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Partial adjustment toward target capital structures ☆

Mark J. Flannery[a,*], Kasturi P. Rangan[b]

[a]Graduate School of Business, University of Florida, Gainesville, FL 32611-7168, USA
[b]Weatherhead School of Management, Case Western Reserve University, Cleveland, OH 44106, USA

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Abstract

The empirical literature provides conflicting assessments about how firms choose their capital structures. Distinguishing among the three main hypotheses ("tradeoff", pecking order, and market timing) requires that we know whether firms have long-run leverage targets and (if so) how quickly they adjust toward them. Yet many previous researchers have applied empirical specifications that fail to recognize the potential for incomplete adjustment. A more general, partial-adjustment model of firm leverage indicates that firms *do* have target capital structures. The typical firm closes about one-third of the gap between its actual and its target debt ratios each year.

JEL classification: G 32

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1. Introduction

Since Modigliani and Miller's irrelevance proposition in 1958 (Modigliani and Miller, 1958), researchers have investigated firms' decisions about how to finance their operations.

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*Corresponding author. Tel.: 352 392 3184; fax: 352 392 0301.
E-mail address: flannery@ufl.edu (M.J. Flannery).

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Initially, they asked whether the irrelevance proposition is consistent with the available data, or, whether instead capital market imperfections make firm value depend on capital structure. In the latter case, it was argued, firms would select target debt-equity ratios, trading off their costs and benefits of leverage. Survey evidence by Graham and Harvey (2001) shows that indeed, 81% of firms consider a target debt ratio or range when making their debt decisions. However, alternative theories remain plausible. Myers (1984) contrasts this tradeoff theory of capital structure with an updated version of Donaldson's (1961) pecking order theory, according to which information asymmetries lead managers to perceive that the market generally underprices their shares. Accordingly, investments are financed first with internally generated funds, the firm issues safe debt if internal funds prove insufficient, and equity is used only as a last resort. In a pecking order world, observed leverage reflects primarily a firm's historical profitability and investment opportunities. Firms have no strong preference about their leverage ratios and, a fortiori, no strong inclination to reverse leverage changes caused by financing needs or earnings growth.

Two additional theories of capital structure also reject the notion of timely convergence toward a target leverage ratio. First, Baker and Wurgler (2002) argue that a firm's observed capital structure reflects its cumulative ability to sell overpriced equity shares: that is, share prices fluctuate around their "true" values, and managers tend to issue shares when the firm's market-to-book ratio is high. Unlike the pecking order hypothesis, this market timing hypothesis asserts that managers routinely exploit information asymmetries to benefit current shareholders; like the pecking order hypothesis, there is no reversion to a target capital ratio if market timing is the dominant influence on firm leverage. Second, Welch (2004) argues that managerial inertia permits stock price changes to have a prominent effect on market-valued debt ratios: "... over reasonably long time frames, the stock price effects are considerably more important in explaining debt-equity ratios than previously identified proxies" (p. 107).

The pecking order, market timing, and inertia theories of capital structure imply that managers perceive no great leverage effect on firm value and therefore make no effort to reverse changes in leverage. In contrast, the tradeoff theory maintains that market imperfections generate a link between leverage and firm value, and firms take positive steps to offset deviations from their optimal debt ratios. The speed with which firms reverse deviations from their target debt ratios depends on the cost of adjusting leverage. With zero adjustment costs, the tradeoff theory implies that firms should never deviate from their optimal leverage. At the other extreme, if transaction costs are infinite we should observe no movements toward a target. Baker and Wurgler (2002) emphasize the connection between adjustment costs and observed capital structure:

> The basic question is whether market timing has a short-run or a long-run impact. One expects at least a mechanical, short-run impact. However, *if firms subsequently rebalance* away from the influence of market timing financing decisions, *as normative capital structure theory recommends*, then market timing would have no persistent impact on capital structure. (page 2, emphasis added)

Estimating the effect of capital adjustment costs is thus a key first step in testing competing theories of capital structure.

The empirical model in this paper accounts for the potentially dynamic nature of a firm's capital structure. The model is general enough that we can test whether there is indeed a leverage target and if so, what is the (adjustment) speed with which a firm moves toward its target. Our evidence indicates that firms do target a long run capital structure, and that the typical firm converges toward its long-run target at a rate of more than 30% per year. This adjustment speed is roughly three times faster than many existing estimates in the literature, and affords targeting behavior an empirically important effect on firms' observed capital structures. When we add market timing or pecking order variables to our base specification, we do find some support for these theories. However, more than half of the observed changes in capital structures can be attributed to targeting behavior while market timing and pecking order considerations explain less than 10% each. Unlike Welch (2004), we find that stock price changes have only transitory effects on capital structure.

Our findings are not consistent with many recent empirical papers on capital structure (e.g., Shyam-Sunder and Myers, 1999; Baker and Wurgler, 2002; Fama and French, 2002; Huang and Ritter, 2005; Welch, 2004). However, the literature also offers some precedents for our rapid estimated adjustment speeds (Marcus, 1983; Jalilvand and Harris, 1984; Roberts, 2002). We argue that some previous empirical models impose unwarranted, yet testable, assumptions about the adjustment speed and/or the dynamic properties of target leverage. These assumptions materially influence the estimation results and consequently the conclusions drawn. Part of our paper's contribution is to identify why previous research produces such disparate estimated adjustment speeds.

The paper is organized as follows. Section 2 derives our preferred regression specification for testing the tradeoff theory in a partial adjustment framework. Section 3 describes the Compustat—CRSP data we use to estimate our regression models. Section 4 presents our basic results. After showing that our regressions are robust to various estimation methods, we establish the statistical and economic significance of a target debt ratio and relate our results to previous discussions of the tradeoff theory. Section 5 explicitly compares our model to the pecking order, market timing, and inertia models. Section 6 presents a series of robustness tests and the final section concludes. An appendix discusses the econometric issues associated with estimating the dynamic panel regression that constitutes our base specification.

2. Regression model specification

A regression specification used to test for tradeoff leverage behavior must permit each firm's target debt ratio to vary over time, and must recognize that deviations from target leverage are not necessarily offset quickly. Both of these requirements are satisfied in a model with partial (incomplete) adjustment toward a target leverage ratio that depends on firm characteristics.

2.1. Target leverage

Our primary leverage measure is a firm's *market debt ratio*,[1]

$$MDR_{i,t} = \frac{D_{i,t}}{D_{i,t} + S_{i,t}P_{i,t}}, \tag{1}$$

[1]Finance theory tends to downplay the importance of book ratios, with previous research largely analyzing market-valued debt ratios (including Hovakimian et al., 2001; Hovakimian, 2003; Fama and French, 2002; Welch,

where $D_{i,t}$ denotes the book value of firm i's interest-bearing debt (the sum of Compustat items 9 plus 34) at time t, $S_{i,t}$ equals the number of common shares outstanding (Compustat item 199) at time t, and $P_{i,t}$ denotes the price per share (Compustat item 25) at time t.

We model the possibility that target leverage might differ across firms or over time by specifying a target capital ratio of the form

$$MDR^*_{i,t+1} = \boldsymbol{\beta} \boldsymbol{X}_{i,t}, \tag{2}$$

where $MDR^*_{i,t+1}$ is firm i's desired debt ratio at $t+1$, $\boldsymbol{X}_{i,t}$ is a vector of firm characteristics related to the costs and benefits of operating with various leverage ratios, and β is a coefficient vector. Under the tradeoff hypothesis, $\beta \neq 0$, and the variation in $MDR^*_{i,t+1}$ should be nontrivial.

2.2. Adjustment to target leverage

In a frictionless world, firms would always maintain their target leverage. However, adjustment costs may prevent immediate adjustment to a firm's target, as the firm trades off its adjustment costs against the costs of operating with suboptimal leverage. We estimate a model that permits incomplete (partial) adjustment of the firm's initial capital ratio toward its target within each time period. The data can then indicate a typical adjustment speed.

A standard partial adjustment model is given by

$$\boldsymbol{MDR}_{i,t+1} - \boldsymbol{MDR}_{i,t} = \lambda(\boldsymbol{MDR}^*_{i,t+1} - \boldsymbol{MDR}_{i,t}) + \tilde{\delta}_{i,t+1}. \tag{3}$$

Each year, the typical firm closes a proportion λ of the gap between its actual and its desired leverage levels. Substituting (2) into (3) and rearranging gives the estimable model

$$\boldsymbol{MDR}_{i,t+1} = (\lambda\beta)\boldsymbol{X}_{i,t} + (1-\lambda)\boldsymbol{MDR}_{i,t} + \tilde{\delta}_{i,t+1}. \tag{4}$$

Eq. (4) says that managers take 'action' or 'steps' to close the gap between where they are ($\boldsymbol{MDR}_{i,t}$) and where they wish to be ($\beta\ \boldsymbol{X}_{i,t}$). The specification further implies that

(1) The firm's actual debt ratio eventually converges to its target debt ratio, $\boldsymbol{\beta X}_{i,t}$.
(2) The long-run impact of $\boldsymbol{X}_{i,t}$ on the capital ratio is given by its estimated coefficient, divided by λ.
(3) All firms have the same adjustment speed (λ).[2]

The smooth partial adjustment in Eq. (4) may only approximate an individual firm's actual adjustments. A reasonable alternative model would permit small deviations from

(*footnote continued*)
2004; Leary and Roberts, 2005). When authors analyze both market and book leverage ratios, the results are generally comparable. We report similar results below in Table 5. Table 11 presents evidence that our conclusions are robust across a range of reasonable definitions for "leverage."

[2]We experiment with modeling λ as a function of firm-specific variables ($\boldsymbol{Y}$), that is,

$$MDR_{i,t+1} = (\lambda(Y)\beta)X_{i,t} + (1-\lambda(Y))MDR_{i,t} + \delta_{i,t+1}. \tag{5}$$

Although we find some evidence that firm characteristics affect adjustment speeds (the coefficients on Y are statistically significant), we do not report this evidence here because the mean adjustment speeds ($\bar{\lambda}(Y)$) and the coefficients on $X_{i,t}$ are very similar to the results of estimating (4). Roberts (2002) analyzes this issue further.

the target to persist because adjustment costs outweigh the gains from removing small deviations between actual and target leverage (Fischer et al. (1989); Mauer and Triantis (1994); Titman and Tsyplakov (2004); Leary and Roberts (2005); Ju et al. (2002)). Indeed, Figs. 1 and 2 below indicate that the mean change in book leverage substantially exceeds the median, a phenomenon also observed by Frank and Goyal (2003, p. 228), Leary and Roberts (2005); and Halov and Heider (2004, Table 1).

We investigate the impact of infrequent adjustments on the parameters estimated by our smooth adjustment specification (4) by simulating 20 sets of panel data, each with 100,000 data points. The data are generated by assuming that while each firm's target changes stochastically every year, the actual debt ratio is adjusted only periodically. For the randomly chosen periods in which debt is adjusted, the simulated firm adjusts completely to its target ratio. When we estimate a partial adjustment model on these generated data sets, we find that the estimated adjustment speed exceeds the true proportion of adjusting firms by less than 2%. (That is, if an average of 30% of sample firms move to their target each year, the estimated adjustment speed is less than 0.306). The average bias is statistically significant, but economically unimportant. We therefore interpret the

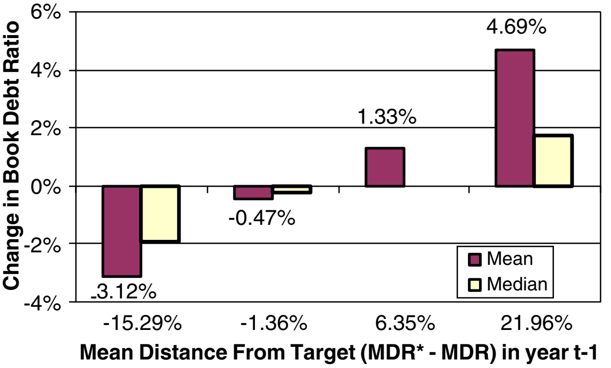

Fig. 1. Subsequent year's change in book debt ratio.

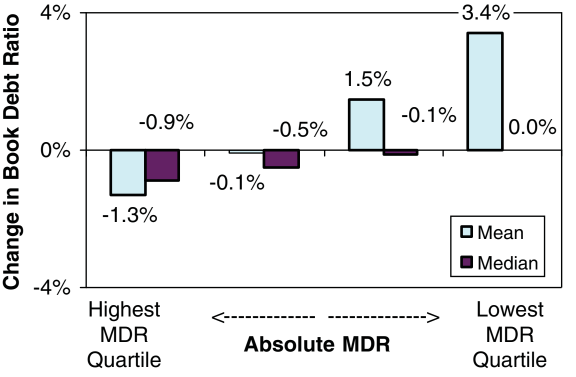

Fig. 2. Mean reversion in leverage.

Table 1
Summary statistics
Sample includes all Industrial Compustat firms with complete data for two or more adjacent years during 1965 to 2001. Total: 12,919 firms; 111,106 firm years. All variables are winsorized at the 1st and 99th percentiles to avoid the influence of extreme observations.

	Number of observations	Mean	Median	Std. Dev.	Min.	Max.
MDR	111,106	0.2783	0.2252	0.2439	0.0000	0.9174
SPE	111,106	0.0038	0.0000	0.0917	−0.3383	0.4334
BDR	111,106	0.2485	0.2296	0.1925	0.0000	0.8635
EBIT_TA	111,106	0.0517	0.0935	0.2142	−1.6371	0.4096
MB	111,106	1.6153	1.0415	1.7888	0.2690	13.6372
DEP_TA	111,106	0.0451	0.0381	0.0327	0.0000	0.2338
LnTA	111,106	18.2400	18.1126	2.0184	12.7227	23.3787
FA_TA	111,106	0.3220	0.2754	0.2200	0.0005	0.9220
R&D_DUM	111,106	0.4654	0.0000	0.4988	0.0000	1.0000
R&D_TA	111,106	0.0337	0.0000	0.0830	0.0000	0.8290
Rated	111,106	0.1035	0.0000	0.3046	0.0000	1.0000
IND_Median	111,106	0.2240	0.2145	0.1339	0.0000	0.8164
MB_EFWA	81,343	1.7552	1.2828	1.3918	0.2690	9.9976
L3MDR	98,709	0.2698	0.2289	0.2189	0.0000	0.9174
FINDEF	111,106	0.0818	0.0074	0.2228	−1.8180	2.4829
$\boldsymbol{MDR_1}$	110,659	0.2110	0.1737	0.1848	0.0000	0.9918
$\boldsymbol{MDR_2}$	111,093	0.4121	0.3979	0.2445	−0.0016	1.0000
$\boldsymbol{MDR_3}$	108,995	0.2064	0.1459	0.2090	0.0000	1.6114

MDR: market debt ratio = book value of (short-term plus long-term) debt (Compustat items [9] + [34])/market value of assets (Compustat items [9] + [34] + [199]∗[25])

$\boldsymbol{SPE_t}$: the surprise impact of share price change on a firm's ***MDR*** during (t, $t+1$).

$$\boldsymbol{SPE}_t = \left(\frac{Debt_t}{(Debt_t + MarketEquity_t(1+\tilde{R}_{t,t+1}))}\right) - MDR_t,$$

where $\tilde{R}_{t,t+1}$ is the realized return in the ith firm's stock between t and $t+1$.
BDR: book debt ratio: (long-term [9] + short-term [34] debt)/total assets [6].
EBIT_TA: profitability: earnings before interest and taxes (Compustat items [18] + [15] + [16]), as a proportion of total assets (Compustat item [6]).
Market Equity: market value of outstanding common stock (Compustat items [199 × 25]).
MB: market to book ratio of assets: book liabilities plus market value of equity (Compustat items [9] + [34] + [10] + [199]*[25]) divided by book value of total assets (Compustat item [6]).
DEP_TA: depreciation (Compustat item [14]) as a proportion of total assets (Compustat item [6]).
lnTA: log of asset size, measured in 1983 dollars (Compustat item (6)*1,000,000, deflated by the consumer price index.
FA_TA: fixed asset proportion: property, plant, and equipment (Compustat item [14])/total assets (Compustat Item [6]).
R&D_DUM: dummy variable equal to one if firm did not report R&D expenses.
R&D_TA: R&D expenses (Compustat item (46)) as a proportion of total assets (Compustat item [6]).
Rated: dummy variable equal to one (zero) if the firm has a public debt rating in Compustat (Item [280]).
Ind_Median: median industry ***MDR*** (excluding the instant firm) calculated for each year based on the industry groupings in Fama and French (2002).
MB_EFWA**:** ''external finance weighted average'' of a firm's past market-book ratios (as defined in Baker and Wurgler, 2002, p. 12).
L3MDR : trailing three-year average of the firm's own MDR.
FINDEF: 'financial deficit' variable constructed as per, used to test the pecking order hypothesis. As defined in Frank and Goyal (2003) (see Table 2), ***FINDEF*** = dividend payments + investments + change in working capital−internal cashflow.

$$\boldsymbol{MDR}_1 = \left[\frac{\mathit{Long\ term}[9] + \mathit{Short\ Term\ Debt}[34]}{\mathit{Total\ assets}[6] - \mathit{Book\ Equity}[216] + \mathit{Market\ Equity}[199{*}25]}\right],$$

$$\boldsymbol{MDR}_2 = \left[\frac{\mathit{Total\ Liabilities}[181]}{\mathit{Total\ Liabilities}[181] + \mathit{Market\ Equity}[199{*}25]}\right],$$

$$\boldsymbol{MDR}_3 = \left[\frac{\mathit{Long\ term\ Debt}[9]}{\mathit{Total\ assets}[6] - \mathit{Currrent\ Liabilities}[181] - \mathit{Book\ Equity}[216] + \mathit{Market\ Equity}[199{*}25]}\right].$$

adjustment speed (λ) as the average speed for a "typical" firm. Table 8 (below) provides further evidence that the partial adjustment specification (4) fits the data well.

3. Data

We construct our sample from all firms included in the Compustat Industrial Annual tapes between the years 1965 and 2001. Following previous research, we exclude financial firms (SIC 6000–6999) and regulated utilities (SIC 4900–4999), whose capital decisions may reflect special factors. Because our regression specification includes lagged variables, we must also exclude any firm with fewer than two consecutive years of data. These exclusions leave us with complete information for 111,106 firm-year observations, which consist of 12,919 firms with an average of 9.6 years each.[3] Some prior studies exclude smaller firms from the analysis, because their adjustment costs may be unusually large or their leverage determinants might be significantly different. We include all firms in our estimations, but Table 9 reports estimates of the main regression model for various firm size classes. We define annual observations on the basis of fiscal (as opposed to calendar) years because sample firms use a variety of fiscal yearends. Table 1 defines the variables used in our study and reports their summary statistics. All of these variables are winsorized at the 1st and 99th percentiles to avoid the influence of extreme observations. Most of our variables are expressed as ratios; where this is not the case (e.g. ***LnTA***), we deflate the nominal magnitudes by the consumer price index to express nominal values in 1983 dollars.

To model a target debt ratio, we use a set of firm characteristics ($\boldsymbol{X}_{i,t}$) that appear regularly in the literature (Rajan and Zingales, 1995; Hovakimian, 2003; Hovakimian et al., 2001; Fama and French, 2002). Their expected effects on the target debt ratio are as follows:

EBIT_TA: A firm with higher earnings per asset dollar could prefer to operate with either lower or higher leverage. Lower leverage might occur as higher retained earnings mechanically reduce leverage, or if the firm limits leverage to protect the "franchise" producing these high earnings. Higher leverage might reflect the firm's ability to meet debt payments out of its relatively high cash flow.

MB: Market to book ratio of assets. A higher ***MB*** is generally taken as a sign of more attractive future growth options, which a firm tends to protect by limiting its leverage.

DEP_TA: Depreciation as a proportion of total assets. Firms with more depreciation expenses have less need for the interest deductions provided by debt financing.

LnTA: Log of (real) total assets. Larger firms tend to operate with more leverage, perhaps because they are more transparent, have lower asset volatility, or have better access to public debt markets.

FA_TA: Fixed asset proportion. Firms operating with greater tangible assets have a higher debt capacity.

R&D_TA: Research and development expenses as a proportion of total assets. Firms with more intangible assets in the form of R&D expenses will prefer to have more equity.

[3] The minimum number of years per firm is two, the maximum is 37, and the median is six. In the parlance of panel data analysis, this constitutes a "large N, small T" data set.

R&D_DUM: A dummy variable equal to one for firms with missing R&D expenses. About 55% of our sample firm-years do not report R&D expenses. For these firms, we set R&D expense to zero and set ***R&D_DUM*** equal to one.

Ind_median: The firm's lagged industry median debt ratio (using Fama and French, 1997 industry definitions), to control for industry characteristics not captured by other explanatory variables. (See also Hovakimian et al., 2001; Roberts, 2002).

In addition to these "usual" determinants of target leverage, we include firm-specific unobserved effects ($\boldsymbol{\mu}_i$) to capture the impact of intertemporally constant, but unmeasured, effects on each firm's target leverage. We find that these unobserved effects explain a large proportion of the cross-sectional variation in target debt ratios, without displacing the other firm characteristics in $\boldsymbol{X}_{i,t}$. At the same time, however, firm fixed effects complicate the estimation problem by making the regression (4) a dynamic panel model (Bond, 2002). We discuss some of these econometric issues in the next section, and provide further details in the appendix.

4. Partial adjustment and the tradeoff theory

4.1. Appropriate estimation techniques

The first column in Table 2 presents Fama and MacBeth (1973) (FM) estimates of (4).[4] Most of the lagged variables representing the target debt ratio carry significant coefficients with appropriate signs. (Only ***MB*** and ***LnTA*** have insignificant coefficients.) The coefficient on lagged ***MDR*** implies that firms close 13.3% (= 1–0.867) of the gap between current and desired leverage within one year. At this rate, it takes approximately five years to close half the gap between a typical firm's current and desired leverage ratios. This slow adjustment is consistent with the hypothesis that other considerations—e.g., pecking order or market timing – outweigh the cost of deviating from optimal leverage. With such a low estimated adjustment speed, convergence toward a long-run target seems unlikely to explain much of the variation in firms' debt ratios.

While the FM estimates have some attractive features, they fail to recognize the data's panel characteristics. A panel regression with unobserved (fixed) effects is more appropriate if firms have relatively stable, unobserved variables affecting their leverage targets. Column (2) of Table 2 reports a fixed effects panel regression, whose estimated coefficients on the determinants of target leverage generally resemble their FM counterparts, except for ***LnTA***. The statistical significance of most variables is greater, and the fixed effects on target ***MDR*** are well justified: an F-test for the joint significance of the unobserved effects in column (2) rejects the hypothesis that these terms are equal across all firms ($F(12918, 98178) = 2.24$; pr $= 0.000$). A prominent difference between columns (1) and (2) are the estimated coefficients on lagged ***MDR***, which indicate a substantially faster adjustment speed (38%) in the panel model. This estimated adjustment speed implies that the typical firm closes half of a leverage gap in about 18 months.

[4]Fama and French (2002) recommend FM estimators to avoid understating coefficient standard errors. OLS yields similar coefficient estimates for similar specifications, as shown in column (2) of Table 3 or column (2) of Table A.1 in the appendix.

Table 2
Alternate estimation methods for specification (4)

Regression results for the model

$$\boldsymbol{MDR}_{i,t+1} = (\boldsymbol{\lambda\beta})\boldsymbol{X}_{i,t} + (\boldsymbol{i} - \boldsymbol{\lambda})\boldsymbol{MDR}_{i,1} + \boldsymbol{\delta}_{i,t+1}, \qquad (4)$$

where ***MDR*** is the market debt ratio. The (lagged) "*X*" variables determine a firm's long-run target debt ratio, and include:

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
***R&D_DUM*:** dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets;
Ind_Median: median debt ratio of firm *i*'s Fama and French (2002) industry classification at time *t*; and
Rated: dummy variable equal to one if the firm has a public debt rating in Compustat, zero otherwise.

Models (2) and (4)–(7) include firm fixed effects and models (4)–(7) include year dummies. *T*-statistics are shown in parentheses. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	FM	FE panel	FM Demeaned	FE Panel (with year dummy)	IV panel	IV panel, Middle 50th percentile	"Base" specification
$\boldsymbol{MDR}_{i,t}$	0.867	0.620	0.639	0.620	0.656	0.636	0.656
	(67.01)	*(218.03)*	*(53.63)*	*(225.14)*	*(172.42)*	*(67.19)*	*(171.58)*
EBIT_TA	−0.035	−0.037	−0.051	−0.039	−0.030	−0.039	−0.030
	(−3.97)	*(−11.80)*	*(−4.70)*	*(−12.96)*	*(−9.64)*	*(−7.64)*	*(−9.66)*
MB	−0.001	0.000	−0.001	−0.001	0.000	0.002	0.000
	(−1.53)	*(−0.34)*	*(−1.45)*	*(−3.38)*	*(−0.68)*	*(2.71)*	*(−0.81)*
DEP_TA	−0.225	−0.280	−0.338	−0.224	−0.226	−0.209	−0.226
	(−7.59)	*(−13.46)*	*(−7.67)*	*(−10.97)*	*(−11.07)*	*(−6.61)*	*(−11.06)*
LnTA	0.000	0.026	0.025	0.027	0.026	0.034	0.025
	(−0.43)	*(38.22)*	*(14.42)*	*(37.52)*	*(34.56)*	*(30.28)*	*(34.00)*
FA_TA	0.022	0.058	0.066	0.059	0.053	0.058	0.053
	(2.68)	*(12.82)*	*(10.33)*	*(13.42)*	*(11.85)*	*(8.33)*	*(11.93)*
R&D_DUM	0.005	−0.006	0.000	0.000	0.000	0.001	0.000
	(3.97)	*(−3.87)*	*(0.23)*	*(−0.14)*	*(−0.01)*	*(0.35)*	*(0.02)*
R&D_TA	−0.081	−0.038	−0.072	−0.036	−0.025	−0.074	−0.025
	(−3.56)	*(−3.80)*	*(−3.10)*	*(−3.63)*	*(−2.55)*	*(−4.09)*	*(−2.57)*
Ind_Median	0.063	0.054	0.087	0.050	0.034	0.028	0.034
	(5.71)	*(9.89)*	*(4.43)*	*(6.34)*	*(4.29)*	*(2.42)*	*(4.30)*
Rated							0.003
							(1.71)
Fixed effects?	No	Yes	No	Yes	Yes	Yes	Yes
N	111,106	111,106	111,106	111,106	111,106	55,526	111,106
R^2	0.756	0.426	0.462	0.467	0.466	0.330	0.466

The more rapid adjustment speed in column (2) might reflect either the addition of firm fixed effects to the target specification, or the panel regression constraint that the slope coefficients remain constant over time. To distinguish between these two possibilities, the regression in column (3) applies the FM method to de-meaned data. That is, each variable is expressed as a deviation from that firm's mean value. Most of the FM estimates in column (3) are very close to the panel results in column (2). We conclude that firm-specific unobserved effects substantially influence estimated adjustment speeds, apparently because they substantially sharpen estimates of the target debt ratio.[5] We return to this issue in Section 4.3.

Column (4) estimates a revised panel model, which includes a separate dummy variable for each year in the sample (except 1966, to avoid a dummy variable trap). The resulting (within) adjusted-R^2 statistic rises slightly from column (2) and the other coefficients remain essentially the same. We include year dummy variables in our subsequent panel regressions to absorb any unmodeled time-varying influences on capital structure. We also estimate this specification with a correction for first-order serial correlation within each panel (not reported). The estimated AR(1) coefficient is sufficiently small (−0.03) that we proceed under the assumption that serial correlation is not a significant effect in our study.

Consistently estimating the adjustment speed in a dynamic panel requires careful attention to the serial correlation properties of the dependent variable and the regression's residuals (Baltagi, 2001, Chapter 8; Wooldridge, 2002). Column (5) addresses the correlation between a panel's lagged dependent variable and the error term, which can bias the estimated adjustment speed. We substitute a fitted value for the lagged dependent variable, using the lagged book value of leverage and $\boldsymbol{X}_t$ as instruments (Greene, 2003).[6] The estimated $\boldsymbol{MDR}_t$ coefficient rises slightly (from 0.620 to 0.656) but the other coefficient estimates remain close to the estimates in column (4). The implied adjustment speed of 34.4% indicates that the typical firm completes more than half of its required leverage adjustment in less than two years—far faster than estimated by many previous authors. Such a rapid adjustment toward a firm-specific capital ratio suggests that pecking order or market timing does not dominate most firms' debt ratio decisions. We return to this issue in Table 4 below.

Column (6) of Table 2 addresses the possibility that the rapid adjustment speed in column (5) reflects the bounded nature of $\boldsymbol{MDR}_{i,t}$ between zero and unity. A firm with a very high leverage thus has nowhere to go but down, and vice versa. Column (6) reports the results of estimating our instrumental variables specification for only the middle 50% of observed $\boldsymbol{MDR}_{i,t}$ values. The 25th and 75th percentile cutoffs for $\boldsymbol{MDR}_{i,t}$ vary across years, but average 6.5% and 41.6%, respectively. All of the coefficient estimates in column (6), including the adjustment speed, are very similar to the results using the entire sample. We are therefore confident that "hard-wired" mean reversion in the dependent variable is not the cause of our high estimated adjustment speeds.

The last column of Table 2 presents our "base" specification that is used going forward. This specification includes an instrumental variable correction for $\boldsymbol{MDR}_t$. Explanatory variables include firm and time fixed effects, plus an additional explanatory variable in the "$\boldsymbol{X}$" matrix:

Rated equals unity when a firm has a public debt rating, and zero otherwise.[7]

[5] When we replace the firm fixed effects in column (2) with a set of 46 industry dummy variables (constructed as in Fama and French, 1997), the estimated coefficients closely resemble those in column (1), which also excludes firm fixed effects.

[6] More recent estimation techniques like that of Arellano and Bond (1991) improve upon this approach under some circumstances, but not for our sample. See the appendix for details.

[7] Because Compustat does not report this variable before 1981, we cannot compute Fama–MacBeth estimates comparable to the other specifications in Table 2 if ***Rated*** is included.

Faulkender and Petersen (2005) control for sample selectivity in their paper because ***Rated*** may be endogenous. We simply include ***Rated*** as an additional dependent variable, for two reasons. First, the impact of bond ratings is not our central concern. Second, the other results are completely insensitive to the inclusion or exclusion of ***Rated*** from the set of variables determining a firm's target debt ratio. This dummy variable carries a marginally significant positive coefficient (as in Faulkender and Petersen, 2005), but its introduction has no meaningful effect on the other coefficient estimates.

Our base specification in column (7) indicates that the typical firm's target debt ratio varies quite a lot. The cross-sectional mean target debt ratio starts at 32.1% in 1966, rises to a maximum of 64.0% in 1974, and ends the period at 27.0% in 2001. Over the entire sample, the estimated target has an average of 30.7% and a standard deviation of 25.1%. (In comparison, the actual ***MDR's*** mean and standard deviation are 27.8% and 24.4%, respectively.) Firm characteristics, fixed effects, and time all contribute to the variation in target debt ratios. The set of nine ***X*** variables explain 16.0% of the total sample standard deviation of ***MDR***, the unobserved (fixed) effects explain 25.2%, and the year dummies explain 9.0%. Within each year, the nine ***X*** variables alone explain between 12.5% and 17.6% of the annual, cross-sectional variations in target debt ratios, with an average (across all years) of 15.03%. In short, our computed leverage targets vary substantially across firms and across time.

4.2. Convergence toward the target

If we estimate meaningful leverage targets, we should find that firms adjust toward these targets over time. Fig. 1 illustrates managers' financing decisions conditional on the firm's deviation from its computed (estimated) target leverage. For each year between 1966 and 2000, we sort firms into quartiles on the basis of their deviations from target leverage (***MDR****–***MDR***). The horizontal axis in Fig. 1 indicates that the firms in Quartile 1 appear to be substantially overleveraged, by an average (median) of 15.29% (13.59%) of assets. Conversely, our model indicates that the firms in Quartile 4 are underleveraged by a mean (median) of 21.96% (19.70%). The vertical axis in Fig. 1 describes the subsequent year's change in book debt ratios (***BDR***), which should reflect the firm's explicit efforts to move toward its target. (In contrast, ***MDR*** confounds the effects of managerial actions and changes in the firm's stock price.) The evidence in Fig. 1 is consistent with convergence. The mean (median) overleveraged firm in Quartile 1 reduces its book leverage the following year by 3.12% (1.94%). Conversely, the underleveraged firms in Quartile 4 raise their ***BDR*** by a mean (median) of 4.69% (1.75%) during the subsequent year. Firms in the middle two quartiles also move toward their target debt ratios, but with much smaller adjustments.

While the results in Fig. 1 are consistent with targeting behavior, they might reflect merely a tendency of firms with relatively high or low debt ratios to move back toward the mean, as indicated by Leary and Roberts' (2005) hazard function estimates. Indeed, Fig. 2 illustrates this tendency in the data. The horizontal axis describes four quartiles formed on the basis of the prior year's absolute ***MDR***. As in Fig. 1, the vertical axis of Fig. 2 plots the subsequent year's mean and median changes in book debt ratio (***BDR***). Independent of their position relative to their target, highly levered firms tend to reduce their book

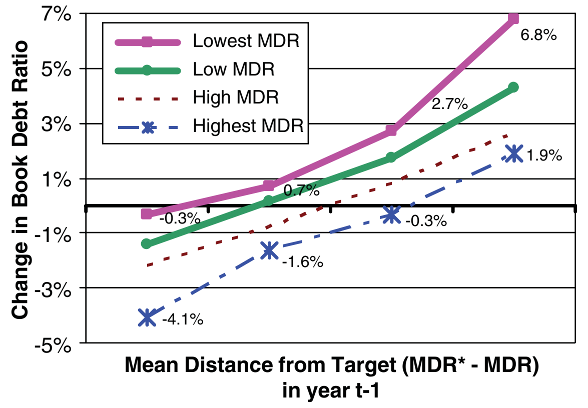

Fig. 3. Subsequent year's change in book debt ratio.

leverage the following year. Conversely, firms in the lowest ***MDR*** quartile tend to increase their ***BDR*** during the subsequent year.[8]

How much of the targeting behavior in Fig. 1 reflects this general tendency for extremely levered firms to revert toward the mean? We evaluate this question using a two-way sort of the data. First, we form four quartiles based on absolute leverage ($\boldsymbol{MDR}_{t-1}$) as in Fig. 2. *Within* each leverage quartile, we construct quartiles based on the firm's deviation from its target leverage. Each line in Fig. 3 then plots the change in ***BDR*** against the prior year's deviation from target (according to our model) for a set of firms with similar absolute ***MDR*** values. As in Fig. 1, the tradeoff theory implies that firms to the left (right) on the horizontal axis in Fig. 3 are overleveraged (underleveraged) and should be acting to reduce (increase) leverage in the subsequent year. This is exactly what we find. Regardless of their absolute leverage, the most overleveraged firms reduce their ***BDR***. Firms with high absolute leverage move toward their target more quickly than those with low absolute leverage, suggesting that deviations from target are more costly for more highly leveraged firms. At the other extreme, the mean underleveraged firm raises ***BDR*** regardless of its absolute leverage level. Among these underleveraged firms, those with the lowest absolute leverage act most aggressively to increase ***BDR***.

4.3. Previous estimates of optimal capital structure

The rapid adjustment speed estimated in Table 2 (34.4% per year) constitutes the most notable feature of our empirical results. Although some prior research has supported such rapid adjustment, the conventional wisdom holds that a firm's annual adjustment speed lies in the neighborhood of 8% to 15%, which Fama and French (2002) consider insufficient for the tradeoff theory to explain the range of observed variation in firms' leverage data. Previous research uses a variety of regression specifications to study the determinants of a firm's capital structure. Why should our specification be preferred? We

[8]Fig. 2 is not inconsistent with targeting behavior, since firms with high (low) leverage are more likely to be above (below) their target leverage.

contend that most previous studies impose unwarranted, but testable, assumptions on the data, which have led to incorrect or misleading inferences.

Table 3 reports a set of capital structure models estimated over the same panel data set. Column (1) presents a typical simple, cross-sectional specification used by many prior studies to infer the determinants of a firm's optimal leverage (e.g., Hovakamian et al., (2001); Fama and French (2002); Korajczyk and Levy (2003); Kayhan and Titman (2005)).[9] The estimated coefficients resemble those of the earlier studies. In particular, higher earnings, ***MB*** ratio, R&D expenditures, and depreciation expenses lower target leverage, while asset size and fixed assets raise it.

The specification in column (1) constrains the coefficient on lagged ***MDR*** to be zero. In other words, a firm's observed capital ratio is also its desired (target) ratio. Column (2) indicates that this hypothesis is strongly rejected by the data. When we add the lagged dependent variable to the specification in column (1), it carries a very highly significant coefficient (0.864). The simple cross-sectional regression in column (1) thus appears to omit an important variable. We also know from Table 2 that column (2)'s exclusion of firm fixed effects is unwarranted.

Column (3) specifies partial adjustment toward a target capital ratio that includes firm fixed effects.[10] Several of the estimated coefficients differ substantially from those for the simple linear model in column (1). For example, column (1) indicates that the coefficient on ***EBIT_TA*** is −0.282, more than three times the estimated long-run magnitude in column (3) ((−0.03/0.343) = −0.087). The long-run coefficients on ***MB, R&D_Dum, R&D_TA***, and ***Rated*** are also substantially lower in column (3), while the long-run impact of firm size (***LnTA***) increases by a factor of six. It appears, therefore, that the estimated determinants of target leverage are materially affected by the omitted variables in column (1).[11]

Regressions like that in column (1) are sometimes used to generate leverage target proxies for use in partial adjustment models. Two-stage estimates based on such a proxy have largely formed the conventional wisdom that firms adjust slowly toward any leverage target. Column (4) of Table 3 presents an estimated partial adjustment model based on a target debt ratio ($\boldsymbol{TDR}_{\mathrm{OLS}}$,), which is computed from column (1). The estimated adjustment speed (9.1%) resembles other estimates derived from target proxies containing no fixed effects. This alone does not indicate a problem with the two-stage estimation. However, the coefficient on $\boldsymbol{TDR}_{\mathrm{OLS}}$ is much smaller than theory would predict. The longrun elasticity of observed ***MDR*** with respect to its target should be unity. Here, it is only 0.56 (= 0.051/0.091), which differs from unity at a very high confidence level

[9] Hovakimian et al. (2001) and Korajczyk and Levy (2003) estimate a target leverage using simple OLS, then use deviations from their computed targets to help predict whether a firm subsequently issues debt or equity.

[10] This regression omits one determinant of the target debt ratio from our base specification, namely, the lagged industry median ***MDR***. We omit this variable in Table 3 in order to provide a cleaner test of the two-stage approach to estimating a partial adjustment coefficient.

[11] Hovakimian et al. (2004) estimate a cross-sectional regression like our column (1) for a set of firms that have recently issued large amounts of both debt and equity, and find that the estimated coefficients differ substantially from those estimated for the rest of the Compustat universe. The authors argue that the security issuers have moved close to their optimal leverage ratios, while the other firms are scattered more widely relative to their target capital ratios.

Table 3
The importance of recognizing partial adjustment

Regression results for the models

(1) $\boldsymbol{MDR_{i,t+1} = \beta X_{i,t} + \delta_{i,t+1}}$,

(2) $\boldsymbol{MDR_{i,t} = (\lambda\ \beta)\ X_{i,t} + (1-\lambda)\ MDR_{i,t} + \delta_{i,t+1}}$,

(3) $\boldsymbol{MDR_{i,t+1} = (\lambda\ \beta)\ X_{i,t} + (1-\lambda)\ MDR_{i,t} + \nu_i + \delta_{i,t+1}}$,

(4) $\boldsymbol{MDR_{i,t+1} = \lambda\ (TDR_{OLS\ i}) + (1-\lambda_1)\ MDR_{i,t} + \delta_{i,t+1}}$,

(5) $\boldsymbol{MDR_{i,t+1} = \beta_1\ L3MDR_{i,t} + (1-\lambda_1)\ MDR_{i,t} + \delta_{i,t+1}}$,

where ***MDR*** is the market debt ratio. The (lagged) "*X*" variables determine a firm's long-run target debt ratio, and include:

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
***R&D_DUM*:** dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets; and
Rated: dummy variable equal to one if the firm has a public debt rating in Compustat, and zero otherwise.

L3MDR is the average of the three-years' lagging ***MDR*** values, and $\boldsymbol{TDR}_{\mathrm{OLS}}$ is the fitted value from model (1). All regressions include(unreported) year dummies. *T*-statistics are shown in parentheses. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics.

	(1)	(2)	(3)	(4)	(5)
$\boldsymbol{MDR_{i,t}}$		0.864	0.657	0.909	0.935
		(469.79)	*(174.09)*	*(382.34)*	*(194.48)*
EBIT_TA	−0.282	−0.026	−0.030		
	(−75.25)	*(−11.62)*	*(−9.73)*		
MB	−0.041	−0.002	0.000		
	(−103.01)	*(−6.84)*	*(−1.07)*		
DEP_TA	−0.566	−0.216	−0.225		
	(−24.87)	*(−16.38)*	*(−11.03)*		
LnTA	0.011	−0.001	0.025		
	(26.39)	*(−3.11)*	*(33.85)*		
FA_TA	0.128	0.027	0.054		
	(36.32)	*(13.16)*	*(12.19)*		
R&D_DUM	0.035	0.007	0.000		
	(24.33)	*(8.73)*	*(0.03)*		
R&D_TA	−0.518	−0.116	−0.026		
	(−50.79)	*(−19.51)*	*(−2.64)*		
Rated	0.066	0.005	0.003		
	(26.45)	*(3.68)*	*(1.75)*		
$\boldsymbol{TDR_{OLS}}$				0.051	
				(12.31)	
L3MDR					−0.023
					(−4.85)
Fixed effects?	No	No	Yes	No	No
N	111,106	111,106	111,106	111,106	81,343
R^2	0.262	0.753	0.466	0.750	0.767

($t = 11.48$).[12] This provides strong evidence against the two-step estimation procedure used previously in the literature.

Target leverage has also been proxied by the trailing average of a firm's actual leverage.[13] In column (5), we test whether ***L3MDR***, a three-year trailing average ***MDR***, provides an adequate proxy for target capital. The estimated adjustment speed is now only 6.5%, and the impact of a one-unit increase in ***L3MDR*** actually reduces a firm's longrun debt ratio. Thus, it appears that ***L3MDR*** measures target leverage quite poorly.

We now investigate more formally how target measurement noise affects a partial adjustment model. Could measurement error alone account for the difference between the adjustment speeds in columns (2) and (3) of Table 3? Substitute a noisy proxy for $\boldsymbol{MDR}^*$ into Eq. (3) to obtain

$$\boldsymbol{MDR}_{i,t+1} = (1-\boldsymbol{\lambda})\boldsymbol{MDR}_{i,t} + \boldsymbol{\lambda}(\boldsymbol{MDR}^*_{i,t+1} + \tilde{\boldsymbol{\xi}}_{i,t}) + \tilde{\boldsymbol{\delta}}_{i,t+1}, \tag{3a}$$

where $\tilde{\xi}_{i,t}$ is a standard normal variate with zero mean. Adding noise to an explanatory variable usually biases the associated coefficient toward zero, which implies an estimated coefficient on $\boldsymbol{MDR}_{i,t}$ biased toward unity. To quantify this effect, we assume that $\boldsymbol{MDR}^* = \boldsymbol{TDR}_{\text{Panel}}$, a target series constructed from the estimated coefficients in column (3) of Table 3. We then increase the standard deviation of $\tilde{\xi}_{i,t}$ from 0.0 to 0.5 across the columns of Table 4.[14] The results indicate that a noisier target measure lowers both the estimated adjustment speed (from 0.345 to 0.104) and the long-run effect on ***MDR*** of a change in the target's value (from 1.00 to 0.31).

Which column of Table 4 is most relevant for our data set? Over the entire sample period, the observed ***MDR*** series has a standard deviation of 24.4%. A good proxy should be similarly distributed and $\boldsymbol{TDR}_{\text{Panel}}$ has a standard deviation of 25.1%. In contrast, the $\boldsymbol{TDR}_{\text{OLS}}$ series' standard deviation is much smaller (12.5%). The standard deviation of the difference between these two target proxies ($\mathbf{TDR}_{\text{Panel}}$–$\mathbf{TDR}_{\text{OLS}}$) is about 22%, which lies between the assumed noise volatilities in columns (4) and (5) of Table 4. We therefore see that a noise volatility of 20% to 25% roughly halves the estimated adjustment speed; from 34.5% ($\approx$1–0.656) to something in the neighborhood of 17%.[15]

We conclude from Tables 3 and 4 that partial adjustment and firm fixed effects should be included in a model of firm capital structure choice. A few previous studies include such

[12]The importance of fixed effects in computing leverage targets can be assessed by reestimating the regression in column (1) with firm fixed effects. When the resulting fitted values are used as leverage targets, the adjustment speed in column (4) rises to 40% and its long-run impact on MDR is 1.05.

[13]Marsh (1982); Jalilvand and Harris (1984); and Shyam-Sunder and Myers (1999) have used various forms of this proxy, with mixed results. In Section 5.3 below, we point out that Welch's (2004) main regression specification can be viewed as a single lag of the dependent variable as a leverage target.

[14]The $\boldsymbol{TDR}_{\text{Panel}}$ series is itself a noisy estimate of the true target, so $\tilde{\xi}_{i,t}$ measures additional "noise," not the total estimation error.

[15]Further qualitative evidence that measurement error depresses estimated adjustment speeds comes from comparing various versions of Kayhan and Titman (2005). Although their focus is quite different from ours, they estimate a regression of the form

$$\boldsymbol{MDR}_t - \boldsymbol{MDR}_{t-k} = \boldsymbol{\alpha X} + \boldsymbol{\beta}(\boldsymbol{MDR}_{t-k} - \boldsymbol{TDR}_{t-k}) + \boldsymbol{\varepsilon}_t, \tag{6}$$

where $\boldsymbol{TDR}_{t-k}$ is the target debt ratio computed from a cross-sectional OLS regression using firm characteristics from year (t–k–1). When $k = 5$ (as it does in Table 6 of their November 2003 manuscript), $\hat{\beta} = 0.45$, which implies an annual leverage adjustment rate of 7.7%. In the corresponding table of their May 2004 revision, they set $k = 10$ and the estimated annual adjustment speed falls to 4.6%. Although this change has no effect on their variables of interest, it does illustrate the effect of noisy targets on the estimated adjustment speed.

Table 4
Effect of Adding Noise to the Target Debt Ratio
Regression results for the model

$$\boldsymbol{MDR}_{i,t+1} = (1-\lambda)\boldsymbol{MDR}_{i,t} + \lambda(\boldsymbol{MDR}^*_{i,t+1} + \tilde{\xi}_{i,t}) + \tilde{\delta}_{i,t+1}. \qquad (3a)$$

where ***MDR*** is the market debt ratio, *MDR** is the estimated target debt ratio from model (3) of Table 3, and $\tilde{\xi}_{i,t}$ is a white noise term with zero mean. Models (1) through (6) are estimated at various levels of standard deviation for $\tilde{\xi}_{i,t}$. *T*-statistics are shown in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
Standard deviation of $\tilde{\xi}_{i,t}$	0%	5%	10%	20%	25%	50%
$\boldsymbol{MDR}_t$	0.656	0.680	0.731	0.818	0.844	0.896
	(230.82)	*(246.07)*	*(278.24)*	*(345.06)*	*(370.89)*	*(432.96)*
$\boldsymbol{MDR}^*_{i,t+1} + \tilde{x}_{i,t}$	0.345	0.313	0.248	0.130	0.100	0.033
	(145.05)	*(138.98)*	*(123.97)*	*(90.45)*	*(78.10)*	*(46.19)*
N	111,106	111,106	111,106	111,106	111,106	111,106
R^2	0.811	0.806	0.795	0.774	0.768	0.755
Long-run effect of target	1.000	0.979***	0.920***	0.729***	0.632***	0.312***

***Significantly different from one at the 1% level.

features in their regression models and produce rapid estimated adjustment speeds. For example, Marcus (1983) estimates a panel model with firm fixed effects for large U.S. banks over the period 1965–1977. His estimated adjustment speed for market leverage is 20–24% per year for the full sample. For the 1965–1971 subperiod, he estimates annual adjustment speeds as high as 32.5%. Roberts (2002) estimates even higher adjustment speeds in his Kalman filter model of partial adjustment. Because the standard Kalman filter specifies that all variables have zero means, he de-means each data series, which "implicitly…accounts for firm-specific effects in the intercepts" (p. 13). Using quarterly data over the period 1980–1998, he estimates a separate model similar to Eq. (4) for the firms in each of 53 industries. His results imply annual adjustment speeds (λ) ranging from a low of 18% to a high of more than 100%.[16]

In a multifaceted paper, Leary and Roberts (2005) use a quarterly Compustat data set (1984–2001) to estimate hazard functions for substantial net debt or equity adjustments.[17] While their primary concern is to infer the form of capital adjustment costs (e.g., fixed vs. proportional vs. convex), but they indirectly address the question of adjustment speeds. They find that a typical firm changes the book value of its debt (equity) by more than 5% of book assets *about once per year*, and conclude that "Firms do indeed respond to equity issuances and equity price shocks by appropriately rebalancing their leverage over the next one to four years" (p. 32). If we define "appropriately rebalancing" as closing 90% of the initial leverage gap, "one to four years" corresponds to an adjustment speed in Eq. (4) that exceeds 40%.

[16]Across all industries, the mean annual adjustment speed is approximately is 43%. His equal-weighted average of 53 industries' adjustment speeds cannot be compared directly to our estimated λ. We weight each sample firm equally, which gives different industries different weights in our estimate of λ. Still, it is comforting to learn that applying Kalman filters to a comparable data set yields roughly similar results.

[17]They describe the estimated model as "similar in spirit to a nonlinear dynamic panel regression *with firm-specific random effects*" (p. 17, emphasis added).

Alti (2004) estimates relatively rapid adjustment speeds without fixed effects in his target variable specification. He compares the capital ratios chosen by 1,363 firms that go public in "hot" vs. "cold" issue markets. He finds that firms making their IPOs in a hot (cold) market tend to have unusually low (high) leverage immediately after going public. He then estimates a model similar to Eq. (4), but without fixed effects, for one and two years after the IPO date. The estimated adjustment speed is surprisingly rapid for a model without fixed effects: 30% per year. We conjecture that this rapid adjustment reflects his sample: rapidly growing, young firms tend to seek additional financing soon after their IPO and hence confront unusually low costs of adjusting leverage.

In conclusion, our model specification is theoretically preferable to many earlier models, and the specification differences account for our main results: firms adjust rapidly toward time-varying target leverage ratios, which depend on plausible firm features.

5. Other capital structure theories

The pecking order model has strong intuitive appeal and a long pedigree. Various forms of the model have been recently studied, with mixed empirical results (Shyam-Sunder and Myers, 1999; Frank and Goyal, 2003; Lemmon and Zender, 2004; Halov and Heider, 2004). The literature also includes two more recent explanations of capital structure, namely, Baker and Wurgler's (2002) market timing theory (also studied in Huang and Ritter, 2005) and Welch's (2004) mechanical stock price explanation. We now compare our results to these three alternatives.

5.1. The pecking order and market timing theories: regression evidence

Previous authors estimate models in which the financing deficit (pecking order) or the weighted sum of past market-to-book ratios (market timing) compete with variables associated with the tradeoff theory of capital structure. The idea is that the variables associated with the "true" theory are more important than their competitors. Frank and Goyal (2003) explain:

> The pecking order theory implies that the financing deficit ought to wipe out the effects of other variables. If the financing deficit is simply one factor among many that firms tradeoff, then what is left is a generalized version of the tradeoff theory. (p. 219)

Baker and Wurgler (2002) make similar statements, particularly concerning their Table III.

Pecking order behavior implies that a firm's financing deficit explains contemporaneous changes in its book debt ratio. We test this proposition by evaluating a book-value analog to our main specification in Eq. (4):[18]

$$\Delta \boldsymbol{BDR}_{i,t+1} = (\lambda\beta)\boldsymbol{X}_{i,t} - \lambda \boldsymbol{BDR}_{i,t} + \gamma_2 \boldsymbol{FINDEF}_{i,t+1} + \varepsilon_{i,t+1}, \tag{7}$$

where ***BDR*** is the ratio of (long-term plus short-term debt) to total assets, and ***FINDEF*** is the firm's financing deficit. In their Table 2, Frank and Goyal (2003) define ***FINDEF*** as:

[18]The bias associated with including the lagged dependent variable in a panel regression applies to (7) and (8) as well as it does to (4). In these cases, we instrument for lagged ***BDR*** using the firm's lagged ***MDR***.

(dividend payments + investments + change in working capital−internal cashflow)/(total assets).

Baker and Wurgler (2002) assert that managers issue relatively overvalued securities, which can be either debt (when the firm's $\boldsymbol{q}$-ratio is low) or equity (when $\boldsymbol{q}$ is high). They construct a backward-looking "external finance weighted average" book-market ratio, which they find to be correlated with a firm's book debt ratio over periods as long as ten years. We test their hypothesis here by estimating the following regression for the level of BDR:

$$\boldsymbol{BDR}_{i,t+1} = (\boldsymbol{\lambda\beta})\boldsymbol{X}_{i,t} - (1-\boldsymbol{\lambda})\boldsymbol{BDR}_{i,t} + \gamma_1 \boldsymbol{MB\_EFWA}_{i,t} + \varepsilon_{i,t+1}, \tag{8}$$

where ***MB_EFWA*** is the firm's external finance weighted average book-market ratio defined on 12 of Baker and Wurgler (2002).

In both regressions (7) and (8), the question is whether ***MB_EFWA*** or ***FINDEF*** affects the estimated coefficients on $\boldsymbol{X}_{i,t}$ or the lagged dependent variable. To set a baseline for the ***BDR*** regressions, the first column in Table 5 reports the results of explaining ***BDR*** with only our standard $\boldsymbol{X}_{i,t}$ (including firm fixed effects), year dummies, and a lagged dependent variable. The partial adjustment model fits ***BDR*** well: the lagged dependent variable's coefficient implies a rapid adjustment (36.1% annually) and the variables meant to capture target leverage carry significant coefficients with the appropriate signs. Adding Baker and Wurgler's (2002) external finance weighted market-book ratio as an explanatory variable in column (2) lowers the estimated adjustment speed only slightly (from 36.1% to 34.2%). The other coefficients remain basically unchanged, except that the simple ***MB*** coefficient loses significance. The Baker and Wurgler (2002) variable is at best marginally significant (p-value $=$ 0.093, two-tailed test), perhaps because the market-to-book effect is split between the two variables (Hovakimian, 2003).

The specification in column (3) explains the change in ***BDR*** with changes in our standard explanatory variables and the firm's financing deficit. The ***FINDEF*** coefficient is significantly positive (t-statistic = 9.96), but does not substantially alter the other variables' signs and significance levels. Thus, the pecking order forces appear to be part of a "generalized version of the tradeoff theory" (Frank and Goyal, 2003, p. 219), rather than a unique determinant of financial leverage.

We next include both ***MB_EFWA*** and ***FINDEF*** in the same regression. This is probably an inappropriate specification because ***MB_EFWA*** is meant to explain the *level* of ***BDR*** while ***FINDEF*** affects the *change* in ***BDR***. Nevertheless, the estimated coefficients in column (4) resemble their values in columns (2) and (3), and the tradeoff variables retain their usual values.

Although both the pecking order and market timing hypotheses apply to book-valued debt ratios, columns (5)–(7) of Table 5 incorporate ***MB_EFWA*** and ***FINDEF*** into regressions explaining the *market* debt ratio. The market-timing variable (***MB_EFWA***) in column (5) now carries a significant coefficient with the proper sign. As in column (2), the simple ***MB*** variable again loses significance. The pecking order conclusions in column (6) replicate those for **ΔBDR** in column (3): ***FINDEF*** carries a significantly positive coefficient but does not displace the tradeoff-related variables from the regression. Once again, including both of the competing theories' variables in column (7) yields significant coefficients without substantially changing the estimated coefficients on the tradeoff or partial adjustment variables.

Table 5
Pecking order and market timing explanations of book debt ratio

In columns (1) (2), and (4), we estimate a regression that explains a firm's book debt ratio:

$$BDR_{i,t+1} = (\lambda\beta)X_{i,t} + (1-\lambda)BDR_{i,t} + \gamma_1 Z_{i,t} + \varepsilon_{i,t+1}.$$

In column (4), we estimate a regression that explains a firm's change in book debt ratio:

$$\Delta BDR_{i,t+1} = (\lambda\beta)X_{i,t} - \lambda BDR_{i,t} + \gamma_2 Z_{i,t} + \varepsilon_{i,t+1},$$

In columns (5) and (7) we estimate our main regression specification that explains a firm's market debt ratio:

$$MDR_{i,t+1} = (\lambda\beta)X_{i,t} - (1-\lambda)MDR_{i,t} + \gamma_1 \boldsymbol{Z_{i,t}} + \delta_{i,t+1}. \quad (4)$$

In column (6) we estimate a regression that explains a firm's change in market debt ratio:

$$\Delta MDR_{i,t+1} = (\lambda\beta)X_{i,t} - \lambda MDR_{i,t} + \gamma_2 Z_{i,t} + \delta_{i,t+1}.$$

The (lagged) "*X*" variables determine a firm's long-run target debt ratio, and include:

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
***R&D_DUM*:** dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets;
Ind_Median: median debt ratio of firm *i*'s Fama and French (2002) industry classification at time *t*; and
Rated: dummy variable equal to one if the firm has a public debt rating in Compustat, and zero otherwise.
$\boldsymbol{Z_t}$ are additional explanatory variables and include:

***FINDEF* = a measure of the firm's financial deficit, defined as dividend payments + investments + change in working capital − internal cashflow; or**
MB_EFWA = an "external finance weighted average" market-book ratio defined by Baker and Wurgler (2002, p. 12).

All models include (unreported) year dummies. *T*-statistics are shown in parentheses. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics.

Panel A: Estimation results							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	***BDR***	**BDR**	**Δ*BDR***	***BDR***	**MDR**	**Δ*MDR***	**MDR**
$\boldsymbol{BDR_{i,t}}$	0.639	0.658	−0.375	0.645			
	(167.21)	*(166.42)*	*(−90.32)*	*(150.22)*			
$\boldsymbol{MDR_{i,t}}$					0.670	−0.341	0.645
					(163.84)	*(−86.53)*	*(146.10)*
EBIT_TA	−0.024	−0.026	−0.018	−0.019	−0.030	−0.021	−0.020
	(−9.48)	*(−8.57)*	*(−6.61)*	*(−5.89)*	*(−7.70)*	*(−6.63)*	*(−4.69)*
MB	−0.001	0.000	−0.001	−0.001	0.001	−0.001	−0.001
	(−2.88)	*(−0.07)*	*(−4.90)*	*(−2.06)*	*(1.53)*	*(−2.20)*	*(−1.54)*
DEP_TA	−0.194	−0.191	−0.144	−0.152	−0.275	−0.155	−0.205
	(−11.32)	*(−10.01)*	*(−7.67)*	*(−7.28)*	*(−11.35)*	*(−7.33)*	*(−7.79)*
LnTA	0.008	0.009	0.008	0.008	0.026	0.026	0.026
	(13.42)	*(13.36)*	*(12.22)*	*(11.13)*	*(31.27)*	*(33.12)*	*(28.30)*
FA_TA	0.042	0.041	0.041	0.038	0.052	0.057	0.056
	(11.17)	*(10.15)*	*(9.92)*	*(8.59)*	*(10.36)*	*(12.24)*	*(10.14)*
R&D_DUM	−0.001	−0.001	−0.001	−0.001	−0.001	0.001	0.001
	(−0.79)	*(−1.01)*	*(−0.75)*	*(−0.77)*	*(−0.33)*	*(0.48)*	*(0.40)*
R&D_TA	−0.026	−0.021	−0.019	−0.013	−0.033	−0.010	−0.015
	(−3.18)	*(−1.85)*	*(−2.18)*	*(−1.08)*	*(−2.31)*	*(−1.08)*	*(−1.04)*
Rated	0.008	0.006	0.008	0.007	0.001	0.003	0.003
	(5.28)	*(4.24)*	*(4.97)*	*(4.25)*	*(0.53)*	*(1.77)*	*(1.35)*
IND_Median	0.032	0.030	0.032	0.031	0.031	0.030	0.037
	(4.93)	*(4.66)*	*(4.47)*	*(4.39)*	*(3.77)*	*(3.68)*	*(4.09)*
MB_EFWA		−0.001		−0.001	−0.003		−0.004
		(−1.68)		*(−1.19)*	*(−4.54)*		*(−4.99)*
FINDEF			0.021	0.028		0.023	0.048
			(9.96)	*(9.82)*		*(9.71)*	*(13.31)*
Fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	111,106	94,235	98,709	83,790	94,235	98,709	83,790
R^2	0.384	0.420	0.198	0.398	0.475	0.240	0.443

Table 5 (*continued*)

Panel B: Relative economic significance of capital structure theories

		Column (2) of Panel A		Column (3) of Panel A		Column (5) of Panel A		Column (6) of Panel A	
		Impact on ***BDR***		Impact on **Δ*BDR***		Impact on ***MDR***		Impact on **Δ*MDR***	
		Absolute	% of ***BDR*'s** Std. Dev.	Absolute	% of **Δ*BDR*'s** Std. Dev.	Absolute	% of ***MDR*'s** Std. Dev.	Absolute	% of **Δ*MDR*'s** Std. Dev.
Tradeoff Theory	Estimated Target	0.0617	32.94%	0.0711	65.49%	0.0676	27.82%	0.0748	60.14%
Market Timing Theory	***MB_EFWA***	−0.0014	−0.73%	NA	NA	−0.007	−2.88%	NA	NA
Pecking Order Theory	***FINDEF***	NA	NA	0.0047	4.31%	NA	NA	0.0022	1.77%

Panel B of Table 5 assesses the economic significance of the tradeoff, market timing, and pecking order models by comparing their ability to explain variations in ***BDR*** and ***MDR***. The first row in Panel B applies the coefficients from column (2) of Panel A. We calculate that changing the target leverage (***BDR****) by one standard deviation changes the (short-run) fitted ***BDR*** by 0.0617, which is about one-third of its standard deviation (0.1925). In contrast, changing ***MB_EFWA*** by one standard deviation lowers ***BDR*** by 0.0014 (less than 1% of its standard deviation). Using coefficient estimates from column (3) of Panel A, a one-standard deviation change in ***BDR**** changes **Δ*BDR*** by 0.0711, while a similar change in ***FINDEF*** affects **Δ*BDR*** by only 0.0047. It therefore appears that variation in target leverage is much more important than mispricing or a financing deficit in explaining book debt ratios. Similar assessments of the three capital structure theories emerge from the last two columns in Panel B, which are based on the regressions in columns (5) and (6) of Panel A. Once again, the target leverage ratio explains far more of the variation in market debt ratios than either the market timing or the pecking order variables.

Although the pecking order and market timing theories each add some information to the regressions, we conclude that neither can replace our model of partial adjustment toward a target debt ratio. Targeting behavior consistent with the tradeoff theory seems to explain the bulk of the observed capital structure.

5.2. Targeting leverage vs. stockpiling debt capacity

Lemmon and Zender (2004) (LZ) suggest a modified version of the pecking order theory, in which each firm has a "debt capacity," or maximum attainable leverage. Empirically, their debt capacity depends on a set of firm characteristics that overlap somewhat with our determinants of target leverage. As we do in Fig. 1, LZ classify a firm as "underleveraged" or "highly leveraged" relative to its estimated debt capacity. They argue that overleveraged firms have no choice but to reduce leverage because they cannot borrow further in the market. However, LZ observe that the tradeoff and pecking order theories have opposite implications for underleveraged firms (our Quartile 4 in Fig. 1). The tradeoff theory predicts that underleveraged firms should move toward their (higher) leverage target by issuing debt (if ***FINDEF*** > 0) or by retiring equity (if ***FINDEF*** < 0). In contrast, the LZ pecking order theory would have these firms "stockpile" debt capacity if ***FINDEF*** < 0 by using their excess cash exclusively to retire outstanding debt.

Table 6 examines the impact of ***FINDEF*** on leverage for the most overleveraged (underleveraged) firms defined in our Table 1. We explicitly discuss only the left-hand side of Table 6, which reports mean values. The Table's right-hand side reports medians, which tell a similar story. Consider first the "Most overleveraged" firms. Row (1) indicates that excess leverage does not vary greatly with the subsequent period's financing deficit. As predicted by LZ, the subsequent year's change in ***BDR*** (row (2)) is negative for all three groups. Inconsistent with the pecking order theory, however, ***BDR*** declines by a similar proportion across a wide range of ***FINDEF*** values. LZ note that this "evidence" against the pecking order theory may arise simply because the capital market is unwilling to lend more to such highly levered firms.

In contrast, the underleveraged firms in rows (4)–(6) can issue additional debt freely. Under LZ's form of the pecking order hypothesis, variations in ***FINDEF*** should therefore induce different amounts of new debt and hence substantially different increases in leverage. Yet we find that all three ***FINDEF*** groups in row (5) raised their ***BDR*** by

Table 6
Underleveraged firms' efforts to converge on targets

The table presents a two-way sort of our sample observations. Observations are first sorted into quartiles based on the distance from target leverage (***MDR****), where target leverage is estimated from model (7) of Table 2. Within each of the quartiles, firms are further sorted into terciles based on the financial deficit (***FINDEF***) values. ***FINDEF*** is defined as dividend payments + investments + change in working capital − internal cashflow.

	Mean values			Median values		
	Quartile #1 of 4: Most overleveraged					
	FINDEF $(t, t+1)$			***FINDEF*** $(t, t+1)$		
	Low (−6.51%)	Medium (1.17%)	High (19.78%)	Low (−3.97%)	Medium (0.58%)	High (13.27%)
(1) Distance from target @ ***t*****: (*MDR*−MDR*)**	−15.90%	−14.74%	−15.40%	−14.00%	−12.88%	−13.57%
(2) $\Delta \boldsymbol{BDR}_{i,t+1}$	−4.03%	−2.71%	−3.53%	−2.99%	−1.63%	−1.91%
(3) $\Delta \boldsymbol{MDR}_{i,t+1}$	−7.31%	−5.43%	−4.47%	−5.84%	−3.66%	−2.73%
	Quartile #4 of 4: Most underleveraged					
	FINDEF $(t, t+1)$			***FINDEF*** $(t, t+1)$		
	Low (−6.32%)	Medium (1.16%)	High (20.57%)	Low (−3.59%)	Medium (0.33%)	High (14.73%)
(4) Distance from target @ ***t*****: (*MDR*−MDR*)**	20.84%	21.31%	23.57%	18.89%	19.00%	20.60%
(5) $\Delta \boldsymbol{BDR}_{i,t+1}$	3.94%	4.87%	5.64%	1.09%	1.26%	3.22%
(6) $\Delta \boldsymbol{MDR}_{i,t+1}$	6.51%	7.31%	10.15%	3.28%	3.31%	7.76%

approximately the same amount. Most importantly, while the "Low ***FINDEF***" firms in Quartile 4 have the opportunity to use their net cash inflow (***FINDEF*** $= -$**6.32%**) to retire some debt, they did not do so. Instead, these firms choose to increase leverage — a decision that is consistent with the tradeoff theory but not the pecking order view that underleveraged firms should stockpile debt capacity.

5.3. The "stock price mechanics" explanation

Welch (2004) finds no evidence of targeting, but concludes that managers passively tolerate almost any change in ***MDR*** caused by share price fluctuations. These conclusions are based on the regression

$$\boldsymbol{MDR}_{i,t+1} = \boldsymbol{a}_0 + \boldsymbol{a}_1\boldsymbol{MDR}_{i,t} + \boldsymbol{a}_2\boldsymbol{IDR}_{i,t+1} + \boldsymbol{\mu}_{i,t+1}, \tag{9}$$

where $\boldsymbol{IDR}_{i,t+1}$, the implied debt ratio equals $D_{i,t}/(D_{i,t} + S_{i,t}P_{i,t}(1 + \tilde{R}_{i,t+1}))$. Note that ***IDR*** is the mechanical effect of stock price changes on leverage, assuming that managers change neither $\boldsymbol{D}_t$ nor $\boldsymbol{S}_t$ during the following period. The variable $\tilde{R}_{i,t+1}$ is the *realized* appreciation in firm i's share price during the period between t and $t+1$, and a_0, a_1, and a_2 are parameters to be estimated. (The intercept, a_0, is sometimes omitted.) Welch's (2004) main conclusions result from Eq. (9)'s implicit and inappropriate constraints on the firm's adjustment process. To understand these constraints, we adjust our base specification in Eq. (4) to allow for the possibility that managers partly counteract the effects of share price changes on leverage. We begin by augmenting our basic partial adjustment model in Eq. (3) as follows:[19]

$$\boldsymbol{MDR}_{i,t+1} - \boldsymbol{MDR}_{i,t} = \boldsymbol{\lambda}_1(\boldsymbol{MDR}^*_{i,t} - \boldsymbol{MDR}_{i,t}) + (1 - \boldsymbol{\lambda}_2)(\boldsymbol{Share\ price\ effect}) + \boldsymbol{\varepsilon}_{i,t+1}, \tag{10}$$

where λ_2 is the adjustment speed to share price effects. Eq. (10) says that the observed change in the debt ratio equals the sum of the partial movement to the target leverage ($\lambda_1(MDR^*_{t+1} - MDR_t)$) and the portion of the share price effect that is not offset within the year ($(1-\lambda_2)$ (*Share price effect*)). We measure the "share price effect" as the change in ***MDR*** due exclusively to share price changes, that is,

$$\boldsymbol{SPE}_{t+1} = \left(\frac{D_t}{D_t + S_tP_t(1 + \tilde{R}_{t,t+1})}\right) - \boldsymbol{MDR}_t. \tag{11}$$

Substituting (11) into (10) gives[20]

$$\boldsymbol{IDR}_{i,t+1} = \boldsymbol{SPE}_{i,t+1} + \boldsymbol{MDR}_{i,t}. \tag{12}$$

The specification in Eq. (12) has two important features. First, finding $\lambda_2 = 0$ does not mean that managers never adjust ***MDR*** in response to share price changes. The residual effect of a price change during the period $(t, t+1)$ is impounded in the next period's lagged ***MDR*** and hence is offset at an annual rate λ_1 in the years following the initial price shock. Second, both ***SPE*** and the dependent variable contain the realized value of $\tilde{R}_{t,t+1}$, which

[19] Marcus (1983) also includes a separate share price effect in his model.

[20] Replacing our base specification (5) with (7) has no important effect on any of the conclusions reported in this paper.

biases the coefficient on $\boldsymbol{SPE}$ toward unity. We therefore estimate (10) using an instrumental variable for $\boldsymbol{SPE}$.[21]

The definition of $\boldsymbol{SPE}$ (11) implies that

$$\boldsymbol{MDR}_{i,t+1} - \boldsymbol{MDR}_{i,t} = \boldsymbol{\lambda}_1(\boldsymbol{MDR}^*_{i,t} - \boldsymbol{MDR}_{i,t}) + (1 - \boldsymbol{\lambda}_2)\boldsymbol{SPE}_{i,t+1} + \boldsymbol{\varepsilon}_{i,t+1}. \tag{11a}$$

Substituting (11a) into (12) gives Welch's specification in our notation:

$$\boldsymbol{MDR}_{i,t+1} = \boldsymbol{\alpha}_0 + \boldsymbol{a}_1\boldsymbol{MDR}_{i,t} + \boldsymbol{a}_2\boldsymbol{SPE}_{i,t+1} + \boldsymbol{\alpha}_2\boldsymbol{MDR}_{i,t} + \boldsymbol{\mu}_{i,t+1}. \tag{13}$$

Juxtaposing (13) and our augmented specification (12) indicates that Welch's (2004) specification can be interpreted as:

(a) Using a multiple of $(a_0 + a_1\ \boldsymbol{MDR}_{i,t})$ as the firm's target leverage. This means that a share price shock becomes fully acceptable to the firm after one year, when the shock has passed into its lagged $\boldsymbol{MDR}$ value.
(b) Using $\boldsymbol{MDR}_{i,t}$ as a starting point for adjustments, as we do. This implies that one should interpret $a_2 = (1-\lambda_1)$.
(c) Constraining $\boldsymbol{MDR}$ and $\boldsymbol{SPE}$ to have the same coefficient (a_2). That is, managers react equally quickly to anticipated and surprise leverage deviations from target.

Table 7 reports the results of estimating several versions of (12) and (13). Column (1) replicates Welch's (2004) specification for our data. Using the Fama and MacBeth (1973) methodology favored by Welch (2004), we find similar results: the lagged debt ratio yields an estimated coefficient close to zero, and the implied debt ratio's coefficient is near unity. These estimates seem to imply that firms permanently accept the impact of share price changes on their leverage. A stock price change is not offset at all before the end of period t, and at the start of period $(t+1)$ the leverage shock becomes fully incorporated into the firm's target. Column (2) replaces the assumption that firms target their previous period's debt ratio with a model of the firm's target debt ratio as $\boldsymbol{\beta X}_{i,t}$ (*without firm fixed effects*). The estimated coefficient on IDR indicates that firms offset only 9.1% (= 1−\$.909) of the market's impact on firm leverage.

From (11a), we know that $\boldsymbol{IDR}$ has two components, $\boldsymbol{SPE}$ and $\boldsymbol{MDR}_{i,t}$. Which part adjusts? We separate the two components of IDR in column (3). The estimated coefficient on SPE indicates that firms do not respond initially to share price surprises $(\lambda_2 = -0.029)$.[22] Typically for a simple OLS regression, however, the estimated adjustment speed for recognized deviations from target is 11.1% (λ_1 = 1–0.889)/year.

The first three columns in Table 7 exclude firm fixed effects, which we show above are important to the estimated adjustment speed. Column (4) therefore reports our base specification, augmented by a share price effect. Comparing these estimates to the last column of Table 2 indicates that the addition of $\boldsymbol{SPE}$ has little effect on our base

[21] We thank Yakov Amihud for pointing out this econometric issue. We regress $\boldsymbol{SPE}$ on the regression's predetermined variables and the realized return to the average firm in the same industry. In unreported results, we find that failing to instrument for $\boldsymbol{SPE}$ yields an estimated value of 0.06 for λ_2, compared to the 0.029 we report in the last column of Table 7. Adding $\boldsymbol{SPE}$ to our base specification has only a small effect on the estimates of λ_1 and the β coefficients.

[22] Intuitively, it may not be surprising that $\boldsymbol{SPE}$ carries a coefficient near unity. If some firms are above their targets and others are below, then any $\boldsymbol{SPE}$ moves some firms closer to their targets and other firms further away. This effect may average out to zero across all firms in the sample.

Table 7
Variations on the regression specification in Welch (2004)

Regression results for the models

Column (1): $\boldsymbol{MDR}_{i,t+1} = a_0 + a_1\ \boldsymbol{MDR}_{i,t} + a_2\ \boldsymbol{IDR}_{i,t+1} + \boldsymbol{\mu}_{i,t+1}$ (12)

Column (2): $\boldsymbol{MDR}_{i,t+1} = \boldsymbol{\alpha}_0 + (\mathbf{1}-\boldsymbol{\lambda}_1)\ \boldsymbol{IDR}_{i,t+1} + (\boldsymbol{\lambda}_1\ \boldsymbol{\beta})\ \boldsymbol{X}_{i,t} + \boldsymbol{\mu}_{i,t+1}$

Column (3): $\boldsymbol{MDR}_{i,t+1} = \boldsymbol{\alpha}_0 + (\mathbf{1}-\boldsymbol{\lambda}_1)\ \boldsymbol{MDR}_{i,t} + (\mathbf{1}-\boldsymbol{\lambda}_2)\ \boldsymbol{SPE}_{i,t+1} + (\boldsymbol{\lambda}_1\boldsymbol{\beta})\boldsymbol{X}_{i,t} + \boldsymbol{\mu}_{i,t+1}$

Column (4): $\boldsymbol{MDR}_{i,t+1} = \boldsymbol{\alpha}_0 + \boldsymbol{a}_1\ \boldsymbol{MDR}_{i,t} + \boldsymbol{a}_2\ \boldsymbol{MDR}_{i,t} + \boldsymbol{\alpha}_2\ \boldsymbol{SPE}_{i,t+1} + \boldsymbol{\mu}_{i,t+1},$ (13)

where ***MDR*** is the market debt ratio, ***IDR*** is the market debt ratio at time t augmented by the firm's realized return in $(t, t+1)$, $\boldsymbol{SPE} = \boldsymbol{IDR} - \boldsymbol{MDR}_{i,t}$ measures the impact of share price changes on ***MDR*** during $(t, t+1)$, and the (lagged) "X" variables determine a firm's long-run target debt ratio, and include:

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
R&D_DUM: dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets; and
Ind_Median: median debt ratio of firm i's Fama and French (2002) industry classification at time t.

T-statistics are shown in parentheses. Models (1)–(3) are undertaken using the Fama and MacBeth methodology. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics.

	(1)	(2)	(3)	(4)
$\boldsymbol{MDR}_{i,t}$	−0.075		0.889	0.658
	(−6.48)		*(201.57)*	*(226.06)*
$\boldsymbol{IDR}_{i,t+1}$	0.990	0.909		
	(71.93)	*(175.79)*		
$\boldsymbol{SPE}_{i,t}$			1.029	0.971
			(30.98)	*(87.18)*
EBIT_TA		0.026	0.022	−0.017
		(4.78)	*(4.22)*	*(−6.99)*
MB		−0.003	−0.004	−0.005
		(−5.10)	*(−6.63)*	*(−18.52)*
DEP_TA		−0.146	−0.148	−0.142
		(−8.29)	*(−9.14)*	*(−9.12)*
LnTA		0.000	0.001	0.002
		(−0.08)	*(1.50)*	*(2.67)*
FA_TA		0.019	0.022	0.045
		(4.44)	*(6.03)*	*(13.22)*
R&D_DUM		0.005	0.005	−0.001
		(6.80)	*(6.90)*	*(−0.54)*
R&D_TA		0.011	0.014	−0.023
		(0.71)	*(0.96)*	*(−3.04)*
Ind_Median				0.078
				(12.95)
Rated				0.007
				(4.88)
Fixed effects?	No	No	No	Yes
N	111,106	111,106	111,106	111,106
R^2	0.860	0.862	0.860	0.691

specification's coefficient estimates. The coefficient on $\boldsymbol{MDR}_{i,t}$ (0.658) implies a rapid adjustment speed to known deviations from target, while managers effectively ignore stock price changes in the year they occur (coefficient on ***SPE*** is 0.971). However, the net ***SPE*** passes into $\boldsymbol{MDR}_{i,t}$ in subsequent periods and is offset at the rate of approximately 34% a year. We conclude, therefore, that our regressions provide little support for Welch's (2004) hypothesis that managers passively accept the impact of share price changes on their firm's leverage.

6. Robustness

Our conclusions about target debt ratios and the speed with which firms adjust toward their targets are robust to changes in the estimation horizon, the sample series, the time period, and the definition of leverage.

6.1. Stability over estimation horizons

The standard partial adjustment model only approximates firm behavior, and theory mandates no specific time interval between empirical observations. We therefore estimated Eq. (4) for time intervals between one and five years to assess whether the estimated adjustment speeds behave consistently with our assumption that a fixed proportion of the remaining leverage gap is closed each period.[23] Given Table 2's one-year adjustment speed of 0.344, a geometric decline would make the two-year coefficient 0.570 ($= 1-(1-0.344)^2$). If the partial adjustment model fits the data well, then the estimated adjustment for a two-year period should be about 57%. The actual estimate in the first column of Table 8 indicates that 59.2% ($= 1-0.408$) of the initial gap would be closed by the end of year two. The longer horizons are also consistent with a continuous rate of adjustment. Following a smooth annual adjustment path of 34.4%, the respective three-, four-, and five-year coefficients would be 71.8%, 81.5%, and 87.9%, vs. the freely-estimated values of 73.4%, 82.9%, and 89.4%. Such a close correspondence between the theoretical and empirical estimates of adjustment provides further support for the hypothesis that our continuous partial adjustment specification appropriately captures variation in the data.

6.2. Stability across firm size

Thus far, we present regression results only for the entire sample of firms. Some previous writers omit relatively small firms, presumably because they might encounter prohibitively large transaction costs when making small leverage adjustments. On the other hand, some small firms grow quickly, which may reduce their costs of adjusting leverage (Alti, 2004). To assess the stability of regression (4), we reestimate our regressions for size-based sub-samples. For each year, we group firms according to CRSP's NYSE size deciles for equity market value. Decile 1 contains the largest firms, and Decile 10 the smallest.[24] The results in Table 9 show that the partial adjustment model (4) fits all firm sizes quite well. Most of

[23]The standard errors in Table 8 are not adjusted for the effect of overlapping observations, but our purpose here is to examine the coefficients' (unbiased) estimated values, not their statistical significance.

[24]The uneven distribution of firms across the deciles reflects the fact that NYSE size deciles are being used to categorize firms drawn from the NYSE-AMEX-Nasdaq universe.

Table 8
Estimates over differing forecast horizons

We estimate variants of a regression based on

$$\boldsymbol{MDR}_{i,t+1} = (\boldsymbol{\lambda\beta})\boldsymbol{X}_{i,t} + (1-\boldsymbol{\lambda})\boldsymbol{MDR}_{i,1} + \boldsymbol{\delta}_{i,t+1} \qquad (4)$$

using different intervals ("k" = 2, 3, 4, or 5 years). ***MDR*** is the market debt ratio. The (lagged) "X" variables determine a firm's long-run target debt ratio, and include:

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
***R&D_DUM*:** dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets;
Ind_Median: median debt ratio of firm i's Fama and French (2002) industry classification at time t; and
Rated: Dummy variable equal to one (zero) if the firm has a public debt rating in Compustat.

All regressions include (unreported) year dummies. T-statistics are shown in parentheses. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics.

	$k=2$ years	$k=3$ years	$k=4$ years	$k=5$ years
$MDR_{i,t}$	0.408	0.266	0.171	0.106
	(93.17)	*(55.62)*	*(32.94)*	*(19.29)*
EBIT_TA	−0.176	−0.224	−0.245	−0.252
	(−46.78)	*(−51.97)*	*(−50.95)*	*(−47.64)*
MB	−0.012	−0.016	−0.019	−0.021
	(−26.21)	*(−31.45)*	*(−32.48)*	*(−32.28)*
DEP_TA	−0.543	−0.419	−0.362	−0.380
	(−20.49)	*(−13.97)*	*(−10.99)*	*(−10.54)*
LNTA	0.051	0.059	0.060	0.059
	(55.39)	*(55.41)*	*(51.12)*	*(46.52)*
FA_TA	0.146	0.180	0.187	0.190
	(26.28)	*(28.72)*	*(27.08)*	*(25.48)*
R&D_DUM	−0.001	−0.004	−0.005	−0.005
	(−0.53)	*(−1.87)*	*(−2.07)*	*(−2.12)*
R&D_TA	−0.146	−0.219	−0.258	−0.274
	(−11.49)	*(−14.74)*	*(−15.20)*	*(−14.36)*
Rated	0.014	0.025	0.031	0.034
	(6.59)	*(10.49)*	*(12.81)*	*(13.31)*
Ind_Median	−0.021	−0.016	−0.031	−0.028
	(−2.16)	*(−1.46)*	*(−2.69)*	*(−2.40)*
Fixed effects?	Yes	Yes	Yes	Yes
N	97,590	85,958	75,886	67,052
R^2	0.278	0.208	0.176	0.166

the ***X*** variables' coefficient estimates do not vary greatly across the four subsamples.[25] Each subsample exhibits a reasonable adjustment speed, which exceeds most past estimates in the literature. Note that the largest firms adjust least rapidly (27.3%). Perhaps larger

[25]Note, however, that the uniformly positive coefficients on ***MB*** in Table 9 contrast with the more common negative coefficients estimated for the full sample. We have no good explanation for this result.

Table 9
Stability across firm sizes

Each year, we divided the universe of firms into ten groups based on CRSP's equity value size deciles for NYSE-traded firms in that year. Decile 1 contains the largest firms. For each size grouping, we then estimate the regression

$$\boldsymbol{MDR}_{i,t+1} = (\boldsymbol{\lambda\beta})\boldsymbol{X}_{i,t} + (1-\boldsymbol{\lambda})\boldsymbol{MDR}_{i,t} + \boldsymbol{\delta}_{i,t+1}, \qquad (4)$$

where ***MDR*** is the market debt ratio. The (lagged) "*X*" variables determine a firm's long-run target debt ratio, and include:

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
R&D_DUM: dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets;
Ind_Median: median debt ratio of firm *i*'s Fama and French (2002) industry classification at time *t*; and
Rated: Dummy variable equal to one if the firm has a public debt rating in Compustat, zero otherwise.

All regressions include (unreported) year dummies. *T*-statistics are shown in parentheses. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics.

	Firms in Deciles 1 & 2	Firms in Deciles 3 & 4	Firms in Deciles 5, 6, & 7	Firms in Deciles 8, 9, & 10
MDR$_{i,t}$	0.727	0.574	0.486	0.608
	(56.33)	*(39.51)*	*(47.97)*	*(123.47)*
EBIT_TA	0.009	0.059	0.013	-0.028
	(0.53)	*(3.53)*	*(1.20)*	*(−7.54)*
MB	0.001	0.010	0.009	0.002
	(0.63)	*(9.25)*	*(10.15)*	*(4.72)*
DEP_TA	−0.354	−0.224	−0.421	−0.138
	(−5.71)	*(−3.05)*	*(−8.04)*	*(−5.50)*
LnTA	0.017	0.063	0.073	0.042
	(8.61)	*(22.93)*	*(38.04)*	*(38.91)*
FA_TA	0.019	0.059	0.082	0.063
	(1.76)	*(4.56)*	*(7.92)*	*(11.06)*
R&D_DUM	0.002	−0.008	−0.004	0.003
	(0.52)	*(−2.13)*	*(−1.34)*	*(1.63)*
R&D_TA	−0.049	0.089	0.094	−0.010
	(−1.12)	*(1.85)*	*(3.03)*	*(−0.83)*
Rated	0.001	−0.004	0.004	0.021
	(0.22)	*(−0.97)*	*(1.45)*	*(5.41)*
Ind_Median	−0.072	−0.036	−0.031	0.037
	(−4.73)	*(−1.99)*	*(−2.06)*	*(3.32)*
Fixed effects?	Yes	Yes	Yes	Yes
N	9,313	9,178	18,050	74,565
R^2	0.590	0.499	0.476	0.434

firms rely more on public debt, which is more expensive to adjust than the private ("bank") debt used by smaller firms. Because public debt has few covenants, the external pressure for a large firm to reverse a leverage increase may be less intense than for a small firm whose bank lenders can enforce relatively tight covenants. Alternatively, if larger firms have less volatile cash flows, they may bear lower costs when they are away from their target leverage.

6.3. Stability over time

Table 10 reports estimation results for three equal time periods, 1966–1977, 1978–1989, and 1990–2001. We find that estimated adjustment speeds are quite similar across time periods, although the estimates in Table 10 all exceed the 0.344 value from Table 2. The other coefficient signs and significance are also generally consistent across periods, with two exceptions: the impact of depreciation expense (***DEP_TA***) on $\boldsymbol{MDR}^{*}$ declines from −0.500 in the first time period to −0.096 in the last, and the sign on ***Ind_Median*** reverses between the first and second periods.

6.4. Alternative "leverage" definitions

Previous research defines leverage in a variety of ways. Table 11 shows that our conclusions about targets and adjustment speeds do not depend on our definition of leverage. We reestimate Eq. (4) using three alternative (new) definitions of the market debt ratio:

$$\boldsymbol{MDR}_1 = \left[\frac{\textbf{\textit{Long Term Debt}} + \textbf{\textit{Short Term Debt}}}{\textbf{\textit{Total assets}} - \textbf{\textit{Book Equity}} + \textbf{\textit{Market Equity}}}\right],$$

$$\boldsymbol{MDR}_2 = \left[\frac{\textbf{\textit{Total Liabilities}}}{\textbf{\textit{Total Liabilities}} + \textbf{\textit{Market Equity}}}\right],$$

$$\boldsymbol{MDR}_3 = \left[\frac{\textbf{\textit{Long Term Debt}}}{\textbf{\textit{Total assets}} - \textbf{\textit{Currrent Liabilities}} - \textbf{\textit{Book Equity}} + \textbf{\textit{Market Equity}}}\right].$$

The estimated adjustment speeds are all rapid (36.6–40.5% annually) and the determinants of target leverage generally carry significant coefficients with appropriate signs.

7. Summary and conclusions

We find strong evidence that nonfinancial firms identified and pursued target capital ratios during the 1966–2001 period. The evidence is equally strong across size classes and time periods, and indicates that a partial adjustment model with firm fixed effects fits the data very well. As earlier research finds, target debt ratios depend on well-accepted firm characteristics. Firms that are under- or overleveraged by this measure soon adjust their debt ratios to offset the observed gap. Targeting behavior is evident in both market-valued and book-valued leverage measures.

Unlike some recent studies, we estimate that firms return relatively quickly to their target leverage ratios when they are shocked away from their targets. The mean sample firm acts to close its (market) leverage gap at the rate of more than 30% per year. While one might dispute whether a 30% annual adjustment speed is "slow" or "rapid," it is

Table 10
Stability over Time

For three equal-sized time periods we estimate the regression

$$\boldsymbol{MDR}_{i,t+1} = (\boldsymbol{\lambda\beta})\boldsymbol{X}_{i,t} + (1-\boldsymbol{\lambda})\boldsymbol{MDR}_{i,t} + \boldsymbol{\delta}_{i,t+1}, \quad (4)$$

where ***MDR*** is the market debt ratio. The (lagged) "*X*" variables determine a firm's long-run target debt ratio, and include:

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
***R&D_DUM*:** dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets;
Ind_Median: median debt ratio of firm *i*'s Fama and French (2002) industry classification at time *t*; and
Rated: dummy variable equal to one if the firm has a public debt rating in Compustat, and zero otherwise.

All models include (unreported) year dummies. *T*-statistics are shown in parentheses. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics. Note that the ***Rated*** coefficients are not estimated for the first sample period (1966–1977), because Compustat does not report that variable before 1981.

	1966–1977	1978–1989	1990–2001
$\boldsymbol{MDR}_{i,t}$	0.566	0.509	0.516
	(53.80)	*(68.72)*	*(75.59)*
EBIT_TA	−0.025	−0.052	−0.025
	(−1.77)	*(−8.77)*	*(−6.01)*
MB	−0.004	−0.001	0.000
	(−3.13)	*(−1.71)*	*(0.21)*
DEP_TA	−0.500	−0.114	−0.096
	(−6.79)	*(−2.99)*	*(−3.14)*
LnTA	0.062	0.048	0.040
	(22.12)	*(27.38)*	*(29.82)*
FA_TA	0.066	0.058	0.060
	(5.09)	*(6.73)*	*(7.87)*
R&D_DUM	−0.003	−0.003	0.003
	(−1.07)	*(−0.99)*	*(0.80)*
R&D_TA	−0.129	−0.014	−0.002
	(−2.32)	*(−0.57)*	*(−0.18)*
Rated		−0.003	0.009
		(−0.90)	*(3.01)*
IND_Median	−0.058	0.088	0.079
	(−3.27)	*(5.88)*	*(5.51)*
Fixed effects?	Yes	Yes	Yes
N	21,032	38,779	51,295
R^2	0.551	0.338	0.336

surely not zero. Indicators of the pecking order and market timing (à la Baker and Wurgler, 2002) theories carry statistically significant coefficients, but their economic effects are swamped by movements toward a firm-specific leverage target. Share price fluctuations have a short-term impact on market debt ratios, but efforts to reach the target leverage ratio offset these transitory effects within a few years.

Table 11
Alternative definitions of leverage
Estimates of the basic regression specification

$$\boldsymbol{MDR}_{i,t+1} = (\boldsymbol{\lambda\beta})\boldsymbol{X}_{i,t} + (1-\boldsymbol{\lambda})\boldsymbol{MDR}_{i,t} + \boldsymbol{\delta}_{i,t+1}, \qquad (4)$$

for three alternative definitions of MDR:

$$\boldsymbol{MDR}_1 = \left[\frac{\textit{Long Term Debt} + \textit{Short Term Debt}}{\textit{Total assets} - \textit{Book Equity} + \textit{Market Equity}}\right],$$
$$\boldsymbol{MDR}_2 = \left[\frac{\textit{Total Liabilities}}{\textit{Total Liabilities} + \textit{Market Equity}}\right],$$
$$\boldsymbol{MDR}_3 = \left[\frac{\textit{Long term Debt}}{\textit{Total assets} - \textit{Currrent Liabilities} - \textit{Book Equity} + \textit{Market Equity}}\right],$$

where ***MDR*** is the market debt ratio. The (lagged) "*X*" variables determine a firm's long-run target debt ratio, and include

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
***R&D_DUM*:** dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets;
Ind_Median: median debt ratio of firm *i*'s Fama and French (2002) industry classification at time *t*;
Rated: dummy variable equal to one (zero) if the firm has a public debt rating in Compustat.

All regressions include (unreported) year dummies. *T*-statistics are shown in parentheses. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics.

Dependent variable:	$\boldsymbol{MDR}_1$	$\boldsymbol{MDR}_2$	$\boldsymbol{MDR}_3$
$\boldsymbol{MDR}_{i,t}$	0.634	0.614	0.595
	(184.09)	*(132.79)*	*(153.82)*
EBIT_TA	−0.023	−0.055	−0.039
	(−9.73)	*(−17.75)*	*(−13.89)*
MB	0.000	−0.001	−0.001
	(0.67)	*(−2.47)*	*(−2.44)*
DEP_TA	−0.192	−0.183	−0.191
	(−12.33)	*(−9.33)*	*(−9.99)*
LnTA	0.020	0.028	0.024
	(35.58)	*(39.45)*	*(33.66)*
FA_TA	0.047	0.047	0.055
	(13.74)	*(11.03)*	*(13.10)*
R&D_DUM	0.000	−0.001	−0.001
	(0.23)	*(−0.52)*	*(−0.94)*
R&D_TA	−0.017	−0.070	−0.035
	(−2.26)	*(−7.47)*	*(−3.93)*
Rated	0.002	0.000	0.005
	(1.77)	*(−0.02)*	*(2.82)*
IND_Median	0.051	0.033	0.044
	(6.01)	*(4.67)*	*(4.92)*
Fixed effects?	Yes	Yes	Yes
N	110,253	111,088	108,476

Appendix A. Estimating our dynamic panel model

Consider a (simplified) dynamic panel data model of the form:

$$\boldsymbol{MDR}_{i,t+1} = \boldsymbol{\alpha MDR}_{i,t} + (\boldsymbol{\mu} + \boldsymbol{\varepsilon}_{i,t+1}), \tag{A.1}$$

where i indexes firms and t indicates the time period. The error term in (A.1) has two components, $\boldsymbol{\mu}_i$, an unobserved, time-invariant, firm-specific effect, and $\boldsymbol{\varepsilon}_{i,t+1}$, the usual residual. Because the residual component of $\boldsymbol{MDR}_{i,t}$ is correlated with the unobserved effect in the error term, an OLS-estimated coefficient on $\boldsymbol{MDR}_{i,t}$ will be biased upwards (Anderson and Hsiao, 1981; Baltagi, 2001; Bond, 2002).

A common way to estimate panel data models with unobserved effects is to perform a "within" transform of (A.1) and then estimate using OLS. A within transformation expresses all variables as deviations from their firm-specific time-series means. This eliminates μ_i from the regression as it is time invariant and thus provides consistent estimates. However, in the presence of a lagged dependent variable, the within transform introduces correlation of the transformed lagged dependent variable with the transformed error term by construction (Wooldridge, 2002; Baltagi, 2001; Hsiao, 2003; etc.). To see this, note that the within transforms of the lagged dependent variable and error terms are

$$\left(\boldsymbol{MDR}_{i,t} - \sum_{t=1}^{T_i} \boldsymbol{MDR}_{i,t}/\boldsymbol{T}_i\right) \text{ and } \left(\boldsymbol{\varepsilon}_{i,t+1} - \sum_{t=1}^{T_i} \boldsymbol{\varepsilon}_{i,t+1}/\boldsymbol{T}_i\right),$$

respectively, where T_i is the number of available observations for firm i. Since $\boldsymbol{MDR}_{i,2}$ is correlated with $\boldsymbol{\varepsilon}_{i,2}$, $\boldsymbol{MDR}_{i,3}$ is correlated with $\boldsymbol{\varepsilon}_{i,3}$, and so on, the transformed variables are correlated with the transformed error term. As a result, the coefficient on the lagged dependent variable, α, is biased downwards by a factor of (approximately) 1/T (Wooldridge, 2002). In panel data sets with large T, the bias becomes insignificant, but in panel data sets such as ours, with large N and small T, the bias can be substantial and needs to be addressed to obtain consistent estimates.

The first two columns of Table A.1 report regressions that contain biased estimates of the lagged dependent variable's coefficient. The OLS estimate (0.86) in column (1) is biased upwards, while the panel estimate (0.62) in column (2) is biased downwards. As Bond (2002) points out, the true lagged dependent variable coefficient must therefore lie in the interval (0.62, 0.86).

Greene (2003) observes that we can obtain unbiased estimates of the levels regression (A.1) via two-stage least squares if an instrument can be found that is correlated with the lagged dependent variable but not the error term. This approach forms the basis for nearly all our results in the paper. The third column of Table A.1 reports a levels panel regression in which the lagged book debt ratio (***BDR***) instruments for the lagged dependent variable. The estimated coefficient on the lagged dependent variable (0.656) lies between the OLS and "within" estimates, as predicted by Bond (2002).

The estimates in column (3) rely on the book debt ratio being a reasonable instrument for the market debt ratio. As always, however, finding reliable instruments can be difficult and a number of techniques have been developed in the literature to estimate unbiased coefficients for a model such as (A.1). (Baltagi, 2001 and Arellano and Honore, 2001 provide surveys.) These alternative techniques generally first-difference the model (A.1) to eliminate fixed effects and use lagged dependent variables to instrument for the lagged

Table A.1
Alternative methods for estimating dynamic panel regressions

In columns (1)–(3) we estimate our main regression specification that explains a firm's market debt ratio:

$$\boldsymbol{MDR}_{i,t+1} = (\boldsymbol{\lambda\beta})\boldsymbol{X}_{i,t} + (1-\boldsymbol{\lambda})\boldsymbol{MDR}_{i,t} + \boldsymbol{\delta}_{i,t+1}, \qquad (4)$$

In columns (4)–(6) we estimate our main regression specification in first differences:

$$\Delta\boldsymbol{MDR}_{i,t+1} = (\boldsymbol{\lambda\beta})\Delta\boldsymbol{X}_{i,t} - \boldsymbol{\lambda}\Delta\boldsymbol{MDR}_{i,t} + (\boldsymbol{\delta}_{i,t+1} - \boldsymbol{\delta}_{i,t})$$

The (lagged) "*X*" variables determine a firm's long-run target debt ratio, and include

EBIT_TA: earnings before interest and taxes as a proportion of total assets;
MB: the market-to-book ratio of firm assets;
DEP_TA: depreciation expense as a proportion of total assets;
LnTA: natural log of total assets;
FA-TA: fixed assets as a proportion of total assets;
***R&D_DUM*:** dummy variable indicating that the firm did not report R&D expenses;
R&D_TA: R&D expenses as a proportion of total assets;
Ind_Median: median debt ratio of firm *i*'s Fama and French (2002) industry classification at time *t*; and
Rated: dummy variable equal to one if the firm has a public debt rating in Compustat, and zero otherwise.

All models include (unreported) year dummies. *T*-statistics are shown in parentheses. Reported R^2 numbers for models including fixed effects are "within" R^2 statistics. For the first-differenced models, R^2 cannot be computed.

	(1)	(2)	(3)	(4)	(5)	(6)
	Simple OLS	Simple FE	Base Specification, column (7) of Table 2	First-Difference Estimates (Anderson and Hsiao, 1981)		Arellano and Bond (1991)
				$\boldsymbol{MDR}_{i,t-1}$ Instruments for $\Delta\boldsymbol{MDR}_{i,t}$	$\boldsymbol{BDR}_{i,t-1}$ Instruments for $\Delta\boldsymbol{MDR}_{i,t}$	
$\boldsymbol{MDR}_{i,t}$	0.860	0.620	0.656	0.467	0.522	0.476
	(457.28)	*(224.50)*	*(171.58)*	*(31.78)*	*(20.69)*	*(74.01)*
EBIT_TA	−0.025	−0.039	−0.030	−0.217	−0.221	−0.231
	(−11.22)	*(−12.93)*	*(−9.66)*	*(−72.93)*	*(−65.67)*	*(−67.75)*
MB	−0.001	−0.001	0.000	−0.020	−0.020	−0.021
	(−5.86)	*(−3.52)*	*(−0.81)*	*(−50.40)*	*(−49.23)*	*(−43.76)*
DEP_TA	−0.206	−0.224	−0.226	−0.269	−0.309	−0.294
	(−15.62)	*(−10.96)*	*(−11.06)*	*(−10.49)*	*(−10.27)*	*(−10.39)*
LnTA	−0.001	0.027	0.025	0.125	0.128	0.131
	(−3.73)	*(36.69)*	*(34.00)*	*(72.42)*	*(63.59)*	*(85.96)*
FA_TA	0.024	0.060	0.053	0.237	0.238	0.246
	(11.41)	*(13.52)*	*(11.93)*	*(37.81)*	*(37.01)*	*(34.38)*
R&D_DUM	0.006	0.000	0.000	−0.001	−0.001	−0.002
	(7.21)	*(−0.10)*	*(0.02)*	*(−0.37)*	*(−0.23)*	*(−0.77)*
R&D_TA	−0.104	−0.036	−0.025	−0.073	−0.070	−0.082
	(−17.27)	*(−3.64)*	*(−2.57)*	*(−6.85)*	*(−6.34)*	*(−6.27)*
Ind_Median	0.047	0.049	0.034	−0.137	−0.163	−0.102
	(12.20)	*(6.32)*	*(4.30)*	*(−10.79)*	*(−10.12)*	*(-8.57)*
Rated	0.005	0.005	0.003	0.025	0.024	0.021
	(3.47)	*(2.56)*	*(1.71)*	*(8.71)*	*(8.13)*	*(6.82)*
Fixed effects?	No	Yes	Yes	No[a]	No[a]	No[a]
N	111,106	111,106	111,106	94,591	94,591	82,395
R^2	0.753	0.467	0.466	–	–	–
H_0: No serial correlation				***		***

[a]Fixed effects are implicitly incorporated through the first-differencing procedure.
***Significantly different from one at the 1% level.

first-difference. For example, Anderson and Hsiao (1981) convert (A.1) into

$$\Delta \boldsymbol{MDR}_{i,t+1} = \boldsymbol{\alpha} \Delta \boldsymbol{MDR}_{i,t} + \boldsymbol{\delta}_{i,t+1} \tag{A.2}$$

and then use the dependent variable's second lag ($\boldsymbol{MDR}_{i,t-1}$) to instrument for the (first-differenced) lagged dependent variable ($\Delta \boldsymbol{MDR}_{i,t}$). Arellano and Bond (1991) show that the instrument space can include further lags of the dependent variable under some circumstances.[26]

These first-difference methodologies rely on two key assumptions to produce unbiased and consistent estimates. First, the error term $\varepsilon_{i,t+1}$ in (A.1) should be serially uncorrelated, because first-order serial correlation would make the lagged dependent variable correlated with the (differenced) regression residual. In other words, lags of the dependent variable fail the exogeneity test if the residual is serially correlated. Second, the dependent variable should not have (near) unit root properties. If the dependent variable series has high persistence then the first-difference will be close to zero and hence the instruments used in the procedure will be weak.

Columns (4)–(6) in Table A.1 present results based on several first-differencing methods of estimating a dynamic panel model. These can be viewed as potential substitutes for the estimation method we use in the text for Eq. (4). Column (4) presents results based on Anderson and Hsiao (1981). We first-difference to remove the unobserved firm effects and then use the second lag of the dependent variable as an instrument. This procedure produces a coefficient on $\boldsymbol{MDR}_{i,t}$ of 0.467, which is inconsistent with Bond's (2002) assertion that the true coefficient lies between 0.62 and 0.86. We also reject the hypothesis of zero serial correlation of ε in (A.1), casting serious doubt on the validity of the instrument used. In column (5) we modify the Anderson-Hsiao method by using the second lag of ***BDR*** as an instrument in place of the second lag of ***MDR***. This instrument should be immune to the serial correlation problem identified in column (4). We find that the estimate (0.522) is higher than column (4)'s, but still outside the interval defined by the OLS and "within" estimates. The problem appears to be that of weak instruments given persistence in the dependent variable. Indeed, the correlation in the lagged levels of our dependent variable is 0.98.

Given the serial correlation in the error terms and the high persistence in our dependent variable, Arellano and Bond's (1991) GMM procedure is unlikely to yield consistent results. To verify, we run the GMM estimation (using Stata's XTABOND procedure) and present the results in column (6). The coefficient on $\boldsymbol{MDR}_{i,t}$ (0.476) implies very rapid adjustment, but both the tests of serial correlation and an (unreported) Sargan test of overidentifying restrictions are rejected at the 1% level. Arellano and Bond's (1991) technique thus cannot be applied to our data.

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[26]Subsequent authors refine Arellano and Bond's (1991) General Methods of Moments procedures (e.g., Arellano and Bover, 1995; Ahn and Schmidt, 1995).

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