $u_1^j(k,p,1)$ as the first element of the function that results from mapping $u(k,p,1)$ into itself j times. We then define the target capital stock as lying in the interval

$$\left[\liminf_{j\to\infty} u_1^j(k,p,1),\ \limsup_{j\to\infty} u_1^j(k,p,1)\right]. \tag{11}$$

The existence of this interval is determined trivially by the compactness of the state space and the boundedness of $u(k,p,z)$. For each capital stock in this interval, there is exactly one optimal level of p because the value function for this class of models is strictly concave (Hennessy and Whited, 2005). In intuitive terms, for any given k, there cannot be two values of p that yield the same maximum value. Of course, because $u(k,p,z)$ has no closed-form solution, we use simulation to solve for the target and to determine its exact form. As elaborated in Section 4.3, whether or not the firm has a unique leverage target depends on whether it has a unique capital stock target.

The target is a special case (i.e., limit) of the policy function. Therefore, like the state-contingent optimum defined by the policy function, the target also positions the firm optimally to raise capital in the future, given the nature of the uncertainty it faces. In addition, the particular limit of the policy function that we use to define a target is economically relevant. It isolates the long-run tax and opportunity cost incentives for optimizing capital structure, while abstracting from optimal financing decisions that are at least in part due to the need to finance specific investment projects.

2.4. Model estimation

Because the solution of the model must be obtained numerically, the quantitative properties of the model can depend on the parameters chosen. To address concerns about this dependency, we select parameters via structural estimation of the model. This procedure helps ensure that the parameters chosen produce results that are relevant given observed data. We use simulated method of moments (SMM), which chooses model parameters that set moments of artificial data simulated from the model as close as possible to corresponding real-data moments. We estimate the following parameters: profit function curvature, θ; shock serial correlation, ρ; shock standard deviation, σ_v; smooth and fixed physical adjustment costs, a and γ; the agency cost parameter, s;

[3] The intuition behind this definition of a long-run target capital structure is analogous to that which drives the notion of a target payout ratio in Lintner (1956). Consider a firm for which last period's dividend and this period's earnings give it an actual payout ratio below its long-run target payout ratio. Suppose the firm experiences a series of neutral earnings shocks, i.e., repeated realizations of this period's earnings. The firm will respond by increasing dividends over time so that its actual payout ratio converges to its long-run target. In the Lintner model, the firm virtually never has an actual payout ratio equal to target, but the existence of a long-run target payout ratio represents an economic force that governs the dynamics of dividend policy. In our model, the existence of a long-run target capital structure governs leverage dynamics in the same sense.

Table 1
Simulated moments estimation.

Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2007 Compustat industrial files. The sample period is 1988–2001. Estimation is done with SMM, which chooses structural model parameters by matching the moments from a simulated panel of firms to the corresponding moments from the data. The first panel reports the simulated and estimated moments and the t-statistics for the differences between the corresponding moments. All moments are self-explanatory, except the serial correlation and innovation to income. These moments are the slope coefficient and error variance from a first-order autoregression of the ratio of income to assets. The second panel reports the estimated structural parameters, with standard errors in parentheses. λ_1 and λ_2 are the linear and quadratic costs of equity issuance. σ_v is the standard deviation of the innovation to $\ln(z)$, in which z is the shock to the revenue function. ρ is the serial correlation of $\ln(z)$. θ is the curvature of the revenue function, zk^θ. γ and a are the fixed and convex adjustment cost parameters, and s is the agency cost parameter. $\overline{p}/k^{ss}$ is the debt ceiling expressed as a fraction of the steady state capital stock, k^{ss}. The J-test is the χ^2 test for the overidentifying restrictions of the model. Its p-value is indicated in parentheses.

A. Moments

	Actual moments	Simulated moments	t-Statistics
Variance of investment (I/k)	0.0385	0.0329	−0.4150
Variance of leverage (d/k)	0.0118	0.0165	1.8220
Average leverage (d/k)	0.2393	0.2423	0.3347
Average equity issuance (e/k)	0.0407	0.0231	−2.0196
Average Tobin's q ($(V+p)/k$)	3.6707	3.9549	0.4181
Third central moment of investment (I/k)	0.0534	0.0363	−0.5629
Average operating income (zk^θ/k)	0.1915	0.1903	−0.0352
Serial correlation of income (zk^θ/k)	0.6635	0.6488	−0.2360
Variance of the innovation to income (zk^θ/k)	0.0048	0.0015	−0.2974
Average cash balances (c/k), conditional on $c>0$	0.1399	0.1350	−0.3395
Variance of equity issuance (e/k)	0.0079	0.0051	−1.1062
Average investment (I/k)	0.1868	0.1657	−1.1146

B. Parameter estimates

λ_1	λ_2	σ_v	ρ	θ	γ	a	s	$\overline{p}/k^{ss}$	J-test
0.1615	0.0041	0.2843	0.7280	0.7880	0.0034	0.1519	0.0077	0.7196	2.0360
(0.0164)	(0.4662)	(0.0479)	(0.1790)	(0.0673)	(0.0016)	(0.0092)	(0.0157)	(0.0143)	(0.5650)

the two external equity cost parameters, λ_1 and λ_2, and the ratio of the debt limit, $\overline{p}$, to the steady state capital stock, k^{ss}, that would prevail in the absence of financing or physical adjustment frictions.[4] We estimate the latter parameter to ensure that the firm's debt limit reflects the asset base that serves as collateral and, more generally, to address concerns that average leverage from our model might be hard-wired by an arbitrary choice of $\overline{p}$. Appendix A contains details concerning the model's numerical solution, the data, the choice of moments, and the estimation.

Table 1 presents the estimation results, with Panel A reporting actual and simulated moments with t-statistics for the difference between the two, and Panel B reporting parameter point estimates and a J-test for general specification. The J-test does not provide a rejection at even the 10% level, implying that the model provides a good overall match to the set of moments viewed collectively. Most simulated moments in Panel A match the corresponding data moments well. In particular, the simulated and actual variances of investment are economically and statistically indistinguishable. In contrast, the models in Hennessy and Whited (2005, 2007) fail to match this particular moment. We attribute this result to the presence of physical adjustment costs in our model and the absence of such costs in their models. Only one moment, average equity issuance, has a simulated value that differs significantly from its corresponding average value in the data. While the quantitative gap between actual and simulated moments is not large, this finding suggests that the model could be improved by the introduction of debt issuance costs, since equity is more attractive as a marginal financing vehicle when it is costly to issue debt. And in fact, when we include such costs (see Section 7), the equity issuance difference is no longer statistically significant (and all other simulated moments remain close to those in Table 1 and insignificantly different from their average values in the data). We maintain the assumption of no debt issuance costs to establish clearly that our leverage predictions are driven by the value of preserving the option to borrow, and not by any other impediment to the use of debt.

The point estimates of the profit function curvature (θ) and of the serial correlation of profit shocks (ρ) in Panel B of Table 1 are qualitatively similar to those in Hennessy and Whited (2005, 2007). The estimates of the external equity cost parameters, λ_1 and λ_2, and the standard

[4] The steady state capital stock is $k^{ss} = (\theta(1-\tau_c)/(r+\delta))^{1/(1-\theta)}$. It equates the marginal product of capital with the user cost: $r+\delta$. In our model, k^{ss} is always close to the average simulated capital stock.

deviation of shocks (σ_v) are, however, much higher than the estimates from their models. The reason makes intuitive sense. Our upper limit on debt does not have as much of a dampening effect on leverage as does the modeling of financial distress in Hennessy and Whited's papers. Therefore, in order for simulated average leverage to be as low as actual average leverage, other parameters in our model need to adjust to hold simulated leverage down. As explained in detail below, both high external equity costs and high shock volatility work to lower optimal average leverage. Our estimates of the physical adjustment cost parameters, a and γ, are also comparable to those in previous studies. For example, they display a different, but understandable, pattern from the estimates in Cooper and Haltiwanger (2006). The estimate of our fixed cost parameter is smaller, while the estimate of our smooth cost parameter is higher. This result makes sense because we estimate these parameters with firm-level data, which are substantially smoother than the plant-level data that they use. Our estimated agency costs are small and statistically insignificant because we operationalize this variable as the marginal cost of maintaining cash balances over and above the statutory tax penalty for holding cash. Finally, the estimate of $\overline{p}/k^{ss}$ is quite high at 0.71. This level is much higher than the model-simulated average leverage, which is approximately 0.24. This large difference indicates that our model predicts that firms set leverage conservatively relative to their debt capacities. This result is remarkable and instructive, given that the only force in the model keeping leverage down is the value of preserving debt capacity for future use.

3. Comparative statics: illustrations and preliminary results

This section provides a highly simplified example to illustrate firms' incentives to issue and retire transitory debt (Section 3.1), and presents our predictions regarding the impact of financing frictions on the average amount of debt employed by firms (Section 3.2).

3.1. Predicted capital structure paths: a simple example

Consider a firm that faces baseline model parameter values (per Section 2) and, for simplicity of illustration, assume temporarily that there is no corporate tax benefit to borrowing. Assume that the firm currently has no debt outstanding so that, given the absence of a tax incentive to borrow, it is at its target capital structure. Assume also that an investment shock arrives with an associated large funding need that the firm cannot fully meet from cash balances and current cash flow. (In our model, firms use internal sources of capital before borrowing because of the costs of maintaining cash balances.) Finally, assume for the moment that managers issue debt to raise the remaining funds they need because equity issuance entails direct costs, whereas debt issuance does not. (As discussed below, in our model, managers sometimes issue equity even when debt capacity is available.) If managers do issue debt today, they will treat that debt as purely transitory.

Intuitively, the ability to issue debt is valuable because borrowing is a low (zero in our model) transactions cost means of raising cash to fund investment, and so a firm that borrows today will subsequently seek to pay off debt to be able to borrow again if and when future funding needs arise.

Fig. 1 plots a realized leverage path for a firm that has no tax motive to borrow, so that its target leverage is zero and any and all debt that it issues is transitory.[5] The figure documents how leverage responds to a sequence of investment shocks, and illustrates three key points. First, transitory debt increases as the firm borrows to meet shock-induced funding needs, and then recedes with a lag as the firm pays down debt and returns to its zero-debt target. Second, full payoff of the debt—i.e., rebalancing leverage back to target—can take multiple periods because of the arrival of multiple investment shocks, each with a new funding need. Third, the amount of debt that the firm has outstanding, on average, is positive and markedly greater than target, and so when a firm issues material amounts of transitory debt, its time-series average leverage ratio may not be a good indicator of its leverage target. We would add that the firm has a positive cash balance target (per Section 2.3) that embeds the option value of drawing down cash to meet funding needs—hence, a time-series average of outstanding cash balances will generally include such draw downs and therefore provide a downward-biased estimate of the firm's cash target.

Our model recognizes that firms' financing decisions are considerably more complicated than in this simple example. In general, managers must decide whether to issue debt to meet an immediate cash need generated by today's investment shock given that future shocks may soon arrive, rendering debt capacity even more scarce, while also considering the likelihood that future cash flow realizations may be inadequate to retire debt. Our model simulations indicate that firms' financing decisions generally do not follow the static pecking order described by Myers and Majluf (1984) and Myers (1984).[6] Specifically,

[5] Specifically, firms continue to incur the same total cost of holding cash as in the Section 2 model, which equals the sum of the marginal agency cost, s, and the tax penalty for holding cash, $\tau_c r$. We adopt this approach in this example because our SMM procedure estimates the total cost of cash balances, and we define the marginal agency cost as that total cost minus $\tau_c r$, an algorithm that assigns maximal weight to taxes. Since $\tau_c r$ is the largest possible tax penalty and since many real-world firms have no taxable earnings, this allocation likely underestimates the non-tax costs of holding cash. We use this approach only in simplified examples to illustrate the intuition of the model, and not in our comparative statics analysis.

[6] Myers (1984, p. 590) notes that, once one moves beyond the single investment outlay decision modeled by Myers and Majluf (1984), firms may issue equity even when debt capacity is not exhausted. Viswanath (1993) and Chang and Dasgupta (2003) extend Myers and Majluf to include a second investment decision, and formally establish this result. Lemmon and Zender (2007) also note that firms may save debt capacity for future use in dynamic versions of Myers and Majluf. Our analysis moves beyond these studies by establishing two fundamental results. First, firms have leverage targets that incorporate an amount of unused debt capacity that reflects the optimal future (state-contingent) utilization

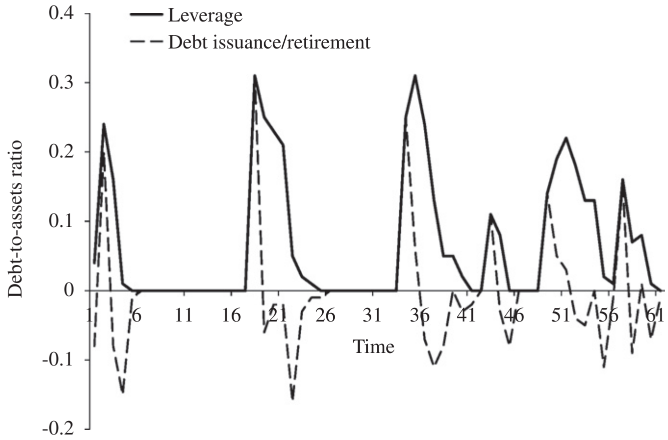

Fig. 1. Illustrative time path of leverage and debt issuance/retirement with no tax incentive to borrow. The time path is generated from the model in Section 2 with estimated parameters from Table 1, in which the tax incentive to borrow has been set to zero. As such, zero debt is the long-run capital structure target.

if managers of a firm with unused debt capacity assess a sufficiently high probability that future funding needs would force them to incur higher equity issuance costs in a present value sense (because borrowing today leaves the firm with inadequate debt capacity), they forego borrowing and instead issue costly equity to meet an immediate funding need. In general, the rational financing response to any given investment shock depends not only on the volatility and serial correlation of those shocks, but also on firm profitability and the nature of any costs of adjusting the stock of physical capital.

3.2. *The capital structure impact of variation in financing frictions*

To obtain comparative statics results, we start with the baseline parameter values (from Section 2's tax-inclusive SMM estimation) and analyze the model for a significant range of parameter values around each baseline value. For each set of specific parameter values, we run the model for 100,200 periods, with each firm receiving random investment shocks and responding to each by adjusting its investment and financing decisions optimally. We discard the initial 200 periods of data and, from the remaining 100,000 observations, we record economically relevant, empirically quantifiable measures of a firm's capital structure decisions, e.g., its average debt-to-assets ratio. We interpret the resultant large sample statistics as expected values implied by the specific parameterization of the model. We repeat the exercise for different combinations of model parameters. We then generate testable predictions based on the difference in the expected value of a given capital structure variable associated with an underlying difference in the model's parameter values.

Table 2 reports expected leverage (Panel A) and the standard deviation of leverage (Panel B) as a function of the costs of issuing equity and of maintaining cash balances, with leverage measured as the debt-to-assets ratio (d/k). Each panel contains a 5×5 matrix whose elements are the model's predicted (leverage or leverage volatility) values as a function of different costs of accessing external equity (columns) and of maintaining cash balances (rows). For example, the northeast corner of the matrix in Panel A reports the expected d/k ratio for the model specified with relatively high costs of accessing external equity coupled with relatively low costs of maintaining cash balances.

Table 2 yields three main findings. First, average leverage is well above zero (never less than 19.3% of assets) under all cost specifications, as one would expect since firms in our model capture tax benefits from debt. Second, variation in the costs of maintaining cash balances has only a modest influence on the cross-firm variation in average leverage and in the volatility of leverage (scan each column in Panels A and B). The intuitive explanation is that corporate taxes themselves provide strong incentives to maintain positive net debt, and so an increase in the cost of holding cash does little on the margin to induce firms to rely more on debt and less on cash balances. Third, average leverage is around 20–30% of assets for all cost specifications except when firms face low costs of accessing external equity, in which case the expected amount of debt is much higher at around 80% of total assets (Panel A), and leverage volatility is around 50% (Panel B).

The third finding contrasts sharply with standard static model reasoning about capital structure, which indicates that cheaper access to equity encourages firms to adopt lower leverage ratios. Our finding indicates that a firm typically maintains *higher* leverage when it faces lower costs of accessing equity capital to meet financing needs. Since the corporate tax subverts a firm's incentive to hold

(*footnote continued*)
of the option to borrow. Second, because unused debt capacity is a valuable asset, firms have the incentive to follow decisions to borrow and deviate from target by subsequently rebalancing toward target.

Table 2
Average and standard deviation of the debt-to-assets ratio.

The average and standard deviation of the debt-to-assets ratio, d/k, are expressed as a function of equity access costs and of agency costs of cash balances. Panel A reports average leverage, and Panel B reports the standard deviation of leverage. We start with the baseline model (per Section 2's SMM estimation results) and consider a significant range of parameter values around each baseline parameter value. Here, we consider variation in (i) the linear cost of accessing outside equity, λ_1 (which varies from 0.001 to 0.3 across the columns of the table) and (ii) the marginal agency cost, s, which varies from 0.0 to 0.05 down the rows. For these experiments, the quadratic cost of equity, λ_2 is set to zero. For each combination of parameter values, we run the model for 100,200 periods, with the firm receiving random productivity shocks and responding to each by adjusting its investment and financing decisions. We discard the initial 200 periods of data, and record and report the average of the debt-to-assets ratio, d/k, and the standard deviation of d/k for the remaining 100,000 observations.

A. Average debt-to-assets ratio (d/k)					
Cost of maintaining cash balances:	Linear cost of accessing external equity:				
	Low				High
Low	0.803	0.313	0.232	0.210	0.193
	0.806	0.324	0.266	0.246	0.234
	0.801	0.326	0.271	0.253	0.240
	0.806	0.328	0.272	0.258	0.243
High	0.794	0.328	0.275	0.265	0.254
B. Standard deviation of d/k					
Low	0.498	0.099	0.093	0.095	0.093
	0.497	0.103	0.098	0.100	0.101
	0.499	0.104	0.099	0.100	0.104
	0.498	0.102	0.102	0.102	0.105
High	0.495	0.103	0.101	0.102	0.105

cash balances, "levering up" is all the more costly in our dynamic analysis because it utilizes debt capacity that could have been preserved as a substitute future source of capital. However, the opportunity cost of utilizing debt capacity loses much of its deterrent value to "levering up" today when it is cheap to tap equity markets. Hence, when firms have the safety-valve alternative of issuing equity at low cost, they will "lever up" and remain highly levered to capture interest tax shields, even though doing so sacrifices their ability to tap the debt market in the future.[7]

4. Comparative statics: leverage and investment opportunities

This section presents comparative statics results that predict how firms' leverage decisions vary with the nature of their investment opportunities. Section 4.1 examines the impact of variation in investment shock volatility on average leverage, leverage volatility, and a broad variety of other dimensions of capital structure. Section 4.2 analyzes how these leverage predictions differ for firms whose investment opportunities are characterized in turn by (i) high as opposed to low shock serial correlation, (ii) high rather than low marginal profitability, and (iii) lumpy versus smooth investment outlays attributable to differences in the fixed and convex costs of capital stock adjustment. Section 4.3 delineates the model's predictions regarding variation in target leverage as a function of differences in the nature of firms' investment opportunities.

4.1. The capital structure impact of variation in investment shock volatility

Table 3 summarizes the predicted capital structure impact of variation in the volatility of investment shocks. The rows of the table list capital structure attributes and the columns detail the predicted impact of various investment shock volatilities centered around the baseline values (per Section 2), with standard deviations ranging from 15% to 50%. The model predicts that average investment as a percent of assets (I/k) is somewhat higher for firms subject to high shock volatility (row 1), while the standard deviation of I/k is markedly higher (row 2) and the frequency of investment is a bit lower (row 3) for such firms. For brevity here and throughout, *shock volatility* refers to the standard deviation of the error term in the investment shock generating process (1), and *leverage volatility* refers to the time-series standard deviation of the debt-to-assets ratio.

Table 3 indicates that firms facing low shock volatility have a debt-to-assets ratio of 0.722, on average, whereas firms facing high shock volatility have average leverage of only 0.091 (row 4). The former firms always carry some debt, whereas the latter have no debt outstanding almost 40% of the time (row 10), reflecting their strong incentives to preserve debt capacity and to accumulate greater cash balances (row 8) to meet the potentially substantial funding needs that can arise with future investment shocks.

[7] This point is conceptually distinct from the idea discussed by Myers (1984), Viswanath (1993), and others that firms time equity issuances in periods when information asymmetries imply temporarily low equity issuance costs, and obtain capital from debt issuances and cash balances in periods with high equity issuance costs. These authors offer a prediction about the *particular times* at which firms make *marginal* financing decisions, whereas our statement is about the *average* leverage ratios that firms maintain over time.

Table 3
Capital structure and investment shock volatility.
This table reports a variety of summary statistics from simulations of the baseline model. We simulate the model for 100,200 periods, with the firm receiving random investment shocks and responding to each by adjusting its investment and financing decisions. We discard the initial 200 periods of data. Each column reports statistics for a different model simulation, each of which corresponds to a different standard deviation of the investment shock. We let this standard deviation range from 0.15 to 0.5. Average transitory debt is the mean value of leverage (d/k) minus target, conditional upon leverage exceeding target.

		Standard deviation of investment shocks:							
		Low			Moderate				High
1.	Average investment (I/k)	0.158	0.160	0.163	0.167	0.169	0.171	0.172	0.171
2.	Standard deviation of investment (I/k)	0.129	0.145	0.166	0.187	0.197	0.211	0.214	0.213
3.	Frequency of investment	0.852	0.833	0.791	0.775	0.763	0.754	0.767	0.772
4.	Average debt-to-assets ratio (d/k)	0.722	0.508	0.336	0.203	0.133	0.104	0.091	0.091
5.	Standard deviation of leverage (d/k)	0.110	0.089	0.101	0.096	0.087	0.077	0.072	0.069
6.	Average net debt ($(d-c)/k$)	0.722	0.508	0.333	0.190	0.081	0.011	−0.010	−0.007
7.	Standard deviation of net debt	0.110	0.089	0.127	0.145	0.227	0.272	0.261	0.248
8.	Average cash balances to assets (c/k)	0.000	0.000	0.002	0.010	0.046	0.085	0.091	0.088
9.	Standard deviation of (c/k)	0.000	0.000	0.083	0.153	0.303	0.306	0.269	0.236
10.	Frequency of positive debt outstanding	1.000	1.000	0.965	0.908	0.779	0.672	0.639	0.627
11.	Average of positive leverage values	0.722	0.508	0.348	0.223	0.171	0.155	0.142	0.146
12.	Average of positive cash balance values	0.000	0.000	0.091	0.165	0.283	0.334	0.322	0.302
13.	Debt issuance frequency	0.468	0.463	0.451	0.438	0.393	0.341	0.330	0.328
14.	Debt repayment frequency	0.521	0.534	0.528	0.499	0.436	0.390	0.367	0.356
15.	Average debt issuance/assets	0.088	0.092	0.106	0.114	0.106	0.111	0.106	0.104
16.	Average debt repayment/assets	−0.069	−0.070	−0.076	−0.075	−0.069	−0.067	−0.064	−0.064
17.	Equity issuance frequency	0.255	0.257	0.261	0.255	0.245	0.237	0.239	0.236
18.	Average equity issuance/assets	0.028	0.024	0.022	0.018	0.019	0.018	0.018	0.017
Average fraction of investment funded from:									
19.	Current cash flow	0.840	0.847	0.832	0.823	0.816	0.802	0.807	0.810
20.	Cash balances	0.000	0.000	0.004	0.017	0.047	0.076	0.083	0.086
21.	Debt issuance	0.143	0.135	0.148	0.148	0.125	0.112	0.098	0.093
22.	Equity issuance	0.017	0.018	0.016	0.012	0.012	0.009	0.011	0.011
23.	Target	0.748	0.503	0.304	0.032	0.000	0.000	0.000	0.000
24.	Incidence of leverage above target	0.398	0.645	0.708	0.890	0.779	0.675	0.642	0.631
25.	Average deviation from target	−0.027	0.005	0.032	0.170	0.133	0.104	0.091	0.092
26.	Average transitory debt	0.065	0.057	0.092	0.195	0.170	0.155	0.142	0.146

The latter needs translate to higher volatility of investment (row 2) and somewhat higher average investment (row 1) for high as opposed to low shock volatility firms.

Table 3's most notable result is that, even in the face of corporate tax incentives to borrow, low leverage is the predicted norm for firms that face high investment shock volatility. Intuitively, high volatility implies a greater probability that large investment outlays will be optimal, and so the firm preserves debt capacity to address the commensurately large need for external finance.

Variation in firms' investment opportunities—and in particular their potential future funding needs—may therefore help resolve the "debt conservatism" puzzle that Graham (2000) poses, i.e., that it is difficult to explain why some firms maintain low leverage despite strong tax incentives to borrow. Such variation may also help resolve Miller's (1977) closely related "horse and rabbit stew" criticism that the corporate tax benefit of borrowing swamps expected bankruptcy costs, leading traditional tradeoff models to predict unrealistically high leverage ratios, and in effect raising the question: what factors are missing from these tradeoff models? The answer offered by the static models of Miller (1977) and DeAngelo and Masulis (1980), among others, is that attributes of the personal and corporate tax codes reduce firms' incentives to borrow. The answer offered by our dynamic model is that, with high investment shock volatility, low leverage is desirable despite the foregone corporate tax benefits because it preserves the option to borrow to fund investment.

Table 3 further indicates that low shock volatility firms have higher leverage volatility than high shock volatility firms (row 5), which reflects the latter's tendency to hold large cash balances (rows 8, 12, and 6) as well as their higher volatility of cash balances and net debt (rows 9 and 7). Low shock volatility firms eschew large cash holdings (row 8) in part because these holdings trigger taxes, but also because, given the relatively high predictability of their funding needs (row 2), they can forego preserving large amounts of debt capacity to address such needs—hence, low shock volatility firms find it attractive to have consistently high leverage and negligible cash balances.

For all shock volatility levels in Table 3, current cash flow is by far the most important source of funding for investment (rows 19–22), with debt issuances occurring more frequently than equity issuances (rows 13 and 17) and in larger amounts (rows 15 and 18). Debt reductions

Table 4
Capital structure comparative statics.

This table reports a variety of summary statistics from simulations of the baseline model. We simulate the model for 100,200 periods, with the firm receiving random investment shocks and responding to each by adjusting its investment and financing decisions. We discard the initial 200 periods of data. Each column reports statistics for a different model simulation. The first two are for low and high shock serial correlation, set at 0.1 and 0.9. The next two are for low and high θ, the parameter governing the marginal profitability of capital, set at 0.4 and 0.9. The last two are for smooth and lumpy investment. For smooth investment we set the convex adjustment cost parameter at 0.3 and the fixed adjustment cost parameter at 0.0. For lumpy investment we set the convex cost parameter to 0.0 and the fixed cost parameter to 0.04. Average transitory debt is the mean value of leverage (d/k) minus target, conditional upon leverage exceeding target.

		Shock serial correlation		Marginal profitability		Optimal investment	
		Low	High	Low	High	Smooth	Lumpy
1.	Average investment (I/k)	0.151	0.178	0.161	0.164	0.158	0.251
2.	Standard deviation of investment (I/k)	0.051	0.244	0.150	0.171	0.129	0.742
3.	Frequency of investment	0.998	0.816	0.828	0.772	0.872	0.426
4.	Average debt-to-assets ratio (d/k)	0.889	0.085	0.711	0.094	0.400	0.088
5.	Standard deviation of leverage (d/k)	0.038	0.084	0.192	0.083	0.087	0.134
6.	Average net debt ($(d-c)/k$)	0.889	−0.453	0.711	−0.004	0.399	−0.184
7.	Standard deviation of net debt	0.038	1.413	0.192	0.258	0.089	0.669
8.	Average cash balances to assets (c/k)	0.000	0.530	0.000	0.090	0.000	0.207
9.	Standard deviation of (c/k)	0.000	1.894	0.000	0.252	0.023	0.811
10.	Frequency of positive debt outstanding	1.000	0.527	1.000	0.644	0.998	0.456
11.	Average of positive leverage values	0.889	0.161	0.711	0.146	0.400	0.194
12.	Average of positive cash balance values	0.000	1.256	0.000	0.318	0.083	0.528
13.	Debt issuance frequency	0.024	0.263	0.420	0.331	0.489	0.217
14.	Debt repayment frequency	0.017	0.272	0.437	0.385	0.503	0.390
15.	Average debt issuance/assets	0.027	0.100	0.030	0.101	0.060	0.564
16.	Average debt repayment/assets	−0.034	−0.059	−0.028	−0.065	−0.052	−0.138
17.	Equity issuance frequency	0.165	0.293	0.061	0.253	0.248	0.248
18.	Average equity issuance/assets	0.016	0.039	0.020	0.015	0.020	0.032
Average fraction of investment funded from:							
19.	Current cash flow	0.987	0.809	0.975	0.786	0.899	0.671
20.	Cash balances	0.000	0.092	0.000	0.090	0.000	0.126
21.	Debt issuance	0.002	0.067	0.022	0.114	0.089	0.198
22.	Equity issuance	0.011	0.028	0.003	0.009	0.011	0.005
23.	Target	0.904	0.000	0.702	0.000	0.371	0.000
24.	Incidence of leverage above target	0.037	0.532	0.501	0.643	0.712	0.593
25.	Average deviation from target	−0.015	0.085	0.009	0.094	0.035	0.129
26.	Average transitory debt	0.012	0.160	0.166	0.146	0.084	0.217

occur roughly as often as debt issuances (rows 13 and 14), reflecting firms' incentives to pay down debt today to free up debt capacity for future use, even though a cost of doing so is the loss of tax benefits.

Although in our model firms have positive debt and cash balances on average, they do not carry both simultaneously. With or without corporate taxes, firms with positive cash balances and debt are always better off if they use the cash to retire debt and thereby avoid the costs of maintaining cash balances, while freeing up debt capacity. Of course, real-world firms do simultaneously borrow and hold cash, most obviously because they require some cash to operate the business, a motive that is easy to incorporate in our analytics and that does not change our transitory debt predictions. Gamba and Triantis (2008) note that, by accumulating cash while debt is outstanding, firms can reduce future debt issuance costs. We exclude direct costs of debt issuance from the model posited in Section 2 to highlight our point that the opportunity cost of issuing debt today (i.e., the debt capacity that is no longer available for borrowing tomorrow) is by itself an impediment to borrowing. Section 7 shows that our qualitative conclusions remain unchanged when we add debt flotation costs to the model and allow firms to carry debt and cash balances simultaneously. In this case, firms are less aggressive in both borrowing and paying down debt, but they still treat debt capacity as a scarce resource and use debt as a transitory financing vehicle.

Firms that face low shock volatility have relatively predictable funding needs and therefore see correspondingly little value from having unused debt capacity, and so they have high target leverage ratios (row 23 of Table 3) and, on average, have leverage ratios close to target (row 25). Firms that face moderate to high shock volatility have lower leverage targets (row 23) because they place greater value on the option to borrow to meet investment needs, and they accordingly have a larger gap between average and target leverage (row 25), which reflects a greater amount of transitory debt outstanding, on average (row 26). In Table 4 (discussed below), we compare target versus average leverage ratios for firms with different shock serial correlations, marginal investment profitability, and capital stock adjustment costs. As in Table 3, target leverage is higher and average leverage is closer to target when firms have less use for unused debt capacity to fund investment (compare rows 23 and 25 of each column pair in Table 4).[8] These comparisons from Tables 3 and 4 indicate that average leverage is a good proxy for target when having the option to borrow to fund investment is of little value, while average leverage markedly exceeds target when the option to borrow is of substantial value, with that option value manifesting in a markedly lower target debt ratio.

4.2. *Serial correlation, profitability, and capital stock adjustment costs*

Table 4 summarizes the capital structure impact of varying the serial correlation of investment shocks, the marginal profitability of investment, and the degree of smoothness in investment outlays. (Smooth investment is generated by no fixed costs of adjusting the capital stock coupled with high convex costs, while lumpy investment is induced by high fixed costs coupled with no variable adjustment costs.) For brevity, Table 4 reports predicted capital structure values for "high" and "low" values of the first two parameters and contrasts smooth versus lumpy investment for the latter, with all other parameters held constant. The table indicates that firms that have high shock serial correlation, high marginal profitability, or lumpy optimal investment programs have relatively low average leverage ratios compared to those with the opposite attributes (row 4). Firms with the former investment characteristics typically forego large tax benefits of debt to preserve debt capacity that can be tapped to fund their more volatile prospective investment outlays (row 2).

The reasons for the attraction of a conservative capital structure differ depending on the investment attribute. The higher the serial correlation of investment shocks, the more likely a current large shock will soon be followed by another shock, with an additional material need for funds. High serial correlation also implies that optimal investment outlays tend to be large because the profitability of these investments is expected to persist. Similarly, the higher a firm's marginal profitability of investment (i.e., the θ parameter), the larger is its optimal investment outlay in response to a given shock, and the possibility of a large funding need induces the firm to maintain conservative leverage, on average. Finally, holding constant the fixed component of capital stock adjustment costs, the lower the convex component of those costs, the more responsive is investment to shock arrival, and the more variable is the resultant optimal time profile of investment (Cooper and Haltiwanger, 2006). Accordingly, lower convexity in capital stock adjustment costs translates to less predictability in funding needs, and therefore to greater value from preserving debt capacity.

The same intuition explains the higher average cash balances and lower net debt of firms with high shock serial correlation, high marginal profitability, and lumpy investment outlays (rows 8 and 6). The volatility of cash balances and net debt are also markedly higher for these firms as opposed to those with the opposite investment attributes (rows 9 and 7). Such firms also exhibit higher volatility of cash balances than of leverage (rows 9 and 5), which reflects their large build-up of cash balances in anticipation of future funding needs followed by large subsequent cash draw downs—coupled with incremental borrowing—when those needs do manifest. In all cases in Table 4, cash flow realizations are the main source of funds for new investment (rows 19–22), with equity issuance typically covering only a small fraction of investment. The latter property conforms to real-world financing patterns and thereby provides something of an "out of sample" check on the model, given that our SMM estimation procedure does not match on any "source of funds" moments.

4.3. *Target capital structures*

Although capital structures exhibit path dependence locally, they are also globally self-correcting in the sense that, when managers find it optimal to borrow and deviate (or deviate further) from target leverage, they subsequently have incentives to return the firm to target by paying down debt as circumstances permit. The reason is that the option to borrow is valuable because it enables the firm to avoid more costly forms of financing in future periods, and so reducing debt is attractive because it restores that option.

Analytically, a given firm's target capital structure is the optimal matching of debt and assets to which that firm would converge if it optimized its debt and assets decisions in the face of uncertainty but then were to receive only neutral investment shocks ($z=1$) for many periods in a row. Absent taxes, the model yields an analytically simple characterization of target capital structure—zero debt is the target for all firms. With taxes, target capital structures typically contain some debt, which enables firms to capture interest tax shields on a permanent basis, and different firms have different leverage targets, which depend on the characteristics of their investment opportunities.

The capital structure target in our (tax-inclusive) model is either a fixed ratio of debt to total assets or a range[9] of such ratios, depending on the precise structure of the costs that a firm faces from adjusting its stock of

[8] Although Section 4.3 explains why some firms have a range of leverage targets, all but one of the parameter values underlying Tables 3 and 4 imply unique targets, i.e., any range of target values for a given firm is less than the grid for p in the model. For high fixed adjustment costs, the target is a range, and we report the upper bound.

[9] Many capital structure models are characterized by a range of target leverage ratios rather than by a unique target ratio independent of the scale of the firm. For example, in static tradeoff models such as Robichek and Myers (1966), Kraus and Litzenberger (1973), and DeAngelo and Masulis (1980), there is no single fixed ratio of debt to assets (or debt to market value) that is optimal independent of scale, unless one imposes restrictive assumptions on the functional forms of investment opportunities and bankruptcy/agency costs.

physical capital. We consider three cases, each characterized by a different specification of capital stock adjustment costs. In case #1, firms face no such costs and, in this case, it is easy to demonstrate that the optimal capital stock at any point in time is the level that equates the price of capital goods with the shadow value of capital. Because the value function is strictly convex, a neutral shock (z=1) corresponds to a uniquely optimal level of the capital stock, k^*, which remains constant in the face of a repeated sequence of neutral shocks. Strict convexity of the value function then implies a unique target level of net debt, p^*, and therefore a unique target level of debt, $d^* = \max(p^*,0)$, and an associated fixed target leverage ratio, d^*/k^*.

In case #2, there are no fixed costs of adjusting the capital stock, but firms face variable costs of adjusting capital that are convex in the rate of investment (I/k). In this case, if a firm receives a long series of neutral shocks, it also converges to a unique capital stock, although this level generally differs from that which obtains in the zero adjustment cost case (case #1 above) because the expected future marginal product of capital incorporates potential future adjustment costs, as discussed by Cooper and Willis (2004). The reasoning is as follows. Because the adjustment cost function is convex in the rate of investment, Jensen's inequality implies that the firm's optimal policy in the face of uncertainty is to avoid changing its rate of investment, except in response to a shock. If the firm receives a long series of neutral (z=1) shocks, the firm keeps investment constant at a rate that just allows for replacement of depreciated capital. The capital stock therefore remains constant at a level k^* (generally different from case #1). This rate equates the marginal adjustment and purchasing costs with the shadow value of capital. As in case #1, in case #2 a unique target capital stock, k^*, implies a unique target level of debt, d^*, and a unique target leverage ratio, d^*/k^*.

In case #3, firms face only fixed costs of capital stock adjustment. In this case, a firm's optimal investment policy (in the limit after a series of neutral shocks) is not to maintain a constant capital stock, but to allow that stock to depreciate from an upper to a lower bound, at which point it invests to restore the depreciated capital. (See Caballero and Leahy, 1996; Caballero, 1999; Whited, 2006) The upper bound is the optimal level of the capital stock at which the shadow value of capital equals the price of capital goods, a level that in general differs from those for both cases #1 and #2. In case #3, the firm does not immediately return to this level when capital depreciates; rather it waits until its capital stock reaches the lower bound, at which point the marginal benefit from returning to the optimal level just covers the fixed cost of doing so. Under the baseline model parameterization, at this lower bound the firm faces a funding need that exceeds its internal resources, which it satisfies by borrowing. As the capital stock depreciates from the upper to the lower bound, the firm uses its cash flow first to pay down debt and then to increase cash balances in anticipation of the approaching large funding need. This behavior dictates a fixed range for the optimal levels of physical capital and debt (and of net debt). Hence, in case #3, the firm has a *range* of target leverage ratios that is determined by its levels of debt and capital as physical capital depreciates from the upper to the lower bound described above.

Fig. 2 plots target ratios of debt to total assets as a function of investment shock volatility and serial correlation for firms that respectively face (i) zero costs of adjusting the physical capital stock, (ii) high convex costs of adjustment, and (iii) high fixed costs of adjustment, i.e., for variants of cases #1–3 discussed above. Target leverage is unique for capital stock adjustment cost scenarios (i) and (ii), but takes a range of values for scenario (iii), with Fig. 2 reporting the upper bound of the target range and for simplicity omitting the lower bound, which is 0.0 in all cases. The figure indicates that lower target leverage is associated with higher levels of shock volatility and of shock serial correlation (Panels A and B, respectively). The intuitive explanation is that a higher value of each parameter implies a higher probability that large investment outlays are optimal, which in turn provides incentives for firms to adopt capital structures with more conservative leverage, hence greater ability to issue transitory debt. Target leverage is also negatively related to the marginal profitability of investment, but the relation is not as strongly negative as it is for shock volatility and serial correlation (details not shown in the figure).

Fig. 3 illustrates the existence of a leverage target and the convergence to target for a firm that faces convex capital stock adjustment costs but no fixed adjustment costs ($a = 0.15, \gamma = 0.00$). Over dates t=0 through t=52, the firm's debt level fluctuates in response to the arrival of investment shocks and to its decision to pay down debt in periods in which cash flow realizations exceed contemporaneous funding needs. In some cases, the firm reduces debt below target because shock realizations—coupled with serial correlation of investment shocks—indicate that large future investment outlays are likely to be optimal, and so the firm temporarily builds debt capacity in anticipation. At t=52, the firm experiences a neutral investment shock, and such shocks continue to arrive. The firm uses its cash flow realizations to pay down debt and, at t=55, it thereby attains its long-run leverage target where it remains as neutral shocks continue to arrive. (Note that the target is not the leverage ratio at which the firm begins receiving neutral shocks, but rather is the leverage to which the firm moves in the limit if it were to experience repeated neutral shocks.) If non-neutral shocks were to resume, leverage would once again follow a volatile path. If instead the firm faced fixed costs of adjusting its capital stock, it would not have a constant leverage target. Rather, after t=52, the firm's target d^*/k^* ratio would fluctuate as the optimal capital stock, k^*, depreciates and the firm delays replenishment, while the debt level, d^*, is adjusted downward in response, but generally not in strict proportion, to the reduction in k^*.

5. Speed of adjustment to target capital structure

Extant tradeoff models predict that, whenever leverage differs from target because of factors beyond managers'

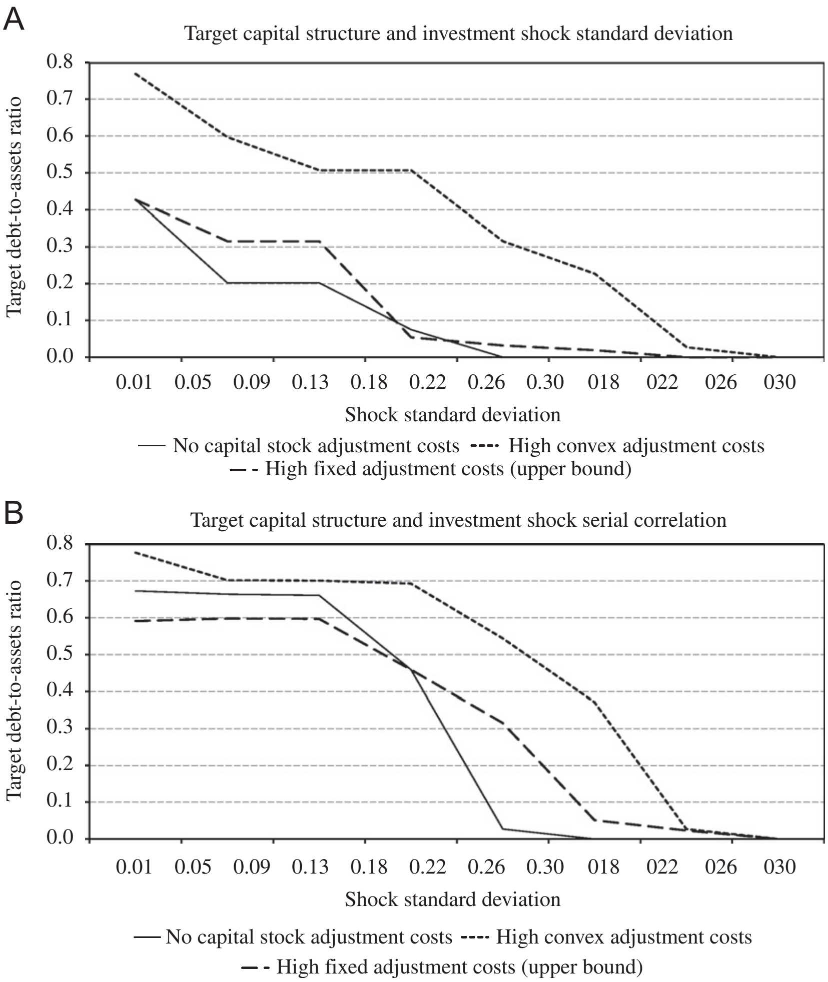

Fig. 2. Target capital structure as a function of the attributes of investment opportunities. Leverage is measured as the ratio of debt to total assets. Shock volatility (σ_v) and serial correlation (ρ) parameters are centered around the estimates from the SMM estimation in Section 2. Target leverage is unique for the no capital-stock adjustment cost and high convex adjustment cost cases, but not for the high fixed cost case. Both panels plot the upper bound on target leverage for the latter case, with the lower bound always equal to 0.00.

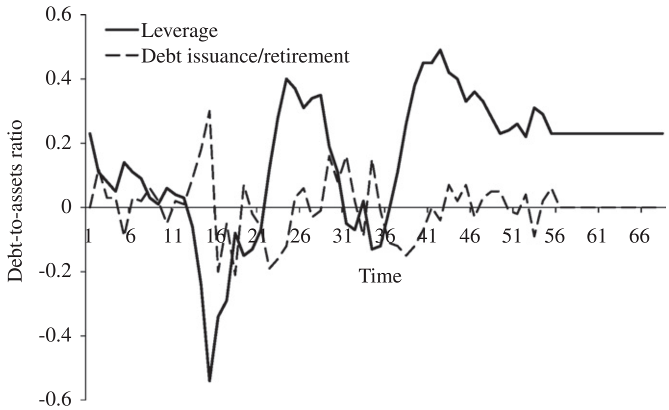

Fig. 3. Illustrative convergence to target leverage in the estimated model. The firm experiences random investment shocks until date t=52, at which point it begins to receive a series of neutral investment shocks. It converges to target at t=55 and remains there as neutral shocks continue to arrive. This illustrative firm faces convex capital stock adjustment costs, but no fixed costs of adjustment, and so it has a unique long-run target leverage ratio.

control, firms rebalance toward target as quickly as is economical, given the costs of security issuance. Fama and French (2002) cast doubt on the explanatory power of tradeoff models because the estimated speed of adjustment (SOA) to target is "suspiciously slow." Subsequent studies support this view with estimates that firms move on average between one-third and one-twelfth of the way toward target each year (see, e.g., Flannery and Rangan, 2006; Kayhan and Titman, 2007; Lemmon, Roberts, and Zender, 2008; Parsons and Titman, 2008).

Our estimated model parameters imply slow average speeds of adjustment to target leverage in the same neighborhood as the average SOA estimates reported in prior empirical studies. The slow SOA in our model reflects an ongoing shock-dependent sequence of both (i) debt issuances that raise funds needed for investment, but that also move firms temporarily away from target, and (ii) debt repayments in which firms rebalance toward target when investment needs slacken, in order to free up debt capacity for future borrowing. Extant tradeoff models treat investment as exogenous, and so they rule out the transitory deviations from target to fund investment which, in our model, slow the average SOA as it is measured in prior empirical studies. As a result, the SOA measures employed in prior studies understate the strength of the actual leverage rebalancing incentives firms face in our model because they inappropriately include leverage changes in which firms deliberately but temporarily move away from target to fund new investment. When we exclude the latter changes from our SOA measures, firms in our model move aggressively toward target leverage.

Table 5 presents our main SOA results, which are generated using the approach employed in prior sections to obtain our comparative statics results, with model parameters set at the estimated baseline values (per Section 2). In rows 1 through 3, we report three different measures of the average rate at which firms move toward target leverage, with each model-generated SOA reported both (i) unconditional on current leverage, and (ii) conditioned on whether current leverage is above/at or below target. The remaining rows (4–33) of Table 5 show model-generated leverage changes and attributes of the related financing decisions that underlie our measured speeds of adjustment to target. Because investment plays an important role in the rate at which firms deviate from and rebalance to target, each variable in rows 4–33 is reported unconditional on investment, as well as conditional on low, moderate, and high levels of investment.

In Table 5, rows 1 and 2 report model-generated average SOA measures that are calculated, as done in prior empirical studies, to include both (i) rebalancing decisions, and (ii) financing decisions that deliberately move firms away from target, while row 3 reports the average SOA measured as our model indicates it should be, i.e., by (i) alone.[10] Since the model is estimated using yearly data, each SOA in Table 5 represents an annual rate of movement toward target. Row 1's average SOA is 0.142, which indicates that, in a randomly selected model year, firms move about one-seventh of the way toward target, on average—a figure that is close to the annual estimates in recent SOA studies. Row 2's average regression-based SOA is 0.378, which implies a movement of a little over one-third of the way toward target in each randomly selected year—a figure that is again close to prior empirical estimates. In sharp contrast, row 3's average SOA, which excludes firms' proactive decisions to deviate from target, is 0.605. This result indicates that firms whose current circumstances favor rebalancing do so aggressively, moving on average about 60% of the distance toward target in each year.

As expected when firms have target leverage ratios, firms are more likely to decrease leverage when it is currently above target (rows 8 and 9 of Table 5) and more likely to increase leverage when it is below target (rows 23 and 24), with the average leverage change negative in the former case and positive in the latter (-0.015 and 0.036, respectively, per rows 4 and 19). While these average changes are modest in absolute value, both include substantial increases and decreases (rows 5, 6, 20, and 21)—an indication that leverage changes often move firms significantly away from target. More precisely, the probability of a leverage increase is 0.372 when leverage is above target (row 7), while the probability of a leverage decrease is 0.347 when leverage is below target (row 23). Firms often take material (temporary) excursions away from target, and that is why conventional SOA measures indicate slow speeds of adjustment for model-generated leverage ratios. In short, conventional SOA measures obscure the consequences of our model's implication that firms aggressively rebalance leverage toward target in some but not all states of the world.

With endogenous investment, the specific attributes of a firm's investment opportunities dictate whether rebalancing toward or deviating further from target leverage is currently optimal. In our model, firms have incentives to avoid maintaining a permanent large cash reserve due to corporate taxes, agency costs, and/or Keynesian liquidity costs. And, since firms are operating on a "tight leash" with respect to cash balances, external financing becomes necessary more often to meet the marginal funding needs associated with investment shocks. Moreover, because equity issuance is more costly than debt issuance, debt is an attractive source of marginal financing, with proactive debt issuance decisions (to fund

[10] "Average SOA" in row 1 is the mean of (1) the change in leverage divided by (2) the distance from current leverage to target leverage. As discussed below, firms sometimes overshoot the leverage target, and inclusion of such overshooting biases upward the measured average rate at which firms adjust leverage towards target. We accordingly cap the ratio at 1.000 for any observation in which the leverage change exceeds the distance from target. "Average SOA toward target" in row 3 is calculated in the same fashion, but excludes observations that do not move leverage toward target. "Regression-based SOA" in row 2 is the SOA implied by a regression that uses model-generated leverage ratios and follows the general approach of extant SOA tests—i.e., current leverage is the left-hand side variable, while the explanatory variables are lagged leverage, firm value/assets, and cash flow/assets. The latter variables are included as proxies for the determinants of target leverage of the type posited in empirical SOA studies.

Table 5
Speed of adjustment to target.

This table reports speeds of adjustment to target in a simulation of the baseline model. We simulate the model for 100,200 periods, with the firm receiving random investment shocks and responding to each by adjusting its investment and financing decisions. We discard the initial 200 periods of data. "Average SOA" in row 1 is the mean of the ratio of the change in leverage to the distance from current leverage to target leverage. "Average SOA toward target" in row 3 is calculated in the same fashion, but excludes observations that do not move leverage towards target. "Regression-based SOA" in row 2 is the SOA implied by a regression that uses model-generated leverage ratios and follows the general approach of extant SOA tests—i.e., current leverage is the left-hand side variable, while the explanatory variables are lagged leverage, firm value/assets, and cash flow/assets. All statistics are reported for the entire simulated sample, as well as for the first through third terciles of the ratio of investment to capital.

A. Alternative SOA measures			Current leverage:	
		Unconditional	at or above target	below target
1.	Average SOA	0.142	0.115	0.204
2.	Regression based SOA	0.378	0.332	0.593
3.	Average SOA towards target	0.605	0.543	0.769

B. Leverage changes and investment			Investment:		
		Unconditional	Low	Moderate	High
Leverage above or at target					
4.	Average change in leverage	−0.015	−0.021	−0.017	−0.007
5.	Average increase in leverage	0.057	0.057	0.052	0.063
6.	Average decrease in leverage	−0.058	−0.061	−0.056	−0.057
7.	Probability of leverage increase	0.372	0.344	0.366	0.414
8.	Probability of leverage decrease	0.627	0.655	0.634	0.585
9.	Probability of overshooting target	0.280	0.293	0.253	0.293
10.	Probability of debt issuance	0.406	0.124	0.238	0.940
11.	Probability of debt repayment	0.592	0.875	0.760	0.059
12.	Probability of equity issuance	0.244	0.083	0.263	0.416
13.	Size of debt issuance	0.089	0.046	0.031	0.113
14.	Size of debt repayment	−0.079	−0.099	−0.059	−0.025
15.	Size of equity issuance	0.015	0.018	0.015	0.015
16.	Average shock	0.061	−0.292	0.113	0.429
17.	Probability of a positive shock	0.561	0.139	0.671	0.949
18.	Fraction of observations	0.702	0.254	0.238	0.210
Leverage below target					
19.	Average change in leverage	0.036	0.021	0.024	0.055
20.	Average increase in leverage	0.099	0.083	0.088	0.115
21.	Average decrease in leverage	−0.053	−0.053	−0.054	−0.053
22.	Probability of leverage increase	0.554	0.524	0.514	0.604
23.	Probability of leverage decrease	0.347	0.410	0.389	0.273
24.	Probability of overshooting target	0.464	0.521	0.434	0.449
25.	Probability of debt issuance	0.547	0.161	0.378	0.930
26.	Probability of debt repayment	0.352	0.717	0.493	0.005
27.	Probability of equity issuance	0.293	0.113	0.293	0.410
28.	Size of debt issuance	0.154	0.047	0.039	0.203
29.	Size of debt repayment	−0.061	−0.073	−0.047	−0.022
30.	Size of equity issuance	0.029	0.028	0.026	0.031
31.	Average shock	−0.150	−0.459	−0.189	0.080
32.	Probability of a positive shock	0.348	0.145	0.222	0.577
33.	Fraction of observations	0.298	0.080	0.095	0.123

current investment) and repayment decisions (to replenish future borrowing capacity) reflecting the sequence of optimal investment outlays. Furthermore, because investment shocks are serially correlated, firms will sometimes respond to a specific favorable shock by moving/remaining temporarily below target in order to obtain/preserve additional borrowing capacity (and perhaps to build cash balances) so as to be in a better position to fund the higher future investment outlays that are more likely given the recent shock realizations.

To clarify the link between investment outlays and movements relative to target, we first consider firms whose current leverage is above/at target. When such firms face high investment outlays, the probability of a debt issuance is 0.940 (row 10 of Table 5), and the average issuance is 11.3% of total capital (row 13). When investment needs are low, the debt issuance probability falls to 0.124 (row 10), and new borrowing averages only 4.6% of capital (row 13). The situation is reversed for debt repayments, as firms with low investment outlays repay debt with a 0.875 probability, which far exceeds the 0.059 repayment probability in high investment states of the world (row 11). Moreover, in low investment states, the average debt reduction is four times that associated with high investment (9.9% versus 2.5% of capital, per row 14). Finally, while the average equity issuance is always small (1.8% of capital or less, per row 15), its likelihood nonetheless depends on investment—at 0.416 with high investment versus 0.083 with low investment (row 12). In sum, with high investment, firms that are currently above target leverage often issue substantial debt (and sometimes issue small amounts of equity), thereby deviating further from target, whereas with low investment, these firms typically pay down debt and thus replenish future borrowing capacity.

The attributes of firms' investment decisions also govern the leverage rebalancing decisions of firms whose current leverage is below target. With high investment, these firms' debt issuance probability is 0.930 (row 25), with an average issuance of 20.3% of capital (row 28). Such debt issuances represent aggressive movements toward target and, because the typical need for cash to fund investment is great, the (conditional) probability is 0.449 that the new leverage ratio overshoots the long-run leverage target (row 24). When investment is low, the debt issuance probability is far smaller (0.161, per row 25), as is the size of the average issuance (4.7% of capital, per row 28). However, the probability of overshooting target is nontrivial in all cases (row 24), indicating that when firms move toward target, they do so aggressively, motivated more by the need to fund investment than by the desirability of quickly returning to target leverage. Finally, when investment is low and leverage is below target, firms repay debt with probability 0.717 (row 26), a result that seems counterintuitive because firms are reducing their debt when leverage is below target.

In general, why do firms sometimes choose to remain or move below target leverage when they could lever up at zero transactions costs by borrowing and immediately distributing the proceeds to stockholders? The answer is that investment shocks are serially correlated in our model, which implies that firms sometimes rationally build additional (temporary) debt capacity by moving below target when a given shock implies an increased likelihood of future shocks that will require additional resources to fund investment. While the influence of each such investment shock erodes over time, serially correlated shocks nonetheless encourage firms to remain below target for multiple periods, even when they could easily lever up. The same logic explains why firms with current leverage above target sometimes overshoot the target when reducing leverage (row 9). It also explains why we analytically define the long-run leverage target in terms of a limiting sequence of capital structures—since the influence on leverage of any given shock approaches zero over time, firms' leverage converges to the long-run target in the limit as neutral shocks continue to arrive and any lingering influence of prior non-neutral shocks fades over time.

Dudley (2009) argues that the SOA toward target is faster when firms raise external capital for investment because capital structure adjustments are lumpy and coincide with discrete investment outlays. Our analysis also indicates that conventional SOA measures vary with the level of investment. But our model differs in its prediction that the measured SOA often takes negative values because firms often issue transitory debt and move away from target to fund investment. Hence, our model explains the empirically observed low average levels of the SOA to target on grounds that many inputs to the average are negative. Dudley presents evidence consistent with his model's prediction that firms adjust leverage toward target when cash is raised for projects. However, our Section 6 evidence is inconsistent with the latter prediction. We examine capital structure changes that accompany investment "spikes" and find that firms with above-average leverage ratios typically issue debt and move further away from target to meet their funding needs.

6. Leverage, investment, and the explanatory power of the model

This section reports the results of four tests of our model's ability to explain observed leverage decisions. First, we use SMM estimation to gauge the model's ability to match industry-level leverage for 41 two-digit SIC code industries. Second, we regress average industry leverage on the structural parameters for 40 of these estimations (excluding railroads, the sole poorly matched industry) and test whether attributes of investment opportunities exert statistically significant influences on leverage in a manner consistent with our model's predictions. Third, we run a "horse race" that compares the explanatory power of our model with that of tradeoff models in which investment policy is exogenous and firms rebalance leverage subject to capital structure adjustment costs. Fourth, we test the investment/capital structure implications delineated in Panel B of Table 5 by analyzing the financing decisions associated with investment "spikes" by Compustat firms.

6.1. Industry leverage

Frank and Goyal (2009, Table III) find that industry median leverage is the single most important (out of 34) determinant of corporate leverage, with almost three times the stand-alone explanatory power of the next most important factor. This finding suggests that a relevant gauge of the empirical usefulness of any model of capital structure is its ability to explain cross-industry variation in leverage. Fig. 4 indicates that our model does a remarkably good job explaining cross-industry variation in leverage.[11] The figure plots the actual versus simulated average debt-to-asset ratios for 41 two-digit SIC industries, each of which has at least 100 firm-year observations over 1988–2001. We obtain the simulated leverage ratios from 41 distinct SMM

[11] Although it would be appealing to be able to gauge the explanatory power of firm-specific SMM estimations, we focus here on industry-level explanatory power because current computational limitations make it problematic to run thousands of different SMM estimations, and because of the impossibility of calculating standard errors for firms that have few observations relative to model parameters.

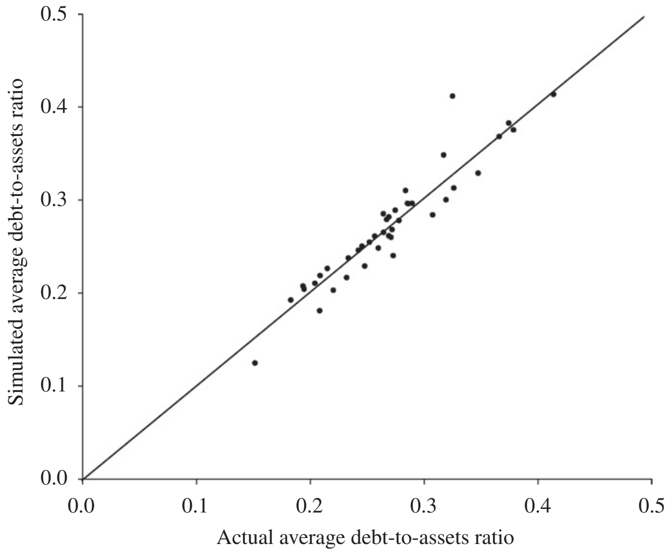

Fig. 4. Actual versus simulated debt: 41 industries. This figure depicts the results of 41 separate SMM estimations, each using data from a different two-digit SIC code industry. Calculations are based on a sample of nonfinancial, unregulated firms from the annual 2007 Compustat industrial files. The sample period is 1988–2001. On the vertical axis is the model-implied average leverage (debt-to-assets) ratio given the industry-specific estimated parameters. On the horizontal axis is the actual average industry leverage ratio. The figure includes a 45° (diagonal) line out of the origin to make it easier to gauge the gap between actual and model-implied leverage. Simulated and actual leverage are not statistically different from each other, except in the case of the railroad industry, which is represented by the point away from the 45° line in the upper right corner.

Table 6
Regression of industry average debt on estimated industry parameters: 40 industries.

OLS regressions are estimated from a cross-section of 40 two-digit SIC code industries over 1988–2001. The left-hand side variable is average industry book leverage. The right-hand side variables are structural parameter estimates from 40 separate SMM estimations of the model in Section 2. λ_1 and λ_2 are the linear and quadratic costs of equity issuance. $\sigma_{v.}$ is the standard deviation of the innovation to ln(z), in which z is the shock to the revenue function. ρ is the serial correlation of ln(z). θ is the curvature of the revenue function, zk^{θ}. γ and a are the fixed and convex adjustment cost parameters, and s is the agency cost parameter. $\overline{p}/k^{ss}$ is the debt ceiling expressed as a fraction of the steady state capital stock, k^{ss}. Standard errors are in parentheses.

	λ_1	λ_2	σ_v	ρ	θ	γ	a	s	$\overline{p}/k^{ss}$	R^2
Coefficient	−0.073	1.730	−1.056	−0.757	−1.154	1.677	0.664	0.935	0.589	0.669
Standard error	(0.186)	(2.315)	(0.470)	(0.423)	(0.387)	(2.353)	(0.180)	(0.272)	(0.219)	
t-statistic	−0.392	0.747	−2.246	−1.789	−2.983	0.713	3.696	3.443	2.691	

estimations (per the approach in Section 2), and take actual leverage ratios from Compustat for the estimation period. With one exception (railroads), all industries plot close to the 45° line in Fig. 4—a graphical manifestation of the fact that our parsimonious nine-parameter SMM estimations generate industry average leverage ratios that are insignificantly different from actual industry average leverage for 40 of the 41 industries. We also find that the model performs respectably in terms of matching most other moments (details not in Fig. 4), with the volatility of equity issuance and the level of industry investment representing the two areas in which modeling and estimation refinements would most likely improve explanatory power.

Table 6 presents the results of a regression of average industry leverage on the structural parameter estimates that we obtain from 40 of the 41 SMM industry estimations described above (excluding railroads). The R^2 of 0.669 indicates that our model explains a substantial proportion of the cross-industry variation in average leverage. Three estimated parameters that describe aspects of the investment opportunity set—shock volatility, profit function curvature, and convex costs of adjusting the capital stock—have statistically significant influences of the predicted signs, with respective t-statistics of −2.246, −2.983, and 3.696, but the serial correlation parameter is only marginally significant (t-statistic of −1.789). The parameters for debt capacity and costs of cash balances are of the expected signs and statistically significant (t-statistics of 3.443 and 2.691, respectively), while the equity issuance cost and fixed capital stock adjustment cost parameters are immaterially different from zero. The overall picture is that the model does a good job explaining variation in industry average leverage, with most estimated parameters exerting significant influences on industry leverage in a manner consistent with the model's predictions.

6.2. The model benchmarked against extant tradeoff models

Table 7 indicates that our model does a better job explaining debt issuances and repayments over 1988–2001 than do extant tradeoff models in which investment policy

Table 7
Model error rates.

Each model error rate equals the absolute value of the difference between the actual frequency of debt issuances (or repayments) over 1988–2001 and the frequency predicted by the model in question. For the current model (labeled DDW), predicted frequencies of issuance or repayment are based on 40 distinct SMM model estimation exercises, one for each of 40 two-digit SIC code industries, as described in the text, and with each target determined as in Section 2.3. The tradeoff model refers to the class of either static or dynamic leverage rebalancing models in which (i) investment policy is exogenous, and (ii) firms potentially face costs of capital structure adjustment. For the tradeoff model, we take industry average leverage as the empirical proxy for target leverage. When leverage is above or at target, the tradeoff model error rate equals the empirical incidence of debt issuances that result in leverage above target (a result that is ruled out by rebalancing theories). Similarly, when leverage is below target, the tradeoff model error rate equals the incidence of debt repayments that result in leverage below target. The mean (median) error rate is the average (median) across the 40 industries of the mean within-industry error rates. The *Z*-statistic is for a test of the null hypothesis that the mean model error rate for the tradeoff model is greater than the mean model error rate for the DDW model.

	Unconditional		Investment:					
			Low		Medium		High	
	Tradeoff model	DDW model	Tradeoff model	DDW model	Tradeoff model	DDW model	Tradeoff model	DDW model
Leverage above or at target:								
Mean model error rate (n=40 industries)	0.441	0.078	0.349	0.282	0.424	0.240	0.588	0.325
Median model error rate	0.440	0.074	0.355	0.292	0.429	0.236	0.572	0.324
% of industries with DDW model error rate < tradeoff model error rate	100.0%		85.0%		100.0%		97.5%	
Z-statistic	22.258		2.682		6.858		8.942	
Leverage below target:								
Mean model error rate (n=40 industries)	0.330	0.062	0.365	0.277	0.367	0.120	0.279	0.287
Median model error rate	0.338	0.047	0.382	0.298	0.377	0.109	0.285	0.282
% of industries with DDW model error rate < tradeoff model error rate	100.0%		62.5%		95.0%		40.0%	
Z-statistic	14.358		2.209		9.055		−0.346	

is exogenous and firms rebalance leverage subject to adjustment costs. We arrive at this inference by first noting that all such tradeoff models share the following two testable predictions about debt issuance and repayment decisions. First, firms with leverage currently above target will never issue debt and have their resultant leverage ratios remain above target, since such issuances unnecessarily move leverage away from target. By symmetric reasoning, extant tradeoff models also predict that firms with leverage currently below target will never pay down debt and have their resultant leverage ratios remain below target. Therefore, when beginning-of-period leverage exceeds target, the tradeoff model error rate in Table 7 is the fraction of cases in which firms both issue debt and have end-of-period leverage above target. Similarly, when beginning-of-period leverage is below target, the model error rate is the fraction of cases in which firms both repay debt and have end-of-period leverage below target. The error rates for our model (labeled DDW in Table 7) are calculated analogously, and equal the absolute value of (i) the actual frequency of debt issuances or repayments minus (ii) the corresponding frequency predicted by the model. Predicted issuance or repayment frequencies are determined as in Table 5 (rows 10, 11, 25, and 26), except that now we generate different predictions for each of the 40 two-digit SIC industries whose SMM estimations are described above. (We take industry average leverage as a proxy for the leverage target under the tradeoff model of all firms in the industry in question, whereas the target for our model is determined as in Section 2.3, with all firms in a given industry assumed to have the same target.)

We follow the structure of Table 5 and report model error rates for the full sample and for subsamples conditioned on low, medium, and high investment. The mean (median) error rate in Table 7 is the average (median) across the 40 industries of the mean within-industry error rates. The *Z*-statistic is for a test of the null hypothesis that the mean of the error rates for the 40 industries under the tradeoff model equals the mean of the absolute value of the error rates under the DDW model. The table also reports the percent of industries for which the value of the mean error rate for the DDW model is less than the corresponding error rate for the tradeoff model.

For all 40 industries (100.0% of the sample), Table 7 indicates that the error rate for the DDW model is less than the error rate for the tradeoff model, both when leverage is currently above (or at) target, and when it is below target. When leverage is above target, the mean DDW model error rate is 0.078, which is roughly one-sixth the corresponding mean error rate of 0.441 for the tradeoff model, and the difference between the mean error rates is highly significant (*Z*-statistic = 22.258). The median error rates (0.074 and 0.440) indicate a similarly large differential in predictive power in favor of the DDW model, as does the compilation in Table 7 of the two models' industry error rate statistics conditioned on leverage currently falling below target.

When leverage is currently above target, the DDW model has a lower absolute error rate than the tradeoff model for 97.5%, or 39 of the 40 industries when investment is high, and for 100.0% and 85.0% of the industries, respectively, when investment falls in the medium and low groups. In all cases, the mean error rate for the DDW model is significantly less than that for the tradeoff model, with t-statistics ranging from 8.942 for high investment to 2.682 for low investment. When leverage is currently below target, the DDW model retains an edge over the tradeoff model, but the difference is narrower, with 62.5% and 95.0% of industries showing smaller error rates under our model at low and medium investment levels. The tradeoff model has a smaller error rate in 60.0% of the industries when investment is high and leverage is below target, but the difference in mean error rates is not significant (t-statistic=0.346).

When leverage is above target and investment is high, the tradeoff model exhibits especially large mean and median error rates of 0.588 and 0.572 versus 0.325 and 0.324 for the DDW model (per Table 7). The large error rates of the tradeoff model reflect its strong tendency to under-predict debt issuances to fund investment, which arises because all such issuances are ruled out by the model's assumption that investment is exogenous. The smaller error rates of the DDW model arise because investment is determined endogenously with capital structure, and because the model assigns a central role to firms' incentive to issue transitory debt to fund investment.

6.3. Debt issuances and investment "spikes"

We next focus on large investment "spikes" to test the predictions about the connection between investment and leverage decisions that are delineated in Panel B of Table 5. We study investment spikes because the data inherently contain a substantial amount of noise, hence there is greater ability to detect any material capital structure changes when focusing on firms at times that they make large investment outlays. Our main findings are reported in

Table 8
Debt issuance and investment spikes.
The table reports mean (median) values of annual investment, debt issuance, and other financing variables for Compustat industrial firms over 1962–2008. An investment spike is defined as an investment outlay (variable 1) that is two or more standard deviations above the mean for the firm's two-digit SIC code industry. Non-spikes are investment outlays that are less than two standard deviations from the industry mean. Variables 1–4, 7, 8, 10, and 11 are standardized by total assets at the beginning of the year. Variable 13 is calculated using the "speed of adjustment toward target" definition for item 3 of Table 5, i.e., excluding observations that do not move leverage toward target. The partitioning into above- and below-average leverage ratios is based on the average of all observations over 1962–2008 for the firm's two-digit industry. Similar results obtain when we restrict attention to observations for 1988–2001 and use the target leverage estimates from our industry SMM analyses and partition the sample into above and below target based on the SMM results.

	Full sample		Above average leverage		Below average leverage	
	Spike	Non-spike	Spike	Non-spike	Spike	Non-spike
1. Investment	0.114 (0.081)	0.071 (0.054)	0.116 (0.077)	0.069 (0.050)	0.113 (0.083)	0.072 (0.057)
2. Change in investment	0.056 (0.031)	0.002 (0.002)	0.053 (0.027)	−0.003 (0.000)	0.058 (0.033)	0.007 (0.004)
3. Debt issuance	0.127 (0.112)	0.008 (0.000)	0.128 (0.123)	−0.008 (−0.003)	0.127 (0.107)	0.021 (0.000)
4. Lagged debt issuance	0.020 (0.000)	0.015 (0.000)	0.066 (0.051)	0.040 (0.027)	−0.005 (0.000)	−0.006 (0.000)
5. Lead debt issuance	0.018 (0.002)	0.010 (0.000)	0.015 (0.008)	−0.004 (−0.002)	0.019 (0.000)	0.022 (0.000)
6. Beginning-of-year debt/assets	0.203 (0.185)	0.248 (0.233)	0.380 (0.345)	0.398 (0.366)	0.108 (0.103)	0.116 (0.116)
7. End-of-year debt/assets	0.283 (0.277)	0.246 (0.229)	0.416 (0.403)	0.379 (0.355)	0.211 (0.212)	0.129 (0.119)
8. Change in cash	−0.014 (−0.002)	0.008 (0.002)	−0.001 (0.003)	0.005 (0.001)	−0.020 (−0.009)	0.010 (0.004)
9. Lagged change in cash	0.024 (0.008)	0.006 (0.002)	0.015 (0.004)	0.002 (0.001)	0.028 (0.012)	0.010 (0.004)
10. Beginning-of-year cash/assets	0.141 (0.086)	0.105 (0.059)	0.086 (0.048)	0.063 (0.038)	0.171 (0.117)	0.142 (0.095)
11. Equity issuance	0.034 (0.002)	0.017 (0.001)	0.039 (0.002)	0.018 (0.000)	0.031 (0.002)	0.016 (0.001)
12. Lagged equity issuance	0.029 (0.002)	0.018 (0.000)	0.020 (0.001)	0.014 (0.000)	0.033 (0.002)	0.021 (0.001)
13. Speed of adjustment	0.234	0.070	−0.295	0.113	0.518	0.032
14. Number of observations	3,756	81,437	1,314	37,978	2,442	43,459

Table 8, which analyzes debt issuance and other financing decisions associated with investment spikes by Compustat industrial firms over 1962–2008. We define an investment spike as an annual capital expenditure outlay (divided by beginning-of-year total assets) that is two or more standard deviations above the mean for the firm's two-digit SIC code industry, with all smaller investment outlays defined as non-spikes. As a check, we also use several other thresholds (as in Whited, 2006, Table 2) to define investment spikes and find results similar to those in Table 8 (details not reported). The sample contains 3,756 spikes and 81,437 non-spikes. The mean investment spike is 11.4% of assets versus 7.1% for non-spikes, and the respective medians are 8.1% and 5.4% (row 1 of Table 8). The typical spike entails a mean increase of 5.6% in the ratio of investment to total assets, while the average non-spike corresponds to an increase in that ratio of only 0.2% (row 2).

Investment spikes are associated with large debt issuances that average 12.7% of assets (row 3 of Table 8), versus an average issuance of only 2.0% in the prior year (row 4) and 1.8% in the year after the spike (row 5), with medians showing a comparably large increase in debt issuance in the year of the spike. In contrast, debt issuances average only 0.8%, 1.5%, and 1.0% in the years around non-spikes (see rows 3, 4, and 5 for the non-spike column). The 12.7% average debt issuance (row 3) is far greater than the 1.4% drawdown of cash balances in the year of the spike (row 8) and the 3.4% equity issuance in that year (row 11). The average change in cash and issuance of equity are closer to zero in non-spike years (rows 8 and 11). In the year before an investment spike, firms increase cash balances by an average of 2.4% (row 9) and issue equity equal to 2.9% of assets (row 12), both of which are swamped by the size of the average debt issuance in the year of the spike (row 12). The overall effect is that the average debt-to-assets ratio increases from 20.3% right before an investment spike to 28.3% at the end of the spike year (rows 6 and 7), while non-spike years begin with an average leverage ratio of 24.8% and end with a virtually identical 24.6% ratio.

Investment spikes are associated with comparably large average debt issuances of 12.8% when leverage is currently above average (see row 3 of the third column of Table 8), and these large issuances now come on the heels of a nontrivial average debt issuance of 6.6% in the immediately prior year (row 4). Cash changes and equity issuances remain modest in the year of and year preceding the investment spike (rows 8, 9, 11, and 12), and so debt issuances continue to be much larger than these alternative sources of capital. In terms of the net impact on leverage, firms with investment spikes and above-average leverage increase the debt-to-assets ratio from an average of 38.0% at the beginning of the spike year to 41.6% at the end of that year. Overall then, even when leverage is above average—and therefore typically above target leverage for the tradeoff model—investment spikes are accompanied by increases in leverage. The explanation offered by our model is that the benefit of issuing debt to fund the current period investment spike typically overrides the advantages of immediately rebalancing leverage in the direction of target.

The findings in Table 8 are close in spirit to those of four prior studies that document that debt issuances commonly move firms away from their leverage targets. Hovakimian (2004) finds that "…debt issues do not reduce the deviation from the target debt ratio. The pre-debt-issue deviation from the target is essentially zero. The issuance of debt increases rather than reduces the deviation from the target." In Hovakimian, Opler, and Titman's (2001, Table 4) sample, the average long-term debt issue is 17.4% of total assets, and is undertaken when the firm's debt-to-assets ratio is 1.3% below the authors' estimate of target. Harford, Klasa, and Walcott (2008) report that, in debt-financed acquisitions, bidding firms typically move away from their target capital structures, and then rebalance back toward target with a lag. Denis and McKeon (2009) document 2,513 cases (over 1971–1999) in which 2,272 firms substantially increase their total debt at a time when their debt ratios are at least 10% above estimated target leverage.

Our Table 8 findings are consistent with those of Mayer and Sussman (2004) for large firms, but differ from theirs on small firms. Mayer and Sussman study 535 investment events, each of five-year duration with an investment spike in the middle, and find that large firms tend to issue debt to fund large investments, while small firms tend to issue equity. In untabulated sensitivity checks, we find results very close to those in our Table 8 for each of nine subsamples, which we form by partitioning our full sample of investment spikes into firms with high, medium, and low (i) values of total assets, (ii) ratios of the market-to-book value of equity, and (iii) ratios of the market-to-book value of total assets. These sensitivity checks indicate that the debt issuance and leverage change inferences drawn from the Table 8 findings continue to hold even when we focus on small firms and on companies with quintessential growth-firm attributes.

Finally, Table 8 highlights the importance of investment outlays in explaining why empirical studies have tended to find more sluggish rebalancing to target than one would expect if extant tradeoff models were empirically descriptive. For firms with investment spikes, the average speed of adjustment (SOA) to target is 0.234, or about four years to reach target, where target is proxied by industry average leverage (row 13). When leverage is below average, the average SOA is twice as fast at 0.518, and the reason is that the attraction of borrowing to fund investment strongly propels the firm to increase leverage and move toward target. On the other hand, when leverage is above target, the SOA is actually negative, i.e., firms typically take on debt and move away from target at a moderate rate (-0.295). Because extant tradeoff models leave no room for transitory debt issuances to fund investment, the latter cases enter into and dampen the SOA estimates, and give the impression that firms have little motive to rebalance leverage. The explanation offered by our model is that the dominant incentive is for firms to fund immediate investment outlays in a cost-effective manner, which often means by issuing transitory debt and deviating from target. Rebalancing toward target occurs most prominently when current period investment incentives are supportive of such leverage changes, and otherwise leverage rebalancing grinds away slowly as dictated by cash flow realizations and the impediments associated with equity issuance costs.

7. Model robustness

To assuage concerns that our results are artifacts of the model's simplicity, in this section we add several more realistic features to the model to examine whether leverage responds to our model parameters in a qualitatively similar way. We examine four extensions to the model, one at a time. First, we add debt issuance costs of 4%. Second, we add an extra state variable that allows the firm to hold cash and debt at the same time. This model contains a small issuance cost of ten basis points to ensure that optimal behavior entails the simultaneous holding of cash and debt. Third, following exactly Hennessy and Whited (2005), we add a collateral constraint on debt

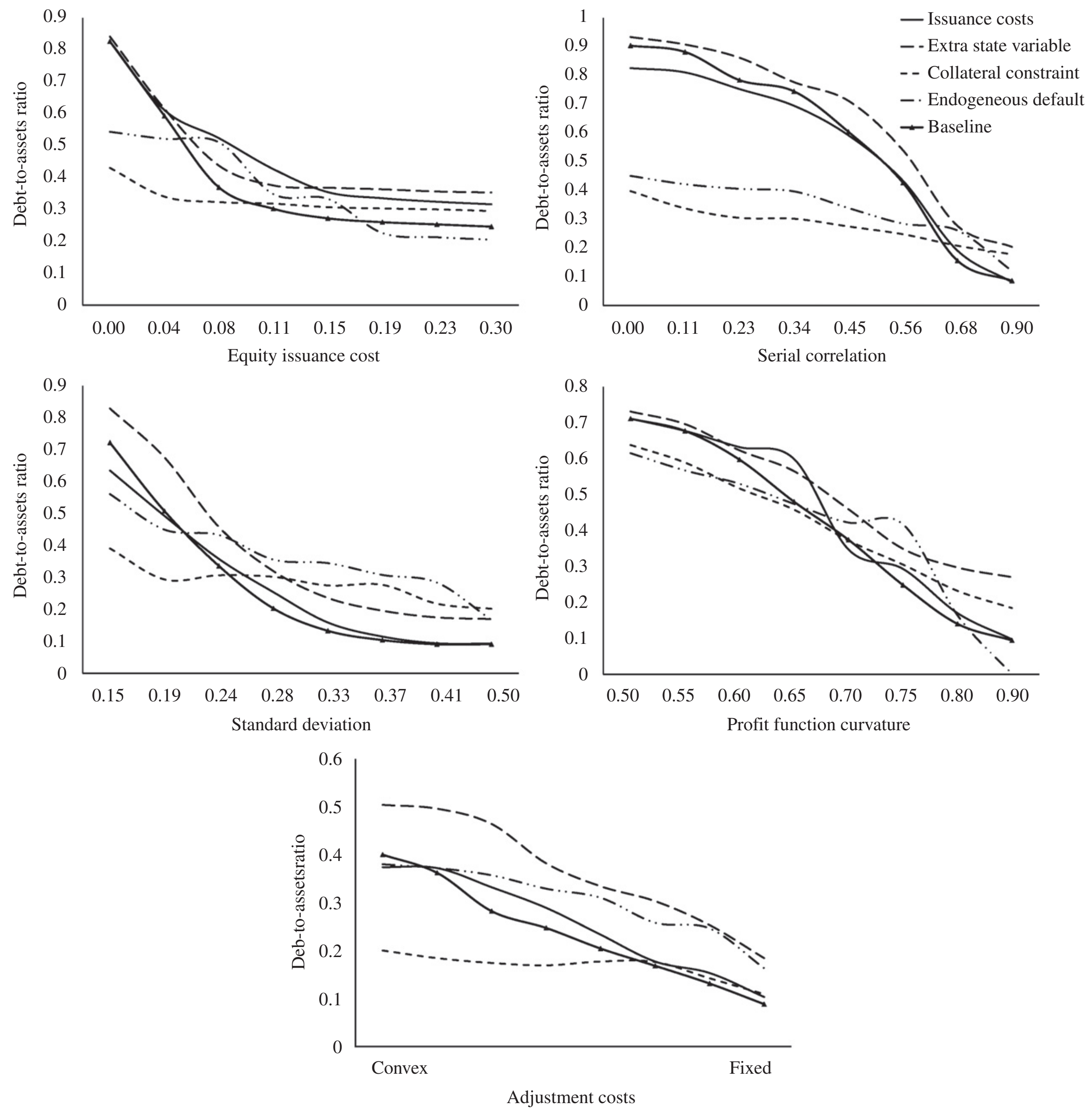

Fig. 5. Comparative statics in models with issuance costs, simultaneous debt and cash balances, collateral constraints, and endogenous default. Each panel depicts average leverage as a function of one of the model parameters: linear equity issuance costs, shock standard deviation, shock serial correlation, profit function curvature, and the convexity of capital stock adjustment costs. Each line in a panel depicts the relation from a particular version of the baseline model: one with issuance costs, one with simultaneous positive amounts of debt outstanding and cash balances (labeled "extra state variable"), one with a collateral constraint, and one with endogenous default.

financing and financial distress in the form of a fire-sale discount of 40% on capital that must be sold when profits are insufficient to pay off debt. Fourth, we allow for endogenous default and deadweight costs of default. This model is described in Appendix B. For each of these four cases, we examine how leverage responds to changes in the linear cost of issuing equity, λ_1, the serial correlation of productivity shocks, ρ, the standard deviation of productivity shocks, σ_v, and the curvature of the production function, θ. We also perform an additional experiment in which we simultaneously increase the fixed cost, γ, and decrease the convex cost, a, of adjusting the capital stock.

The results from these comparative statics exercises appear in Fig. 5. In the first panel, we plot the relation between average leverage and linear equity issuance costs, λ_1, for the baseline model estimates from Table 1, as well as for the four model variants described above. We allow λ_1 to vary from near 0.0 to 0.3, which is roughly double its baseline estimate of 0.1615. In all four model variants, we find the same negative relation between equity issuance costs and leverage as in the baseline model. Although the patterns from the model with separate cash holding and with debt issuance costs are almost identical to the pattern from the baseline model, the negative relation between equity issuance costs and leverage is attenuated in the models that incorporate financial distress because both equity issuance costs and financial distress work to depress leverage.

This same general pattern appears in the second and third panels, which depict the relations between leverage and the serial correlation of productivity shocks, ρ, and the standard deviation of productivity shocks, σ_v. We allow ρ to vary from 0.1 to 0.9 and σ_v to vary from 0.15 to 0.5. In all five models, leverage decreases with both ρ and σ_v, and the models with a collateral constraint and endogenous default generate slightly weaker relations. The fourth panel shows the relation between leverage and profit function curvature, θ, in which we let θ range from 0.5 to 0.9. In this case leverage falls sharply with profitability in all five models. Finally, the fifth panel shows the relation between leverage and the nature of physical adjustment costs. To generate this plot, we allow the fixed cost of adjustment to vary from 0.0 to 0.04, while the convex cost varies from 0.3 to 0.0. Once again, leverage falls in all five models as adjustment costs become more fixed in nature and investment therefore optimally becomes more lumpy.

In sum, our original simple model with a fixed debt capacity generates qualitatively the same comparative statics as do more complicated models. The advantage of the simple model is its ability to highlight the role of preserving debt capacity in a dynamic setting. In contrast, the additional features, such as financial distress, in these more complicated models sometimes muddy but never erase the tradeoff between utilizing debt capacity today and preserving it for future usage. We therefore view the results from our original simple model as broadly representative of the results from a much broader class of dynamic models.

8. Summary and conclusions

We develop and estimate a dynamic capital structure model in which debt serves as a transitory financing vehicle that enables firms to meet funding needs associated with imperfectly anticipated investment shocks, while allowing them to economize on the costs of issuing equity and of maintaining cash balances. Firms that issue debt incur no flotation or other direct issuance costs, but nonetheless face an economically meaningful opportunity cost of borrowing, since a firm's decision to issue debt in a given period reduces the debt capacity available to meet its future funding needs or, more generally, reduces the firm's future ability to borrow at the terms it currently faces. The firm's ex ante optimum debt level reflects the value of the option to use its debt capacity to borrow ex post and deliberately, but temporarily, move away from target to fund investment. The opportunity cost of borrowing—and the resultant transitory role of debt in capital structures—radically alters the nature of predicted leverage dynamics from those of other tradeoff models in which firms have leverage targets, but all proactive financing decisions move firms toward target.

Our emphasis is squarely on the role of transitory debt, a concept that plays no role in extant tradeoff theories in which firms have leverage targets because those theories ignore the interplay among target leverage, leverage dynamics, and firms' desire to raise capital to meet the intertemporal sequence of funding needs that arise from investment shocks. Because in our model firms issue transitory debt to finance investment outlays, the time path of deviations from and rebalancing to target is shaped both by the nature of prospective investment opportunities and by the precise sequence of shock realizations from the firm's stochastic investment opportunity set. Our approach yields a variety of new testable predictions that link capital structure decisions to variation in the volatility and serial correlation of investment shocks, the marginal profitability of investment, and properties of capital stock adjustment costs. The model offers plausible explanations for otherwise puzzling aspects of observed capital structure decisions, including why firms often choose to deviate from their leverage targets and why empirical studies find such slow average speeds of adjustment to target. And our evidence indicates that the model replicates industry leverage very well, that it explains firms' debt issuance/repayment decisions better than extant tradeoff models of capital structure, and that it can account for the leverage changes that accompany investment "spikes."

Appendix A

This appendix discusses the numerical procedure, the data, and the estimation procedure.

A.1. Model solution

To find a numerical solution, we need to specify a finite state space for the three state variables. We let the capital stock lie on the points

$$[\bar{k}(1-\delta)^{35},\ldots,\bar{k}(1-\delta)^{1/2},\bar{k}]. \quad (12)$$

We let the productivity shock z have 19 points of support, transforming (1) into a discrete-state Markov chain on the interval $[-4\sigma_v, 4\sigma_v]$ using the method in Tauchen (1986). We let p have 29 equally spaced points in the interval $[-\bar{p}/2, \bar{p}]$, in which $\bar{p}$ is a parameter to be estimated. The optimal choice of p never hits the lower endpoint, although it occasionally hits the upper endpoint when the firm finds it optimal to exhaust its debt capacity. For our estimated value of $\bar{p}$, equity value, V, is always strictly positive in all states of the world.

We solve the model via iteration on the Bellman equation, which produces the value function $V(k,p,z)$ and the policy function $\{k',p'\}=u(k,p,z)$. In the subsequent model simulation, the space for z is expanded to include 152 points, with interpolation used to find corresponding values of V, k, and p. The model simulation proceeds by taking a random draw from the distribution of z' (conditional on z), and then computing $V(k,p,z)$ and $u(k,p,z)$. We use these computations to generate an artificial panel of firms.

A.2. Data

We obtain data on U.S. nonfinancial firms from the 2007 Standard and Poor's Compustat industrial files. These data constitute an unbalanced panel that covers 1988 to 2001. As in Hennessy and Whited (2005), we choose this sample period because the tax code during this period contains no large structural breaks. To select the sample, we delete firm-year observations with missing data and for which total assets, the gross capital stock, or sales are either zero or negative. Then for each firm we select the longest consecutive times series of data and exclude firms with only one observation. Finally, we omit all firms whose primary SIC code is between 4900 and 4999, between 6000 and 6999, or greater than 9000, because our model is inappropriate for regulated, financial, or quasi-public firms. We end up with between 3,066 and 5,036 observations per year, for a total of 53,677 firm-year observations.

A.3. Estimation

We now give a brief outline of the estimation procedure, which closely follows Ingram and Lee (1991). Let x_i be an i.i.d. data vector, $i=1,\ldots,n$, and let $y_{ik}(b)$ be an i.i.d. simulated vector from simulation k, $i=1,\ldots,n$, and $k=1,\ldots,K$. Here, n is the length of the simulated sample, and K is the number of times the model is simulated. We pick $n=53{,}677$ and $K=10$, following Michaelides and Ng (2000), who find that good finite-sample performance of a simulation estimator requires a simulated sample that is approximately ten times as large as the actual data sample.

The simulated data vector, $y_{ik}(b)$, depends on a vector of structural parameters, b. In our application, $b\equiv(\theta,\rho,\sigma_v,a,\gamma,s,\lambda_1,\lambda_2)$. Three parameters we do not estimate are the depreciation rate, δ, the real interest rate, r, and the effective corporate tax rate, τ_c. We set δ at 0.15, which is approximately equal to the average in our data set of the ratio of depreciation to the capital stock. We set the real interest rate equal to 0.015, which is approximately equal to the average of the realized real interest rate over the twentieth century. We set τ_c at the statutory rate of 0.35.

The goal is to estimate b by matching a set of *simulated moments*, denoted as $h(y_{ik}(b))$, with the corresponding set of actual *data moments*, denoted as $h(x_i)$. The candidates for the moments to be matched include simple summary statistics, Ordinary Least Squares (OLS) regression coefficients, and coefficient estimates from non-linear reduced-form models. Define

$$g_n(b)=n^{-1}\sum_{i=1}^{n}\left[h(x_i)-K^{-1}\sum_{k=1}^{K}h(y_{ik}(b))\right].$$

The simulated moments estimator of b is then defined as the solution to the minimization of

$$\hat{b}=\underset{b}{\operatorname{argmin}}\ g_n(b)'\hat{W}_n g_n(b),$$

in which $\hat{W}_n$ is a positive definite matrix that converges in probability to a deterministic positive definite matrix W. In our application, we use the inverse of the sample covariance matrix of the moments, which we calculate using the influence-function approach in Erickson and Whited (2000).

The simulated moments estimator is asymptotically normal for fixed K. The asymptotic distribution of b is given by

$$\sqrt{n}(\hat{b}-b)\xrightarrow{d}\mathcal{N}(0,\text{avar}(\hat{b}))$$

in which

$$\text{avar}(\hat{b})\equiv\left(1+\frac{1}{K}\right)\left[\frac{\partial g_n(b)}{\partial b}W\frac{\partial g_n(b)}{\partial b'}\right]^{-1} \times\left[\frac{\partial g_n(b)}{\partial b}W\Omega W\frac{\partial g_n(b)}{\partial b'}\right]\left[\frac{\partial g_n(b)}{\partial b}W\frac{\partial g_n(b)}{\partial b'}\right]^{-1}, \quad (13)$$

in which W is the probability limit of $\hat{W}_n$ as $n\to\infty$, and in which Ω is the probability limit of a consistent estimator of the covariance matrix of $h(x_i)$. We set $W\equiv\Omega^{-1}$.

The success of this procedure relies on picking moments h that can identify the structural parameters b. In other words, the model must be identified. Global identification of a simulated moments estimator obtains when the expected value of the difference between the simulated moments and the data moments equals zero if and only if the structural parameters equal their true values. A sufficient condition for identification is a one-to-one mapping between the structural parameters and a subset of the data moments of the same dimension. Although our model does not yield such a closed-form mapping, we take care in choosing appropriate moments to match, and we use a minimization algorithm, simulated annealing, that avoids local minima.

We pick the following 12 moments to match. Because the firm's real and financial decisions are intertwined, all of the model parameters affect all of these moments in some way. We can, nonetheless, categorize the moments roughly as representing the real or financial side of the firm's decision-making problem. The first of the nonfinancial or "real" moments are the first and second moments of the rate of investment, defined in the simulation as I/k, and defined in Compustat as the sum of items 128 and 129 divided by item 7.[12] Average investment helps identify the adjustment cost parameters, a and γ, because smooth investment tends to be less skewed than lumpy investment. Therefore, the mean is lower because it tends to lie nearer the median than the upper percentiles of the distribution of investment. The variance helps identify both the curvature of the profit function, θ, and the adjustment cost parameters. Lower θ, higher a, and lower γ produce less volatile investment. The next moment is the skewness of the rate of investment, which helps identify the fixed adjustment cost parameter, γ. Higher values of this parameter lead to more intermittent, and thus more skewed investment. The next moment, average operating income, is primarily affected by the curvature of the profit function. This relation can be seen by the definition of simulated operating income as zk^{θ}/k: the higher θ, the higher average operating income. Our next two moments capture the important features of the driving process for z. Here, we estimate a first-order panel autoregression of operating income on lagged operating income, in which actual operating income is defined as the ratio of Compustat items 13 and 6. The two moments that we match from this exercise are the autoregressive coefficient and the shock variance. Our next moment is the mean of Tobin's q. Simulated Tobin's q is constructed as $(V+p)/k$ and actual Tobin's q is constructed following Erickson and Whited (2000). All model parameters affect the mean of q.

The remaining moments pertain to the firm's financing decisions. The first two are the mean and second moment of the ratio of debt to assets. In our simulation, debt is defined as d/k, and in Compustat, this variable is defined as items 9 plus 34, all divided by item 6. All of the parameters in the model affect these two moments. The next two moments are average equity issuance and the variance of equity issuance. In the model, equity issuance is defined as e/k and in Compustat, it is defined as the ratio of items 108 and 6. These two moments help identify the two equity adjustment cost parameters, λ_1 and λ_2. Our final moment is the ratio of cash to assets. In our simulations it is defined as c/k, conditional on $c>0$, and in Compustat, it is defined as the ratio of item 1 to item 6. This moment helps identify the agency cost parameter.

Because our moment vector consists of separately estimated regression coefficients and first through third moments, we use the influence-function approach in Erickson and Whited (2000) to calculate the covariance matrix of the moment vector. Specifically, we stack the influence functions for each moment and then form the covariance matrix by taking the inner product of this stack.

[12] We define investment this way because our model allows for the optimality of lumpy investment. Therefore, we can allow for a much more general definition of investment than that in Hennessy and Whited (2005, 2007).

One final issue is unobserved heterogeneity in our data from Compustat. Recall that our simulations produce i.i.d. firms. Therefore, in order to render our simulated data comparable to our actual data we can either add heterogeneity to the simulations, or remove the heterogeneity from the actual data. We opt for the latter approach, using fixed firm and year effects in the estimation of our regression-based data moments and our estimates of variance and skewness.

Appendix B

The model that includes endogenous default replaces the upper bound on leverage, $\overline{p}$, with the following mechanism, which is similar to that in Hennessy and Whited (2007) and Cooley and Quadrini (2001), except that physical adjustment costs prevent the firm from costlessly transforming capital into liquid assets. The presence of physical adjustment costs complicates slightly what happens to the firm when it defaults, that is, when equity value reaches zero. The endogenous default schedule is then defined implicitly by the equation $V(k,p,z)=0$. In the event of default, debtholders seize the firm's profits and almost all of its capital stock, less any applicable adjustment costs and less a fraction, ξ, of the capital stock that can be thought of as deadweight default costs. Because physical adjustment costs are a function of the rate of investment, they are not well-defined for a firm with a zero capital stock. We therefore leave the firm with the smallest capital stock in the discrete grid described by (12), k, and require the firm to pay the amount $(1-\xi)(1-\delta)k$ in cash to the debtholders.

The debtholders' recovery in default (R) is equal to

$$\begin{aligned} R(k',z') &= (1-\xi)(1-\delta)(k'-k)+(1-\tau_c)(z'\pi(k')-\delta k')-A(k',k) \\ &\quad +(1-\xi)(1-\delta)k \qquad (14) \\ &= (1-\xi)(1-\delta)k'+(1-\tau_c)(z'\pi(k')-\delta k')-A(k',k). \qquad (15) \end{aligned}$$

As an approximation to the U.S. tax code, this formulation of the debtholders' recovery assumes that in the event of default, interest deductions on the debt obligation are disallowed.

The interest rate on debt, r_d, is determined endogenously via a zero-profit condition for the debtholders. Let $Z_d(k',p',z)$ be the set of states in which the firm defaults, as a function of k', p', and the current state z. Similarly, let $Z_s(k',p',z)$ be the set of states in which the firm remains solvent. The interest rate, $r_d(k',p',z)$, is then defined by

$$\int_{Z_d(k',p',z)} R(k',z')dg(z',z)+(1+r_d(k',p',z))p'\int_{Z_s(k',p',z)} dg(z',z)=(1+r)p'.$$

In words, debtholders expect over all states to earn the risk-free rate. For a proof of the existence of a solution to this class of models, see Hennessy and Whited (2007).

In this model debt does not have an arbitrary upper bound, but the higher interest rate charged by debtholders limits the optimal amount of debt chosen by the firm.

References

Altinkilic, O., Hansen, R., 2000. Are there economies of scale in underwriting fees? Evidence of rising external financing costs. Review of Financial Studies 13, 191–218.

Bolton, P., Chen, H., Wang, N., 2009. A unified theory of Tobin's q, corporate investment, financing, and risk management. Unpublished working paper. Columbia University.

Brennan, M., Schwartz, E., 1984. Optimal financial policy and firm valuation. Journal of Finance 39, 593–607.

Caballero, R., 1999. Aggregate investment. In: Taylor, J., Woodford, M. (Eds.), Handbook of Macroeconomics, vol. 1B. North-Holland, Amsterdam, pp. 813–862.

Caballero, R., Leahy, J., 1996. Fixed costs: the demise of marginal q. Unpublished working paper. NBER.

Carlstrom, C., Fuerst, T., 1997. Agency costs, net worth, and business fluctuations: a computable general equilibrium analysis. American Economic Review 87, 893–910.

Chang, X., Dasgupta, S., 2003. Financing the deficit: debt capacity, information asymmetry, and the debt–equity choice. Unpublished working paper. Hong Kong University of Science and Technology.

Cooley, T., Quadrini, V., 2001. Financial markets and firm dynamics. American Economic Review 91, 1286–1310.

Cooper, R., Haltiwanger, J., 2006. On the nature of capital adjustment costs. Review of Economic Studies 73, 611–634.

Cooper, R., Willis, J., 2004. A comment on the economics of labor adjustment: mind the gap. American Economic Review 94, 1223–1237.

DeAngelo, H., Masulis, R., 1980. Optimal capital structure under corporate and personal taxation. Journal of Financial Economics 8, 3–29.

Denis, D., McKeon, S., 2009. Financial flexibility and capital structure policy: evidence from proactive leverage increases. Unpublished working paper, Purdue University.

Dudley, E., 2009. Capital structure and large investment projects. Unpublished working paper. University of Florida.

Eisfeldt, A., Rampini, A., 2006. Financing shortfalls and the value of aggregate liquidity. Unpublished working paper. Northwestern University.

Erickson, T., Whited, T., 2000. Measurement error and the relationship between investment and q. Journal of Political Economy 108, 1027–1057.

Fama, E., French, K., 2002. Testing tradeoff and pecking order predictions about dividends and debt. Review of Financial Studies 15, 1–33.

Fischer, E., Heinkel, R., Zechner, J., 1989. Dynamic capital structure choice: theory and tests. Journal of Finance 44, 19–39.

Flannery, M., Rangan, K., 2006. Partial adjustment toward target capital structure. Journal of Financial Economics 79, 469–506.

Frank, M., Goyal, V., 2009. Capital structure decisions: which factors are reliably important? Financial Management 38, 1–37.

Gamba, A., Triantis, A., 2008. The value of financial flexibility. Journal of Finance 63, 2263–2296.

Goldstein, R., Ju, N., Leland, H., 2001. An EBIT-based model of dynamic capital structure. Journal of Business 74, 483–511.

Gomes, J., 2001. Financing investment. American Economic Review 91, 1263–1285.

Graham, J., 2000. How big are the tax benefits of debt? Journal of Finance 55, 1901–1941.

Harford, J., Klasa, S., Walcott, N., 2008. Do firms have leverage targets? Evidence from acquisitions. Journal of Financial Economics 93, 1–14.

Hennessy, C., Whited, T., 2005. Debt dynamics. Journal of Finance 60, 1129–1165.

Hennessy, C., Whited, T., 2007. How costly is external financing? Evidence from a structural estimation. Journal of Finance 62, 1705–1745.

Hovakimian, A., 2004. The role of target leverage in security issues and repurchases. Journal of Business 77, 1041–1071.

Hovakimian, A., Opler, T., Titman, S., 2001. The debt–equity choice. Journal of Financial and Quantitative Analysis 36, 1–24.

Ingram, B., Lee, B., 1991. Simulation estimation of time-series models. Journal of Econometrics 47, 197–205.

Jaffee, D., Russell, T., 1976. Imperfect information and credit rationing. Quarterly Journal of Economics 90, 651–666.

Jensen, M., 1986. The agency costs of free cash flow: corporate finance and takeovers. American Economic Review 76, 323–329.

Kane, A., Marcus, A., McDonald, R., 1984. How big is the tax advantage to debt? Journal of Finance 39, 841–853.

Kayhan, A., Titman, S., 2007. Firms' histories and their capital structures. Journal of Financial Economics 83, 1–32.

Keynes, J., 1936. The General Theory of Employment, Interest and Money. Harcourt Brace, London.

Kraus, A., Litzenberger, R., 1973. A state preference model of optimal financial leverage. Journal of Finance 28, 911–921.

Leary, M., Roberts, M., 2005. Do firms rebalance their capital structures? Journal of Finance 60, 2575–2619.

Lemmon, M., Roberts, M., Zender, J., 2008. Back to the beginning: persistence and the cross-section of corporate capital structure. Journal of Finance 63, 1575–1608.

Lemmon, M., Zender, J., 2007. Debt capacity and tests of capital structure theories. Unpublished working paper. University of Utah and University of Colorado at Boulder.

Lintner, J., 1956. Distribution of incomes of corporations among dividends retained earnings and taxes. American Economic Review 46, 97–113.

Mauer, D., Triantis, A., 1994. Interaction of corporate financing and investment decisions: a dynamic framework. Journal of Finance 49, 1253–1277.

Mayer, C., Sussman, O., 2004. A new test of capital structure. Unpublished working paper. University of Oxford.

Michaelides, A., Ng, S., 2000. Estimating the rational expectations model of speculative storage: a Monte Carlo comparison of three simulation estimators. Journal of Econometrics 96, 231–266.

Miller, M., 1977. Debt and taxes. Journal of Finance 32, 261–275.

Morellec, E., Schürhoff, N., 2010. Dynamic investment and financing under personal taxation. Review of Financial Studies 23, 101–146.

Myers, S., 1984. The capital structure puzzle. Journal of Finance 39, 575–592.

Myers, S., Majluf, N., 1984. Corporate financing and investment decisions when firms have information that investors do not have. Journal of Financial Economics 13, 187–221.

Parsons, C., Titman, S., 2008. Empirical capital structure: a review. Foundations and Trends in Finance 3, 1–93.

Riddick, L., Whited, T., 2008. The corporate propensity to save. Journal of Finance 64, 1729–1766.

Robichek, A., Myers, S., 1966. Problems in the theory of optimal capital structure. Journal of Financial and Quantitative Analysis 1, 1–35.

Smith, C., Warner, J., 1979. On financial contracting: an analysis of bond covenants. Journal of Financial Economics 7, 117–161.

Stiglitz, J., Weiss, A., 1981. Credit rationing in markets with imperfect information. American Economic Review 71, 393–410.

Stokey, N., Lucas, R., 1989. Recursive Methods in Economic Dynamics. Harvard University Press, Cambridge, MA.

Strebulaev, I., 2007. Do tests of capital structure theory mean what they say? Journal of Finance 62, 1747–1787.

Stulz, R., 1990. Managerial discretion and optimal financing policies. Journal of Financial Economics 26, 3–27.

Sundaresan, S., Wang, N., 2006. Dynamic investment, capital structure, and debt overhang. Unpublished working paper. Columbia University.

Tauchen, G., 1986. Finite state Markov-chain approximations to univariate and vector autoregressions. Economics Letters 20, 177–181.

Titman, S., Tsyplakov, S., 2007. A dynamic model of optimal capital structure. Review of Finance 11, 401–451.

Tserlukevich, Y., 2008. Can real options explain financing behavior? Journal of Financial Economics 89, 232–252.

Viswanath, P., 1993. Strategic considerations, the pecking order hypothesis and market reactions to equity financing. Journal of Financial and Quantitative Analysis 28, 213–234.

Whited, T., 1992. Debt, liquidity constraints, and corporate investment: evidence from panel data. Journal of Finance 47, 1425–1460.

Whited, T., 2006. External finance constraints and the intertemporal pattern of intermittent investment. Journal of Financial Economics 81, 467–502.