Do Measures of Financial Constraints Measure Financial Constraints?

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Financial constraints are fundamental to empirical research in finance and economics. We propose two tests to evaluate how well measures of financial constraints actually capture constraints. We find that firms typically classified as constrained do not actually behave as if they were constrained: they have no trouble raising debt when their demand for debt increases exogenously and use the proceeds of equity issues to increase payouts to shareholders. Our evidence suggests that extant findings that have been attributed to constraints may instead reflect differences in the growth and financing policies of firms at different stages of their life cycles. (*JEL* G12, G31, G32, G33, E44, E52, L26)

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How financial constraints affect firm behavior is a core question not only in corporate finance[1] but also in asset pricing (Gomes, Yaron, and Zhang 2006; Whited and Wu 2006) and the literatures on monetary policy (Gertler and Gilchrist 1994; Bernanke, Gertler, and Gilchrist 1996), firm dynamics (Cooley and Quadrini 2001), and entrepreneurship (Kerr and Nanda 2009), among others. Answering this question requires a way to identify constrained firms with reasonable accuracy. Since the financial constraints a firm faces are not directly observable, the empirical literature finds itself having to rely on indirect proxies (such as having a credit rating or paying dividends) or on one of three popular indices based on linear combinations of observable firm characteristics, such as

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[1] See, for example, Fazari, Hubbard, and Petersen (1988), Whited (1992), Froot, Scharfstein, and Stein (1993), Kaplan and Zingales (1997), Gomes (2001), Almeida, Campello, and Weisbach (2004), Rauh (2006), Almeida and Campello (2007), Hennessy and Whited (2007), Denis and Sibilkov (2009), and Duchin, Ozbas, and Sensoy (2010).

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size, age, or leverage (the Kaplan-Zingales, Whited-Wu, and Hadlock-Pierce indices).

In this paper, we ask a simple question: how well do these measures of financial constraints identify firms that are plausibly constrained? The short answer is: not well. We demonstrate that supposedly constrained firms have no difficulty obtaining credit when their demand for debt increases exogenously as a result of a tax increase. In fact, they respond to such tax increases just as vigorously as do supposedly unconstrained firms. Moreover, "constrained" firms behave in a way that suggests they have no trouble tapping the equity markets either: they tend to "recycle" some of the proceeds of their equity raises to increase payouts to their shareholders—a tendency they share with "unconstrained" firms.

One researcher's intuitive notion of financial constraints need not coincide with another's. We introduce two formal definitions that capture the main notions prevalent in the literature. The first builds on Stiglitz and Weiss (1981), Almeida and Campello (2002), and Whited and Wu (2006) in characterizing constraints in terms of the *curvature* of the supply-of-capital curve: the more inelastic the supply of capital, the more costly the firm finds it to raise an additional unit of external capital. In the limit, the curve becomes vertical and the firm is shut out of the capital markets. The second, broader definition draws on Fazari, Hubbard, and Petersen (1988), who characterize constraints in terms of the *wedge* between a firm's opportunity cost of internal capital and its cost of external capital. The larger the wedge, the more constrained a firm is.

To analyze the extent to which firms face constraints in the debt markets, we use a natural experiment first analyzed by Heider and Ljungqvist (Forthcoming) and consisting of 43 staggered increases in corporate income taxes levied by individual U.S. states. Debt confers a tax benefit because the IRS allows firms to deduct interest payments from taxable income. All else equal, an increase in tax rates raises the value of tax shields, thereby increasing a firm's demand for debt. A firm facing a highly inelastic supply of debt should be unable to significantly increase its leverage in response to a tax increase. Thus, a simple test of how well a constraints measure identifies firms facing an inelastic supply of debt is to measure how responsive their leverage is to a tax increase.

A firm can be constrained under the wedge definition without having an inelastic capital supply curve. Thus, it may be both willing and able to raise debt in response to a tax increase. Critically, however, the greater the wedge between its internal and external costs of debt, the more value the firm transfers to debtholders when issuing debt and so the less debt it should raise in response to a given tax increase, all else equal.[2] As a result, we can examine how well a constraints measure fares under the wedge definition by testing whether it

[2] To operationalize the "all else equal" clause, we measure the geographic distribution of firms' tax liabilities across U.S. states. This ensures that we capture the impact of tax increases on a firm's demand for debt quite precisely, regardless of how geographically dispersed the firm is.

correctly classifies those firms whose leverage is less responsive to tax increases as more constrained.

To analyze the extent to which firms face constraints in the equity markets, we exploit the tendency of firms to simultaneously raise and pay out equity, a practice Grullon et al. (2011) call equity recycling. A firm that faces an inelastic supply of equity should never engage in equity recycling. This prediction allows us to test how well a financial constraints measure identifies firms that are truly constrained in the equity markets according to the curvature definition. As for the wedge definition, we test whether firms classified as constrained pay out a smaller fraction of their issuance proceeds than those classified as unconstrained.[3] This test captures the notion that for a firm facing an elastic supply of equity, the tendency to recycle equity should decrease in the size of the wedge between its internal and external costs of equity.

When we apply our tests to five widely used measures of financial constraints, a strikingly consistent picture emerges: firms classified by the literature as constrained do not behave in ways that suggest they are in fact constrained. For each of the five constraints measures, we find that the average "constrained" firm is able to borrow more in response to an increase in state corporate income tax rates and to simultaneously raise equity and increase payouts to shareholders, even though the capital supply curves firms face when doing so appear no flatter than when raising capital for investment. These findings imply that "constrained" firms do not in fact face an inelastic capital supply curve. Nor do "constrained" firms appear to face a systematically larger wedge between their internal and external costs of capital. For all five measures, the leverage of supposedly constrained firms is no less responsive to tax increases than that of their supposedly unconstrained counterparts. "Constrained" firms also recycle as much equity as "unconstrained" ones, except when using the dividends and Kaplan-Zingales measures.

To evaluate the performance of our tests out of sample, we apply them to two sets of firms that are a priori likely to be financially constrained: privately held firms and public firms that are close to default according to Merton's (1974) distance-to-default measure. As expected, we find that both private firms (especially small ones) and public firms that are close to default are unresponsive to corporate tax increases, suggesting that they may have difficulty increasing their leverage to take advantage of tax shields. We also show that neither privately held firms nor public firms close to default engage in equity recycling, consistent with the notion that external capital, once raised, is too precious to pay out to shareholders.

The tests we introduce in this paper are designed to identify behavior that is *not* consistent with being financially constrained. Thus, they allow us to evaluate the extent to which popular constraints measures (or, for that matter,

[3] Section 3 discusses the identifying assumptions and limitations of our debt and equity tests at length.

any constraints measure) classify as constrained those firms whose behavior is in fact consistent with being constrained. While the behavior our tests focus on is an unequivocal marker of a firm not being constrained, factors other than constraints could help explain the absence of such behavior. This means that our tests can suggest, but cannot definitively establish, whether some group of firms (say, private firms or public firms with a high default probability) is indeed constrained. But we can categorically conclude that the average "constrained" firm, according to five widely used constraints measures, is not in fact constrained.

Our findings indicate that caution is needed when interpreting empirical results based on these measures. Rather than capturing constraints, these measures identify young and fast-growing firms that obtain financing primarily from the equity and loan markets. Our evidence thus suggests that extant findings that have been attributed to constraints may instead reflect differences in the growth and financing policies of firms at different stages of their life cycles.

1. Measures of Financial Constraints

Existing proxies aim to infer financial constraints from firms' statements about their funding situation or changes in investment plans, their actions (such as not paying a dividend), or their characteristics (such as being young or small, having low leverage, or no credit rating). The literature is divided on which of these best captures financial constraints and as a result, empirical studies tend to employ a range of measures for robustness.

Judged by Google Scholar citations, the KZ index is the most popular measure of financial constraints. It has its origins in an influential debate between Fazari, Hubbard, and Petersen (FHP; 1988) and Kaplan and Zingales (1997). Augmenting Hayashi's (1982) Q-investment model, FHP find a significant sensitivity of investment to cash flow in a sample of 422 firms over the period 1970 to 1984. Based on the finding that cash-flow sensitivities are especially large among the 49 sample firms that pay no or low dividends, FHP conclude that significant cash-flow sensitivities reflect empirically important financial constraints. Implicit in their argument is the assumption that low dividends are a useful indicator of financial constraints.

Using a text-based approach that has proved popular, Kaplan and Zingales (1997) challenge FHP's conclusions. They assess whether a firm is financially constrained by reading the 10-Ks (annual reports) of the 49 supposedly constrained low-dividend firms in the FHP sample. Based on their reading, only 15% of firm-years show evidence of firms being unable to fund their desired investments. Moreover, estimated cash flow sensitivities are greatest not among these arguably constrained firms but among the firms that, based on their 10-Ks, are the *least* constrained. The implication is that neither absence of dividends nor significant cash-flow sensitivities are useful indicators of financial constraints.

The actual KZ index is due to Lamont, Polk, and Saa-Requejo (2001). These authors estimate an ordered logit model relating the degree of financial constraints according to Kaplan and Zingales' (1997) classification to five readily available accounting variables: cash flow, market-to-book, leverage, dividends, and cash holdings. The model is estimated on the 49 firms in FHP's sample and the estimated regression coefficients are used to construct the KZ index. The index loads positively on market-to-book and leverage and negatively on cash flow, dividends, and cash. A higher index value suggests a firm is more constrained. Subsequent authors have used Lamont, Polk, and Saa-Requejo's coefficient estimates to create an index for samples other than FHP's 49 firms, assuming implicitly that the coefficient estimates are stable across samples and over time. The convention in the literature is to classify, each year, the top tercile of firms as constrained and the bottom tercile as unconstrained. Implicit in this approach is the assumption that the prevalence of financial constraints varies neither over time nor over the business cycle.

Hadlock and Pierce (2010) update Kaplan and Zingales' (1997) text-based approach by searching the 10-Ks of 356 randomly selected firms over the period 1995–2004 for evidence of firms identifying themselves as financially constrained.[4] They use this classification to create their own index of financial constraints, based on size (with a negative loading), size-squared (positive), and age (negative). As with the KZ index, subsequent users of the HP index proceed by applying Hadlock and Pierce's coefficients to their own samples.

Another popular approach is to treat firms without a credit rating as constrained.[5] The empirical literature offers two main motivations for this. First, unrated firms are assumed to have no access to the public debt markets (Faulkender and Petersen 2006) and so must borrow on less competitive terms from intermediaries, such as banks. Second, the rating process may reduce information asymmetries between the firm and investors, implying that unrated firms are more opaque than rated firms and so more likely to be rationed by lenders (Whited 1992).

Whited and Wu (2006) follow a different approach. Their index is based on the coefficients obtained from a structural model. The index is effectively measured as the projection of the shadow price of raising equity capital onto the following variables: cash flow to assets (with a negative loading), a dummy capturing whether the firm pays a dividend (negative), long-term debt to total assets (positive), size (negative), sales growth (negative), and industry sales

[4] Hoberg and Maksimovic (2015) take the text-based approach to its logical conclusion by machine-reading the 10-Ks of essentially all publicly traded firms from 1997 to 2009. Buehlmaier and Whited (2014) follow a similar approach. Neither set of classifications is publicly available.

[5] See, for example, Kashyap, Lamont, and Stein (1994), Almeida, Campello, and Weisbach (2004), or Adam (2009).

growth (positive). Rather than re-estimating the structural model on their own samples, users of the WW index then extrapolate out of sample using Whited and Wu's reported coefficient estimates.[6]

2. Sample and Data

Our sample of public firms consists of all U.S. firms traded on the NYSE, Amex, or NASDAQ in fiscal years 1989 through 2011. Applying the same filters as in Heider and Ljungqvist (Forthcoming) gives a sample of 91,487 firm-years for 10,112 firms (though the need to lag certain variables as well as gaps in some firms' panel structure reduce the sample size used in our regressions).[7]

2.1 Cross-tabulations

Table 1 reports cross-tabulations of the five measures outlined in Section 1. The first two measures classify firms as constrained based on whether they lack either a history of paying dividends[8] or a rating from a credit rating agency (i.e., S&P, Moody's, Fitch, or Duff & Phelps). The final three measures classify as constrained firms ranked in the top tercile of the KZ, HP, and WW indices, respectively. Firms in the bottom tercile are classified as unconstrained.[9] For all variable definitions and details of their construction, see Appendix A.

For each measure, the first five rows show the fraction of firms classified as constrained that would also be classified as constrained under each of the other four measures. This illustrates the extent to which the five measures produce similar classifications. The KZ index correlates the least with the other four measures, which in turn correlate highly with each other. Generally, the greatest agreement is between the HP and WW indices. To illustrate, Column 4 shows that, among firms classified as constrained according to the HP index, 85.9% do not pay dividends, 99.1% are unrated, and 99.4% are also constrained according to the WW index. But only 45.1% of them are constrained according to the KZ index.

The last five rows of Table 1 report the fraction of firms classified as *unconstrained* that would be classified as constrained under the other measures. Except for the HP and WW indices, the results reflect somewhat lower agreement between the measures. For example, 58.1% of dividend payers lack a credit rating, while 29.8% of rated firms do not pay dividends. The KZ index

6 As Whited and Wu note, one concern with the practice of out-of-sample extrapolation of index coefficients is "parameter stability both across firms and over time." Despite this warning, the practice continues.

7 Starting with the merged CRSP-Compustat Fundamentals Annual database, Heider and Ljungqvist filter out financial firms (SIC = 6), utilities (SIC = 49), public-sector entities (SIC = 9), non-U.S. firms, and firms traded OTC or in the Pink Sheets, firm-years with negative or missing total assets or missing return on assets, and firms with a single panel year or a CRSP share code >11 (REITS, etc.).

8 To establish the necessary history, we look back as far as 1970.

9 Accordingly, as is customary in the literature, we exclude firms in the middle tercile from our analysis. The use of terciles is necessarily arbitrary—as the indices are silent on appropriate breakpoints—but follows convention.

Table 1
Cross-tabulations of financial constraints measures

		Financial constraints measure				
		Dividends (1)	Credit ratings (2)	Kaplan-Zingales (3)	Hadlock-Pierce (4)	Whited-Wu (5)
Constrained firms	Fraction no dividend	1.000	0.653	0.610	0.859	0.818
	Fraction unrated	0.860	1.000	0.663	0.991	0.973
	Fraction constrained KZ	0.509	0.428	1.000	0.451	0.529
	Fraction constrained HP	0.785	0.671	0.470	1.000	0.949
	Fraction constrained WW	0.785	0.691	0.580	0.994	1.000
Unconstrained firms	Fraction no dividend	0.000	0.298	0.537	0.207	0.198
	Fraction unrated	0.581	0.000	0.810	0.429	0.386
	Fraction constrained KZ	0.435	0.619	0.000	0.482	0.426
	Fraction constrained HP	0.136	0.014	0.501	0.000	0.005
	Fraction constrained WW	0.168	0.038	0.476	0.042	0.000

This table reports cross-tabulations of five popular measures of financial constraints to illustrate the extent to which the measures produce overlapping classifications. The first five rows show the fraction of firms classified as constrained by each measure that would also be classified as constrained under each of the other four measures. For instance, 86.0% of the firms classified as constrained by the dividends measure would also be classified as constrained by the ratings measure. The last five rows report the fraction of firms classified as unconstrained by each measure that would be classified as constrained under the other measures. For instance, 58.1% of the firms classified as unconstrained by the dividends measure would be classified as constrained by the ratings measure.

again stands out as an outlier. For example, lack of a credit rating is *more* common among firms the KZ index classifies as unconstrained than among constrained firms.

2.2 Summary statistics

Table 2 shows summary statistics for public firms classified as constrained or unconstrained according to each of the five measures. With the exception of the KZ index, which we discuss separately below, the measures classify similar kinds of firms as constrained. "Constrained" firms according to the dividend, ratings, HP, or WW measures are smaller and younger, carry more cash on their balance sheets, have fewer tangible assets, lower return on assets, and lower marginal tax rates, and are more likely to face a zero marginal tax rate. They are also less leveraged and rely more on short-term debt. (Each of these differences between "constrained" and "unconstrained" firms is statistically significant at the 1% level or better.)

"Constrained" firms have significantly higher market-to-book ratios and experience faster growth in both sales and employment. For example, nondividend payers grow sales and employment by 32.5% and 15.8% a year on average, compared to less than half that (10.8% and 6.1%) among dividend payers. "Constrained" firms also invest significantly more in R&D. The differences are quite substantial. For example, nondividend payers spend an average of 9.6% of total assets on R&D a year, compared to 2.1% for dividend payers. The differences are similar for the other three measures. The evidence on fixed investment is more mixed. On average, nondividend payers invest significantly more than dividend payers (7% versus 5.3% of assets),

Table 2
Summary statistics of “constrained” and “unconstrained” firms

		Dividends		Credit ratings		Kaplan-Zingales		Hadlock-Pierce		Whited-Wu	
		Nondiv. payer	Dividend payer	Unrated	Rated	Constrained	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained
Total real assets, $m	Mean	502.5	3,702.1	271.5	6,511.6	[1,733.2	1,665.8]	48.2	4,884.8	53.2	5,713.6
	SD	*2,691.6*	*15,185.4*	*856.3*	*19,492.6*	*10,848.6*	*8,142.8*	*89.7*	*17,058.1*	*114.1*	*18,145.4*
Age (since founding)	Mean	21.0	57.2	29.4	58.1	[35.6	35.9]	17.9	62.1	22.5	60.3
	SD	*19.1*	*40.1*	*27.9*	*43.7*	*32.6*	*35.2*	*16.0*	*39.9*	*18.4*	*42.7*
Cash/assets	Mean	0.263	0.115	0.232	0.102	0.082	0.336	0.313	0.107	0.263	0.107
	SD	*0.264*	*0.146*	*0.249*	*0.134*	*0.135*	*0.262*	*0.284*	*0.135*	*0.261*	*0.139*
Tangibility	Mean	0.235	0.309	0.245	0.331	0.381	0.140	0.207	0.321	0.207	0.328
	SD	*0.222*	*0.220*	*0.216*	*0.232*	*0.254*	*0.128*	*0.212*	*0.220*	*0.205*	*0.221*
ROA	Mean	−0.030	0.127	0.009	0.125	0.015	0.033	−0.119	0.132	−0.089	0.142
	SD	*0.324*	*0.121*	*0.299*	*0.100*	*0.290*	*0.275*	*0.390*	*0.095*	*0.342*	*0.094*
Marginal tax rate	Mean	0.144	0.227	0.172	0.205	0.145	0.196	0.122	0.225	0.115	0.237
	SD	*0.146*	*0.146*	*0.152*	*0.150*	*0.143*	*0.154*	*0.137*	*0.148*	*0.133*	*0.145*
Zero marginal tax rate?	Fraction	0.140	0.054	0.121	0.048	0.127	0.077	0.196	0.056	0.154	0.035
Total book leverage	Mean	0.199	0.237	0.175	0.329	0.353	0.115	0.156	0.256	0.173	0.256
	SD	*0.216*	*0.189*	*0.192*	*0.198*	*0.209*	*0.161*	*0.193*	*0.188*	*0.200*	*0.185*
Long-term book leverage	Mean	0.145	0.193	0.121	0.292	0.277	0.085	0.092	0.216	0.108	0.220
	SD	*0.193*	*0.175*	*0.162*	*0.196*	*0.211*	*0.142*	*0.150*	*0.179*	*0.164*	*0.177*
% short-term debt (1 year)	Mean	0.367	0.240	0.378	0.145	0.263	0.376	0.480	0.202	0.458	0.188
	SD	*0.355*	*0.291*	*0.350*	*0.215*	*0.319*	*0.357*	*0.354*	*0.262*	*0.359*	*0.252*
Investment opportunities	Mean	2.167	1.399	1.988	1.379	1.581	2.264	2.518	1.377	2.086	1.538
	SD	*2.293*	*1.180*	*2.112*	*1.128*	*1.975*	*2.061*	*2.646*	*1.107*	*2.300*	*1.340*
Sales growth	Mean	0.325	0.108	0.261	0.140	0.182	0.236	0.393	0.097	0.255	0.120
	SD	*1.070*	*0.420*	*0.947*	*0.496*	*0.797*	*0.874*	*1.283*	*0.338*	*1.079*	*0.362*
Employment growth	Mean	0.158	0.061	0.129	0.075	0.057	0.138	0.181	0.047	0.093	0.069
	SD	*0.569*	*0.343*	*0.520*	*0.367*	*0.460*	*0.488*	*0.657*	*0.289*	*0.555*	*0.311*
R&D	Mean	0.096	0.021	0.077	0.023	0.047	0.093	0.122	0.024	0.111	0.023
	SD	*0.156*	*0.050*	*0.141*	*0.054*	*0.133*	*0.138*	*0.185*	*0.050*	*0.171*	*0.052*
Gross investment	Mean	0.070	0.053	[0.062	0.064]	0.060	0.044	0.067	0.049	0.042	0.060
	SD	*0.181*	*0.142*	*0.166*	*0.163*	*0.195*	*0.110*	*0.196*	*0.131*	*0.175*	*0.135*
Geographic concentration	Mean	0.767	0.568	0.747	0.490	0.662	0.709	0.861	0.517	0.834	0.488
	SD	*0.302*	*0.359*	*0.309*	*0.363*	*0.349*	*0.327*	*0.234*	*0.358*	*0.250*	*0.357*
No. of firm-years		46,986	36,931	62,104	22,174	21,893	23,930	26,037	29,434	22,462	25,269

The table reports summary statistics for 91,487 firm-years for 10,112 nonfinancial and nonutility public U.S. companies between 1989 and 2011 that are classified as “constrained” and “unconstrained” by five popular measures of financial constraints. For variable definitions and details of their construction, see Appendix A. All pairwise differences in means or fractions are significant at the 1% level, except for those shown in brackets.

while unrated firms invest nearly as much as rated firms (6.2% versus 6.4%). Similarly, constrained firms according to the HP index invest significantly more (6.7% versus 4.9%), but the opposite is the case according to the WW index (4.2% versus 6%).[10]

These patterns suggest that being smaller, younger, less profitable, and less leveraged—that is, being "constrained" according to the dividends, ratings, HP index, and WW index measures—does not appear to impede fast growth, R&D, or investment. Of course, this is not to say that these fast-growing firms are necessarily unconstrained: given the firms' investment opportunity sets, it might be optimal to invest more and grow even faster.

2.3 Lamont, Polk, and Saa-Requejo's KZ index

As Whited and Wu (2006) note, Lamont, Polk, and Saa-Requejo (2001) version of the KZ index identifies a markedly different set of firms as constrained, on almost every dimension considered in Table 2. "Constrained" firms according to the KZ index are no smaller and only marginally younger than "unconstrained" firms. They hold *less* cash and have *more* tangible assets (though their ROA is somewhat lower, as is their marginal tax rate). They also have substantially *higher* leverage than do "unconstrained" firms (27.7% versus 8.5% on average).[11] Their market-to-book ratios are lower, as is their growth in sales or employment, and while they invest more in fixed assets, they spend considerably less on R&D.

3. Do Measures of Financial Constraints Measure Financial Constraints?

The cross-tabulations and summary statistics reported in Tables 1 and 2 indicate that there are important commonalities among firms classified as constrained by the dividends, ratings, HP, and WW measures. (The KZ index appears to be more of an outlier.) Our aim is to investigate whether these commonalities are driven by financial constraints, as the literature assumes, or whether they reflect some other differences (say, a firm's life cycle stage).

One researcher's intuitive meaning of the term "financial constraints" need not coincide with another's. We therefore begin by formalizing two definitions of financial constraints, designed to capture the two main notions of financial constraints prevalent in the literature. Given that researchers using constraints measures often do not specify which definition they have in mind, we investigate the extent to which each of the five constraints measures introduced in Section 1 identifies constrained firms according to either definition. To this end, we introduce two tests. The first examines "constrained" firms' ability to raise debt

[10] The latter is a rare instance of the HP and WW indices producing different results.

[11] This is not surprising: both leverage and cash enter into the KZ index, with the index increasing in leverage and decreasing in cash.

while the second focuses on their ability to raise equity. Overall, the evidence from our tests suggests that the behavior of firms classified as financially constrained by the five measures is *not* consistent with in fact being constrained according to either of the two constraints definitions.

3.1 Defining financial constraints

Financial constraints arise due to frictions in the supply of capital, chiefly due to information asymmetries between investors and the firm (Tirole 2006). Section 3.1.1 defines financial constraints based on the *curvature* of the supply of capital curve. Section 3.1.2 formalizes a broader definition that focuses on the *level* of the supply of capital curve and, in particular, on the wedge between this curve and the firm's opportunity cost of internal capital.

3.1.1 Financial constraints and the curvature of the capital supply curve. Stiglitz and Weiss (1981), Almeida and Campello (2002), and Whited and Wu (2006), among others, define financial constraints in terms of the effect that supply frictions have on the elasticity of the supply of external capital. Almeida and Campello observe that "constrained firms are at the point where the supply of capital becomes inelastic" (12). Whited and Wu define a firm as financially constrained if it would like to raise an additional dollar of external capital but cannot do so because it faces a vertical supply of external capital curve. This captures Stiglitz and Weiss's notion of credit rationing in the sense that the firm "would not receive a loan even if it offered to pay a higher interest rate" (394–5).

To formalize this notion of financial constraints, denote a firm's capital supply curve by $p(k)$, a function capturing the price at which a firm with k units of financial capital can raise an incremental unit of capital in the capital markets. Our curvature definition of financial constraints then characterizes financial constraints in terms of the elasticity of $p(k)$. A firm is financially constrained if it faces a highly inelastic capital supply curve and so is unable to raise capital at any price when it tries to do so. Figure 1 illustrates this definition graphically.

3.1.2 Financial constraints and the wedge between the internal and external costs of funds. Fazari, Hubbard, and Petersen (1988) use a different notion of financial constraints. They note that frictions in the capital markets can imply that "the cost of new debt and equity may differ substantially from the opportunity cost of internal finance generated through cash flow and retained earnings" (142). Essentially, a constrained firm only has access to external capital at a price higher than the price that would reflect its actual risk, as captured by its opportunity cost of internal capital.[12] As in Tirole (2006), the

[12] A firm's opportunity cost of internal capital is given by the capital supply curve the firm would face in a world with no financing frictions. It is thus defined for any level of capital, regardless of how much cash the firm actually carries on its balance sheet.

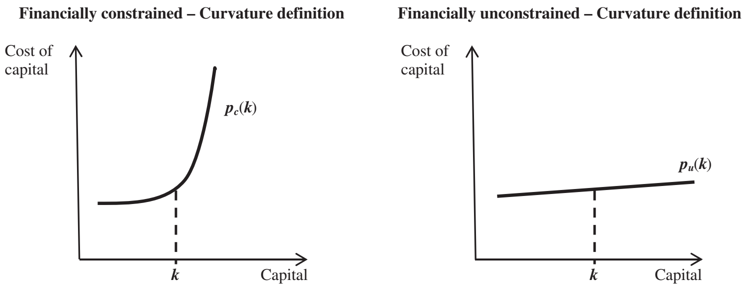

Figure 1
Financially constrained and unconstrained firms according to the curvature definition.
This figure shows the supply of capital curves faced by two hypothetical firms, both currently holding k units of capital. The firm on the left is financially constrained according to the curvature definition introduced in Section 3.1.1. The firm on the right is financially unconstrained.

difference in prices reflects information asymmetries between the firm and its suppliers of capital. Fazari, Hubbard, and Petersen (1988) thus characterize financial constraints in terms of the wedge between a firm's internal and external costs of capital.

As Kaplan and Zingales (1997) note, if one were to define any firm facing a positive wedge between its internal and external costs of funds as financially constrained, then all firms would be classified as constrained because "a small transaction cost of raising external funds would be sufficient to put a firm into this category" (172). Therefore, this notion of financial constraints is useful only as a means to rank firms "according to the extent to which they are financially constrained. A firm is considered more financially constrained as the wedge between its internal and external cost of funds increases" (172–3).

We formalize this wedge definition as follows. As before, let $p(k)$ denote a firm's external capital supply curve. Let $i(k)$ denote its opportunity cost of internal capital. Fazari, Hubbard, and Petersen's (1988) notion of financial constraints can then be characterized in terms of the wedge between $p(k)$ and $i(k)$: the larger the wedge $p(k)-i(k)$, the more financially constrained the firm—even when its supply of external capital curve is elastic. Figure 2 illustrates this.

3.1.3 Discussion. The wedge definition is broader than the curvature definition. Whenever a firm faces a (close to) vertical external supply of capital curve and so is constrained according to the curvature definition, there is also a large wedge between its internal and external costs of funds. The converse, however, is not true. Figure 2 above illustrates how a firm may face a flat external capital supply curve and yet be financially constrained according to the wedge definition. This will happen if the price at which it can raise capital exceeds its opportunity cost of internal funds.

As a firm's external capital supply curve is not readily observable to the econometrician, measuring financial constraints according to either definition

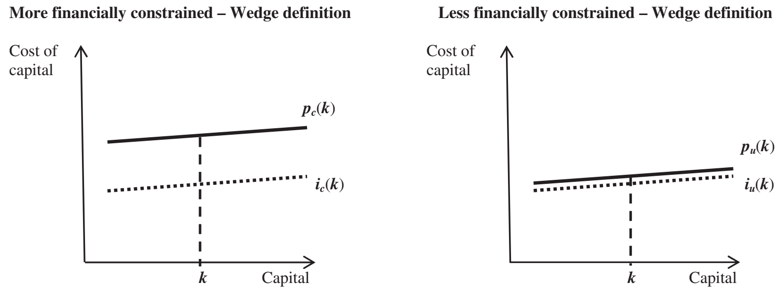

Figure 2
More and less financially constrained firms according to the wedge definition.
This figure shows the external supply of capital curves, $p(k)$, faced by two hypothetical firms that currently hold k units of capital, as well as their opportunity cost of internal funds curves, $i(k)$. The firm on the left is more financially constrained than the firm on the right according to the wedge definition introduced in Section 3.1.2.

is empirically challenging. When using the wedge definition, the difficulty is compounded since it is hard to estimate a firm's opportunity cost of internal funds. This is why the literature instead attempts to measure financial constraints indirectly, by looking either at what managers say in their 10-Ks (as in the KZ or HP indices) or at a particular action they take (e.g., paying a dividend or obtaining a credit rating).

The identifying assumption behind measures based on these approaches is that managers' words or actions reflect the shape and location of the external supply of capital curve as they perceive it. If this assumption is correct, firms classified by these measures as financially constrained should behave as if their supply of capital curve were indeed highly inelastic or, at least, as if they faced a substantial wedge between their internal and external costs of funds. This intuition is the motivation for our tests.

When interpreting our results, it is important to recognize that a firm's capital supply curve affects its financial and corporate policies, from its choice of liquidity and capital structure to its choice of CEO, and at the same time, these policies affect the firm's capital supply curve. Our tests take these endogenous choices as predetermined and then try to assess whether, conditional on these choices, the behavior of firms the literature classifies as "constrained" is consistent with being constrained. In this sense, our tests are designed to inform empirical researchers as to whether, conditional on firms' choices, supposedly "constrained" firms truly are constrained.

3.2 Debt test: Exploiting tax increases as exogenous shocks to the demand for debt

Debt confers a tax benefit when interest is tax deductible. The trade-off theory of capital structure predicts that a firm's demand for debt should increase in its marginal tax rate. In recent work, Heider and Ljungqvist (Forthcoming) provide evidence consistent with this prediction. Their identification strategy exploits 43 increases in corporate income tax rates staggered across 24 U.S. states between 1989 and 2011.[13] They find that the average public firm increases its long-term leverage in response to a corporate income tax increase in its headquarter state.

Motivated by this evidence, we use increases in state corporate income tax rates as plausibly exogenous shocks to a firm's demand for debt. These demand shifts allow us to estimate the elasticity and relative location of the debt supply curve faced by firms classified as "constrained" and "unconstrained" by traditional measures, following the standard identification strategy used to estimate the shape of a supply curve (see, for example, Hayashi's 2000 textbook, 189).[14]

3.2.1 External validity. Before providing further details on our debt test, it is important to discuss its external validity. The capital supply curve a firm faces is likely to be project specific. A firm may be unable to raise capital for a positive-NPV project that generates little collateral or involves a high degree of information asymmetry (e.g., an R&D project). But this does not mean it is unable to raise capital for a safe, transparent, and easy-to-monitor project generating substantial collateral (e.g., buying machinery to expand capacity). Our debt test examines whether firms are able to raise debt to increase their leverage in response to a tax increase. The external-validity question then is whether tax-induced debt issues are more representative of hard-to-fund or easy-to-fund investment projects.

Conceptually, there are three reasons to believe tax-induced debt issues may lie toward the hard-to-fund end of the spectrum. First, a tax increase reduces a firm's after-tax cash flow and thus its interest coverage. All else equal, this will reduce lenders' willingness to provide additional capital. Second, Heider and Ljungqvist (Forthcoming) show that tax-induced leverage increases are pure capital structure changes that do not alter a firm's asset base and so generate no new collateral. The lack of new collateral makes a tax-induced debt issue more akin to, say, a hard-to-fund R&D project. Third, such tax-induced debt-for-equity swaps make the firm's existing debt riskier and may trigger the need for covenants on existing debt to be waived before new debt can be issued. Such waivers should be particularly hard to obtain for a constrained firm. On the other hand, these effects could be offset by the fact that tax-related debt issues likely involve little information asymmetry between lenders and borrowers to the extent that tax increases are easy to verify. If so, the conclusions of our debt test might be less generalizable to situations in which a firm seeks to raise capital for projects whose value is particularly hard to verify.

13 See Heider and Ljungqvist's Appendix A for a list of the relevant tax increases.

14 Our identification strategy is thus related to those of Khwaja and Mian (2008) and Almeida et al. (2012), who also identify capital market frictions using exogenous shocks rather than potentially endogenous firm characteristics. A difference between our approach and theirs is that we focus on shocks to the demand (rather than the supply) of debt.

To shed light on the external validity of our debt test, we examine the interest rates lenders charge in debt-for-equity swaps and in tax-related debt issues. For the former, we use data from DealScan. As Table IA.1 in the Internet Appendix shows, interest rates are on average around 10% higher on debt-for-equity swaps than on loans used for investment purposes, and loans used to fund debt-for-equity swaps are significantly more likely to be collateralized and to carry financial covenants. While this evidence is only suggestive, these patterns are consistent with our conjecture that lenders consider debt-for-equity swaps riskier than the average investment loan.

Next, we compare the interest rate a firm pays when increasing its leverage following a tax increase to the interest rate it pays following other debt issues. To do so, we use Capital IQ's Capital Structure database, which provides comprehensive details on every loan or other form of credit facility that a firm obtains, starting in 2000. We first compute, separately for each fiscal year, a firm's average interest rate weighted by the outstanding principal on each of its loans. We then ask by how much a firm's weighted average interest rate changes when it increases its leverage. This reveals that tax-induced debt issues have a *larger* impact on a firm's weighted average interest rate than do non-tax-related debt issues. On average, a firm's weighted average interest rate increases by 33 basis points (bp) when the firm issues debt to take advantage of increased tax shields, nearly 50% more than the 23-bp increase we see following non-tax-related debt issues.[15] In other words, the average firm faces a steeper—but by no means vertical—debt supply curve when raising debt following a state corporate income tax increase than when raising debt for a different project.

While eliminating concerns about the external validity of a test is all but impossible, these findings suggest that lenders consider tax-induced debt issues to have above-average risk on average. By implication, if we find that firms classified as "constrained" by traditional measures have no trouble raising debt to fund tax-induced recapitalizations, they should also have little trouble raising debt to fund investment projects of average (or even above-average) risk.

3.2.2 Applying the debt test to the curvature definition. The essence of our debt test is that a firm that faces a highly inelastic supply of debt curve and so is financially constrained according to the curvature definition should not increase its leverage in response to an increase in state taxes. An unconstrained firm, on the other hand, can make full use of the additional tax shields by issuing debt. Figure 3 illustrates these predictions.

Empirically, therefore, we can judge how well a financial constraints measure actually captures constraints, according to the curvature definition, by testing whether firms classified as constrained by that measure are indeed unable to increase their leverage in response to a tax increase. This is our null hypothesis.

[15] Controlling for changes in firm characteristics, such as profitability, tangibility, market-to-book, size, or leverage, makes little difference to this finding.

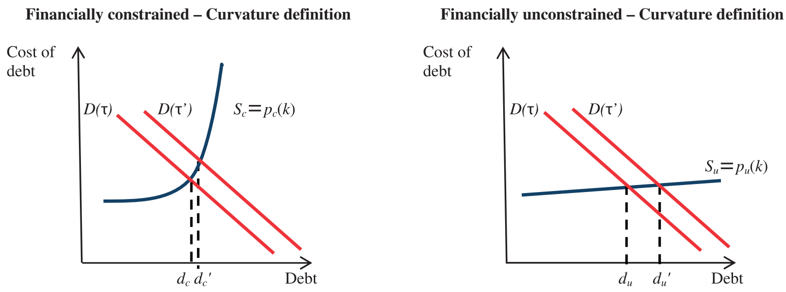

Figure 3
Applying the debt test to the curvature definition.
This figure illustrates the identification strategy of our debt test under the curvature definition of financial constraints. It shows how a tax increase from τ to τ' shifts the demand curve for debt, D, and the effect that this shift has on the debt holdings of a financially constrained firm according to the curvature definition (from d_C to d_C') and of a financially unconstrained firm (from d_u to d_u').

Rejection of this null casts doubt on the measure's ability to correctly identify firms that are truly constrained according to the curvature definition.

3.2.3 Applying the debt test to the wedge definition. A firm that is financially constrained according to the wedge definition (i.e., one that faces a large wedge between its internal and external financing costs) need not be unresponsive to a tax increase: even though its external cost of debt exceeds its internal cost of capital, it may still find it optimal to raise debt if the value of the additional tax shields is large enough to compensate for the wedge. As a result, rejecting the null of no response to a tax increase does not imply that a particular measure of financial constraints fails to correctly identify firms that are constrained according to the wedge definition.

Instead of no response to a tax increase, we expect a smaller response among constrained firms for a measure to correctly capture financial constraints under the wedge definition. The reason is that the wedge between a firm's cost of debt and its opportunity cost of capital, which reflects its actual risk, captures the value transfer from shareholders to debtholders when the firm raises debt. As a result, the net tax benefit (the difference between the value of the tax shield and the cost to shareholders of issuing debt) decreases in the firm's wedge, all else equal. Thus, the greater the wedge, the less new debt the firm should issue in response to a tax increase.

3.2.4 Identifying assumptions. Under either definition of financial constraints, a key requirement for our identification strategy to be valid is that we are able to capture increases in leverage that are the direct result of an increase in the demand for capital, unconfounded by changes in the supply of capital. A key concern in this regard is that state tax increases, in addition to triggering an increase in the demand for credit, could also coincide with an increase in the supply of credit. This would occur, for example, if states tended to increase tax rates in a boom and if the supply of capital increased procyclically.

Heider and Ljungqvist (Forthcoming) find no evidence that state tax changes correlate with observed local business cycle effects. To mitigate the potential influence of *un*observed business-cycle effects, we follow their approach and exploit the local and staggered nature of state tax increases. First, we estimate difference-in-differences tests, using firms that have not been affected by a tax increase in their headquarter state as controls. This establishes a counterfactual for the observed change in leverage. Second, we restrict the control group to firms headquartered in a state adjacent to the tax-increase state. This difference-in-differences approach allows us to difference away changes in leverage that are the result of shocks to local economic conditions common to both states, as well as to national shocks affecting all states.

The only potential confound that remains after these empirical design choices is one that coincides in time and space with the tax increases. The key concern is that tax increases may coincide with other state-level fiscal or regulatory shocks that expand credit supply and thus allow all firms—even those initially constrained—to borrow more. A review of the literature suggests two state-level shocks to credit supply that would confound our test if they coincided with the tax increases in our sample: bank tax cuts (Smolyansky 2014) and bank branching deregulation (Jayaratne and Strahan 1996). Fortunately, none of our corporate income tax increases coincides with a bank tax cut, and only four coincide with branching deregulation. As we show in the Internet Appendix, our results are robust to excluding these four tax increases.

Another potential concern is that a tax increase reduces after-tax returns on investment, prompting firms to invest less. As an empirical matter, Asker, Farre-Mensa, and Ljungqvist (2015) find no evidence that public firms' investment spending responds to state-level tax changes. Nor do we find any evidence that tax increases lead to a change in investment or asset base among either "constrained" or "unconstrained" firms in our sample; but even if they did, cuts in investment spending would only make it harder for us to observe firms raising debt in response to a tax increase.

Under the wedge definition, our identification strategy makes an additional assumption: other than in their wedge, "constrained" and "unconstrained" firms do not differ systematically in their exposure to factors that influence how a tax increase affects their demand for debt. Depending on whether such factors, if omitted, offset or aggravate the effect of any potential difference in wedges, our test would be either biased against or in favor of the null that "constrained" and "unconstrained" firms have similar sized wedges (and so have similar tax sensitivity).

The chief confound potentially biasing the test in favor of the null stems from the fact, shown in Table 2, that "unconstrained" firms are more geographically dispersed than their "constrained" counterparts (except when using the KZ index). This matters because firms pay state income taxes in all states in which they operate, in proportion to the share of their economic activity that takes place in each state. (States typically use an apportionment formula based on an average of the fractions of the firm's total payroll, sales, and property located in that state. A firm's state of incorporation has no bearing on where it pays state income taxes.) If "constrained" firms are more geographically concentrated, they have greater exposure to a given tax increase in their headquarter state. This may offset the effect of any wedge difference that may exist between them and "unconstrained" firms, leading us to wrongly conclude that "constrained" and "unconstrained" firms have a similar tax sensitivity of leverage and thus face similar constraints under the wedge definition. Fortunately, we have access to high-quality data on the geographic dispersion of each firm's activities, so this confound is easily addressed.

The chief confound potentially biasing the test against the null stems from the fact that "constrained" firms tend to have lower marginal tax rates than "unconstrained" ones (see Table 2). All else equal, firms with lower marginal tax rates will respond less strongly to a given tax increase as tax shields are less valuable to them. This will make it harder for our debt test to conclude that "constrained" and "unconstrained" firms have similar-sized wedges (and so face similar constraints under the wedge definition) when in fact they do.

The debt test has one important limitation. Given that tax shields are only of value to firms that have (or expect soon to have) profits to shield from tax, the test cannot be applied to chronically loss-making firms.[16] To conservatively account for this, the test excludes firm-years with a zero marginal tax rate. As Table 2 shows, this filter removes between 12.1% and 19.6% of the "constrained" firm-year observations (depending on the constraints measure we use) and a smaller fraction of the "unconstrained" firms (which tend to have higher marginal tax rates).

3.2.5 Empirical specification. Equation (1) implements our empirical strategy for the debt test as follows:

$$\Delta D_{ijt} = \beta T^{+}_{it-1} + \delta \Delta X_{it-1} + \alpha_{jt} + \varepsilon_{ijt}, \tag{1}$$

where i indexes firms, j industries, and t fiscal years. Following Heider and Ljungqvist (Forthcoming), the dependent variable D is long-term book leverage. The vector X includes ROA, tangibility, firm size, and a proxy for investment opportunities, thus controlling for firm-specific factors (unrelated to a tax increase) that could correlate with changes in leverage. We include industry-by-year fixed effects to remove unobserved time-varying industry shocks. The equation is estimated in first differences to remove time-invariant unobserved firm heterogeneity.

[16] This limitation does not apply to our equity test as it does not require firms to have taxable profits.

The main variable of interest, T^+, is a weighted average of all the tax increases that have taken place in the states in which firm i operates.[17] To approximate the geographic distribution of a firm's tax liabilities, we use data from the National Establishment Time Series (NETS) database, which contains a complete record of all business establishments in the United States since 1989. Using these data, we define a firm's exposure to tax increases as follows:

$$T_{it}^{+}=\sum_{s}\left(\frac{1}{2}\frac{employees_{ist}}{employees_{it}}+\frac{1}{2}\frac{sales_{ist}}{sales_{it}}\right)\max\{\Delta T_{st},0\}, \tag{2}$$

where $employees_{ist}$ and $sales_{ist}$ are firm i's number of employees and sales in state s in year t, $employees_{it}$ and $sales_{it}$ are the firm's total number of employees and sales across all states it operates in during year t, and T_{st} is the top corporate income tax rate in state s in year t. Formula (2) uses a 50/50 average of the fractions of the firm's total employment and sales in a state to approximate the firm's tax nexus with each state.[18]

Following Heider and Ljungqvist (Forthcoming), we restrict the sample to firms headquartered in states with a tax increase and their immediate neighbors headquartered in adjacent states without tax changes. As noted earlier, constraining treated and control firms to be neighbors minimizes the impact of unobserved differences in local economic conditions.

Raising debt in response to a tax increase (a positive β in Equation (1)) is a sufficient condition for a firm *not* to be financially constrained, but it is not a necessary condition. The reason is that an unconstrained firm could, for idiosyncratic reasons, choose not to respond to a tax increase. As a result, not every unconstrained firm need increase its leverage when tax rates rise. This means that not responding to a tax increase does not imply that a firm is necessarily constrained: the set of firms that do not respond includes those that cannot (because they are financially constrained) and those that choose not to respond even though they could. Methodologically, this means that our debt test allows us to identify only whether a constraints measure identifies as constrained a subsample of firms that are not in fact constrained on average. The test cannot unambiguously identify firms that *are* financially constrained.

3.2.6 How financially constrained are "constrained" firms? Table 3 examines the tax sensitivity of leverage for different partitions of the data based on the dividend and credit-rating measures and the KZ, HP, and WW indices. This reveals that firms classified as "constrained" according to these five measures have no difficulty increasing their leverage significantly in response

[17] Following Heider and Ljungqvist (Forthcoming), we lag this variable in Equation (1) to ensure that firms have enough time to adjust their leverage in response to a tax increase.

[18] This is an approximation because (1) NETS lacks data on the third nexus factor, the value of a firm's property in each state, and (2) different states use different weighting schemes for the three nexus factors.

to tax increases. In other words, none of the five measures identifies a set of firms that behave as if they faced a highly inelastic supply of debt, as should be the case if the firms were truly constrained according to the curvature definition.

The estimated supply curves are in fact remarkably flat: the coefficients among "constrained" firms range from 0.663 (when using credit ratings to identify constrained firms) to 1.618 (when using the KZ index). Economically, this implies that the average "constrained" firm that is hit with a tax rise increases its leverage by between 66 and 162 bp for every percentage-point increase in its weighted tax rate. These are large increases. To illustrate, they imply that the median "constrained" firm raises new debt equivalent to between 22% and 57% of its annual CAPEX spending for every percentage-point tax increase.

Our finding that "constrained" firms increase their leverage in response to a tax increase and are thus unconstrained according to the curvature definition is not sufficient to conclude that they are also unconstrained according to the wedge definition. As noted earlier, a positive leverage response simply implies that the tax benefits of greater leverage are large enough to compensate for any potential wedge that "constrained" firms might face between their opportunity cost of internal capital and their cost of debt.

To examine how the five constraints measures fare according to the wedge definition, we need to determine whether the tax sensitivities of "constrained" and "unconstrained" firms are consistent with the notion that "constrained" firms face a larger wedge than "unconstrained" ones. As Table 3 shows, this is not the case: none of the five constraints measures identifies as "unconstrained" firms that increase their leverage by more in response to a given tax increase than supposedly "constrained" firms.[19] These patterns run counter to what we would expect if "constrained" firms truly faced a larger wedge. Importantly, they are not driven by the tendency for "constrained" firms to have more geographically concentrated operations and so greater exposure to a given tax shock in their headquarter state: our tax measure explicitly accounts for such differences in geographic concentration.[20]

In sum, the results of our debt test show that standard constraints measures do *not* identify firms that face an inelastic supply of debt (and so are financially constrained under the curvature definition), and they do not correctly rank firms according to the wedge between their internal cost of capital and their cost of debt (as required under the wedge definition).

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[19] Interestingly, dividend payers have a lower tax sensitivity. This finding goes against the notion that they are unconstrained compared to nondividend payers. It is consistent with dividend payers attempting to preserve debt capacity to avoid having to respond to future adverse cash flow shocks with costly dividend cuts.

[20] Another dimension along which "constrained" and "unconstrained" firms differ is the extent to which they earn income abroad. Table IA.2 in the Internet Appendix shows that our conclusions remain unchanged if we weight the tax measure T_{it}^{+} by the share of each firm's income that is generated in the United States. Our findings are also robust to lifting the restriction that treated and control firms be neighbors and to removing four tax shocks that coincided with deregulation of state bank branching restrictions; see Tables IA.3 and IA.4 in the Internet Appendix.

Table 3
Debt test: Tax sensitivity of leverage by financial constraints measure

	Dep. var.: Change in long-term book leverage									
	Dividends		Credit ratings		Kaplan-Zingales		Hadlock-Pierce		Whited-Wu	
	Nondiv. payer (1)	Dividend payer (2)	Unrated (3)	Rated (4)	Constrained (5)	Unconstrained (6)	Constrained (7)	Unconstrained (8)	Constrained (9)	Unconstrained (10)
Corp. tax increase at $t-1$	1.265***	0.287	0.663**	0.638	1.618**	0.631***	0.797**	0.415*	0.974**	0.295*
	0.349	*0.244*	*0.256*	*0.416*	*0.614*	*0.189*	*0.392*	*0.235*	*0.444*	*0.162*
Lagged change in										
ROA	−0.022	0.000	−0.016	−0.096	−0.065**	0.000	−0.014	0.068	−0.017	−0.018
	0.015	*0.020*	*0.013*	*0.065*	*0.025*	*0.017*	*0.012*	*0.053*	*0.017*	*0.038*
Tangibility	−0.023	−0.015	−0.029	0.092*	0.001	−0.033	−0.074**	0.024	−0.048	0.026
	0.021	*0.048*	*0.024*	*0.052*	*0.052*	*0.045*	*0.033*	*0.035*	*0.033*	*0.034*
Firm size	0.009**	−0.003	0.002	0.021	0.003	0.007	0.010*	0.007	−0.002	0.001
	0.004	*0.010*	*0.003*	*0.012*	*0.011*	*0.007*	*0.006*	*0.013*	*0.006*	*0.009*
Investment opportunities	−0.001	−0.004	−0.002	0.003	−0.003	−0.001	0.000	−0.009***	0.001	−0.002
	0.001	*0.003*	*0.001*	*0.005*	*0.004*	*0.001*	*0.002*	*0.002*	*0.001*	*0.004*
Diagnostics										
R^2	12.3%	13.1%	8.6%	20.8%	21.6%	14.4%	17.6%	18.5%	18.5%	18.0%
Wald test: Equal tax effect	5.79**		0.02		2.97*		0.69		2.71	
No. of firms	2,514	2,068	3,299	1,333	1,676	1,815	1,474	1,601	1,564	1,604
No. of observations	4,391	4,941	6,446	2,902	2,524	3,179	2,229	3,898	2,429	3,598
No. of treated obs.	679	896	1,070	509	395	550	357	702	386	661

We estimate standard capital structure regressions to test whether "constrained" firms increase their leverage in response to increases in state corporate income taxes, and if so, whether the tax sensitivity of "constrained" firms' is lower than that of "unconstrained" firms. Firms are categorized as "constrained" or "unconstrained" according to the five measures of financial constraints introduced in Table 2. We follow a difference-in-differences approach, restricting our sample to firm-years headquartered in a state affected by a tax rise and the control group to firm-years headquartered in a neighboring state. We screen out firms with a zero marginal tax rate (according to John Graham's estimates), as only firms with profits to shield from tax have an incentive to increase debt as taxes increase. To capture the possibility that a firm may have operations (and thus pay taxes) in multiple states, we measure its exposure to corporate tax increases as the weighted average of all the tax increases that have taken place in the states in which it operates. To approximate the geographic distribution of a firm's tax liabilities, we use a 50/50 average of the fractions of the firm's total employment and sales located in each state, measured using data from the National Establishment Time Series (NETS) database. For variable definitions and details of their construction, see Appendix A. All specifications are estimated using OLS in first differences with industry-by-year fixed effects. Heteroscedasticity-consistent standard errors clustered at the state level are shown in italics underneath the coefficient estimates. For each constraint measure, we report a Wald test that compares the tax sensitivity of "constrained" and "unconstrained" firms. It is based on estimating a fully interacted model in which each coefficient is allowed to differ between "constrained" and "unconstrained" firms. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

3.3 Equity test: Equity recycling

The debt test is silent regarding firms' ability to tap the equity markets. Our equity test aims to fill this gap. The test is motivated by a practice Grullon et al. (2011) call "equity recycling." This practice involves raising cash from the equity market only to pay it out again to shareholders. Equity recycling is widespread: in the average year in our sample, firms pay out (through dividends or share repurchases) 19% of the aggregate proceeds of their SEOs and private placements completed that year.

As Farre-Mensa, Michaely, and Schmalz (2015) argue, the literature offers a number of motivations for this practice. Equity recycling can be the result of a monitoring strategy according to which investors force managers to pay increasingly high payouts so that firms are frequently forced to raise external capital to finance investments. By subjecting investment decisions to the scrutiny of the capital markets, this strategy minimizes the risk that managers invest suboptimally. Alternatively, firms could engage in market timing, issuing shares when they perceive them to be overvalued and either paying dividends throughout or, even more pointedly, repurchasing shares when they are undervalued (Warusawitharana and Whited 2014).[21]

Whatever the motivation for equity recycling, the fact that a firm simultaneously raises and pays out equity capital indicates that it does not face an inelastic supply of equity curve and so is not constrained according to the curvature definition. In other words, a firm that is truly constrained under the curvature definition should not engage in equity recycling. Under the wedge definition, a constrained firm may still find it optimal to recycle equity, namely, when the benefits of recycling compensate for the wedge between its internal and external costs of equity capital. Even so, equity recycling should decrease in the size of the firm's wedge: all else equal, the larger the wedge the more value the firm's current shareholders transfer to new shareholders when issuing equity and so the costlier is equity recycling. Thus, firms that are truly constrained according to the wedge definition should pay out a smaller fraction of their equity issuance proceeds compared to unconstrained firms.

3.3.1 External validity. If firms faced a particularly flat equity supply curve when raising equity for recycling, our test would not be informative of "constrained" firms' ability to fund investment projects. To investigate this possibility, we compare market reactions (measured as three-day size-adjusted abnormal returns) to the announcement of SEOs that are (partly) recycled and those that are not.

Two results stand out. First, firms rarely disclose their intention to recycle the equity they are seeking to raise. In fact, only 1.3% of them do, which suggests

[21] Signaling considerations seem to have fallen out of favor. As Allen and Michaely (2003) note in their survey, "the accumulated evidence indicates that changes in payout policies are not motivated by firms' desire to signal their true worth to the market" (339). Consistent with this evidence, Farre-Mensa, Michaely, and Schmalz (2015) show that signaling considerations are not a main motivation of equity recycling behavior.

that our equity test captures a situation in which investors face substantial information asymmetry. Second, Table IA.5 in the Internet Appendix shows that, when firms are explicit about their intention to recycle the equity, the market reaction tends to be *more* negative than when they are not (see Column 1), though the difference is not statistically significant. Similar results hold when we compare SEOs that are subsequently recycled (in the same year or up to one year later, and regardless of whether firms are explicit about it) to those that are not (Columns 2 and 3). In other words, we find no evidence that firms face a flatter equity supply curve when issuing equity to fund payouts.

These results suggest that our equity test has a plausible claim to reasonable external validity. Therefore, if we find that "constrained" firms have no trouble recycling equity, there is a good chance they would not be constrained in their ability to raise equity to finance investment projects either.

3.3.2 Identifying assumptions. For both the curvature and wedge definitions, the equity test assumes that a firm's decision to engage in equity recycling is informative about its equity supply curve as the firm perceives it. In addition, under the wedge definition, the equity test relies on the notion that equity recycling is more costly for a (truly) constrained firm than for an unconstrained one, implying that the constrained firm should recycle less. For this to be the case, constrained firms must not derive systematically higher benefits from equity recycling; otherwise, they might recycle more than unconstrained ones, even though it is more costly for them to do so. In practice, this scenario is unlikely. To the extent that equity recycling reflects a desire to mitigate agency costs associated with high free cash flows (Easterbrook 1984; Jensen 1986), it should be less common among constrained firms, which presumably have low or no free cash flows. To the extent that equity recycling reflects market timing, it should be concentrated among unconstrained firms: after all, market timing involves raising overvalued equity, an option not open to constrained firms.

Like our debt test, the equity test relies on behavior that is sufficient, but not necessary, to conclude that a firm is unconstrained. Indeed, there is no reason to expect *all* unconstrained firms to recycle equity. But we do expect a firm's propensity to engage in equity recycling to be decreasing in the wedge it faces between its internal and external costs of equity. For firms with an inelastic equity supply curve, we expect no equity recycling at all.

3.3.3 Empirical specification. Our analysis of what firms do with the proceeds of their equity issues builds on the framework proposed by Kim and Weisbach (2008). Specifically, we use OLS in first differences to estimate the following equation:

$$\Delta Payout_{ijt} = \beta \Delta Equity\ Issue_{ijt} + \delta \Delta Other\ Sources\ of\ Funds_{ijt} + \gamma \Delta Size_{ijt} + \alpha_{jt} + \varepsilon_{ijt}, \tag{3}$$

where i indexes firms, j industries, and t fiscal years. The dependent variable, *Payout*, is the sum of dividends and share repurchases. The variable of interest, *Equity Issue*, captures a firm's proceeds from firm-initiated equity issues (i.e., SEOs and private placements), defined as in McKeon (2015). *Other Sources of Funds* captures operating cash flows, debt issues net of debt repurchases, and the proceeds of stock option exercises and asset sales. We control for firm size and include industry-by-year fixed effects. All variables (except for size) are scaled by beginning-of-year total assets.

3.3.4 Comparing the behavior of "constrained" and "unconstrained" firms. Table 4, panel A, reports our findings. Two results stand out. First, across all five constraints measures, we find that supposedly constrained firms do engage in equity recycling ($p < 0.001$). This behavior is hard to reconcile with the notion that the average firm classified as "constrained" faces a highly inelastic equity supply curve and is thus truly constrained under the curvature definition. Second, "constrained" firms recycle no less than "unconstrained" ones for three of the five measures. For these measures—credit ratings and the HP and WW indices—the results of the equity test are thus in line with those of the debt test, in the sense that we find no evidence that "constrained" firms face a larger wedge between their internal and external costs of capital. In other words, these three measures fail to correctly identify firms that are equity constrained under the wedge definition.

For two of the five measures—the dividends measure and the KZ index—we find that "constrained" firms do recycle significantly less.[22] This result is consistent with their truly facing a larger wedge, but it is not conclusive evidence of this: "constrained" firms could equally well have a similar wedge but fewer agency costs of free cash flow than their "unconstrained" counterparts.

Be that as it may, one thing the dividends measure and the KZ index have in common is that both load heavily on dividends. Since our measure of equity recycling involves total payouts—including dividends—one may worry that the equity test effectively just relies on information about whether a firm is not a dividend payer to identify firms whose behavior is consistent with being wedge constrained. To investigate this, we check whether the conclusions of our equity test are robust to removing dividends from the dependent variable. Table 4, panel B, shows that they are. This finding indicates that the equity test does not simply rely on information on dividends to capture constraints, in contrast to the dividends measure or (perhaps) the KZ index.

Unlike the debt test, the equity test does not exploit exogenous variation in firms' demand for capital. This opens the door to endogeneity confounding the equity test. For example, say that the constraints measures correctly

[22] That said, it is worth emphasizing that the extent of recycling by firms classified as "constrained" according to these two measures is similar to that of the average public firm (see Table 5, panel B). This suggests that such "constrained" firms do not face a particularly large wedge between their internal and external costs of equity.

Table 4
Equity test: Equity recycling by financial constraints measure

	Dividends		Credit ratings		Kaplan-Zingales		Hadlock-Pierce		Whited-Wu	
	Nondiv. payer (1)	Dividend payer (2)	Unrated (3)	Rated (4)	Constrained (5)	Unconstrained (6)	Constrained (7)	Unconstrained (8)	Constrained (9)	Unconstrained (10)
Panel A. Baseline results										
	Dep. var.: Change in dividends and repurchases									
Change in										
Equity issuance proceeds	0.008***	0.020***	0.009***	0.007*	0.007***	0.013***	0.009***	0.007	0.010***	0.013***
	0.001	*0.005*	*0.001*	*0.004*	*0.002*	*0.002*	*0.001*	*0.006*	*0.002*	*0.003*
Other sources of funds	0.008***	0.020***	0.009***	0.015***	0.007***	0.012***	0.007***	0.018***	0.005***	0.016***
	0.001	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*	*0.002*	*0.002*	*0.001*	*0.002*
Log total assets	0.006***	0.016***	0.008***	0.009***	0.002	0.016***	0.007***	0.009***	0.008***	0.007***
	0.001	*0.002*	*0.001*	*0.003*	*0.001*	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*
Diagnostics										
R^2	15.2%	23.4%	14.5%	32.8%	27.9%	26.1%	21.9%	30.3%	19.9%	29.8%
Wald test:										
Equal equity issuance effect	5.66**		0.16		8.05***		0.08		0.75	
No. of firms	6,108	3,264	7,389	2,237	5,342	4,876	4,752	2,340	4,909	3,460
No. of observations	38,375	32,640	51,113	20,170	20,917	22,918	22,014	24,264	21,600	24,086
Panel B. Focusing on share repurchases only										
	Dep. var.: Change in repurchases									
Change in										
Equity issuance proceeds	0.006***	0.014***	0.007***	0.006	0.005***	0.011***	0.007***	0.006	0.008***	0.011***
	0.001	*0.004*	*0.001*	*0.004*	*0.001*	*0.002*	*0.001*	*0.006*	*0.001*	*0.003*
Other sources of funds	0.007***	0.012***	0.006***	0.010***	0.006***	0.009***	0.005***	0.015***	0.003***	0.012***
	0.001	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*
Log total assets	0.006***	0.011***	0.007***	0.006***	0.002*	0.012***	0.007***	0.009***	0.007***	0.008***
	0.001	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*
Diagnostics										
R^2	15.1%	23.9%	14.4%	33.0%	27.5%	25.2%	21.4%	30.0%	20.6%	30.3%
Wald test:										
Equal equity issuance effect	4.43**		0.20		6.99***		0.01		1.06	
No. of firms	6,108	3,271	7,394	2,239	5,347	4,884	4,755	2,340	4,914	3,460
No. of observations	38,423	32,709	51,200	20,205	20,967	22,939	22,041	24,317	21,634	24,136

(*continued*)

Table 4
Continued

	Dividends		Credit ratings		Kaplan-Zingales		Hadlock-Pierce		Whited-Wu	
	Nondiv. payer (1)	Dividend payer (2)	Unrated (3)	Rated (4)	Constrained (5)	Unconstrained (6)	Constrained (7)	Unconstrained (8)	Constrained (9)	Unconstrained (10)
Panel C. Forward-looking measures of financial constraints										
	Dep. var.: Change in dividends and repurchases									
Change in										
Equity issuance proceeds	0.008***	0.018***	0.009***	0.002	0.008***	0.008***	0.009***	0.000	0.011***	0.011***
	0.001	*0.005*	*0.001*	*0.003*	*0.002*	*0.002*	*0.002*	*0.005*	*0.002*	*0.004*
Other sources of funds	0.008***	0.020***	0.009***	0.013***	0.008***	0.009***	0.008***	0.013***	0.009***	0.015***
	0.001	*0.002*	*0.001*	*0.002*	*0.001*	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*
Log total assets	0.005***	0.016***	0.008***	0.004*	0.001	0.010***	0.009***	0.005**	0.009***	0.005**
	0.001	*0.002*	*0.001*	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*
Diagnostics										
R^2	16.9%	24.2%	15.7%	33.5%	31.8%	27.4%	24.1%	29.6%	21.4%	31.0%
Wald test:										
Equal equity issuance effect	4.63**		4.97**		0.00		3.46*		0.02	
No. of firms	5,223	3,109	6,414	2,116	4,761	4,194	3,957	2,295	4,341	3,101
No. of observations	32,586	30,084	44,253	18,869	18,680	19,852	18,192	23,152	19,061	22,117

We compare the extent to which "constrained" and "unconstrained" firms use the proceeds of firm-initiated equity issues to increase their payouts to shareholders. In panels A and C, payouts are measured as the sum of dividends and share repurchases. Panel B focuses on share repurchases. In panels A and B, firms are categorized as "constrained" or "unconstrained" according to the five measures of financial constraints introduced in Table 2, dated as of year t. Panel C uses forward-looking measures of financial constraints, categorizing a firm as "constrained" or "unconstrained" in year t if the relevant constraints measure identifies the firm as "constrained" or "unconstrained" in year t+1. Our choice of control variables follows that of Kim and Weisbach (2008). For variable definitions and details of their construction, see Appendix A. All specifications are estimated using OLS in first differences with industry-by-year fixed effects. Heteroscedasticity-consistent standard errors clustered at the firm level are shown in italics underneath the coefficient estimates. For each constraints measure, we report a Wald test that compares the tax sensitivity of "constrained" and "unconstrained" firms. It is based on estimating a fully interacted model in which each coefficient is allowed to differ between "constrained" and "unconstrained" firms. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

classify firms most of the time, but they capture switches in status only with a delay. In that case, newly unconstrained firms might systematically use their improved access to the equity market to start engaging in equity recycling while still being classified as constrained. This would compromise the ability of the test to capture differences in equity recycling between "constrained" and "unconstrained" firms. To investigate this concern, Table 4, panel C, uses forward-looking measures of financial constraints, categorizing a firm as "constrained" or "unconstrained" in year t if the relevant constraints measure identifies the firm as "constrained" or "unconstrained" in year $t+1$. The results are little changed, implying that the conclusions of our equity test are not driven by staleness in the constraints measures.

A related concern is that "constrained" firms might raise (and pay out) equity only in years when the economy is booming, when arguably few firms have trouble accessing the equity market. This does not appear to be the case. In fact, "constrained" firms raise plenty of equity in recessions. Specifically, depending on the constraints measure used, between 9% and 18% of the equity issued by "constrained" firms during our sample period was raised in the four years coinciding with NBER recessions.

In sum, the results in Table 4 indicate that none of the five constraints measures correctly identifies those firms that face an inelastic equity supply curve as "constrained". Nor is the behavior of "constrained" firms consistent with facing a larger wedge between their internal and external costs of equity, except when using the dividend and the KZ measures. That said, recall that our debt test shows that firms classified as "constrained" by these two measures are not in fact constrained under the wedge definition as far as access to debt is concerned. This means that they could not be constrained overall, even if they truly faced a relatively larger wedge between their internal and external costs of equity.

3.4 Evaluating our tests: Privately held firms and firms close to default

The results of our two tests paint a consistent picture: the behavior of firms classified by the literature as financially constrained does not appear to differ systematically from the behavior of firms classified as unconstrained. In particular, both the average "constrained" firm and the average "unconstrained" firm are able to increase their leverage when their demand for debt increases exogenously and to recycle a significant portion of the proceeds of their equity issues to increase their payouts to shareholders. These findings imply that "constrained" firms do not face an inelastic capital supply curve and so are not constrained under the curvature definition. As for the wedge definition, supposedly constrained firms are no more constrained than supposedly unconstrained firms in their ability to raise debt, for any of the five measures. The results of the equity test are more mixed: "constrained" firms recycle as much equity as their "unconstrained" counterparts when using the ratings, HP, and WW measures, though they recycle less when using the dividends and KZ measures.

To evaluate the performance and power of our tests out of sample, we apply them to two sets of firms that are a priori likely to be financially constrained: privately held firms and public firms that are close to default according to Merton's (1974) distance-to-default measure.

3.4.1 Privately held firms. Saunders and Steffen (2011) and Longstaff and Strebualev (2014), among others, argue that privately held firms, particularly those that are relatively small, are substantially more likely to be financially constrained than stock market listed firms. If our tests have power to identify financial constraints, we should find that (small) private firms respond less strongly (or even not at all) to tax-induced increases in their demand for debt and engage in less equity recycling (or refrain from it altogether).

To implement this power test, we compare the behavior of private U.S. firms (available in the Sageworks database) to that of public firms.[23] Table 5 reports results consistent with our predictions. While the average public firm in panel A responds strongly to a tax increase (raising its leverage by a highly significant 67.6 basis points for every percentage-point increase in its weighted tax rate), the average private firm barely responds at all: its leverage increases by an insignificant 7.8 bp ($p=0.395$). When we allow the tax sensitivity of private firms to vary with their size, we find that it is the smallest private firms that are the least responsive to a tax increase, consistent with Saunders and Steffen's (2011) and Longstaff and Strebualev's (2014) claim that these are the most financially constrained.[24,25]

The results of the equity test are similar. While the average public firm in panel B recycles equity, the average private firm tends to *reduce* its payout when raising equity, and this tendency is most pronounced among the smallest private firms. These patterns are consistent with private firms facing a large wedge between their internal and external costs of equity and so first exhausting their internal funds, and reducing their payouts, before raising external equity to fund increases in their investment or operating needs. In other words, the observed behavior is consistent with (small) private firms facing financial constraints in the equity markets.

23 See Asker, Farre-Mensa, and Ljungqvist (2015) for details on these data. For the debt test, we restrict the sample of private firms to include only profitable C corps. S corps and unincorporated private firms pay personal, rather than corporate, income taxes and so are not affected by corporate income tax shocks.

24 Wald tests reject both the null that the tax sensitivities of public and private firms are equal ($p=0.049$) and the null that the tax sensitivity of private firms does not vary with size ($p=0.002$).

25 While size correlates with the extent of financial constraints among private firms, our previous results for the HP index (which loads heavily on size) show that it is a poor proxy for financial constraints among public firms. This difference in the importance of size it not surprising, given that public firms are vastly larger than most private ones.

Table 5
Power tests: Private firms

Panel A. Tax sensitivity of leverage

Dep. var.:	Change in long-term book leverage		
	Public firms	Private firms	
	(1)	(2)	(3)
Corporate tax increase at t –1	0.676***	0.078	
	0.237	*0.090*	
… x quartile 1 (smallest)			−0.836*
			0.466
… x quartile 2			−0.025
			0.086
… x quartile 3			0.400***
			0.094
… x quartile 4 (largest)			0.396***
			0.088
Lagged change in			
ROA	−0.017	0.000	0.000
	0.012	*0.003*	*0.003*
Tangibility	−0.012	0.026	0.025
	0.022	*0.018*	*0.018*
Firm size	0.004	0.009	0.008
	0.003	*0.008*	*0.008*
Investment opportunities	−0.002	0.003	0.003
	0.001	*0.003*	*0.003*
Diagnostics			
R^2	7.0%	6.0%	6.4%
Wald test: Equal tax effect	4.10**		5.83***
No. of firms	4,430	4,394	4,394
No. of observations	9,348	4,710	4,710
No. of treated obs.	1,579	874	874

Panel B. Equity recycling

Dep. var.:	Change in dividends and repurchases		
	Public firms	Private firms	
	(1)	(2)	(3)
Change in equity issuance proceeds	0.009***	−0.366***	
	0.001	*0.009*	
… x quartile 1 (smallest)			−0.441***
			0.014
… x quartile 2			−0.284***
			0.012
… x quartile 3			−0.277***
			0.014
… x quartile 4 (largest)			−0.281***
			0.016
Change in			
Other sources of funds	0.011***	0.062***	0.064***
	0.001	*0.003*	*0.003*
Log total assets	0.008***	−0.049***	−0.046***
	0.001	*0.006*	*0.006*
Diagnostics			
R^2	3.7%	11.6%	12.0%
Wald test: Equal equity issuance effect	1,738.19***		36.23***
No. of firms	8,807	98,567	98,567
No. of observations	71,283	207,604	207,604

In this table, we apply our tests to a set of firms that are a priori likely to be constrained: privately held firms, especially small ones. Data on private firms come from the Sageworks database (see Asker, Farre-Mensa, and Ljungqvist 2015 for details). Panel A reports results for the debt test. Columns 1 and 2 compare public and private firms' tax sensitivities of leverage, and column 3 allows private firms' tax sensitivity to vary with firm size. As before, the set of public firms is restricted to those with a positive marginal tax rate (MTR). MTR estimates are not available for private firms, so instead we restrict the sample to those that are profitable. We also screen out private firms that are not C corps, as only C corps have exposure to corporate taxes. The Wald test reported under Columns 1 and 2 tests the null that public and private firms have the same tax sensitivity of leverage. It is based on estimating a fully interacted model in which each coefficient is allowed to differ between public and private firms. The Wald test in Column 3 tests the null that the tax sensitivity of private firms does not vary with size. Panel B reports analogous results for the equity test. Heteroscedasticity-consistent standard errors clustered at the state level (panel A) and at the firm level (panel B) are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

Of course, our previous caveat still applies: our tests identify behavior that is sufficient but not necessary for a firm to be unconstrained, so we cannot conclude that small private firms are necessarily constrained. Public and private firms clearly differ on a number of observable and unobservable dimensions, and these differences—rather than financial constraints—may explain the observed differences in tax sensitivity and equity recycling found in Table 5. For instance, private firms may be unresponsive to tax increases not due to financial constraints but because they lack the financial sophistication needed to engage in tax planning. And they may suffer from fewer agency problems and short-termist pressures than their public counterparts (Asker, Farre-Mensa, and Ljungqvist 2015), and so have no need to mitigate the agency costs of free cash flow by recycling equity.

3.4.2 Firms close to default. As a final validation of our approach to investigating whether financial constraints measures are successful at identifying truly constrained firms, we apply our tests to a second set of firms that are a priori likely to be constrained: public firms that are close to default according to Merton's (1974) distance-to-default measure. There are a number of reasons to expect firms close to default to be financially constrained. Proximity to default leads to risk-shifting incentives (Jensen and Meckling 1976), which in turn limit firms' ability to raise debt. Proximity to default also leaves firms effectively shut out of the public equity market, leading them to turn to costly and restrictive private investments in public equity instead (Chaplinsky and Haushalter 2010).

Table 6 compares the behavior of public firms with low and high probabilities of default. We measure distance to default as in Bharath and Shumway (2008); see Appendix A for details. Panel A shows that firms with a low probability of default (below 25%) respond strongly to a tax-induced increase in their demand for debt, raising their leverage by 63 bp for every percentage-point increase in their weighted tax rate ($p=0.001$). By contrast, the response of firms whose default probability is above the 25% cutoff is an order of magnitude smaller, at 2 bp, and statistically indistinguishable from zero ($p=0.987$).[26] Panel B shows that firms with a low probability of default engage in a significant amount of equity recycling ($p<0.001$), whereas firms with a high probability of default do not ($p=0.518$). These results are robust to alternative cutoffs; see Tables IA.6 and IA.7 in the Internet Appendix.

In sum, firms that are close to default pass both our debt and equity tests: like small private firms, but unlike public firms classified as "constrained" by traditional constraints measures, they behave as if they faced inelastic debt and equity supply curves and thus were constrained according to both the curvature and wedge definitions. Of course, given that our debt and equity

[26] The small number of firms that are not only close to default but also have a positive marginal tax rate and face a tax increase prevents us from rejecting the null that the point estimates for the two groups are the same.

Table 6
Power tests: Firms close to default

Panel A. Tax sensitivity of leverage

Dep. var.:	Change in long-term book leverage		
	High default prob. (1)		Low default prob. (2)
Corporate tax increase at $t-1$	0.022		0.632***
	1.324		*0.172*
Lagged change in			
ROA	−0.194***		−0.010
	0.062		*0.010*
Tangibility	0.176		−0.017
	0.109		*0.022*
Firm size	0.009		0.005
	0.027		*0.003*
Investment opportunities	−0.003		−0.001
	0.022		*0.001*
Diagnostics			
R^2	37.5%		7.8%
Wald test: Equal tax effect		0.32	
No. of firms	554		4,202
No. of observations	631		8,674
No. of treated obs.	112		1,454

Panel B. Equity recycling

Dep. var.:	Change in dividends and repurchases		
	High default prob. (1)		Low default prob. (2)
Change in equity issuance proceeds	0.003		0.010***
	0.005		*0.001*
Change in			
Other sources of funds	0.006***		0.010***
	0.002		*0.001*
Log total assets	−0.003		0.009***
	0.003		*0.001*
Diagnostics			
R^2	58.0%		13.5%
Wald test: Equal equity issuance effect		2.82*	
No. of firms	2,921		8,519
No. of observations	5,237		65,582

In this table, we apply our tests to a second set of firms that are a priori likely to be constrained: public firms that are close to default. The table compares the behavior of firms with high and low default probabilities according to Merton's (1974) distance-to-default measure. We classify firm-years as having a high probability of default if the default probability at the beginning of the year exceeds 25%; the remainder are classified as having a low probability of default. Default probabilities are computed as in Bharath and Shumway (2008) (see Appendix A for details). Panel A reports results for the debt test, and panel B reports results for the equity test. The Wald tests compare the tax sensitivity (panel A) and the equity recycling behavior (panel B) of high and low default probability firms. They are based on estimating fully interacted models in which each coefficient is allowed to differ between firms with a high or low default probability. Heteroscedasticity-consistent standard errors clustered at the state level (panel A) and at the firm level (panel B) are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

tests capture behavior that is sufficient but not necessary for a firm to be unconstrained, passing the test does *not* prove that public firms close to default, or small private firms, are in fact constrained. But it helps alleviate the concern that the only reason our tests reject that public firms popularly deemed "constrained" are truly constrained is that our tests lack statistical power to identify constraints.

4. What Do Traditional Measures of Financial Constraints Actually Measure?

The evidence in Section 3 shows that firms classified as "constrained" or "unconstrained" by traditional measures do not actually differ, on average, in their ability to raise debt or equity or in the wedge they face between their internal and external costs of capital. Does this mean there are no meaningful differences between these groups of firms? The fact that the empirical literature documents plenty of differences in behavior suggests that these measures do pick up important differences in firm types—just not, according to our tests, in financial constraints.

According to the summary statistics in Table 2, public firms classified as constrained by the dividends, ratings, HP, and WW measures look very different from unconstrained firms (the KZ index is more of an outlier): they tend to be smaller, younger, and less profitable and have fewer tangible assets and lower leverage than "unconstrained" firms, but they also grow faster and invest more, particularly in R&D. Next, we show that they also differ markedly in terms of funding patterns.

Table 7 reports the frequency with which public firms raise equity, sell bonds, or take out a loan. This reveals three differences. First, "constrained" firms are substantially more likely to fund themselves by issuing common equity. For example, 10% of nondividend payers raise equity in a given year, while only 3.6% of dividend-paying firms do so (a difference that is significant at the 1% level). "Constrained" firms according to the KZ, HP, and WW indices similarly raise equity more frequently than "unconstrained" firms, which is consistent with the notion that the lower tangibility of their assets reduces "constrained" firms' debt capacity.

Second, "constrained" firms rarely issue bonds. For example, 20.3% of "unconstrained" firms according to the HP index issue bonds in a given year, versus only 1.3% of "constrained" firms.[27] This difference is mostly driven by issues of public bonds, which are extremely rare among "constrained" firms, but it persists if we focus on bonds issued under rule 144A or placed privately.

Third, while "constrained" firms do not use the bond markets much, they do regularly access the syndicated loan market: the fraction of "constrained" firms obtaining a loan in a given year ranges from 9.2% for the HP index to 26.4% for the KZ index. The finding that "constrained" firms rely more on private loans than on public bonds is consistent with the notion that small, opaque, and high-growth borrowers benefit the most from borrowing privately (Houston and James 1996; Denis and Mihov 2003).

Taken together, the results in Tables 2 and 7 suggest that the five financial constraints measures we examine do not generate a random partition of the

[27] As in much of Table 2, the KZ index departs from this pattern: here, "constrained" firms are *more* likely to issue bonds than "unconstrained" firms (12.1% vs. 7.2%).

Table 7
Sources of financing of “constrained” and “unconstrained” firms

	Dividends		Credit ratings		Kaplan-Zingales		Hadlock-Pierce		Whited-Wu	
	Nondiv. payer	Dividend payer	Unrated	Rated	Constrained	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained
Equity										
Common stock issues (primary)	0.100	0.036	[0.075	0.073]	0.096	0.066	0.104	0.049	0.084	0.058
excluding IPOs	0.100	0.036	[0.075	0.072]	0.096	0.066	0.104	0.048	0.083	0.057
Preferred stock issues	[0.009	0.010]	0.006	0.025	0.016	0.006	0.009	0.013	0.009	0.014
Bonds										
All bond issues	0.054	0.235	0.019	0.413	0.121	0.072	0.013	0.203	0.013	0.235
Public bond issues	0.018	0.174	0.002	0.308	0.060	0.042	0.002	0.129	0.002	0.149
Rule 144A bonds	0.028	0.038	0.005	0.112	0.054	0.022	0.004	0.059	0.004	0.073
Private placements	0.014	0.057	0.013	0.061	0.026	0.015	0.008	0.043	0.008	0.046
Loan issues										
All loans	0.174	0.321	0.144	0.456	0.264	0.155	0.092	0.334	0.094	0.365
Term loans	0.062	0.050	0.045	0.111	0.100	0.033	0.032	0.081	0.036	0.086
Revolvers / lines of credit	0.156	0.302	0.131	0.421	0.236	0.142	0.079	0.310	0.082	0.339

This table shows the annual frequency of a given “constrained” or “unconstrained” firm raising equity from outside investors, selling bonds, or taking out a syndicated loan. Firms are categorized as “constrained” or “unconstrained” according to the five measures of financial constraints introduced in Table 2. The table combines data from SDC and Mergent FISD (which we match to Compustat by CUSIPs) and DealScan. All pairwise differences in frequencies are significant at the 1% level, except for those shown in brackets.

universe of public firms. Rather (except for the KZ index), they tend to identify as "constrained" firms that are smaller, younger, and faster growing than "unconstrained" firms. A plausible reading of the evidence is that these measures identify as "constrained" firms that find themselves in the growth phase of their life cycle. However, these firms face neither inelastic capital supply curves nor a large wedge between their internal and external costs of capital. In fact, they regularly access the public equity and bank-loan markets (though not the bond market).

5. Conclusions

Identifying which firms are financially constrained is key to understanding not only the effect of financing frictions on investment, capital structure, and risk management policies (Fazari, Hubbard, and Petersen 1988; Whited 1992; Denis and Sibilkov 2009) but also the role that financing frictions play in a variety of topics ranging from the cross-section of returns (Gomes, Yaron, and Zhang 2006) to the transmission of monetary policy (Gertler and Gilchrist 1994).

Most empirical research proxies for financial constraints using indirect measures that are based on what firms say, do, or look like. We introduce two novel tests to evaluate how well such measures identify firms that are indeed constrained. Our tests exploit exogenous shocks to the demand for debt and firms' tendency to recycle the proceeds of equity issues to increase shareholder payouts.

We find that none of the five measures we evaluate is able to identify firms that behave as if they were in fact constrained. Specifically, public firms classified as constrained for not paying dividends or not having a credit rating or according to the KZ, HP, or WW indices appear to have no trouble raising debt when their demand for debt increases exogenously and engage in equity recycling. Furthermore, they differ little in these respects from supposedly unconstrained firms, even though they are much smaller and younger, grow considerably faster, and rarely access either the public or the private bond markets. But they have ready access to both the equity market and bank lending, which appear to supply capital to them when they need it.

Our results imply that popular measures of financial constraints identify as constrained subsets of firms that, while differing from the general population of firms on a number of dimensions, are not constrained in their ability to raise external funding. Therefore, caution is needed when interpreting results based on traditional measures that rely on potentially endogenous firm characteristics to identify constraints, as these characteristics may capture other unobservable differences across firms that can contaminate empirical tests. In particular, our evidence suggests that extant findings that have been attributed to constraints may instead reflect differences in the growth and financing policies of firms that find themselves at different stages of their life cycles.

Appendix A. Variable Definitions

A.1 Company-Level Variables

Total real assets is defined as the book value of assets (Compustat item *at*) in year 2005 real dollars.

Age is years since founding. We hand-collect founding dates from regulatory filings, business directories, and a comprehensive search of online and offline sources.

Cash /assets is defined as Compustat items *che/at*.

Tangibility is defined as net property, plant, and equipment (Compustat item *ppent*, or Sageworks *NetFixedAssets*), over total assets.

ROA (return on assets) is defined as operating income before depreciation (Compustat item *oibdp* or its Sageworks equivalent, *Sales – CostOfSales – Payroll – Rent – Advertising – Overhead + OtherOperatingIncome – OtherOperatingExpenses*) over total assets.

***Marginal tax rates* (*MTR*)** come from John Graham (http://faculty.fuqua.duke.edu/~jgraham/taxform.html). Following Graham, Lemmon, and Schallheim (1998), we use after-interest marginal tax rates (variable *mtrafter*). Missing values are filled in as recommended by Graham and Mills (2008).

Zero marginal tax rate? is an indicator set equal to one if the marginal tax rate is zero, and zero otherwise.

Total book leverage is defined as the sum of long-term debt (Compustat item *dltt*) and short-term debt (Compustat item *dlc*), over total assets.

Long-term book leverage is defined as long-term debt (Compustat item *dltt*) over total assets (Compustat item *at*). For private firms, it is defined as Sageworks variables *SeniorDebt* + *SubordinatedDebt* over *TotalAssets*.

***% short-term debt* (*1 year*)** is defined as Compustat items *dlc* / (*dlc* + *dltt*).

Investment opportunities is measured, for public firms, using a firm's market to book ratio, constructed as in Frank and Goyal (2009). It is defined as (fiscal year-end closing price [$prcc\_f$] times common shares used to calculate earnings per share [*cshpri*] + the liquidation value of preferred stock [*pstkl*] + long-term debt [*dltt*] + short-term debt [*dlc*] – deferred taxes and investment tax credits [*txditc*]) / total assets [*at*]. For private firms, we use the industry market-to-book ratio, estimated separately for each four-digit NAICS industry and each year.

Sales growth is the annual percentage increase in sales: $Sales_{it}/Sales_{it-1}$–1 (using Compustat item *sale*).

Employment growth is the annual percentage increase in employment: $Employees_{it}/Employees_{it-1}$–1 (using Compustat item *emp*).

R&D is defined as Compustat item *xrd* over beginning-of-year total assets.

Gross investment is the annual increase in gross fixed assets (Compustat data item *ppegt*) scaled by beginning-of-year total assets.

Geographic concentration measures the geographic concentration of a firm's operations and hence of its tax base across states. Data on the geographic distribution of a firm's operations come from the National Establishment Time Series (NETS) database, which contains a complete record of all business establishments in the United States since 1989, with information on their sales and employees. (The main source for the NETS data is Dun & Bradstreet, a credit-reference agency.) We match NETS to Compustat using information on a firm's name, its industry, and its headquarter state. For each firm-year observation, we use NETS data to compute the fraction of employees that the firm employs in each U.S. state as well as the fraction of sales that it produces in each state. Our geographic concentration measure is then defined as 0.5 × HHI(employees) + 0.5 × HHI(sales), where HHI(employees) is the sum of the squared state-by-state fraction of employees, and analogously for HHI(sales). For example, a "single-state" firm has concentration of one, as all its employees and sales are in a single state, while a firm whose employees and sales are evenly distributed across all 50 states has concentration of 1/50.

Firm size is defined as the natural logarithm of the book value of assets (Compustat item *at*, or Sageworks *TotalAssets*) in year 2005 real dollars.

Dividends and repurchases equals the sum of dividends plus repurchases (Compustat items *dv* + *prstkc* for public firms, or Sageworks *Dividends* minus min{ Δ (*TotalEquity* – *RetainedEarnings*), 0}for private firms), scaled by beginning-of-year total assets.

Firm-initiated equity issuance proceeds is computed following McKeon (2015). For each firm-quarter, we classify the equity raised by the firm during the quarter as firm-initiated if the proceeds represent at least 3% of the firm's end-of-quarter market equity. (The equity raised during a quarter is Compustat item *sstky* for Q1 and Δ*sstky* for Q2-Q4; a firm's end-of-quarter market equity is *prccq* × *cshoq*.) We then add up the quarterly proceeds of firm-initiated equity issues over all four quarters in a year and scale the resulting sum by beginning-of-year total assets. For private firms, where the distinction between firm- and investor-initiated issues is negligible because their employees rarely exercise their stock options prior to an IPO, it is calculated as the change in Sageworks items *TotalEquity* – *RetainedEarnings* (set to 0 if negative), scaled by beginning-of-year total assets.

Other sources of funds is defined, for public firms, as the sum of Compustat items *dltis* + *ibc* + *dpc* + *sppe* + *siv* plus the proceeds of investor-initiated equity issues, scaled by beginning of year total assets. The proceeds of investor-initiated equity issues is the difference between Compustat item *sstk* and the proceeds of firm-initiated equity issues. For private firms, it is the sum of the change in long-term debt (Sageworks *SeniorDebt* + *SubordinatedDebt*, set to 0 if negative) + *NetIncome* + *Depreciation* + *Amortization* – change in *GrossFixedAssets* (set to 0 if negative), also scaled by beginning-of-year total assets.

Log total assets is defined as the natural logarithm of beginning-of-year total assets (Compustat item *at*, or Sageworks *TotalAssets*) in year 2005 real dollars.

A.2 Financial Constraints Measures

Nondividend payers are firms with a history of zero dividends on common stock (Compustat item *dvc*), going as far back as 1970.

Dividend payers are firms with a history of nonzero dividends on either common stock (Compustat item *dvc*), going as far back as 1970.

Unrated firms are those that do not have a credit rating from S&P, Moody's, Fitch, or Duff & Phelps, using data obtained from Compustat (variable *splticrm*) and Mergent FISD.

Rated firms are those that have a credit rating from S&P, Moody's, Fitch, or Duff & Phelps, using data obtained from Compustat (variable *splticrm*) and Mergent FISD.

KZ Index is constructed following Lamont, Polk, and Saa-Requejo (2001) as –1.001909[(*ib* + *dp*)/lagged *ppent*] + 0.2826389[(*at* + *prcc_f* × *csho* - *ceq* - *txdb*)/*at*] + 3.139193[(*dltt* + *dlc*)/(*dltt* + *dlc* + *seq*)] – 39.3678[(*dvc* + *dvp*)/lagged *ppent*] – 1.314759[*che*/lagged *ppent*], where all variables in italics are Compustat data items. Following convention, firms are sorted into terciles based on their index values in the previous year. Firms in the top tercile are coded as constrained and those in the bottom tercile are coded as unconstrained.

WW Index is constructed following Whited and Wu (2006) and Hennessy and Whited (2007) as –0.091 [(*ib* + *dp*)/*at*] – 0.062[indicator set to one if *dvc* + *dvp* is positive, and zero otherwise] + 0.021[*dltt*/*at*] – 0.044[log(*at*)] + 0.102[average industry sales growth, estimated separately for each three-digit SIC industry and each year, with sales growth defined as above] – 0.035[sales growth], where all variables in italics are Compustat data items.[28] Following convention, firms are sorted into terciles based on their index values in the previous year. Firms in the top tercile are coded as constrained and those in the bottom tercile are coded as unconstrained.

[28] Whited and Wu estimate their index using quarterly data. Strictly speaking, when working with annual data, the coefficient on (*ib* + *dp*) should be divided by 4 and sales growth should be replaced by $(1 + \text{annual sales growth})^{1/4} - 1$. These adjustment are virtually never done in the literature, so we follow common practice and use Whited and Wu's coefficients unadjusted. All our results are robust (and indeed become more damning) when adjusted.

HP Index is constructed following Hadlock and Pierce (2010) as –0.737Size + 0.043Size^2 – 0.040Age, where Size equals the log of inflation-adjusted Compustat item *at* (in 2004 dollars), and Age is the number of years the firm is listed with a nonmissing stock price on Compustat. In calculating the index, we follow Hadlock and Pierce and cap Size at (the log of) \$4.5 billion and Age at 37 years. Following convention, firms are sorted into terciles based on their index values in the previous year. Firms in the top tercile are coded as constrained and those in the bottom tercile are coded as unconstrained.

A.3 Merton's (1974) Distance-to-Default Measure

Distance to default is constructed following Bharath and Shumway (2008). Using their equation (12), distance to default (DD) over the next year is defined as $DD = [\ln[(E+F)\,/\,F] + r - 0.5\sigma^2]/\sigma$, where E equals CRSP items $|prc| \times$ *shrout* $/10^3$, F equals Compustat items *dlc* +0.5*dltt*, r is the firm's annual stock return computed by cumulating monthly returns (CRSP item *ret*) over the previous 12 months, and σ^2 captures the volatility of the firm's total value (debt and equity). σ is approximated as $(E/(E+F)) \times \sigma_E + (F/(E+F)) \times (0.05 + 0.25\sigma_E)$, where σ_E is the annualized percent standard deviation of returns, estimated from monthly stock returns (CRSP item *ret*) over the previous 12 months. A firm's probability of default is then defined as N(–DD), where N is the cumulative standard normal distribution function. When F is 0, DD is not defined and the probability of default is set to zero. We classify firm-years as having a high probability of default if the default probability at the beginning of the year exceeds 25%, though our results are robust to using alternative cutoffs.

A.4 Aggregate Recycling Measure

Fraction of aggregate firm-initiated equity issues that are recycled is computed as follows. For each year, we compute the ratio $R_t = \sum_i \min\{EqIs_{it},\ P_{it}\} / \sum_i EqIs_{it}$, where $EqIs_{it}$ denotes the proceeds of equity issues initiated by firm i during year t, P_{it} denotes its total payout, and the sums $\sum_i$ are over all firms in our sample in year t. In Section 3.3, we report the average of R_t across all the years in our sample.

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