Capital Misallocation and Earnings-Based Borrowing*

Yuhao Qian†

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Abstract

Does the form of borrowing constraints matter for aggregate productivity? Roughly 80% of U.S. corporate borrowing is earnings-based, yet most theories of financial frictions and capital misallocation use borrowing constraints with asset-based limits. I exploit the Enron–Arthur Andersen accounting scandal, which caused a sharp decline in earnings-based borrowing, to provide the first natural-experiment evidence on the causal effects of earnings-based financial frictions on capital misallocation. A 10-percentage-point decline in the share of new debt subject to earnings-based constraints widens the gap in the growth of marginal revenue product of capital between initially high- and low-MRPK firms by 7.7 percentage points, indicating a deterioration in capital allocative efficiency. A heterogeneous-firm general-equilibrium model provides the intuition: conditioning borrowing capacity on earnings directs capital toward high-productivity, low-asset firms because earnings proxy productivity more closely than asset values do. Quantitatively, the Enron shock lowers aggregate TFP by 0.6%, whereas an asset-based tightening that generates the same contraction in aggregate borrowing among firms with positive borrowing lowers TFP by only 0.3%. Thus, the composition of borrowing constraints has first-order consequences for allocative efficiency.

Keywords: Capital misallocation, Earnings-based borrowing, Financial frictions, Heterogeneous firms, Aggregate productivity, Enron-Arthur Andersen accounting scandal.
JEL Classification: D24, E22, E44, G32, O47.

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†Department of Economics, London School of Economics; London WC2A 2AE, UK; Email: y.qian12@lse.ac.uk; Website: www.yuhaoqian.com

1 Introduction

Identifying the sources of capital misallocation is particularly important given the marked slowdown in productivity growth across advanced economies (Fernald, Inklaar and Ruzic, 2025). While most models of financial frictions tie firms' borrowing capacity to their assets, roughly 80 percent of U.S. corporate debt is earnings-based, and the remaining 20 percent is mainly asset-based (Lian and Ma, 2021).

This distinction shapes which firms obtain capital. Asset-based constraints favor firms with larger stocks of assets, whereas earnings-based constraints allow productive firms with few assets to borrow more. Does what firms borrow against affect capital allocative efficiency and aggregate productivity?

This paper shows that it does. I exploit the Enron–Arthur Andersen accounting scandal as the first natural experiment in earnings-based financial frictions. The Enron shock exogenously tightens earnings-based financial frictions for pre-scandal Arthur Andersen auditees because the scandal undermines the credibility of their reported EBITDA (earnings before interest, taxes, depreciation, and amortization), on which earnings-based borrowing capacity depends. A calibrated heterogeneous-firm general-equilibrium model shows that the earnings-based tightening implied by the Enron shock lowers total factor productivity (TFP) by 0.61%, compared with 0.34% under an asset-based tightening that produces the same level of aggregate borrowing among firms with positive debt. These model-based counterfactuals imply that the aggregate consequences of financial frictions depend not only on how much firms can borrow, but also on what they can borrow against.

It is difficult to identify a treatment such as the Enron shock because earnings- and asset-based borrowing often coexist within a firm. Existing natural experiments on financial frictions do not distinguish an exogenous tightening of earnings-based borrowing constraints from a tightening of asset-based constraints. Instead, they tighten overall credit conditions. Established natural experiments on financial frictions include banking crises (Peek and Rosengren, 1997, 2000; Klein, Peek and Rosengren, 2002; Khwaja and Mian, 2008; Richardson and Troost, 2009; Ziebarth, 2013; Huber, 2018; Amiti and Weinstein, 2018), financial crises (Chodorow-Reich, 2014) and sovereign debt crises (Schnabl, 2012).

The Enron shock allows me to isolate the effects of earnings-based financial frictions because it undermines the credibility of reported earnings without directly affecting the liquidation value of assets. Arthur Andersen audited its clients' income statements, whereas third-party appraisers—not accounting firms—assess the liquidation values underlying asset-based borrowing. I therefore classify firms audited by Andersen before the scandal as treated and other public firms as controls.

Causally identifying the effects of earnings-based financial frictions on capital misallocation empirically is difficult. Borrowing arrangements, productivity, capital, and MRPK are jointly determined. Firms may select earnings-based borrowing precisely when their sales, profitability, collateral, or desired operating flexibility make those financing arrangements advantageous

(Demiroglu and James, 2010; Benmelech, 2024).

More generally, cross-sectional MRPK dispersion is an imperfect measure of true misallocation because it can also reflect factors unrelated to allocative inefficiency.[1] Identifying an exogenous shift in a particular borrowing constraint therefore isolates the component of capital misallocation caused by that financial friction and reveals a clear margin for policy intervention (Bau and Matray, 2023).

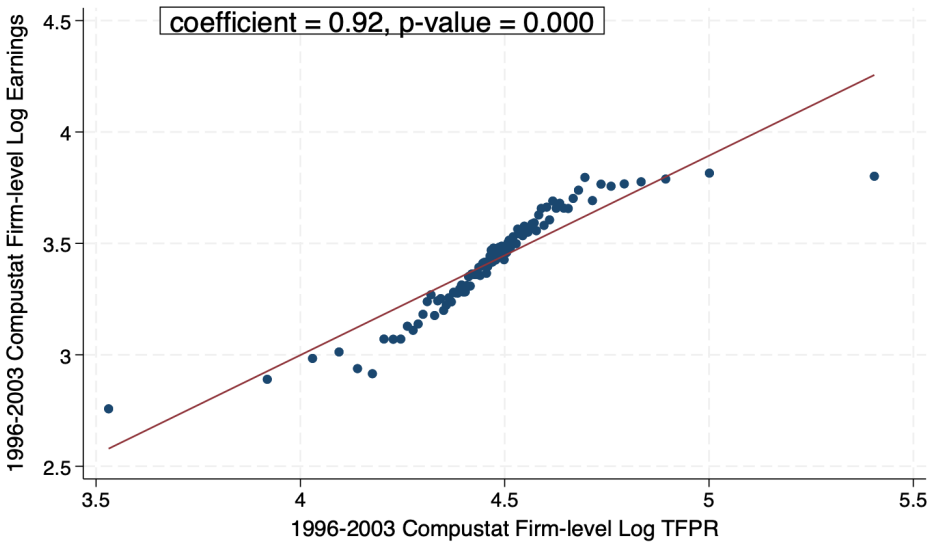
The treatment is "as good as random" for the following reasons: (i) The treatment status is predetermined given firms' pre-scandal auditor choice. (ii) There was no anticipation of the accounting scandal. By their nature, accounting frauds are designed to remain concealed and are therefore unlikely to be anticipated by the public. Moreover, before the scandal became public, there was little reason to suspect fraud, as both Enron and Arthur Andersen were large and highly reputable firms. (iii) The parallel trends assumption is likely to hold, as the event-study estimates indicate. Consistent with this assumption, Healy and Palepu (2003) and Eisenberg and Macey (2004) also find that Andersen clients did not systematically restate their financial reports differently from other firms. I also conduct a battery of robustness checks on the key identifying assumptions, including the exclusion restriction, the parallel trends assumption, and the Stable Unit Treatment Value Assumption (SUTVA). For robustness, I include empirical specifications with a rich set of controls. I also perform placebo tests to rule out concurrent shocks.

Nearly all of the literature on capital misallocation and financial frictions focuses on settings in which firms can borrow only against their assets (Banerjee and Moll, 2010; Buera and Shin, 2013; Moll, 2014; Midrigan and Xu, 2014; Buera and Moll, 2015; Gopinath et al., 2017; Catherine et al., 2022; Cui, 2022). The underlying idea is that asset-based borrowing constraints impede capital from flowing to its most productive uses. However, productive firms generate higher earnings. Figure 1 documents an almost one-for-one positive association between firm-level productivity and operating earnings (EBITDA): a 1% increase in total factor productivity revenue (TFPR) is associated with a 0.92% increase in operating earnings (EBITDA). Li (2022) is the first to show that the pledgeability of earnings-based borrowing allows borrowing limits to rise with firm-level productivity. The model in Buera, Kaboski and Shin (2011) allows borrowing limits to depend on a combination of earnings and capital through an enforcement constraint. The authors show that sectors operating at a larger scale have greater financing needs, and their sector-level TFPs are therefore disproportionately affected by financial frictions.

This paper delivers a new theoretical result through the lens of capital allocation: relative to a setting with only asset-based borrowing, earnings-based borrowing improves the allocative efficiency of capital by financing high-productivity firms with low assets. In an economy with only asset-based borrowing, highly productive firms with few assets are especially constrained, exhibit very high marginal products of capital (MPK), and contribute disproportionately to the

[1] These factors include measurement error (Rotemberg and White, 2020; Bils, Klenow and Ruane, 2021; Gollin and Udry, 2021), model misspecification (Nishida, Petrin and White, 2013; Haltiwanger, Kulick and Syverson, 2018), productivity volatility combined with adjustment costs (Asker, Collard-Wexler and De Loecker, 2014; Gopinath et al., 2017), unobserved heterogeneity in technology (Gollin and Udry, 2021), and informational frictions and uncertainty (David, Hopenhayn and Venkateswaran, 2016).

Figure 1 Log TFPR and Log Earnings



Notes. This figure plots firm-level log earnings against log TFPR. TFPR is estimated using the control-function approach of Olley and Pakes (1996), with labor as the variable input, capital as the predetermined state variable, and investment as the productivity proxy. Earnings are measured by EBITDA from Compustat. The sample is the merged Compustat–SDC Platinum panel from 1996–2003. Firm and year fixed effects are included, and robust standard errors are used.

dispersion of MPK. Earnings-based borrowing allows these firms to borrow against their productivity through earnings, compresses MPK dispersion, and mitigates capital misallocation. High-productivity firms have higher optimal capital levels. Their demand for capital is therefore high enough that their MPK remains high even when they can borrow against earnings.

The model then yields a sharp empirical prediction: tightening earnings-based borrowing should withdraw disproportionately more capital from these firms with high pre-scandal MRPK, causing their MRPK to rise relative to that of initially low-MRPK firms. This prediction determines the empirical specifications. The panel 2SLS specification focuses on the interaction between the Andersen treatment and an indicator for high pre-scandal MRPK. The event-study specifications interact these variables with year indicators to trace the differential response over time. The mechanism predicts that, after the scandal, capital should fall and MRPK should rise most strongly among treated firms with high pre-scandal MRPK.

Using SDC Platinum and Compustat, I measure the earnings-based share of each firm's new borrowing and test the model's prediction for how the Enron shock reallocates capital across firms. The principal 2SLS estimate implies that a 10-percentage-point decline in earnings-based borrowing raises MRPK growth by 7.7 percentage points more among initially high-MRPK firms than among initially low-MRPK firms. Event studies trace the mechanism underlying this estimate. The scandal reduces the earnings-based share of new debt among treated firms by 10.0 percentage points. Treated firms with high pre-scandal MRPK subsequently experience an 11.0-log-point larger decline in capital than those with low pre-scandal MRPK. Because this decline

in capital is not accompanied by an increase in sales, their MRPK rises by 8.9 log points more and their MRPK growth increases by an additional 6.5 percentage points. The latter estimate is statistically indistinguishable from the panel 2SLS estimate. Thus, the shock withdraws capital disproportionately from firms for which its marginal product was already high, identifying a borrowing-driven source of variation in MRPK dispersion rather than interpreting unconditional dispersion as evidence of inefficiency.

The empirical estimates identify how an earnings-based tightening reallocates capital, but they do not quantify its aggregate productivity effect or allow a direct comparison with an equally sized asset-based tightening. I therefore quantify the mechanism in a heterogeneous-firm general-equilibrium model. The model is calibrated to match moments from Compustat firm-level microdata. The central counterfactual compares the Enron-induced tightening of earnings-based borrowing with an asset-based tightening chosen to produce the same level of aggregate borrowing among firms with positive debt. Li (2022) is the first paper to quantify the role of earnings-based borrowing in aggregate productivity losses. Her counterfactual exercises show that, when aggregate debt-to-capital is targeted, the implied TFP loss from financial frictions is much larger if firms cannot borrow against earnings than if earnings and capital are assumed to be equally pledgeable. However, because a fall in aggregate TFP also reduces aggregate output for a given aggregate endowment of wealth, holding the debt-to-output ratio fixed can mechanically generate a proportional decline in aggregate borrowing. This complicates the interpretation, since changes in the amount of aggregate borrowing may be difficult to separate from changes in its allocation. In my quantitative exercise, to isolate how the basis on which firms borrow affects allocative efficiency, I hold borrowing fixed to separate the allocation of a given pool of credit from its total quantity. The earnings-based tightening lowers TFP by 0.61%, while the matched asset-based tightening lowers TFP by 0.34%. The difference arises from which firms lose financing: the tightening of earnings-based borrowing constraints disproportionately affects high-productivity firms because they rely more heavily on earnings-based debt.

This paper builds on the growing literature on earnings-based borrowing and the broader literature on misallocation. In the earnings-based borrowing literature, Lian and Ma (2021) document the prevalence of earnings-based borrowing and, in doing so, open up new directions for modeling firms' borrowing constraints. They also exploit a change in accounting rules, SFAS 123(r), as a natural experiment that generates exogenous variation in operating earnings (EBITDA), since the rule requires stock option compensation expenses to be recognized in operating earnings. Other papers in the area have examined the role of earnings-based borrowing in business-cycle dynamics (Drechsel, 2023), the allocation of investment and innovation (Ottonello and Winberry, 2024), and markup dispersion (Li et al., 2025).

In the misallocation literature, beyond the papers discussed above, Banerjee, Duflo and Munshi (2003) were among the first to interpret unequal marginal products of capital as an indicator of misallocation. Hsieh and Klenow (2009) provide a tractable empirical framework for quantifying within-industry misallocation through the dispersion of marginal revenue products. Restuccia and Rogerson (2008, 2017) and Hopenhayn (2014) highlight the importance of misallocation

for aggregate TFP losses. Recent advances in this literature include David, Hopenhayn and Venkateswaran (2016), David and Venkateswaran (2019), Baqaee and Farhi (2020), Whited and Zhao (2021), Liu, Wang and Xu (2021), Karabarbounis and Macnamara (2021), Carrillo et al. (2023), Sraer and Thesmar (2023), and Cui, Wright and Zhu (2025).

The article proceeds as follows. In Section 2, I describe a simple model showing how earnings-based borrowing allows firms to borrow against earnings and explaining why the empirical analysis assesses capital misallocation by estimating the treatment effect on the MRPK of initially high-MRPK firms. Section 3 describes the Enron–Arthur Andersen scandal as the natural experiment, presents the identification strategy, and reports the empirical results. Section 4 presents the quantitative model, calibration, and counterfactual exercises, which demonstrate that tightening the earnings-based borrowing constraint results in greater TFP losses than a comparable tightening of the asset-based borrowing constraint. Section 5 concludes.

2 Theoretical Framework

This section develops a theoretical framework to clarify the mechanism and to guide the empirical analysis in Section 3. Section 4 extends the baseline framework along several dimensions.

2.1 Preferences and Technology

The model is static, which contains two stages: (i) ex-ante endowment of wealth, and (ii) ex-post misallocation of capital due to borrowing constraints. There is a continuum of firms indexed by productivity z and the wealth endowment a. The state of the economy is the joint distribution $g(a, z)$. Entrepreneurs have preferences

$$u(c) = \log c. \tag{1}$$

Every entrepreneur owns a private firm that uses capital of k units to produce

$$y = f(z, k) = zk^{\alpha} \tag{2}$$

units of output, where $\alpha \in (0, 1)$. The setup with capital k as the only input is for simplicity.

2.2 Budgets

Entrepreneurs rent capital in a competitive capital market at a rental rate r. The budget constraint of the entrepreneur is

$$c = f(z, k) - rk + (1 + r)a. \tag{3}$$

Consumption c equals profits, which are output minus interest payment to capital, plus the

wealth and the rental receipts from wealth. An entrepreneur faces a mixed borrowing constraint

$$k - a \leq \max\{\theta_e \cdot zk^{\alpha}, \theta_a k\}, \tag{4}$$

where $\theta_a \in (0,1)$ stands for asset-based financial frictions, and θ_e captures the earnings-based financial frictions. Note θ_e is typically estimated to be larger than 1 in the literature. One institutional narrative for less earnings-based financial frictions is the improvement in accounting standards (Benmelech, Kumar and Rajan, 2024). I model capital-market imperfections as in Li et al. (2025), for analytical tractability. Consistent with Benmelech, Kumar and Rajan (2024), when strong and predictable earnings are available, firms tend to prefer earnings-based over asset-based borrowing because collateral requirements restrict the ability to sell or redeploy assets, reducing profitability. Firms' borrowing is the capital minus their wealth. The term of $\theta_e \cdot zk^{\alpha}$ represents the earnings-based borrowing limit, which is proportional to the earnings of the firm. The term of $\theta_a k$ is the asset-based borrowing limit given the amount of capital available to the firm. Note that by adjusting (θ_e, θ_a) I can vary the degrees of access to earnings-based borrowing and asset-based borrowing for the constrained firms; when $\theta_e zk^{\alpha} > \theta_a k$, the constrained firm's borrowing capacity is primarily earnings-based; when $\theta_e zk^{\alpha} < \theta_a k$, it is primarily asset-based.

2.3 Individual Behavior

Entrepreneurs maximize the value of utility from consumption (1) subject to the budget constraint (3). Their production and saving decisions can be analyzed separately. Define the profit function

$$\Pi(a,z) = \max_{k} \left\{ zk^{\alpha} - rk \quad \text{s.t. } k - a \leq \max\{\theta_e \cdot zk^{\alpha}, \theta_a k\} \right\}. \tag{5}$$

Note that profits are a function of wealth a because of the existence of the borrowing constraint (4). The budget constraint (3) can be rewritten as

$$c = \Pi(a,z) + (1+r)a. \tag{6}$$

The interpretation is that entrepreneurs first solve the profit-maximization problem. They then consume the profits, the wealth endowment, and the rental receipts from their wealth endowment.

Lemma 1 *Fix firm wealth a and consider a constrained firm. The optimal capital policy is*

$$k(a,z) = \begin{cases} \dfrac{a}{1-\theta_a}, & \text{if } z < \tilde{z}(a), \\ \mathcal{K}^{-1}(a,z), & \text{if } z \geq \tilde{z}(a), \end{cases} \tag{7}$$

where the productivity cutoff is

$$\tilde{z}(a) = \frac{\theta_a}{\theta_e}\left(\frac{a}{1-\theta_a}\right)^{1-\alpha}, \tag{8}$$

and $\mathcal{K}^{-1}(a,z)$ *is the inverse in* k *of*

$$z = \mathcal{K}(k,a) := \frac{k-a}{\theta_e k^{\alpha}}. \tag{9}$$

For fixed a, $\mathcal{K}^{-1}(a,z)$ *is strictly increasing and convex in* z. *Hence,* $k(a,z)$ *is weakly increasing and continuous in productivity, with*

$$\mathcal{K}^{-1}\left(a,\tilde{z}(a)\right) = \frac{a}{1-\theta_a}.$$

All proofs are in the appendix. Lemma 1 is illustrated in Panel A of Figure 2. For a given wealth level a, constrained firms with productivity less than $\tilde{z}(a)$ have the constant capital inputs at $\frac{a}{1-\theta_a}$ by issuing asset-based borrowing. When the productivity surpasses the threshold of $\tilde{z}(a)$, borrowing turns earnings-based and becomes strictly increasing in the productivity z.

Figure 2 plots capital k against productivity z for a given wealth a. The figure shows that at a given wealth level a, high-z firms can borrow more by issuing earnings-based borrowing, since earnings-based borrowing $\theta_e z k^{\alpha}$ taps into productivity z via earnings zk^{α}. Earnings zk^{α} have the same form as output in the simple model. The quantitative model in Section 4 demonstrates that a model incorporating labor inputs and a frictionless labor market would yield an isomorphic form of earnings to this simple model. Constrained firms with lower productivity issue asset-based borrowing, and those with higher productivity issue earnings-based borrowing, as Figure 2 and Figure 3 show. This is delivered by the max operator in the borrowing constraint.

Figure 2 Panel B shows capital k against productivity z when the earnings-based financial frictions θ_e decrease. This figure presents an earnings-based curve tilting clockwise as a result of the lower θ_e. When earnings-based financial frictions deteriorate and θ_e decreases, firms have more limited access to earnings-based borrowing. High-z constrained firms could issue less borrowing, consequently. As a result, the average share of earnings-based borrowing in the economy shrinks (Online Appendix B.6).

Lemma 2 *Fix productivity* z *and consider a constrained firm. The optimal capital policy is*

$$k(a,z) = \begin{cases} \mathcal{A}^{-1}(a,z), & \text{if } a \le \tilde{a}(z), \\ \dfrac{a}{1-\theta_a}, & \text{if } a > \tilde{a}(z), \end{cases} \tag{10}$$

where the wealth cutoff is

$$\tilde{a}(z) = (1-\theta_a)\left(\frac{\theta_e}{\theta_a}z\right)^{\frac{1}{1-\alpha}}, \tag{11}$$

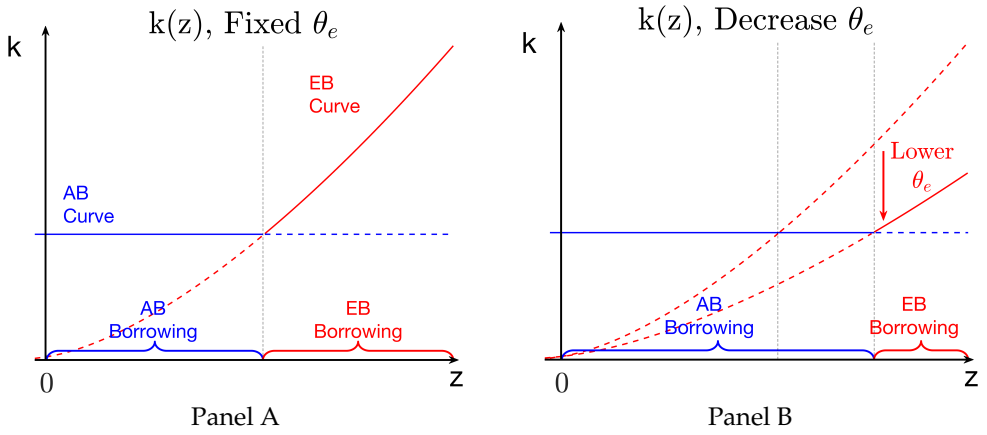


Figure 2 Constrained Firms' Capital on Productivity

Notes. Panel A of Figure 2 reports the policy function of capital $k(z)$ when firm's wealth a and earnings-based financial frictions θ_e are fixed. Less productive firms rely more heavily on asset-based borrowing, as shown by the solid portion of the blue curve. By contrast, more productive firms rely more heavily on earnings-based borrowing, as indicated by the solid portion of the red curve. Panel B of Figure 2 shows the shift in the capital policy function $k(z)$ given wealth a when the earnings-based constraint tightens. As a result, the red EB curve shifted down from the dashed curve to the red solid curve.

and $\mathcal{A}^{-1}(a,z)$ *is the inverse in* k *of*

$$a = \mathcal{A}(k,z) := k - \theta_e z k^{\alpha}. \tag{12}$$

For fixed z, $\mathcal{A}^{-1}(a,z)$ *is strictly increasing and concave in* a. *Hence,* $k(a,z)$ *is strictly increasing and continuous in wealth, with*

$$\mathcal{A}^{-1}\left(\tilde{a}(z),z\right) = \frac{\tilde{a}(z)}{1-\theta_a}. \tag{13}$$

Lemma 2 and Figure 3 study the capital k employed by constrained firms over wealth a. The intuition is that constrained firms with more wealth have more collateral so they can access more capital. The following focuses on a special case that clarifies how earnings-based borrowing improves aggregate efficiency from the perspective of heterogeneous firms.

Special Case 1 *When wealth* a *gets close to* 0, *high-*z *firms could gain access to a relatively large amount of capital*

$$k(a,z) \to (\theta_e z)^{\frac{1}{1-\alpha}} >> 0,\ a \to 0, z >> 0. \tag{14}$$

As shown in Panel A of Figure 3, the gap between the earnings-based curve and the asset-based curve widens, as wealth a approaches 0. When capital k is plotted along wealth a as in Figure 3, the firms with less wealth a issue earnings-based borrowing, and firms with more wealth a issue asset-based borrowing. A negative shock to θ_e would shift the earnings-based curve lower and reduce the issuance of earnings-based borrowing. Consequently, the negative shock to θ_e decreases the average share of earnings-based borrowing in the economy.

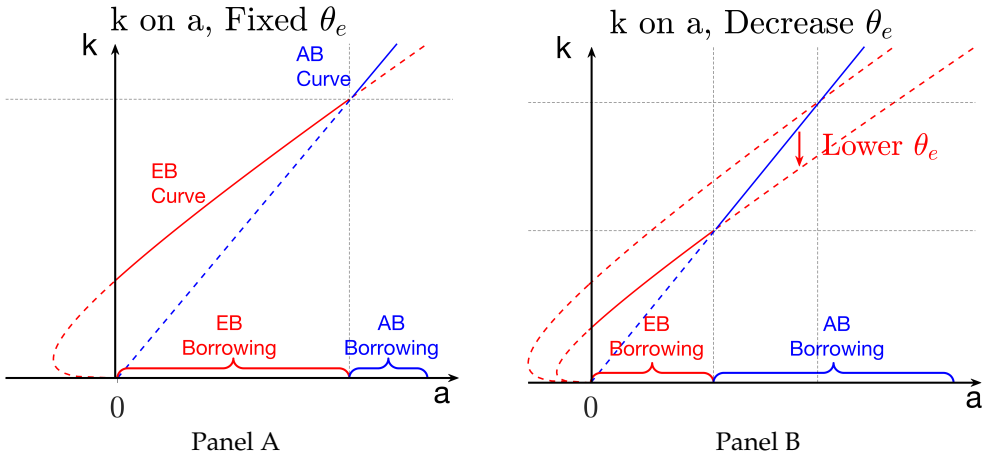


Figure 3 Constrained Firms' Capital on Wealth

Notes. Panel A of Figure 3 presents the policy function of capital $k(a)$ given productivity z and earnings-based financial frictions θ_e. Firms with less wealth choose earnings-based borrowing, as the solid part of the red earnings-based curve. Firms with more wealth issue asset-based borrowing as the solid part of the blue asset-based curve. Panel B of Figure 3 plots the policy function $k(a)$ given productivity z when the earnings-based constraint tightens. When earnings-based frictions θ_e are lowered, the red EB curve shifts down.

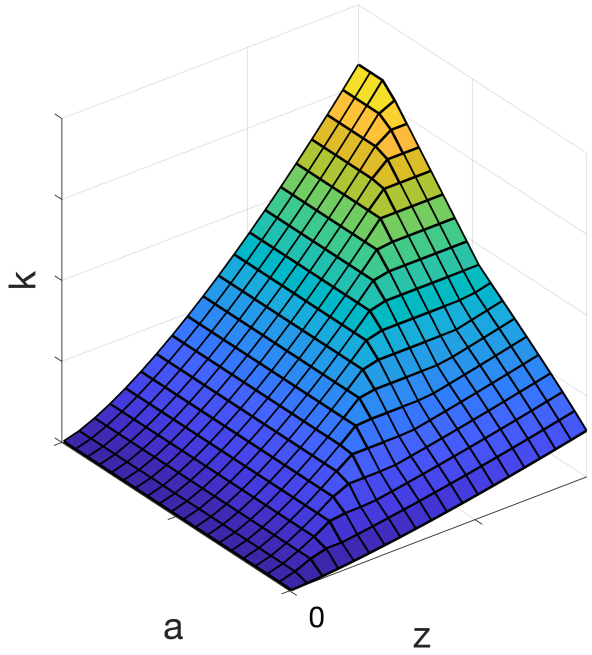


Figure 4 Policy Function of Capital

Notes. This figure shows the policy function of capital k on the grids of wealth a and productivity z. On the ridge are the firms with a weakly binding borrowing constraint. To the left of the ridge are the unconstrained firms with relatively high wealth a and relatively low productivity z. To the right of the ridge are the constrained firms, which have relatively low wealth a and high productivity z.

To have a comprehensive understanding of the capital inputs by firms, the policy function of capital $k = k(a, z)$ on the axes of (a, z) is plotted in Figure 4. On the ridge in the figure are the firms with a weakly binding borrowing constraint. To the left of the ridge are firms with relatively high wealth a and low productivity z. Due to the relatively high endowment of wealth, the firms to the left of the ridge in Figure 4 are the unconstrained firms. To the right of the ridge are firms with relatively low wealth a and high productivity z. The relatively low endowment of wealth leads firms to be constrained. As Figure 4 shows, just to the right of the ridge—especially near it—firms rely on asset-based borrowing; their capital policy function is flat in productivity z, so the policy function runs parallel to the z-axis. Farther to the right, as one moves away from the ridge, firms increasingly rely on earnings-based borrowing, and the capital policy becomes increasing in z.

2.4 Equilibrium

An equilibrium consists of a price r and policy functions for entrepreneurs $k(a, z)$ and $y(a, z)$, such that (i) entrepreneurs maximize (1) subject to (4) taking as given the equilibrium prices, and (ii) the capital market clears

$$\int k(a, z)\, dG(a, z) = \int a\, dG(a, z), \tag{15}$$

where $\int k(a, z)\, dG(a, z)$ is the aggregate capital demand and $\int a\, dG(a, z)$ is the aggregate wealth supply. By Walras's law, integrating the budget constraint (3) over firms and imposing capital-market clearing (15) yields the aggregate resource constraint

$$C = Y + A, \tag{16}$$

where C is the aggregate consumption, Y is the aggregate output, A is the aggregate wealth. Equation (16) states that total consumption is equal to the total amount of output and the total amount of wealth endowment. Because the framework is static and abstracts from intertemporal capital accumulation, I omit depreciation; including it would not alter the core mechanism.

2.5 Earnings-Based Financial Frictions and Capital Misallocation

Section 2.3 shows how earnings-based borrowing collateralizes productivity and improves capital allocative efficiency by directing capital to low-assets and high-productivity firms. This section focuses on the mechanism between tightening the earnings-based financial frictions and the deteriorated capital allocative efficiency.

Lemma 3 *Fix firm wealth a and consider constrained firms. Let $mpk(a, z)$ denote the marginal product of capital evaluated at the optimal capital choice. Then $mpk(a, z)$ is strictly increasing in productivity z.*

The intuition for Lemma 3 is that more productive firms have a higher optimal choice of capital inputs, so high-productivity firms are also more constrained due to the financial frictions in the sense that high productivity leads to higher MPK when the capital inputs are constrained. Because firms rely increasingly on earnings-based relative to asset-based borrowing as productivity rises, firms that issue earnings-based borrowing also tend to have high MPK. Figure 5 Panel A illustrates Lemma 3: the firm-level marginal product of capital $MPK(a,z)$ is monotonically increasing in productivity z. Fixing wealth a, under the asset-based constraint the optimal capital choice $k(a,z)$ is locally independent of z; hence $MPK(a,z) = \alpha z\, k(a,z)^{\alpha-1}$ rises linearly with z. For $z > \tilde{z}$, firms rely on earnings-based borrowing. Relative to the asset-based counterfactual, the less restrictive borrowing constraint raises k and therefore lowers MPK, as illustrated by the red solid curve relative to the blue dashed curve. The proof of Lemma 3 (Online Appendix B.3) establishes that $MPK(a,z)$ remains increasing in z even when high-productivity firms borrow against earnings. That is to say, the firms issuing earnings-based borrowing are among the high-MPK firms.

Proposition 1 *Fix firm wealth a. Consider a constrained firm on the high-productivity, earnings-based branch of the piecewise policy, and write its capital and marginal-product policies as $k(a,z;\theta_e)$ and $mpk(a,z;\theta_e)$. Pointwise on this branch, a reduction in the earnings-based borrowing parameter θ_e reduces optimal capital and raises the marginal product of capital.*

By Lemma 3, the high-z firms are also the high-MPK firms. Figure 5 and 6 illustrate that the high-MPK and high-z firms, which are subject to the earnings-based borrowing constraint, experience increases in the MPK, and the constrained firms with relatively low MPKs are unaffected when earnings-based borrowing constraints tighten. The result does not rely on the max operator in the borrowing constraint in the simple model. Similar results can be obtained if earnings-based and asset-based borrowing are additive in the borrowing constraint. Figure 5 plots MPK over productivity z at a given value of firm wealth a. For a given level of earnings-based financial frictions θ_e (Panel A of Figure 5), the high-z firms have higher MPKs and rely more on earnings-based borrowing. When a negative shock happens to earnings-based financial frictions (Panel B of Figure 5), high-MPK firms, which rely on earnings-based borrowing, become more constrained by borrowing and yield higher MPKs.

MPK over wealth a is shown in Figure 6 for a given productivity z. Firms with lower wealth a are more financed by earnings-based borrowing because the asset-based constraint is tighter for them due to their low wealth. As Figure 3 shows, firms with lower wealth a at the same productivity z still receive less capital and therefore have higher MPKs (Figure 6). When earnings-based financial frictions θ_e worsen, low-assets firms that have high MPKs become more constrained and have higher MPKs because of their reliance on the earnings-based borrowing.

Lemma 4 *Every unconstrained firm satisfies*

$$mpk = r,$$

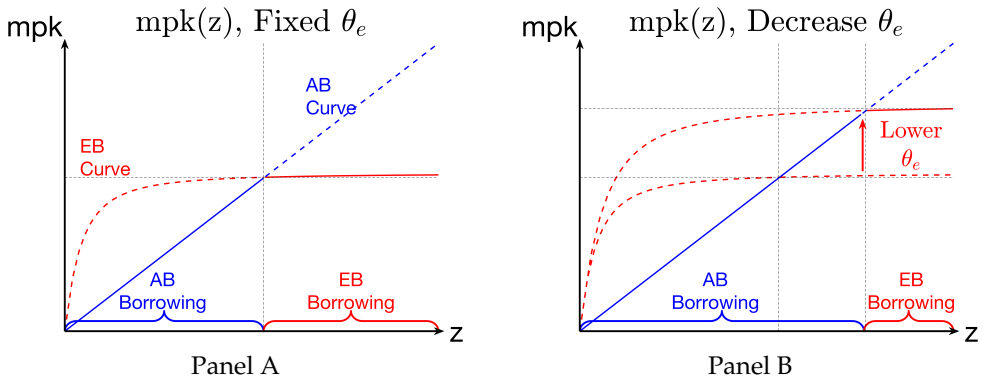


Figure 5 Constrained Firms' MPK on Productivity

Notes. Panel A of Figure 5 presents the corresponding MPK policy function of Figure 2 on productivity z given wealth a and earnings-based financial frictions θ_e. The red curve is MPK's earnings-based curve. The blue curve is the asset-based curve of MPK. Panel B of Figure 5 shows the MPK on productivity z when the earnings-based constraint tightens. As a result, the red EB curve shifts up.

where r is the equilibrium rental rate of capital. In general equilibrium, $r = r(\theta_e)$ is increasing in the earnings-based borrowing parameter θ_e. Therefore, a reduction in θ_e lowers both the rental rate and the marginal product of capital of every unconstrained firm.

As shown by the Lemma 4, the $MPK = r$ of the unconstrained and hence low-MPK firms decreases when the earnings-based borrowing constraint tightens. The interpretation is that when the earnings-based borrowing constraint tightens, the demand for capital by constrained firms declines, and the rental rate falls in general equilibrium. To sum up, tightening the earnings-based borrowing constraint widens the gap between the MPKs of high- and low-MPK firms by raising the MPK of high-MPK firms and lowering the MPK of low-MPK firms.

Following the theoretical analysis, the empirical strategy examines the Enron shock's effects on capital misallocation by focusing on how it affects the logged MPK of firms with high pre-scandal MPK, since earnings-based financial frictions disproportionately affect high-MPK firms. The empirical specifications resemble those of (Bau and Matray, 2023).

3 Empirical Analysis

3.1 Data and Summary Statistics

This section outlines the data sources, describes the sample and key variables in the analysis, and provides summary statistics.

3.1.1 Data Sources, Samples, and Variable Definitions

1. SDC Platinum. The analysis is based on the SDC Platinum Global New Issues Dataset, which comprehensively covers all corporate bond and syndicated loan issues worldwide. My empir-

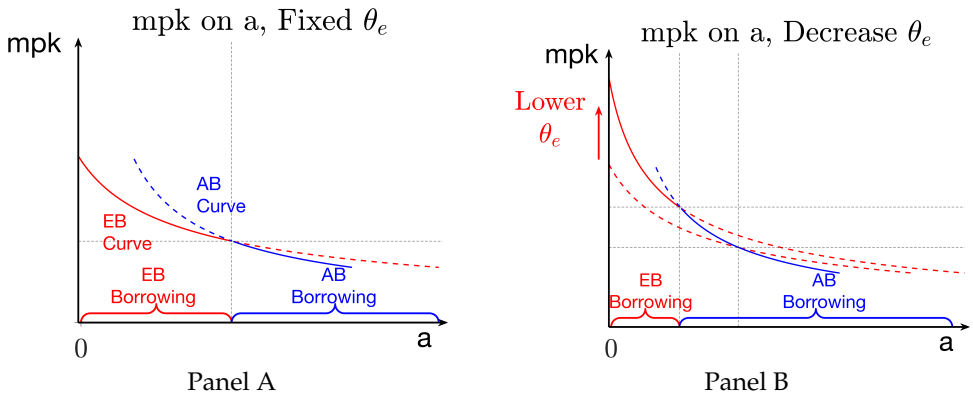


Figure 6 Constrained Firms' MPK on Wealth

Notes. Panel A of Figure 6 plots the MPK policy function on wealth a given productivity z and earnings-based financial frictions θ_e. The red earnings-based curve is the MPK for firms that issue earnings-based borrowing. The blue asset-based curve is the MPK for firms with asset-based borrowing. Panel B of Figure 6 presents the MPK policy function on wealth a given productivity z when the earnings-based constraint tightens. The red EB curve shifts up.

ical analysis focuses on the sample period surrounding the 2001 Enron scandal, from 1996 to 2003, which covers the issuance of approximately 140,000 syndicated loans and corporate bonds in the US. Backed by the Thomson Reuters international team, the SDC Platinum is the industry standard for information on corporate bond and syndicated loan new issues. A key advantage of this data set is that it contains issue descriptions by debt type, which allow me to categorize debt as earnings-based versus asset-based borrowing following Lian and Ma (2021).

2. *Compustat North America*. Compustat North America is a commonly used firm-level panel data set for financial reporting information. A key benefit of Compustat for my natural experiment is that it provides the names of the primary auditors for annual financial reports. It is therefore feasible to identify firms audited by Arthur Andersen prior to the 2001 Enron scandal as the treatment group. The treatment group is defined as firms audited by Arthur Andersen in the three years preceding the Enron-Arthur Andersen accounting scandal in 2001, as it is common practice to require the financial reports of the most recent three years when conducting financial analysis (U.S. Securities and Exchange Commission, 1999). Compustat also provides financial reporting items, such as sales, capital, employment, and industry classification. I use these financial report items to conduct the firm-level analysis on capital misallocation. The well-known disadvantage of using Compustat is its restriction to publicly listed firms.

I matched the SDC Platinum and Compustat North America using the 6-digit CUSIP and year. I obtain a matched data set (SDC-Compustat) recording the share of issued earnings-based borrowing and the marginal revenue product of capital (MRPK) measurements for over 8,000 firm-level panel observations from 1996 to 2003. The number of matched observations is substantially smaller than the full SDC Platinum sample for two reasons. First, the SDC Platinum is structured at the financial transaction level, so a single firm may issue multiple corporate debts within a given year. In other words, I now count firm-year, not transactions. Second, the analysis

is restricted to firms that can be matched to Compustat.

3. Share of Issued earnings-based Borrowing. The SDC Platinum provides information on the security type of the corporate debt issuance. Since the SDC Platinum only provides information on debt issuance but lacks data on the actual timing of repayments, it is not clean to estimate the share of earnings-based borrowing in the total stock of firms' debt holdings. The timing of repayments on corporate debt can be influenced by various common firm actions, including refinancing, early repayment, and default. In practice, I therefore focus on the flow measurement, the share of issued earnings-based borrowing in year t by firm i, rather than the stock measurement, for a more robust empirical analysis. The share of issued earnings-based borrowing in year t of firm i is expressed as the ratio of the amount of earnings-based borrowing issued in year t by firm i to the amount of total borrowing issued in year t by firm i.

The commonly used proxy for firm-level financial frictions in the borrowing constraint literature is the firm-level debt-to-capital ratio. This proxy is widely recognized in the literature as an imperfect measure, since not all firms reach their borrowing limits (Lian and Ma, 2021). The share of earnings-based borrowing is, however, theoretically justified by the simple model as a monotonically increasing function of the financial friction parameter for earnings-based borrowing, θ_e, in Online Appendix B.6. The static model abstracts from debt maturity and rollover. I therefore interpret the choice of earnings-based borrowing and asset-based borrowing for constrained firms as the contemporaneous financing flows needed to support the firm's equilibrium capital choice. Equivalently, the model can be interpreted as a one-period debt economy in which all borrowing is repaid and refinanced each period. Under this timing, the equilibrium stock of borrowing coincides with current-period issuance. So, the share of earnings-based borrowing in the model corresponds to the share of issued earnings-based borrowing in the data in the quantitative exercise. This match is not perfect due to the data limitations imposed by the debt issuance data from SDC Platinum.

4. Sales-to-Capital Ratio. I proxy the MRPK in year t of firm i by the ratio of sales to capital in year t of firm i while controlling for the industry-year fixed effects in the analysis. Under the assumption of a Cobb-Douglas production function, a common firm-level measure of the MRPK of firm i in industry s and year t is the elasticity estimate of industry s in year t from the control function approach in De Loecker, Eeckhout and Unger (2020), multiplied by the firm's sales-to-capital ratio in year t as

$$MRPK_{ist} = \hat{\alpha}_{st} \frac{Sale_{ist}}{Capital_{ist}},$$

where $\hat{\alpha}_{st}$ is the output elasticity of capital estimates from De Loecker, Eeckhout and Unger (2020) that vary on the industry-year level. Despite being a reasonable estimation method, the control function approach for estimating production function elasticities with Compustat data

is known to yield biased and inconsistent estimates.[2] To avoid these disadvantages, I control for variation in production function elasticities at the industry-year level by including industry-year fixed effects in the analysis.

Under the CES production function used in the quantitative analysis in Section 4, the output elasticity of capital multiplying the sales-to-capital ratio depends on the firm's capital-labor ratio. I therefore control flexibly for firms' predetermined input structure by interacting year fixed effects with pre-scandal log employment and pre-scandal log firm wealth. These controls allow firms with different pre-scandal input structures to follow different time paths, thereby absorbing differential trends associated with persistent variation in capital-labor structure.

3.1.2 Summary Statistics

Panels A and B of Figure 7 compare the distribution of the main outcome variable between the matched SDC-Compustat sample used in the empirical analysis and the broader Compustat North America sample. The comparison is conducted by 2-digit NAICS industry, both over the full sample period, 1996–2003, and during the Enron–Arthur Andersen episode, 2001–2002.

The matched sample closely tracks the broader Compustat sample. Panel A of Figure 7 shows that the industry-level distributions of the log sales-to-capital ratio are similar across the two samples, both in terms of medians and dispersion. Panel B of Figure 7 shows a similar pattern for annual changes in the log sales-to-capital ratio. The alignment is present not only over the full sample period, but also during the scandal period, which is the key window for the empirical design.

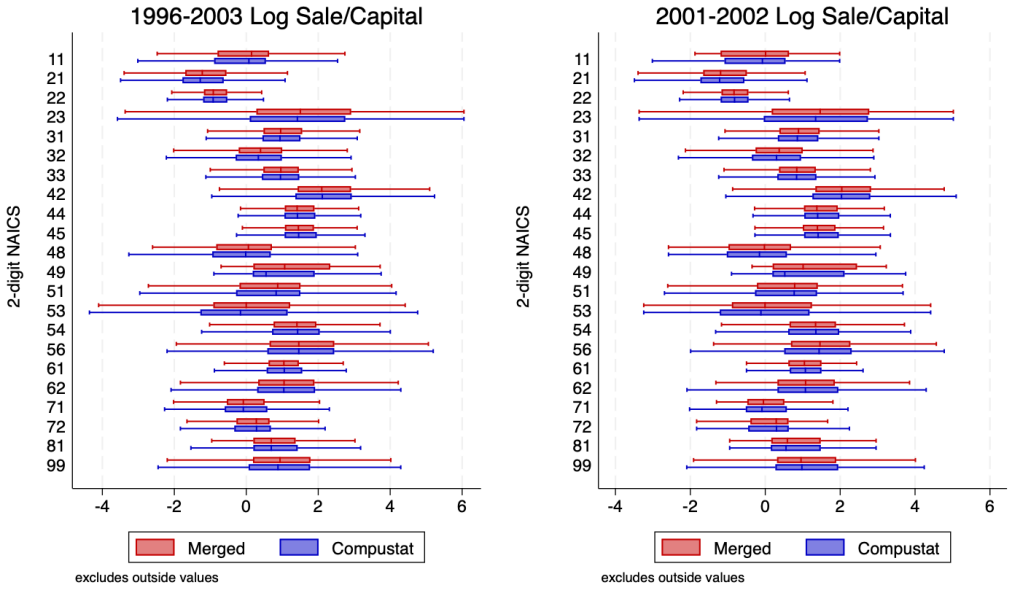
This evidence suggests that matching SDC debt issuance data to Compustat does not select a sample with systematically different sales-to-capital dynamics. The matched sample therefore preserves the relevant cross-industry variation in the outcome variable observed in the broader population of publicly listed firms. I use this matched SDC-Compustat sample in the subsequent empirical analysis. Table 1 reports summary statistics for the firm-level sample used in the baseline regressions.

3.2 Heterogeneity in Borrowing

This section documents two stylized facts about heterogeneity in firms' borrowing choices that are consistent with the theoretical framework in Section 2. First, quantile regressions of the share of earnings-based issuance on log TFP show that the estimated coefficient rises from 0.004 at the 10th percentile to 0.14 at the 99th percentile. The coefficient is statistically distinguishable from zero at the 5% level from the 60th percentile onward, indicating that the positive association

[2]This is acknowledged by De Loecker, Eeckhout and Unger (2020), and discussed by Bond et al. (2021). Compustat reports revenues and nominal input expenditures rather than physical quantities. Because production elasticities are defined with respect to input quantities, unobserved prices are loaded into the composite error term when one estimates the production function using these data. Firm-specific output prices and input prices contaminate the residual and are typically correlated with observed expenditures. Consequently, the resulting input-elasticity estimates are biased and inconsistent.

(A) Log Sales-to-Capital Ratio



(B) Annual Change in Log Sales-to-Capital Ratio

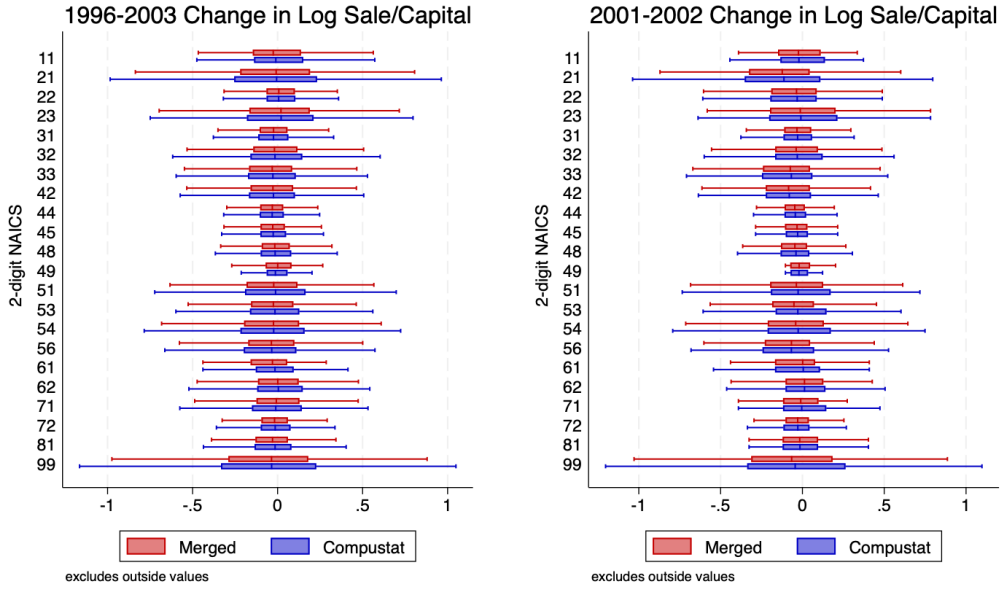


Figure 7 Summary Statistics on the Log Sales-to-Capital Ratio and Its Annual Change by Industry

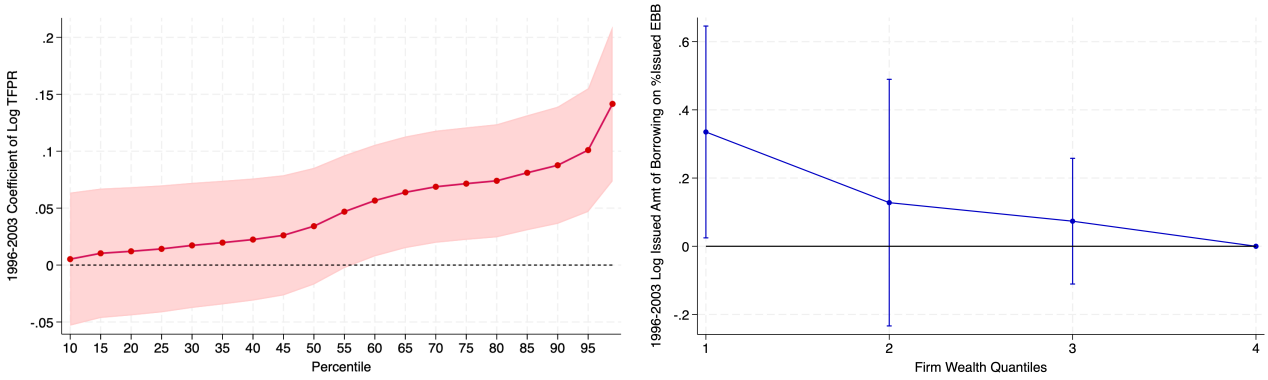
Notes. Panel A shows box plots of the log sales-to-capital ratio by industry, and Panel B shows box plots of its annual change. Industries are defined at the two-digit NAICS level. In each panel, the left-hand plot covers the full empirical sample period, 1996–2003, and the right-hand plot focuses on the Enron–Arthur Andersen episode, 2001–2002. Blue denotes the full Compustat North America sample, while red denotes the matched SDC–Compustat sample used in the main analysis.

Table 1 Summary Statistics

	Obs	Mean	SD	p25	p50	p75	Min	Max
Share of Issued Earnings-Based Borrowing	8340	0.34	0.40	0.00	0.09	0.72	0.00	1.00
Sales/Capital	50250	5.28	70.67	0.98	2.27	4.51	0.00	15203.60
Log Sales/Capital	50250	0.73	1.29	-0.02	0.82	1.51	-9.41	9.63
Change in Log Sales/Capital	45477	-0.02	0.39	-0.15	-0.02	0.10	-2.00	2.00
Capital (Million USD)	51274	1793.77	5363.81	12.51	76.89	574.99	0.04	37137.83
Total Amount of Issued Borrowing (Million USD)	51274	88.36	355.56	0.00	0.00	0.00	0.00	3800.00
Employment (Thousand)	51274	5.53	15.29	0.14	0.73	3.58	0.00	280.00
Intangible Assets (Million USD)	51274	721.35	1795.94	0.00	6.97	191.52	0.00	8359.85
Common Equity (Million USD)	51274	682.37	1897.15	12.39	80.76	389.66	-616.99	16977.01

Notes. This table reports summary statistics for firms in the merged Compustat North America and SDC Platinum dataset from 1996 to 2003. Columns report the number of observations, mean, standard deviation, 25th percentile, median, 75th percentile, minimum, and maximum at the firm-year level. Share of issued earnings-based borrowing is the ratio of the issued amount of earnings-based borrowing to the total amount of issued borrowing by the firm in the year. Sales/Capital is the sales-to-capital ratio. Log Sales/Capital is the logged sales-to-capital ratio. Capital is the total book value of property, plant, and equipment. Employment is the number of workers at the firm. Intangible assets are the firm's book value of intangible assets. Common equity is the firm's book value of common equity. All monetary values are deflated by a US GDP deflator using 2017 as the base year.

is concentrated in the upper part of the conditional distribution. Second, the regressions of log total borrowing on interactions between wealth-quantile indicators and the earnings-based share indicate that, among firms in the lowest wealth quartile, total borrowing increases with the share of earnings-based borrowing. This pattern is consistent with earnings-based borrowing, enabling greater access to credit when collateral is scarce in the model.



Panel A Panel B

Figure 8 Heterogeneity in Earnings-Based Borrowing

Notes. Panel A (left) reports quantile regressions of the share of issued earnings-based borrowing on log TFPR, as in equation (17). Panel B (right) reports coefficients on interactions between firm-wealth-quartile indicators and the share of issued earnings-based borrowing, as in equation (18); the fourth quartile is omitted. Both panels use the merged Compustat–SDC Platinum sample, 1996–2003. Bars show 95% confidence intervals based on standard errors clustered by firm.

Panel A of Figure 8 presents the quantile regression results of the form

$$\%\text{Issued Earnings-Based Borrowing}_{ist} = \beta \text{Log TFPR}_{ist} + \alpha_i + \tau_t + \epsilon_{ist}, \tag{17}$$

where i indexes firm, s indexes industry, t indexes year, α_i is the firm fixed effect, τ_t is the year fixed effect, and ϵ_{ist} is the error term. Standard errors are clustered by firm. Year t ranges from 1996 to 2003. $\%\text{Issued Earnings-Based Borrowing}_{ist}$ is calculated as the issued amount of earnings-based borrowing by firm i in industry s in year t divided by the total issued amount of borrowing by firm i in industry s in year t. The share of issued earnings-based borrowing is estimated by the SDC Platinum data. Log TFPR_{ist} is the logged TFPR of firm i in industry s in year t. I estimate log TFPR as the residual of the sales from inputs, which are capital and employment. The elasticities of capital and labor are estimated using the control function approach of Olley and Pakes (1996), with investment as a proxy for TFP. Following Olley and Pakes (1996), the production function is assumed to be of the Cobb-Douglas form with inputs of capital and labor. The elasticities are estimated separately by two-digit NAICS industry using the available Compustat observations in the estimation sample. Panel A of Figure 8 shows that the coefficient increases monotonically from 0.004 at the 10th percentile to 0.14 at the 99th percentile. The 95% confidence interval includes zero through the 55th percentile and excludes zero from the 60th percentile onward. Intuitively, more productive firms rely more heavily on earnings-based borrowing, consistent with Lemma 1 in Section 2.3.

Panel B of Figure 8 shows the regression results of the form

$$\begin{aligned} &\text{Log Total Amount of Issued Borrowing}_{ist} \\ &= \sum_{q=1}^{3} \delta_q \mathbb{1}(\text{Wealth Quantile} = q)_{ist} \cdot \%\text{Issued EBB}_{ist} \\ &+ \tilde{\delta}_1 \%\text{Issued EBB}_{ist} \\ &+ \sum_{q=1}^{3} \tilde{\delta}_{2q} \mathbb{1}(\text{Wealth Quantile} = q)_{ist} + \tilde{\alpha}_i + \tilde{\tau}_t + \varepsilon_{ist}, \end{aligned} \tag{18}$$

where i indexes firm, s indexes industry, t indexes year, $\tilde{\alpha}_i$ is the firm fixed effect, $\tilde{\tau}_t$ is the year fixed effect, and ε_{ist} is the error term. Standard errors are clustered by firm. $\text{Log Total Amount of Issued Borrowing}_{ist}$ is the logged sum of amounts of borrowing of all categories by firm i in industry s in year t. The dummy $\mathbb{1}(\text{Wealth Quantile} = q)_{ist}$ is equal to 1 if the total book value of common equity of firm i in industry s in year t is in the quantile of q. The dummy $\mathbb{1}(\text{Wealth Quantile} = q)_{ist}$ is normalized to be 0 for the fourth quantile. Panel B of Figure 8 shows that, relative to the omitted fourth wealth quartile, the interaction coefficient is 0.335 for the first wealth quartile, 0.128 for the second, and 0.074 for the third. The corresponding 95% confidence intervals are [0.025, 0.646], [-0.234, 0.490], and [-0.111, 0.258]. Thus, the interaction estimates decline with firm wealth, but only the estimate for the lowest wealth quartile is statistically

distinguishable from zero at the 5% level. The evidence therefore indicates that the positive association between earnings-based borrowing and total borrowing is concentrated among the lowest-wealth firms, consistent with the special case in equation (14) in Section 2.3.

3.3 Endogeneity and Instrument

Using the share of issued earnings-based borrowing as the independent variable to empirically study its effects on the dispersion of MPK raises concerns about endogeneity. For example, Demiroglu and James (2010) show that firms with higher EBITDA-to-sales ratios are subject to less restrictive debt-to-EBITDA covenants, suggesting that earnings-based financial constraints vary endogenously with sales, which is a key determinant of MRPK. The negative relationship between earnings-based financial frictions and sales, operating through firms' EBITDA-to-sales ratios, combined with the positive relationship between sales and the sales-to-capital ratio—my proxy for MRPK—biases the estimated effect downward. Benmelech (2024) also document an operational-flexibility cost of collateralization: restructuring pledged assets typically requires lender approval, potentially constraining firms' operations and reducing profitability, which is closely related to sales as well. The positive correlations between operational flexibility concerns and the share of issued earnings-based borrowing, as well as the sales-to-capital ratio, lead to upward biases in the estimates.

3.3.1 A Natural Experiment

I employ the Enron–Arthur Andersen accounting scandal as a natural experiment to study the causal effects of changes in earnings-based borrowing financial frictions on capital misallocation. The treatment group comprises firms that were audited by Arthur Andersen prior to the scandal.

1. *The Enron–Arthur Andersen Accounting Scandal as an Exogenous Shock on Earnings-Based Financial Frictions*. The accounting scandal introduces earnings-based financial frictions by undermining the credibility of income statements. [3] Income statements contain EBITDA on which the earnings-based borrowing relies. the scandal affects asset-based borrowing less because the de facto standards in the lending industry and those of the US government agency, the Office of the Comptroller of the Currency, require lenders to obtain an

[3] As a concrete example, EchoStar DBS Corporation's September 2002 Form S-4/A warned that Arthur Andersen's conviction and diminished ability to satisfy future claims could constitute a "negative factor in considering an investment decision with respect to future securities offerings." The filing further explained that, if the SEC ceased accepting Andersen-audited financial statements, EchoStar could be required to have another accounting firm re-audit those statements, delaying its access to public capital markets by roughly one to one-and-a-half months. The same filing makes clear that EchoStar's capacity to issue debt depended explicitly on information reported in its financial statements. More generally, its indentures prohibited the issuance of additional indebtedness unless the firm's pro forma indebtedness-to-cash-flow ratio remained no greater than 8.0 to 1. The denominator of this ratio was constructed from consolidated net income after adding back taxes, interest, depreciation, and amortization and was therefore effectively an EBITDA-based measure. Thus, the availability and regulatory usability of Andersen-audited financial statements directly affected the firm's access to borrowing whose permissible amount was determined by reported earnings (EchoStar DBS Corporation, 2002).

appraisal of collateral from a third-party appraiser. The appraisal provides the collateral's liquidation value. Unlike the book value of assets on the balance sheets, which are historic values in most cases, the core methods to derive the liquidation value are based on current or future values of assets [4]: (i) the market approach, using the market offerings and sales of comparable items in determining the value of a subject property; (ii) the cost approach, using the current replacement cost of a new item less the depreciation; (iii) the income approach, using the future monetary benefit to be received from the ownership of a property. The third-party evaluators are also not the major "Big 5" accounting firms, as the SEC staff has long provided independence guidance that limits auditors' ability to offer appraisal and valuation services to audit clients (Independence Standards Board, 1999). Since the liquidation value of collateral is derived from different methods than the book value of assets by third-party evaluators who are not accounting firms, the asset-based borrowing is comparatively insulated from the accounting shock.

The following gives more details about the accounting fraud. This accounting scandal broke out in 2001. Enron was an American energy, commodities, and services company. The company was the seventh largest publicly traded corporation in the United States before 2001 (US Congressional report, 2002). Enron's longtime auditor, Arthur Andersen, was a major accounting firm famous as one of the "Big Five". The main malpractices in the scandal include (Healy and Palepu, 2003): (i) Camouflaging the true financial conditions of Enron by hiding extensive undisclosed off-the-books activity. In some cases, Enron ignored the accounting standard requiring special-purpose entities to be consolidated with the sponsor firm's business when independent equity investors hold less than 3% of the assets. As a result, Enron's financial reports understated its liabilities, overstated its equity, and overstated its earnings. (ii) Abusing the mark-to-market accounting approach. Adopting the mark-to-market accounting approach requires assumptions in many aspects (Financial Accounting Standards Board, Emerging Issues Task Force, 1998, 2000), such as comparable transactions, spot and forward prices, and expected price volatility. Enron invests in projects that violate such assumptions due to questionable technical viability, market demand, and policy risks. (iii) Misrepresenting the downside risk in trading. Enron told investors it had hedged the downside risk in its own illiquid investments through transactions with special-purpose entities. The special purpose entities, in fact, hedged the risks using Enron's own stock and financial guarantees, which do not provide protection against downside risks. (iv) Allowing key employees to be partners of the special purpose entities.

[4]These sources value collateral using its current market or recoverable value, or the present value of its expected future cash flows, rather than its historical book value reported in financial statements. Appraisal Institute (1996) covers commercial and residential real estate; American Society of Farm Managers and Rural Appraisers and Appraisal Institute (2000) covers agricultural land and farm property; Alico (1989) covers machinery, equipment, and vehicles; Pratt, Reilly and Schweihs (2000) covers closely held businesses and ownership interests; Reilly and Schweihs (1999) covers patents, trademarks, software, and other intangible assets; Office of the Comptroller of the Currency (2000) covers the recoverable value of receivables and the liquidation value of inventory; Damodaran (1994) and Fabozzi (1996) cover publicly traded equities and fixed-income securities, respectively; and American Society of Appraisers (1989) covers art, antiques, jewelry, household contents, and other personal property.

The employees profited handsomely, raising questions about fulfillment of their fiduciary responsibility to Enron's shareholders.

After the scandal broke out in 2001, Arthur Andersen was found guilty of obstructing justice by destroying literally tons of paper documents and other electronic information related to the Enron inquiries in 2002. This indictment further explains that Arthur Andersen fully knew that these documents were relevant to Enron's scandal (U.S. Department of Justice, 2002). After Arthur Andersen's conviction, the accounting firm ceased practicing accounting in 2002 (U.S. Securities and Exchange Commission, 2002)[5].

2. *2SLS Framework*. The aim is to understand how capital misallocation responds to an exogenous shift in financial frictions affecting earnings-based borrowing within industries. Therefore, I want to find a shock to the earnings-based borrowing only and observe the impact on capital misallocation. As I have shown in the simple model (Online Appendix B.6), there is a positive one-to-one mapping between the share of earning based borrowing χ_{ist} and the financial frictions on the earning base borrowing θ_e, given the firm's wealth a_{ist} and productivity z_{ist}. Proposition 1 establishes that tightening the earnings-based borrowing constraint widens the dispersion of MPK by binding capital more stringently for high-MPK firms than for low-MPK firms, thereby raising MPK disproportionately at the high-MPK firms.

   The use of issuance shares is the flow-data analogue of a specification based on the unobserved stock share of earnings-based borrowing. Intuitively, new issuance changes the composition of a firm's debt stock, so the share of issued earnings-based borrowing proxies for changes in the underlying stock share of earnings-based borrowing. Hence, the coefficient β in equation (19) has the same interpretation as in the corresponding stock-share specification: it measures whether an increase in earnings-based borrowing has a disproportionately larger effect on sales-to-capital growth for firms with high pre-scandal sales-to-capital ratios. The assumptions and formal derivation are provided in Appendix A.1.

   Guided by this result, I measure capital misallocation with the coefficient β on the interaction between a high sales-to-capital indicator and the share of issued earnings-based borrowing in the following specification

$$\begin{aligned}\Delta \log \frac{Sales_{ist}}{Capital_{ist}} =& \beta \chi_{ist} \cdot \mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{is}}} + \eta \chi_{ist} \\ &+ \phi \mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{is}}} + \alpha X_{ist} + \delta_{st} + \epsilon_{ist},\end{aligned} \tag{19}$$

   where the dummy variable $\mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{ist}}} = 1$ if the sales-to-capital ratio of the firm i in

[5]To restore public confidence in the accounting sector, the US government enacted the Sarbanes-Oxley Act on 30 July 2002, which mandated audit-partner rotation. After Arthur Andersen quit its role as a public independent accountant in 2002, its former clients mostly switched to the "Big Four" (U.S. General Accounting Office, 2003). The natural experiment ended in 2003.

industry s is higher than the annual median of the sales-to-capital ratio in 2000 before the Enron-Arthur Andersen scandal, X_{ist} is a vector of characteristics of firm i in industry s in year t including a constant, δ_{st} is the industry-year fixed effect, ϵ_{ist} is the error term, and $E[\epsilon_{ist}] = E[X_{ist} \cdot \epsilon_{ist}] = 0$. Consistency by OLS would require $E[\chi_{ist} \cdot \mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{is}}} \cdot \epsilon_{ist}] = 0$ and $E[\chi_{ist} \cdot \epsilon_{ist}] = 0$, which is not a plausible assumption because the amount of earnings-based borrowing is endogenous to sales and capital.

The IV framework exploits cross-firm variation in χ_{ist} induced by exposure to the Enron shock. Define $\text{Treat}_{ist} = 1$ if firm i was audited by Arthur Andersen prior to the scandal and 0 otherwise. Firms with $\text{Treat}_{ist} = 1$ are the treatment group; those audited by other firms form the control. The scandal constitutes a shock to earnings-based borrowing because earnings-based covenants are tied to EBITDA, an income-statement item verified by external auditors. The collapse of Andersen's reputation led to heightened scrutiny and revisions of clients' audited EBITDA, reducing their effective earnings-based borrowing capacity. I use this differential change between treated and control firms to identify the effect on χ_{ist}.

I use the treatment dummy in a standard two-stage least squares (2SLS) framework. The first stage is

$$\begin{aligned} \chi_{ist} =& \theta_1 Treat_{ist} + \theta_2 Treat_{ist} \cdot \mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{is}}} \\ &+ \theta_3 \mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{is}}} + \sigma X_{ist} + \omega_{st} + \varepsilon_{ist}, \\ \chi_{ist} \cdot \mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{is}}} =& \tilde{\theta}_1 Treat_{ist} + \tilde{\theta}_2 Treat_{ist} \cdot \mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{is}}} \\ &+ \tilde{\theta}_3 \mathbb{1}^{\text{High } \frac{Sales_{is}}{Capital_{is}}} + \tilde{\sigma} X_{ist} + \tilde{\omega}_{st} + \tilde{\varepsilon}_{ist}. \end{aligned} \tag{20}$$

The second stage is equation (19). I describe the practical implementation of the instrument. First, I use firm-level panel data variation of firm i in industry s at year t. I define industries s using 3-digit NAICS codes. The panel regression spans two years, from 2001 to 2002, yielding 1724 observations. The natural experiment concluded in 2003 with the implementation of the Sarbanes-Oxley Act. This act mandates audit-partner rotation, which restored public confidence in accounting firms and ended my natural experiment. Second, the dependent variable, the sales-to-capital ratio is a proxy for $MRPK$, because i) Under a Cobb–Douglas production function, marginal revenue product of capital can be measured as $MRPK_{ist} = Output\ Elasticity\ on\ Capital_{st} \cdot \frac{Sales_{ist}}{Capital_{ist}}$. To accommodate a more general CES production function, under which the output elasticity of capital varies with the firm's factor mix, I also estimate specifications that control for pre-scandal firm characteristics interacted with year fixed effects. Specifically, I include pre-scandal log employment, pre-scandal log common equity, and pre-scandal log intangible assets, each interacted with year dummies. These controls absorb differential trends associated with predetermined differences in firms' factor mixes. ii) The literature commonly estimates the elasticity of capital using the control function approach on the industry-year level. The industry-year fixed

effect has absorbed the variation in the estimates of the elasticity of capital on the industry-year level. I only exploit within industry-year variation. The change in the log sales-to-capital is measured as the annual log change in the sales-to-capital ratio of firm i between year t and year $t-1$. Finally, the endogenous variable, the share of Issued earnings-based borrowing, is measured as the ratio of the amount of issued earnings-based borrowing by firm i in year t to the total borrowing by firm i in year t. Data on financial accounting items and NAICS are obtained from Compustat North America, and the share of issued earnings-based borrowing is calculated from SDC Platinum data.

3. *Summary Statistics on the Instrument*. Table 2 describes the variation in $Treat_{is}$, the treatment dummy of firm i in industry s. The mean is 0.18, with heterogeneity across firms. The standard deviation is 0.38, and the interquartile range is 0.00. I restrict the sample to observations from 1996 to 2003 in order to capture pre-event trends leading up to the Enron–Arthur Andersen scandal and the subsequent treatment period. The sample ends in 2003, shortly after the enactment of the Sarbanes–Oxley Act, which restored public confidence in the accounting profession and marked the end of the natural experiment.

Table 2 Summary Statistics on the Treatment Dummy

	Mean	Standard Deviation	Interquartile Range
	0.180	0.380	0.000
N Total		51103	
N Industry (3-digit NAICS)		99	

Notes. Columns report the mean, standard deviation, and interquartile range of the treatment dummy using the merged Compustat and SDC Platinum dataset from 1996 to 2003. The treatment dummy equals 1 if the firm was audited by Arthur Andersen from 1998 to 2000, and 0 otherwise.

4. *Identification Conditions*. IV consistency requires instrument relevance, which means treatment $Treat_{is}$ and χ_{ist} are correlated, and instrument validity, which means $Treat_{is}$ is uncorrelated with ϵ_{ist}. Relevance is checked by the first stage of the 2SLS. The treatment dummy $Treat_{is}$ is as good as random because, First, the treatment dummy is pre-determined. The treatment dummy equals 1 if firms were Arthur Andersen's clients in auditing before the scandal broke out. The outcome variable and the endogenous variable during the scandal, therefore, cannot affect the treatment status. Second, confounders are also not likely to have effects on the treatment dummy because: i) No anticipation of treatment before the scandal. By their nature, accounting frauds are intended to remain hidden from the public. Moreover, Enron was widely regarded as a highly successful firm before the scandal became public: it ranked 18th on the Fortune 500 list in 2000 (Fortune, 2000). In early 2001, before the scandal surfaced, Bethany McLean, the author of *The Smartest Guys in the Room: The Amazing Rise and Scandalous Fall of Enron*, interviewed financial professionals on Wall Street. At the time, they described Enron as "just the type of company you have to

believe in" (McLean and Elkind, 2004). ii) Parallel trends assumption. Arthur Andersen was a credible major accounting firm among the "Big Five". Even after Arthur Andersen quit accounting in 2002, Healy and Palepu (2003) and Eisenberg and Macey (2004) do not find that their clients systematically restate their financial statements differently from other firms. The pre-trends of event study specifications in Section 3.3.2 and the baseline balance checks in Table 3 test for the parallel trends assumption. The propensity score distribution by treatment status prior to the scandal in Section 3.3.2 also provides suggestive evidence of comparability between the treatment group and the control group.

The Enron–Arthur Andersen scandal had a larger impact on earnings-based borrowing than on asset-based borrowing, because earnings-based borrowing relies on book values from income statements, whereas asset-based borrowing depends on liquidation values of assets provided by a third-party appraiser. This fact partly validates the exclusion restriction assumption by insulating the asset-based financial frictions. It, nevertheless, does not rule out other channels through which the Enron shock can affect capital misallocation. To address this concern regarding the exclusion restriction, I provide two additional robustness checks in the next section: tests on the "zero earnings-based borrowing" firms and event-study tests on firms' equity issuance along both the intensive and extensive margins.

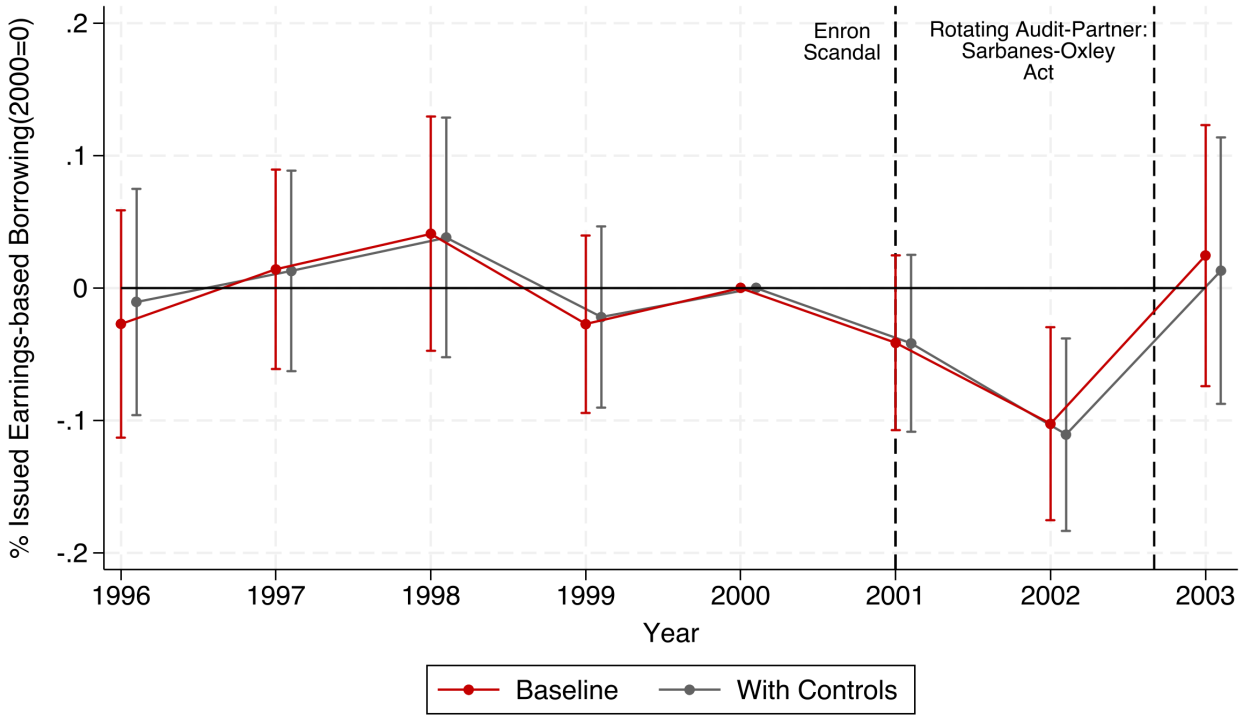
The natural experiment may raise concerns about violations of the Stable Unit Treatment Value Assumption (SUTVA), particularly if the shock to Andersen clients spilled over to other firms. I address this concern using the robustness tests on firms with zero earnings-based borrowing, discussed above. I return to the SUTVA assumption and its implications in the results section.

5. *Exclusion Restriction and SUTVA*: *i) Arthur Andersen's Clients with Zero Exposure to Earnings-Based Borrowings*. To assess the validity of the exclusion restrictions, it is useful to examine the effects of treatment status among "zero earnings-based borrowing" firms. I define "zero earnings-based borrowing" firms as those that issued zero earnings-based borrowing from 1996 to 2003. I interpret this definition of "zero earnings-based borrowing" as a deep feature of the firm, such that it does not issue earnings-based borrowing and is immune to shocks to earnings-based borrowing. Intuitively, if the reduced-form event study results of the treatment dummy on capital misallocation and the logged capital with the "zero earnings-based borrowing" firms do not provide significant coefficients, the evidence does not support the conclusion that the natural experiment violates the exclusion restrictions. This test on the "zero earnings-based borrowing" firms also partly addresses concerns over SUTVA. The small and statistically insignificant coefficient estimates provide no evidence of interference between units.

   ii) Arthur Andersen's Clients and Equity Issuance. I also examine whether the treatment affected firms through equity issuance rather than earnings-based borrowing. I estimate analogous event-study specifications using two outcomes: the log amount of equity issued, which captures the intensive margin, and an indicator for whether the firm issues

Figure 9 Event Study on the Share of Issued Earnings-Based Borrowing

Treatment: Audited by Arthur Andersen in 1998-2000
Coefficient on the interaction of the year dummy and the treatment dummy



Notes. This figure plots the estimates of the coefficient β_τ on the interaction of the year dummy and the treatment dummy in equation (21) using the merged dataset of Compustat and the SDC Platinum. The baseline specification controls for industry × year fixed effects. In the specifications with controls, I also include pre-treatment log employment, pre-treatment log common equity, and pre-treatment log intangible assets, each interacted with year dummies. Standard errors are clustered by auditor × year. The error bars are at the 95% confidence level.

equity, which captures the extensive margin. When the event-study coefficients are close to zero and statistically insignificant, the results do not support the view that the equity channel through which the Enron–Arthur Andersen scandal could have affected firms' capital inputs is quantitatively important.

3.3.2 Results

1. *Event Study Estimates of the First Stage*. A key step in my analysis is to identify the change in the endogenous variable due to the treatment. Using data on firm i in industry s over years t, I first present the results of event study specifications for the share of issued earnings-based borrowing. I estimate the coefficient for the regression of outcome variables on the interaction of the treatment dummy and the year dummy for every year, relative to 2000.

Specifically, I estimate:

$$\frac{b^+_{e,i,s,t}}{b^+_{i,s,t}} = \sum_{\tau \neq 2000} \beta_\tau \mathbb{1}^{t=\tau} \cdot Treat_{i,s} + \alpha_i + \delta_{s,t} + \nu_{i,s,t}, \tag{21}$$

where $\frac{b^+_{e,i,s,t}}{b^+_{i,s,t}}$ is the share of issued earnings-based borrowing; $\mathbb{1}^{t=\tau}$ is the year dummy, such that each β_τ coefficient represents the treatment effect of the Enron shock on the share of issued earnings-based borrowing in year τ; $Treat_{i,s}$ is the treatment dummy; α_i is the firm fixed effect; $\delta_{s,t}$ is the industry-year fixed effect; $\nu_{i,s,t}$ is the error term, clustered by auditor $\times$ year.

Figure 9 plots the estimates of β_τ, the difference across treatment and control in the share of issued earnings-based borrowing $\frac{b^+_{e,i,s,t}}{b^+_{i,s,t}}$ relative to the difference in 2000, along with the 95% confidence intervals. The set of pre-2000 β_τ coefficients is statistically indistinguishable from zero. This suggests that the parallel trends assumption is satisfied. The treatment group began decreasing its share of issued earnings-based borrowing in 2001, when the Enron scandal broke out. In 2002, Arthur Andersen's reputation in auditing was severely damaged, and as a result, the share of issued earnings-based borrowing by the affected firms decreased by 10.0 percentage points. For robustness, I also examine the treatment's effects on the ratio of earnings-based borrowing to EBITDA in Online Appendix A.4. Online Appendix A.6 shows that the treatment reduces the amount of earnings-based borrowing issued along the intensive margin. Online Appendix A.7 provides no evidence that the treatment induced firms that had issued earnings-based borrowing before the Enron shock to switch to asset-based borrowing.

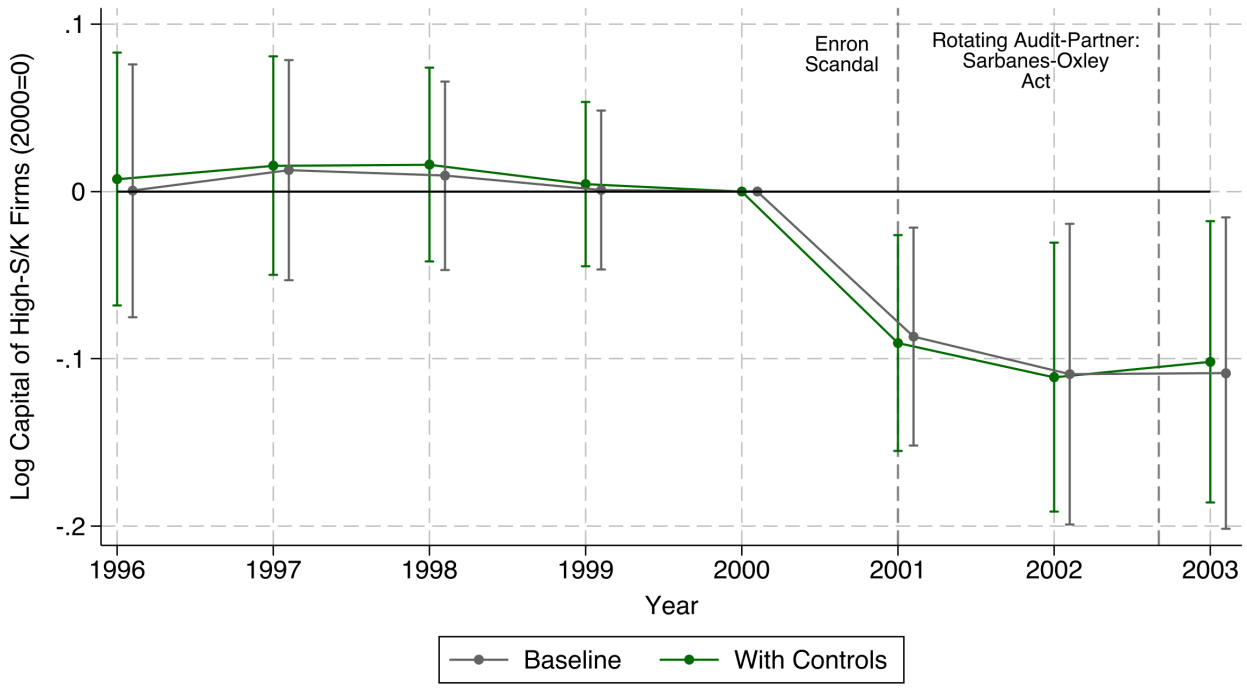
2. *Reduced-form event-study estimates*. To study how earnings-based financial frictions affect capital allocation, I estimate the following event-study specification:

$$\begin{aligned} Y_{i,s,t} = & \sum_{\tau \neq 2000} \widetilde{\beta}_\tau \mathbb{1}^{High\ S/K}_{i,s} \mathbb{1}^{t=\tau} Treat_{i,s} \\ & + \sum_{\tau \neq 2000} \widetilde{\gamma}_{1\tau} \mathbb{1}^{t=\tau} Treat_{i,s} \\ & + \sum_{\tau \neq 2000} \widetilde{\gamma}_{2\tau} \mathbb{1}^{t=\tau} \mathbb{1}^{High\ S/K}_{i,s} + \widetilde{\alpha}_i + \widetilde{\delta}_{s,t} + u_{i,s,t}. \end{aligned} \tag{22}$$

Here, firms are indexed by i, industries by s, and years by t. The outcome $Y_{i,s,t}$ is, depending on the exercise, log capital, log sales-to-capital, the change in log sales-to-capital, or log sales. The indicator $\mathbb{1}^{High\ S/K}_{i,s}$ identifies firms whose pre-shock sales-to-capital ratio is high, and $Treat_{i,s}$ identifies firms in the relevant treatment group. Thus, $\widetilde{\beta}_\tau$ is the differential treatment effect for high-sales-to-capital firms in year τ relative to the omitted year 2000. Firm fixed effects are denoted by $\widetilde{\alpha}_i$, industry-by-year fixed effects by $\widetilde{\delta}_{s,t}$, and the error term by $u_{i,s,t}$.

Figure 10 Event Study on the Logged Capital for High Sales-to-Capital Ratio Firms

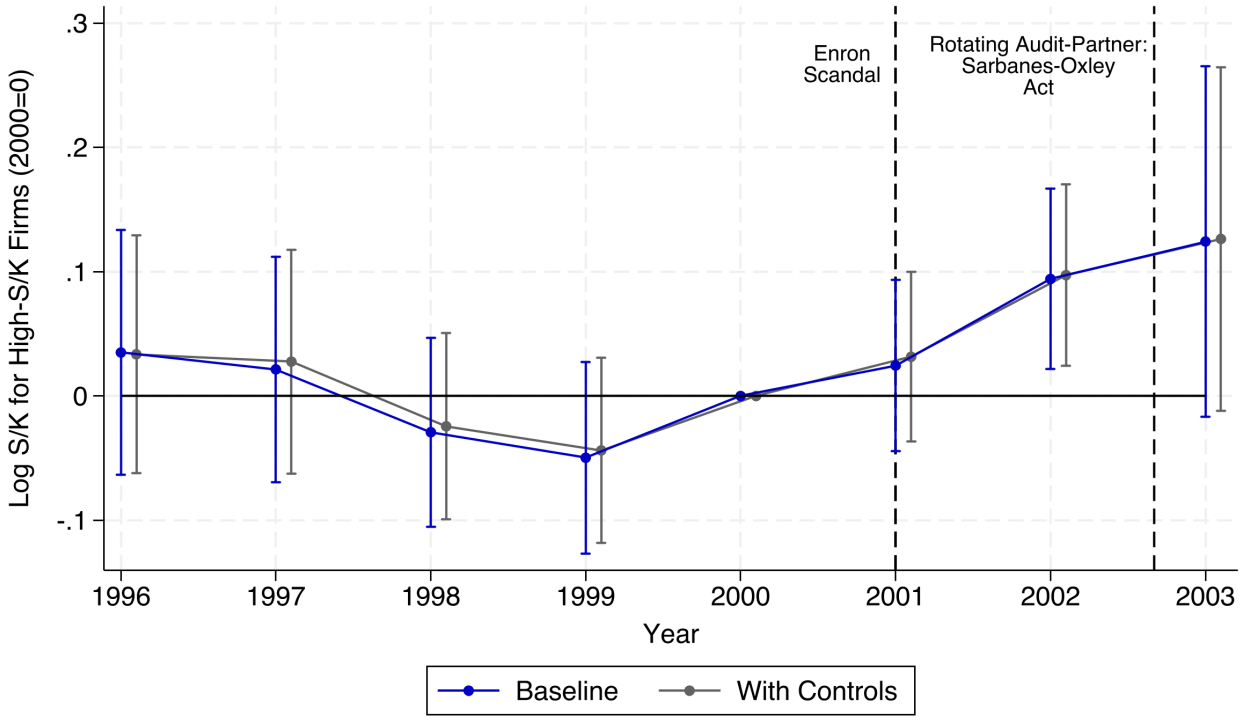
Treatment: Audited by Arthur Andersen in 1998-2000
Coefficient on the interaction of the year dummy, high Sales-to-Capital ratio dummy and the treatment dummy



Notes. This figure plots the estimates of coefficient $\widetilde{\beta}_\tau$ on the interaction of the year dummy, the high sales-to-capital ratio dummy and the treatment dummy when the outcome variable $Y_{i,s,t}$ is logged capital in equation (22). The baseline specification controls for industry × year fixed effects. In the specifications with controls, I also include pre-treatment log employment, pre-treatment log common equity, and pre-treatment log intangible assets, each interacted with year dummies. The sample is a merged dataset of Compustat and SDC Platinum, covering the period from 1996 to 2003. Standard errors are clustered by auditor × year. The error bars are at the 95% confidence level.

Figure 11 Event Study on the Logged Sales-to-Capital Ratio for High Sales-to-Capital Ratio Firms

Treatment: Audited by Arthur Andersen in 1998-2000
Coefficient on the interaction of the year dummy, high sales/capital ratio dummy, and the treatment dummy

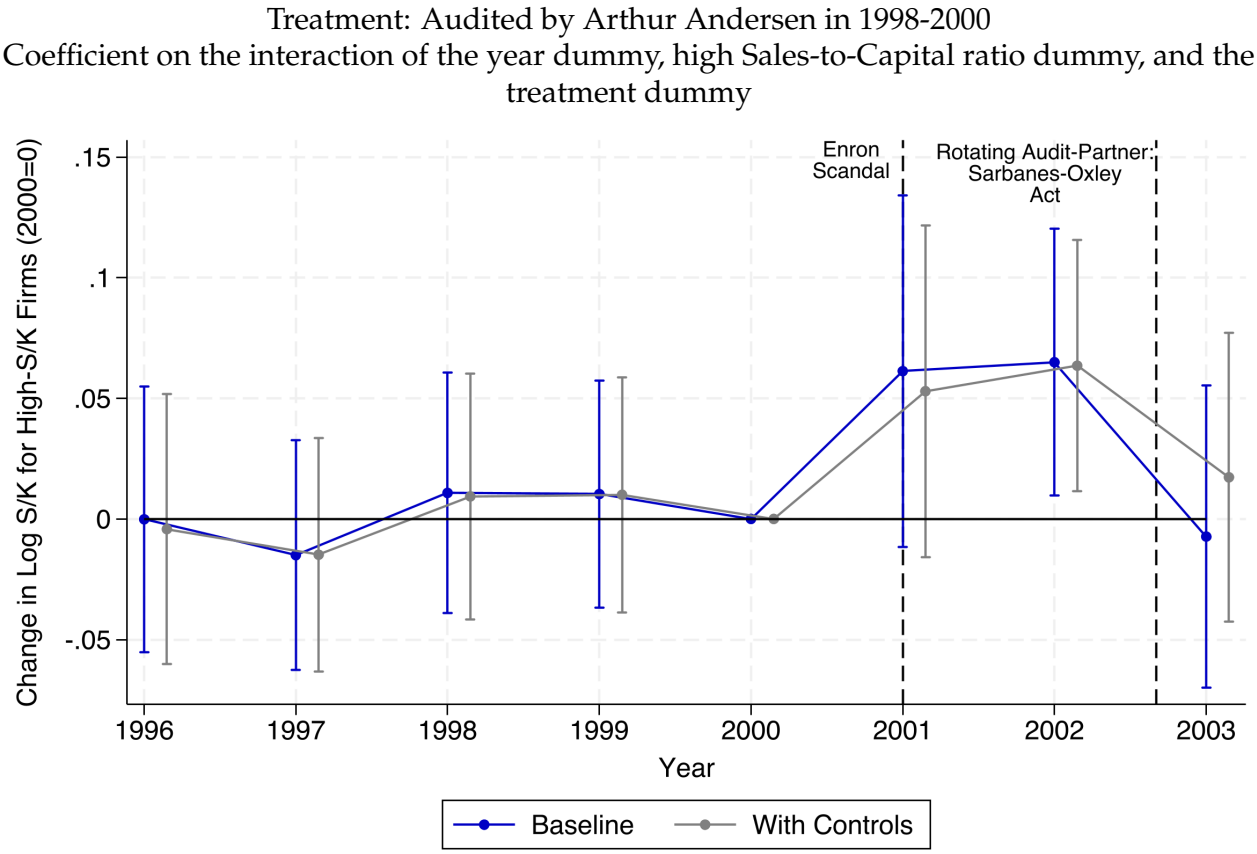


Notes. This figure plots the estimates of coefficient $\widetilde{\beta}_\tau$ on the interaction of the year dummy, the high sales-to-capital ratio dummy and the treatment dummy when the outcome variable $Y_{i,s,t}$ is the logged sales-to-capital ratio in equation (22). The baseline specification controls for industry × year fixed effects. In the specifications with controls, I also include pre-treatment log employment, pre-treatment log common equity, and pre-treatment log intangible assets, each interacted with year dummies. The sample is a merged dataset of Compustat and SDC Platinum, covering the period from 1996 to 2003. Standard errors are clustered by auditor × year. The error bars are at the 95% confidence level.

To test whether the dispersion in log sales-to-capital ratio is driven by lower capital inputs, as Proposition 1 suggests, I examine the treatment effects on capital inputs across firms. In Figure 10, I plot the coefficient $\widetilde{\beta}_\tau$, the log-point difference in capital by the high-sales-to-capital-ratio firms between the treatment group and the control group relative to 2000, and the 95% confidence intervals. The pretrends before 2000 provide no evidence against the parallel trends assumption with coefficients $\widetilde{\beta}_\tau$ close to zero and statistically insignificant. Figure 10 shows a statistically significant, persistent decline of 11.0 log points in the capital stock of high-sales-to-capital treatment firms relative to controls, continuing even after the natural experiment ended in 2003 by the Sarbanes–Oxley Act. Figure 6 in Online Appendix A.3 shows that the Enron shock does not increase the dispersion in log sales-to-capital ratio by increasing sales.

The main analysis of the 2SLS specification focuses on changes in the logged sales-to-capital

Figure 12 Event Study on the Growth of Sales-to-Capital Ratio for High Sales-to-Capital Ratio Firms



Notes. This figure plots the estimates of coefficient $\widetilde{\beta}_\tau$ on the interaction of the year dummy, the high sales-to-capital ratio dummy and the treatment dummy when the outcome variable $Y_{i,s,t}$ is the change in the log sales-to-capital ratio in equation (22). The control variables are the change in logged employment, the change in logged intangible assets, and firm age. The sample is a merged dataset of Compustat and SDC Platinum, covering the period from 1996 to 2003. Standard errors are clustered by auditor × year. The error bars are at the 95% confidence level.

ratio, given the data limitation that SDC Platinum provides only issuance-level corporate debt data. Issuance of debt is a component of capital flows. The share of issued earnings-based borrowing is essentially the composition of debt flows. The flows of capital correspond to the change in the logged sales-to-capital ratio. To provide a measure of capital misallocation caused by the treatment, Figure 11 plots the coefficient $\widetilde{\beta}_\tau$, the difference in log sales-to-capital ratio of the high-sales-to-capital-ratio firms versus the low-sales-to-capital-ratio firms between the treatment and the control group relative to 2000, with the 95% confidence intervals. This event study also satisfies the parallel trends assumption. Among high-sales-to-capital-ratio firms, the treatment group has an 8.9 percent higher sales-to-capital ratio compared to the control group in 2002.

For robustness of the main specification, Figure 12 plots the estimates of $\widetilde{\beta}_\tau$, the difference of the change in logged sales-to-capital ratio across treatment status in the high-sales-to-

capital-ratio firms versus the low-sales-to-capital-ratio firms relative to 2000 and the 95% confidence intervals. The parallel trends assumption is also satisfied, as the pre-2000 estimates of $\widetilde{\beta}_\tau$ are close to zero and statistically insignificant. The change in the logged sales-to-capital ratio of the high-sales-to-capital-ratio firms in the treatment group peaked in 2002 at 6.5 percentage points. This estimate is not statistically distinguishable from the main two-stage least squares estimate.

Table 3 Baseline Balance

	Control	Treatment	p-value	Sample size
Log Sales	7.350	7.269	0.391	1147
Log Employment	1.819	1.766	0.564	1147
Log Costs of Goods Sold	6.898	6.841	0.566	1147
Log Common Equity	6.242	6.149	0.396	1104
Stockholders Equity	7.028	7.061	0.899	125
Log Assets	7.382	7.322	0.516	1147
Log Capital	6.491	6.389	0.391	1147
Log Debt	6.058	6.116	0.555	1147
Log Intangible Assets	5.289	5.410	0.274	1147
Firm Age	35.625	38.594	0.272	685
Sales/Capital	4.836	5.200	0.624	1147
Leverage	0.371	0.383	0.336	1147
Net Leverage	0.324	0.344	0.132	1147
Short-term Debt/Assets	0.062	0.052	0.097	1147
Cash/Assets	0.048	0.040	0.037	1147
EBITDA/Assets	0.140	0.127	0.021	1146
EBITDA/Sales	0.148	0.155	0.414	1146
Δ Log Sales	0.328	0.318	0.873	854
Δ Log Capital	0.288	0.405	0.190	851
Δ Log Sales/Capital	0.044	0.028	0.581	851
Tobin's Q	1.649	1.532	0.153	1039
Investments/Capital	0.142	0.147	0.492	1129
Log Issued Amount of Debt	5.603	5.552	0.537	1147
Share of Issued Asset-based Borrowing	0.005	0.004	0.919	1147
Share of Issued Earnings-based Borrowing	0.337	0.335	0.923	1147

Notes. Columns (1)–(2) report unweighted means for the control and treatment groups, respectively. Column (3) reports the p-value from a test of equality of the two means reported in columns (1)–(2), estimated using a regression with robust standard errors. Column (4) reports the number of observations with nonmissing values. The sample covers the pre-scandal period from 1998 to 2000.

The pre-trends in the event studies in this section and the baseline balance in Table 3 suggest that the treatment group and the control group are comparable prior to the Enron shock. Table 3 examines baseline balance between the treatment and control groups. Columns (1) and (2) report the pre-treatment means of firm characteristics for control and treated firms, respectively, while column (3) reports p-values from tests of equality of means using

heteroskedasticity-robust standard errors. The two groups are similar across a broad set of baseline characteristics, including firm size, employment, costs, equity, assets, capital, intangible assets, age, leverage, cash holdings, profitability, growth rates, Tobin's Q, investment, debt issuance, and the composition of borrowing. The table shows that firms in the control group have higher short-term debt-to-assets, cash-to-assets, and EBITDA-to-assets ratios. These differences do not support the view that Andersen clients in the treatment group engaged in more aggressive financial reporting. Treated firms exhibit higher capital growth but lower growth in the sales-to-capital ratio, although neither difference is statistically significant. None of the remaining differences is economically large or statistically significant at conventional levels. These patterns suggest that treated and control firms were broadly comparable along observable firm characteristics before the shock. Consistent with this absence of pre-existing differences, Healy and Palepu (2003) and Eisenberg and Macey (2004) find no evidence that Andersen clients were more likely to restate their financial statements relative to clients of other audit firms. Although there is no evidence that former Andersen clients systematically engaged in aggressive financial reporting, subsequent studies suggest that their reporting became, if anything, more conservative than that of clients of other audit firms following Andersen's collapse (Cahan and Zhang, 2006; Blouin, Grein and Rountree, 2007). Overall, the evidence supports treating the scandal as an exogenous shock to Andersen clients relative to comparable firms audited by other large accounting firms.

I present event studies on firms with zero earnings-based borrowing to address concerns about the exclusion restriction and SUTVA in Online Appendix A.2.1. I estimate equation (22) on this subsample using three outcomes. Figure 1 reports the change in log sales-to-capital, Figure 2 reports log capital, and Figure 3 reports log sales-to-capital. In all three cases, the differential estimates for high-sales-to-capital firms are close to zero and statistically insignificant. These reduced-form results provide no evidence of either a violation of the exclusion restriction or interference between units. Because the placebo specifications include industry-by-year fixed effects, they compare Andersen and non-Andersen firms within the same industry-year, alleviating concerns that differential post-Enron industry shocks drive the estimates.

Online Appendix A.2.2 presents event-study evidence on equity issuance as an additional check on concerns regarding the exclusion restriction. I estimate equation (22) using two outcome variables: the log amount of equity issued, which captures the intensive margin, and an indicator for whether the firm issues equity, which captures the extensive margin. Figure 4 shows that the treatment effect on the log amount of equity issued is economically small and statistically weak. Figure 5 shows that the treatment effect on the probability of issuing equity is also close to zero and statistically insignificant throughout the post-period. These event-study results provide no evidence that the Enron–Arthur Andersen shock materially affected treated firms' access to equity finance. They therefore mitigate

the concern that the reduced-form effects are driven by a broad deterioration in external financing conditions rather than by the earnings-based borrowing channel. The literature finds that debt finance and equity finance are used with systematically different intensity by different kinds of firms (Strebulaev and Yang, 2013; Minton and Wruck, 2001; Lemmon, Roberts and Zender, 2008; Faulkender and Petersen, 2006; Rajan and Zingales, 1995; Frank and Goyal, 2009; Carpenter and Petersen, 2002; Brown, Fazzari and Petersen, 2009; Falato et al., 2022; Bates, Kahle and Stulz, 2009; Hall, 2002; Fama and French, 2005; Leary and Roberts, 2010).

3. *Main Estimates*. The event studies in the previous section are consistent with the notion that the Enron shock affected capital misallocation by reducing earnings-based borrowing and firms' capital inputs. I report the results of the 2SLS in equations (20) and (19), which provide the standard errors of the structural parameter estimates. The baseline specification includes industry×year fixed effects to isolate within-industry-year variation in MRPK. I cannot include firm fixed effects in the 2SLS because the treatment indicator is time-invariant within firms and thus perfectly collinear with the firm fixed effects.

   Table 4 reports regression results for the first-stage relationships and the IV estimates. Panels A and B report the two first-stage regressions: there are two clear negative relationships: (i) the treatment indicator and the share of issued earnings-based borrowing; (ii) the interaction of the treatment indicator and the high sales-to-capital ratio dummy, and the interaction of the share of issued earnings-based borrowing and the high sales-to-capital ratio dummy. The Sanderson-Windmeijer F-statistics confirm that the treatment is not a weak instrument for the share of issued earnings-based borrowing, and the interaction of the treatment and the high sales-to-capital ratio dummy is also not a weak instrument for the interaction of the share of issued earnings-based borrowing and the high sales-to-capital ratio dummy. I report the individual F statistics for the 2SLS with interaction terms in each first-stage regression, following Alsan et al. (2025) and Autor et al. (2024). Column (1) in Panels A–C of Table 4 presents the baseline results. In the baseline results, I controlled for the industry × year fixed effects.

   Table 4, Panel C reports the IV estimates. An exogenous 10-percentage-point decline in the share of issued earnings-based borrowing induced by the Enron shock raises the growth rate of the sales-to-capital ratio by 7.7 percentage points more for high- than for low-sales-to-capital firms. Intuitively, when the MRPK of the high-MRPK firms grows at a faster rate than the low-MRPK firms, the gap in MRPK between the high-MRPK firms and the low-MRPK firms is enlarged since the high-MRPK firms have high starting points in MRPK.

4. *Robustness*. Table 4 reports a set of robustness checks. Panels A and B present the stability of the first-stage estimates as control variables are added one at a time to the specification. Column (2) controls for pre-treatment log common equity interacted with year dummies. Column (3) adds pre-treatment log intangible assets interacted with year dummies, and

Table 4 The Enron Shock and the Share of Issued Earnings-Based Borrowing

	(1)	(2)	(3)	(4)
Panel A: First Stage. Dependent variable: $\%EBB_{i,t}$				
$Treat_{i,s}$	-0.105***	-0.104***	-0.106***	-0.105***
	(0.022)	(0.022)	(0.023)	(0.023)
$Treat_{i,s} \times$ High $S/K_{i,s}$	0.056	0.054	0.057	0.056
	(0.044)	(0.043)	(0.043)	(0.043)
Sanderson–Windmeijer F	23.59	24.40	23.01	22.46
Panel B: First Stage. Dependent variable: $\%EBB_{i,t} \times$ High $S/K_{i,s}$				
$Treat_{i,s}$	0.004	0.005	0.003	0.004
	(0.004)	(0.004)	(0.005)	(0.005)
$Treat_{i,s} \times$ High $S/K_{i,s}$	-0.061**	-0.062**	-0.061**	-0.061**
	(0.029)	(0.029)	(0.028)	(0.029)
Sanderson–Windmeijer F	36.85	28.32	28.28	24.89
Panel C: IV. Dependent variable: $\Delta \log(Sales/Capital)_{i,t}$				
$\%EBB_{i,t} \times$ High $S/K_{i,s}$	-0.765*	-0.775*	-0.782*	-0.752*
	(0.427)	(0.428)	(0.432)	(0.432)
Wild bootstrap p-value	0.025	0.049	0.069	0.064
$\%EBB_{i,t}$	0.040	0.043	0.049	0.044
	(0.146)	(0.147)	(0.146)	(0.152)
Wild bootstrap p-value	0.257	0.930	0.862	0.849
log Common $\text{Equity}_{\text{pre}} \times$ Year FE		✓	✓	✓
log Intangible $\text{Assets}_{\text{pre}} \times$ Year FE			✓	✓
log $\text{Employment}_{\text{pre}} \times$ Year FE				✓
Industry × Year FE	✓	✓	✓	✓
Observations	1724	1724	1724	1724

Notes. This table reports the 2SLS estimates of Section 3.3.1 on the merged Compustat–SDC Platinum sample for 2001–2002. $\%EBB_{i,t}$ denotes the share of firm i's debt issuance in year t classified as earnings-based, and High $S/K_{i,s}$ indicates a sales-to-capital ratio above the industry median in 2000. Panels A and B report the two first-stage regressions in equation (20); Panel C reports the IV estimates from equation (19). Column (1) includes industry × year fixed effects only; columns (2)–(4) add predetermined controls interacted with year fixed effects as indicated. Firm fixed effects are excluded because $Treat_{i,s}$ is time-invariant within firms. Standard errors, clustered by auditor × year, are in parentheses; wild bootstrap p-values adjusted for the small number of clusters are reported for Panel C. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Column (4) further includes pre-treatment log employment interacted with year dummies. The magnitude of the treatment effects remains stable across specifications. In Panel A, the treatment reduces the share of issued earnings-based borrowing by about 10.5 percentage points across all specifications, with the coefficient statistically significant at the 1% level. The first-stage coefficient on the interaction between the treatment dummy and the high-sales-to-capital-ratio dummy, which instruments for the interaction between the share of issued earnings-based borrowing and the high-sales-to-capital-ratio dummy, is also stable at around -6.1 percentage points and statistically significant at the 5% level. Across Panels A and B, the Sanderson–Windmeijer F-statistics range from 22.46 to 36.85.

Table 4, Panel C reports the IV estimates across specifications. Columns (2)–(4) sequentially add pre-treatment log common equity, intangible assets, and employment, each interacted with year dummies. The coefficient on %EBB interacted with the High S/K indicator remains stable at approximately -0.77 and is statistically significant at the 10% level.

The Online Appendix A.5 reports the placebo tests. The placebo tests use the "Big Four" auditors before the Enron-Arthur Andersen scandal as the treatment. The treatment effect of the "Big Four"s on firms is small in scale and statistically insignificant. Before the Enron-Arthur Andersen scandal, Arthur Andersen and the current "Big Four" formed the "Big Five" accounting firms.

Online Appendix A.7.1 further examines whether the results are driven by firms in industries similar to Enron. I define firms classified in two-digit NAICS industry 42—the industry in which Enron operated—during 1998–2000 as a placebo treatment group and re-estimate the event-study specifications. The coefficients for earnings-based borrowing, capital, the sales-to-capital ratio, and its growth are statistically insignificant and show no systematic post-Enron pattern. These results provide no evidence that the main findings are driven by differential shocks to energy or trading-related firms after Enron.

4 Quantitative Analysis

This section presents a direct extension of the simple model above, implementing quantitative analysis to clarify the importance of earnings-based borrowing for capital allocative efficiency. Calibrating the tightening on the earnings-based constraint to the Enron shock, I find that a tightening of earnings-based borrowing generates a substantially larger loss in TFP than a commensurate tightening of the asset-based constraint.

4.1 The Model

This section augments the simple model to improve quantitative fit. In particular, I assume (i) wealth a and productivity z are jointly lognormal; (ii) a CES production technology with labor inputs; (iii) a borrowing constraint, the limit of which equals the sum of an asset-based

component and an earnings-based component; and (iv) a convex cost of borrowing. This section outlines the key adapted ingredients.

Joint distribution of firm wealth and productivity $G(a, z)$ has material implications for the effects of tightening the earnings-based borrowing constraint versus tightening the asset-based borrowing constraint. In particular, the correlation between log wealth $\log a$ and log productivity $\log z$ determines whether earnings-based borrowing improves capital misallocation relative to asset-based borrowing. Intuitively, when the correlation between earnings and productivity is larger than the correlation between assets and productivity, the earnings-based borrowing is more efficient than the asset-based borrowing. As shown in Figure 1, log EBITDA rises almost one-for-one with log TFPR: the estimated coefficient is 0.92 and is statistically significant. By contrast, the correlation between log firm wealth and log TFPR is only 0.17 (Table 5)[6]. Empirically, firm size and productivity exhibit right-skewed, heavy-tailed distributions; accordingly, the literature commonly models them as lognormal. Following this convention, I assume that firm wealth a and productivity z are jointly lognormal (allowing for arbitrary correlation).

Complementarity between capital and labor is important for misallocation. The degree of complementarity affects the output, especially when there are frictions in the factor markets. The CES production function differs from the Cobb-Douglas production function in that it allows for stronger complementarity between capital and labor, with the elasticity of substitution being less than 1. Assume that the CES production technology employs k units of capital and l units of labor.

$$y = f(z, k, \ell) = z\left[\alpha^{\frac{1}{\sigma}} k^{\frac{\sigma-1}{\sigma}} + (1-\alpha)^{\frac{1}{\sigma}} \ell^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}\eta}, \tag{23}$$

where z is the firm-level productivity, α is the capital share, σ is the elasticity of substitution, and η is the span-of-control parameter. Workers are assumed to be hand-to-mouth and supply labor. Entrepreneurs still have log utility (1).

Borrowing costs are a common source of dispersion in the marginal product of capital. Let borrowing be $b = \max\{k - a, 0\}$. Borrowing entails the convex cost

$$C(b) = \frac{\phi}{2} b^2 = \frac{\phi}{2} \max\{k - a, 0\}^2, \tag{24}$$

where $\phi \geq 0$ governs the curvature of borrowing costs. The specification captures financing costs that rise more than proportionally with borrowing. Since $C'(b) = \phi b$, larger borrowers face higher marginal external-finance costs. The entrepreneur's budget constraint becomes

$$c = f(z, k, \ell) - rk - w\ell - \frac{\phi}{2} \max\{k - a, 0\}^2 + (1 + r)a. \tag{25}$$

[6] I also estimate the same regression specification as in Figure 1, using log TFPR as the dependent variable and log firm wealth as the independent variable, with standard errors clustered by firm and with firm and year fixed effects. The estimated coefficient on log firm wealth is 0.12 and is statistically significant. Because the TFPR measure in Figure 1 is estimated under a Cobb–Douglas production function, I repeat the regression using TFPR calculated under the CES production function employed in the quantitative analysis. The estimated coefficient on log EBITDA remains large, at 0.54, and is statistically significant.

The entrepreneur consumes firm profits, net of capital and labor costs, plus the gross return on firm wealth, less the quadratic cost of borrowing.

Fractional shares of issued Earnings-Based borrowing between 0 and 1 exist to a relatively large extent in the data, while the simple model only allows discrete values of the share of issued earnings-based borrowing of 0 or 1. The additive borrowing limits also imply an intensive-margin decline in earnings-based borrowing issuance among firms that had previously issued earnings-based debt when earnings-based financial frictions tighten, consistent with the event-study evidence in Online Appendices A.6 and A.7. Therefore, I assume that the firm's capital input k is the sum of the firm's earnings-based borrowing b_e, asset-based borrowing b_a, and wealth a,

$$k = b_e + b_a + a. \tag{26}$$

The earnings-based borrowing limit is assumed to be proportional to earnings (Drechsel, 2023)

$$b_e \leq \theta_e[f(z,k,l) - wl], \tag{27}$$

and the asset-based borrowing limit is assumed to be proportional to capital

$$b_a \leq \theta_a k. \tag{28}$$

Entrepreneurs still maximize the value of utility from consumption (1) subject to the budget constraint (25). Define the profit function

$$\tilde{\Pi}(a,z) = \max_{k,\ell} \left\{ f(z,k,\ell) - rk - w\ell - \frac{\phi}{2}\max\{k-a,0\}^2 \text{ s.t. } k - a \leq \theta_e[f(z,k,\ell) - w\ell] + \theta_a k \right\}. \tag{29}$$

The budget constraint (25) can be rewritten as

$$c = \tilde{\Pi}(a,z) + (1+r)a. \tag{30}$$

The capital market and labor market clear

$$\int a dG(a,z) = \int k(a,z) dG(a,z), \tag{31}$$

$$\int \ell(a,z) dG(a,z) = L. \tag{32}$$

Simulation of the model captures the effect of the Enron shock to efficiency by estimating the model for the year 2000 and the year 2002. Moments of the firm-level micro data in the US in the year 2000 discipline asset-based financial frictions, pre-scandal earnings-based financial frictions, the borrowing-costs parameter, and the distribution of firm wealth and productivity. Mid-scandal earnings-based financial frictions are calibrated to US firm-level micro data from the year 2002. I matched the pre-scandal state to data in the year 2000 and the new mid-scandal

state to that of the year 2002, because the Enron-Arthur Andersen scandal broke out in the year 2001 and peaked in the year 2002, as demonstrated by the results of event studies in Section 3.3.2.

4.2 Calibration

Distribution of firm-level wealth a and TFP z. The distribution of firm wealth a and firm TFP z is informed by the moments of firm-level microdata from Compustat North America in 2000, prior to the Enron-Arthur Andersen scandal. Since the literature on misallocation focuses on the within-industry dispersion of marginal products, I absorb the industry (3-digit NAICS) × year fixed effect from the firm-level log TFP, $\log z$, and the log firm wealth, $\log a$, before estimating the moments (David and Venkateswaran, 2019). After absorbing for the industry × year fixed effect, the externally calibrated moments from the firm-level micro data are mean $\mu_{\log a} = 0.50$ and standard deviation $\sigma_{\log a} = 2.38$ of log firm wealth, mean $\mu_{\log z} = 0.05$ and standard deviation $\sigma_{\log z} = 0.87$ of log firm TFP, and the correlation $\rho = 0.17$ between log firm wealth and log firm TFP (Table 5).

Production Function. I use the estimates of elasticity of substitution from Acemoglu and Restrepo (2018) to calibrate $\sigma = 0.70$, which is also the midpoint of values of the elasticity of substitution in the literature. The span-of-control parameter η is calibrated to be 0.85 following Midrigan and Xu (2014). The capital share is equal to $\alpha = 0.39$, which is within the reasonable range in the literature.

Financial Frictions. To avoid assuming all firms are constrained in the data,[7] the financial friction parameters are calibrated to match the average firm-level leverage ratios of both constrained and unconstrained firms in the model to the data. The average firm-level debt-to-wealth ratio of 3.98 from Compustat North America in 2000 is the targeted moment to calibrate the asset-based financial frictions $\theta_a = 0.33$, because I measure firm wealth to closely with common equity in the data, so the externally calibrated distribution of wealth a is pinned down by moments of common equity. Under the model's financing identity $k = a + b$, this implies that the debt-to-wealth ratio $\frac{b}{a}$ maps directly into the firm's capital inputs. The earnings-based financial frictions parameter, $\theta_e = 1.62$, is internally calibrated to reproduce the average firm-level debt-to-EBITDA ratio in the Compustat North America firm-level microdata from 2000. Because earnings-based borrowing is underwritten and monitored against EBITDA in practice, the debt-to-EBITDA moment provides clean identification of θ_e. The Enron shock to earnings-based financial frictions $\Delta\theta_e = -1.24$ is set such that earnings-based financial frictions during the shock $\theta_e + \Delta\theta_e = 0.38$ can replicate the average firm-level debt-to-EBITDA ratio for the treated Compustat firms in 2002.

[7] Literature usually sets the financial friction parameters to be the average leverage ratios from firm-level microdata, assuming that all firms are constrained. However, not all firms have binding borrowing constraints. For example, the average US public firm can retire all debt obligations with its cash holdings from 1980 to 2006 (Bates, Kahle and Stulz, 2009), which covers the period of the Enron-Arthur Andersen scandal.

Borrowing Costs. The convex borrowing cost parameter is internally calibrated to match the standard deviation of the debt-to-output ratio in Compustat North America in 2000, prior to the Enron shock. The resulting calibrated value is $\phi = 0.0023$.

4.3 Model's Fit

While the natural experiment in Section 3 identifies an exogenous tightening of earnings-based borrowing, assessing its implications for capital allocative efficiency requires comparison with a commensurate tightening of the asset-based borrowing constraint. The calibrated model provides this comparison and quantitatively reproduces the main 2SLS findings.

Panel A of Table 6 compares the 2SLS coefficients in the data and the model and shows a good quantitative fit. In particular, the model generates a statistically significant IV coefficient of -0.81 on the interaction between the share of issued earnings-based borrowing and the high-sales-to-capital indicator, close to the data estimate of -0.77. Thus, the model closely reproduces the increase in capital misallocation induced by the Enron shock. Consistent with Proposition 1, tighter earnings-based financial frictions disproportionately constrain high-MPK firms, raising their MPK relative to low-MPK firms.

The model also reproduces the decline in the share of issued earnings-based borrowing caused by the Enron shock. In the second row of Panel A in Table 6, the model generates a first-stage coefficient of -0.10 on the treatment indicator, close to the data estimate of -0.11 from equation (20). Thus, for low-MPK firms, the Enron shock reduces the share of issued earnings-based borrowing by about 10–11 percentage points. Relative to a sample mean of 0.34 and standard deviation of 0.40 (Table 1), this decline is economically meaningful. The model also reproduces the empirical pattern that high-MPK firms experience a larger decline in the share of earnings-based borrowing. In particular, the model-implied coefficient on the interaction between treatment and the high-sales-to-capital indicator is negative, consistent with the empirical estimate. I map the model borrowing stocks into issuance, following the one-period interpretation discussed in Section 3.1.

Panel B of Table 6 reports three additional non-targeted moments concerning financing status, and the allocation of capital. The quantitative model performs well in replicating these moments. I compare the model's pre-shock moments with the 2000 data and its mid-shock moments with the 2002 data. First, the model closely reproduces the negative correlation between capital and sales-to-capital ratio. This correlation is -0.15 in both 2000 and 2002. The model generates -0.15 in the pre-shock equilibrium and -0.13 after the Enron shock. Second, the model accurately captures the inverse relationship between borrower status and firms' wealth-to-capital ratios observed in the data. The correlation is -0.25 in 2000 and becomes more negative, -0.29, in 2002. The model generates -0.24 in the pre-shock equilibrium and -0.25 after the shock. Finally, the model also replicates the negative correlation between the firm wealth-to-sales ratio and the sales-to-capital ratio. The correlation is -0.14 in 2000 and -0.13 in 2002, whereas the model generates -0.09 in the pre-shock equilibrium and -0.08 in the mid-shock equilibrium.

Table 5 Estimated Parameters

Parameter		Value	Target/Source
Panel A: Internally Calibrated Parameters			
θ_e	Earnings-Based financial frictions	1.62	Average firm-level debt/EBITDA ratio in 2000 (Compustat North America)= 4.63
$\Delta\theta_e$	Enron shock to earnings-based financial frictions	-1.24	Average firm-level debt/EBITDA ratio of the treated in 2002 (Compustat North America)= 3.75
θ_a	Asset-based financial frictions	0.33	Average firm-level debt/wealth ratio in 2000 (Compustat North America) = 3.98
ϕ	Convex borrowing-cost parameter	0.0023	SD of Debt-to-Output Ratio in 2000 (Compustat North America)= 0.67
Panel B: Externally Calibrated Parameters			
Distribution of firm wealth a and productivity z			
$\mu_{\log a}$	Mean of log firm wealth	0.50	Compustat North America in 2000
$\sigma_{\log a}$	Standard deviation of log firm wealth	2.38	Compustat North America in 2000
$\mu_{\log z}$	Mean of log firm revenue productivity	0.05	Compustat North America in 2000
$\sigma_{\log z}$	Standard deviation of log firm revenue productivity	0.87	Compustat North America in 2000
ρ	Correlation between log firm wealth and log firm revenue productivity	0.17	Compustat North America in 2000
Production function			
α	Capital share	0.39	
σ	Elasticity of substitution	0.70	Acemoglu and Restrepo (2018)
η	Span-of-control parameter	0.85	Midrigan and Xu (2014)

Notes. This table reports the calibrated parameters of the quantitative model. Panel A reports internally calibrated parameters and Panel B externally calibrated parameters. Columns report the parameter symbol, its interpretation, the calibrated value, and the calibration target or source. All targets are moments of Compustat North America microdata for 2000 unless stated otherwise.

Table 6 Nontargeted Moments: Model versus Data

Panel A: 2SLS Coefficients

	Data	Model
IV coefficient on share of issued EBB × high sales/capital ratio	-0.77^{*}	-0.81^{***}
	(0.43)	(0.09)
First-stage coefficient on treatment dummy	-0.11^{***}	-0.10^{***}
	(0.02)	(0.01)
First-stage coefficient on treatment dummy × high sales/capital ratio	-0.06^{**}	-0.25^{***}
	(0.03)	(0.01)

Panel B: Moments from Compustat Firm-Level Microdata

	Pre-Shock		Mid-Shock	
	Data	Model	Data	Model
Corr(capital, sales-to-capital ratio)	-0.15	-0.15	-0.15	-0.13
Corr(borrower status, firm wealth-to-capital ratio)	-0.25	-0.24	-0.29	-0.25
Corr(firm wealth-to-sales ratio, sales-to-capital ratio)	-0.14	-0.09	-0.13	-0.08

Notes. Panel A reports empirical and model-implied 2SLS estimates, with standard errors in parentheses. The first row reports the IV coefficient on the interaction between the share of issued earnings-based borrowing and the high-sales-to-capital indicator; the remaining rows report first-stage coefficients. $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.10$. Panel B reports nontargeted moments in the data and model. Pre-shock moments use a balanced sample of Compustat firms in 2000; mid-shock moments use the same firms in 2002.

4.4 The Experiments on the Tightness of Borrowing Constraints

Experiment Design. The economy starts from the pre-scandal equilibrium in 2000. The Enron shock tightens the earnings-based borrowing constraint by reducing θ_e from 1.62 to 0.38, moving the economy to the mid-scandal equilibrium in 2002. Consistent with the natural experiment in Section 3, the asset-based borrowing constraint remains at its pre-scandal level. To make the tightening on the earnings-based and asset-based borrowing comparable, I set the counterfactual asset-based financial friction so that the resulting equilibrium generates the same aggregate borrowing by borrowers as under the Enron shock. Aggregate borrowing by constrained firms measures the amount of firm wealth reallocated through credit. Holding aggregate borrowing fixed, differences in TFP losses reflect the distinct allocative roles of earnings-based and asset-based borrowing.

Results. Figure 13 compares the TFP loss from the Enron shock with that from a comparable tightening of the asset-based borrowing constraint. The red curve shows the Enron shock, which reduces θ_e from 1.62 to 0.38 while holding $\theta_a = 0.33$, lowering TFP by 0.61%. The blue curve shows a comparable tightening of the asset-based borrowing constraint, holding $\theta_e = 1.62$, calibrated to generate the same aggregate borrowing. This counterfactual lowers TFP by 0.34%.

Implications. The main lesson from the model is that tightening the earnings-based borrowing constraint generates larger efficiency losses than a comparable tightening of the asset-based borrowing constraint. Because more productive firms have higher earnings, they rely more on earnings-based borrowing and are therefore disproportionately affected when this constraint

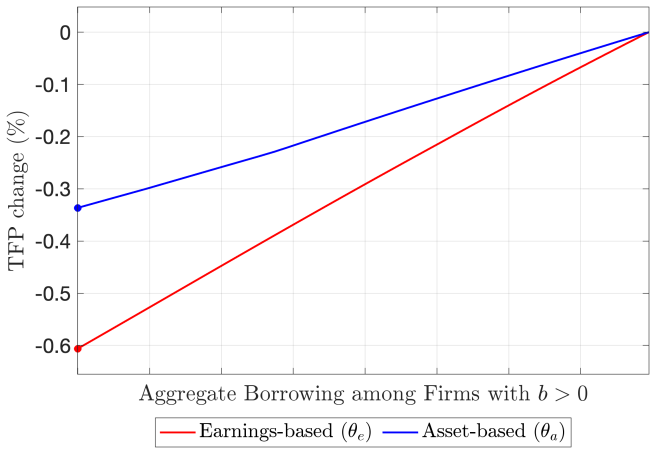


Figure 13 TFP Loss from Tightening Borrowing Constraints, Baseline $\rho = 0.17$

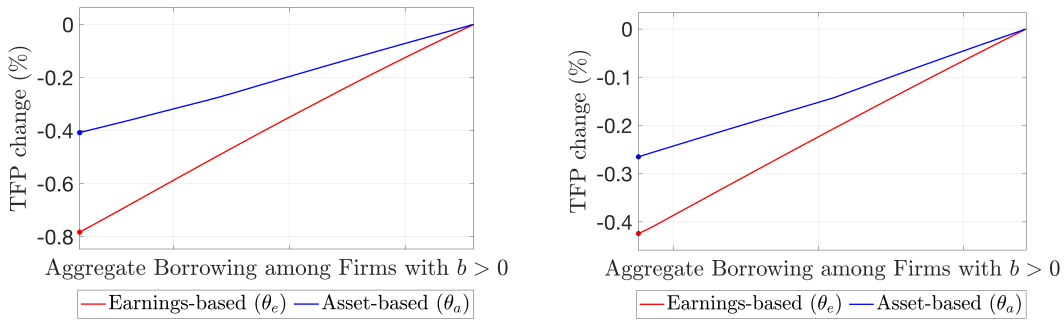
Notes. The figure compares TFP losses from tightening earnings-based and asset-based borrowing constraints. The red curve varies θ_e from its pre-scandal value of 1.62 to the Enron-shock value of 0.38, holding $\theta_a = 0.33$, and generates a TFP loss of 0.61%. The blue curve tightens θ_a, holding $\theta_e = 1.62$, until aggregate borrowing among firms with $b > 0$ matches the Enron-shock level, generating a TFP loss of 0.34%. TFP losses are measured relative to the pre-shock equilibrium.

tightens. These firms reduce borrowing and capital more sharply, while less productive firms respond less because their earnings-based borrowing capacity is already limited. Capital consequently shifts away from more productive firms, increasing misallocation and generating larger TFP losses.

Importance of the correlation between firm wealth and productivity. The larger efficiency losses from tightening the earnings-based constraint depend importantly on the correlation between firm wealth and productivity. When wealth is less correlated with productivity, earnings provide a better proxy for productivity than firm wealth does. To illustrate this mechanism, Figure 14, Panels A and B set the correlation between $\log a$ and $\log z$ to $\rho = 0$ and $\rho = 0.99$, respectively. For each value of ρ, I compare the Enron shock with a tightening of the asset-based constraint that generates the same aggregate borrowing among firms with positive borrowing. When $\rho = 0$, the Enron shock reduces TFP by 0.78%, about 1.9 times the loss from the comparable asset-based tightening. When $\rho = 0.99$, the TFP loss falls to 0.42%, about 1.6 times the corresponding asset-based loss. Under the baseline calibration, $\rho = 0.17$, the Enron shock lowers TFP by 0.61%, about 1.8 times the loss from the comparable asset-based tightening.

5 Conclusion

Earnings-based borrowing dominates the U.S. corporate debt market. This article provides the first natural experiment on earnings-based financial frictions by exploiting the Enron–Arthur Andersen scandal. I find that the Enron shock reduces the share of issued earnings-based borrowing by 10.0 percentage points among firms audited by Arthur Andersen before the scandal. At the same time, log MRPK growth rises by 6.5 percentage points more for high-MRPK firms



(A) $\rho = 0$ (B) $\rho = 0.99$

Figure 14 TFP Loss from Tightening Borrowing Constraints across Wealth–Productivity Correlations

Notes. Both panels compare the TFP effects of tightening the earnings-based and asset-based borrowing constraints under alternative correlations between log firm wealth and log productivity. Panel A (left) sets $\rho = 0$; the Enron shock generates a TFP loss of 0.78%, approximately 1.9 times the loss from the comparable asset-based tightening. Panel B (right) sets $\rho = 0.99$; the Enron shock generates a TFP loss of 0.42%, approximately 1.6 times the loss from the comparable asset-based tightening. In both panels, the red curve varies θ_e while holding θ_a fixed at its pre-shock value, and the blue curve varies θ_a while holding θ_e fixed at its pre-shock value. The two tightenings are evaluated at the same level of aggregate borrowing among firms with $b > 0$. TFP losses are plotted as negative log percentage changes relative to the initial pre-shock equilibrium.

than for low-MRPK firms, increasing MRPK dispersion and worsening capital allocative efficiency.

More broadly, the Enron–Arthur Andersen scandal provides a rare source of exogenous variation in earnings-based financial frictions. This natural experiment can be used in future research to study how earnings-based borrowing, the dominant form of U.S. corporate debt, affects other firm outcomes and aggregate economic activity.

The theoretical contribution is to show that earnings-based borrowing improves capital allocation relative to a benchmark with only asset-based borrowing, by financing productive firms that hold few assets and would otherwise remain severely constrained. Tightening the earnings-based constraint therefore harms these firms disproportionately, because they rely most heavily on this form of finance. Applied to the Enron shock, the quantitative model implies a 0.61% TFP loss through tighter earnings-based financial frictions, against 0.34% under a comparable tightening of the asset-based constraint. These could be read as lower bounds, because the model abstracts from propagation through production networks.

The analysis also has implications for credit policy and capital misallocation. First, earnings-based credit allocation can be more efficient than asset-based allocation because earnings better direct funds toward high-productivity firms. Second, policymakers should be particularly cautious when tightening debt-to-earnings limits. Although leverage regulation is important for macroprudential policy, the model implies that a tighter earnings-based borrowing limit can generate substantially larger TFP losses than a comparable tightening of an asset-based limit.

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A Issuance Shares and Debt-Stock Shares

This appendix clarifies the relationship between the stock share of earnings-based borrowing and the share of issued earnings-based borrowing observed in the data.

Let

$$\begin{aligned} y_{it} &\equiv \log\left(\frac{\text{Sales}_{it}}{Capital_{it}}\right), \\ s_{it} &\equiv \frac{B^E_{it}}{B_{it}}, \end{aligned} \tag{33}$$

where B^E_{it} denotes the outstanding stock of earnings-based borrowing and B_{it} denotes total outstanding borrowing for firm i in year t. If debt-stock data were observed, a natural specification would be

$$y_{it} = \beta s_{it} \mathbb{1}_i^{S/K} + \eta s_{it} + \phi \mathbb{1}_i^{S/K} + X'_{it}\gamma + \varepsilon_{it}, \tag{34}$$

where $\mathbb{1}_i^{S/K}$ is an indicator for firms with a high pre-shock sales-to-capital ratio. The marginal effect of the stock share of earnings-based borrowing is

$$\frac{\partial y_{it}}{\partial s_{it}} = \eta + \beta \mathbb{1}_i^{S/K}. \tag{35}$$

Hence, the effect is η for firms with $\mathbb{1}_i^{S/K} = 0$ and $\eta + \beta$ for firms with $\mathbb{1}_i^{S/K} = 1$. The coefficient β therefore captures the differential effect of relative reliance on earnings-based borrowing for high-sales-to-capital firms.

In the data, I observe debt issuance rather than the full stock of borrowing. Define

$$\chi_{it} \equiv \frac{I^E_{it}}{I_{it}}, \tag{36}$$

where I^E_{it} denotes newly issued amount of earnings-based borrowing and I_{it} denotes total newly issued amount of borrowing.

Suppose debt stocks evolve according to

$$\begin{aligned} B^E_{it} &= (1-\delta)B^E_{i,t-1} + I^E_{it}, \\ B_{it} &= (1-\delta)B_{i,t-1} + I_{it}, \end{aligned} \tag{37}$$

where the debt repayment rate δ is assumed to be constant. Using

$$\begin{aligned} B^E_{i,t-1} &= s_{i,t-1}B_{i,t-1}, \\ I^E_{it} &= \chi_{it}I_{it}, \end{aligned} \tag{38}$$

the current earnings-based debt-stock share can be written as

$$s_{it} = \frac{(1-\delta)s_{i,t-1}B_{i,t-1} + \chi_{it}I_{it}}{(1-\delta)B_{i,t-1} + I_{it}}. \tag{39}$$

Define

$$\lambda_{it} \equiv \frac{I_{it}}{(1-\delta)B_{i,t-1} + I_{it}} = \frac{I_{it}}{B_{it}}. \tag{40}$$

It follows that

$$1 - \lambda_{it} = \frac{(1-\delta)B_{i,t-1}}{(1-\delta)B_{i,t-1} + I_{it}}, \tag{41}$$

and therefore

$$s_{it} = (1-\lambda_{it})s_{i,t-1} + \lambda_{it}\chi_{it}. \tag{42}$$

Subtracting $s_{i,t-1}$ from both sides gives

$$\begin{aligned} \Delta s_{it} &= s_{it} - s_{i,t-1} \\ &= (1-\lambda_{it})s_{i,t-1} + \lambda_{it}\chi_{it} - s_{i,t-1} \\ &= \lambda_{it}\left(\chi_{it} - s_{i,t-1}\right). \end{aligned} \tag{43}$$

Equation (43) is an exact accounting identity. The stock share of earnings-based borrowing rises when the current share of issued earnings-based borrowing exceeds the lagged stock share, and the magnitude of the change depends on the ratio of new issuance to the outstanding debt stock.

Taking first differences of Equation (34) yields

$$\Delta y_{it} = \beta \mathbb{1}_i^{S/K} \Delta s_{it} + \eta \Delta s_{it} + \Delta X'_{it}\gamma + \Delta \varepsilon_{it}. \tag{44}$$

The term $\phi \mathbb{1}_i^{S/K}$ is canceled because $\mathbb{1}_i^{S/K}$ is predetermined before the Enron shock. Equivalently,

$$\Delta y_{it} = \left(\eta + \beta \mathbb{1}_i^{S/K}\right) \Delta s_{it} + \Delta X_{it}' \gamma + \Delta \varepsilon_{it}. \tag{45}$$

Substituting Equation (43) into Equation (45) gives

$$\Delta y_{it} = \left(\eta + \beta \mathbb{1}_i^{S/K}\right) \lambda_{it} \left(\chi_{it} - s_{i,t-1}\right) + \Delta X_{it}' \gamma + \Delta \varepsilon_{it}. \tag{46}$$

Rewriting this expression gives

$$\begin{aligned} \Delta y_{it} = {} & \eta \lambda_{it} \chi_{it} + \beta \mathbb{1}_i^{S/K} \lambda_{it} \chi_{it} \\ & - \eta \lambda_{it} s_{i,t-1} - \beta \mathbb{1}_i^{S/K} \lambda_{it} s_{i,t-1} \\ & + \Delta X_{it}' \gamma + \Delta \varepsilon_{it}. \end{aligned} \tag{47}$$

The stock of debt B_{it}^E and B_{it} are not observed by borrowing type, neither $s_{i,t-1}$ nor λ_{it} is directly observed due to data limitation. SDC Platinum provides issuance-level information that allows me to classify borrowing as either asset-based or earnings-based. However, data on whether firms adhere to their repayment schedules is limited. The realized repayment path may differ from the original schedule because of prepayment, debt restructuring, default, or other subsequent modifications. The issuance-share specification therefore relies on an approximation. Suppose that, conditional on the included fixed effects and predetermined controls,

$$\lambda_{it} \approx \kappa, \tag{48}$$

where κ is approximately stable across firms and over time. Equation (43) then becomes

$$\Delta s_{it} \approx \kappa \chi_{it} - \kappa s_{i,t-1}. \tag{49}$$

Substituting Equation (49) into the first-differenced outcome equation gives

$$\begin{aligned} \Delta y_{it} \approx {} & \kappa \eta \chi_{it} + \kappa \beta \mathbb{1}_i^{S/K} \chi_{it} \\ & - \kappa \eta s_{i,t-1} - \kappa \beta \mathbb{1}_i^{S/K} s_{i,t-1} \\ & + \Delta X_{it}' \gamma + \Delta \varepsilon_{it}. \end{aligned} \tag{50}$$

Define

$$\begin{aligned} \widetilde{\eta} &\equiv \kappa \eta, \\ \widetilde{\beta} &\equiv \kappa \beta. \end{aligned} \tag{51}$$

Assume the terms involving lagged debt composition are uncorrelated with the treatment after conditioning on the included fixed effects and controls, the estimable issuance-share specifica-

tion can be written as

$$\Delta \log\left(\frac{\text{Sales}_{it}}{Capital_{it}}\right) \approx \widetilde{\beta}\chi_{it}\mathbb{1}_i^{S/K} + \widetilde{\eta}\chi_{it} - \widetilde{\beta}s_{i,t-1}\mathbb{1}_i^{S/K} - \widetilde{\eta}s_{i,t-1} + \Delta X_{it}'\gamma + u_{it}. \tag{52}$$

The coefficient on $\chi_{it}\mathbb{1}_i^{S/K}$ is therefore a flow-data analogue of the differential effect of the earnings-based debt-stock share. Its magnitude combines the underlying stock-share effect, β, with the pass-through from new issuance to the outstanding debt stock, κ:

$$\widetilde{\beta} \approx \kappa\beta. \tag{53}$$

Accordingly, the issuance-share coefficient should not be interpreted as numerically identical to the coefficient that would be obtained using debt-stock shares. Rather, it captures the same underlying economic mechanism, scaled by the rate at which new issuance changes the composition of outstanding debt.

The baseline balance tests reported in Table 3 show that, before the Enron shock, treated and control firms did not differ significantly in their total debt holdings, the amount of debt issued, or the composition of debt issuance. These results provide no evidence of systematic pre-shock differences in the observed debt issuance measures. Because SDC records debt issuances rather than outstanding debt stocks, however, I cannot directly measure the composition of firms' existing debt stocks since data the actual repayment timing is limited. Firms may deviate from the original repayment schedule through early repayment, debt restructuring, default, or other changes to the loan terms. I therefore do not include interactions between the pre-shock share of earnings-based debt issuance and year indicators in the baseline specification.

As a robustness check, this appendix additionally controls for firms' pre-shock share of issued earnings-based borrowing interacted with year fixed effects. Although the interaction does not directly measure the composition of outstanding debt, they proxy for cross-firm variations in reliance on earnings-based borrowing before the Enron shock across years. The estimated coefficient does not meaningfully differ from the baseline estimate, although it is estimated less precisely, with a p-value of 0.101. This specification reduces the sample size by approximately 25%, which may compromise the statistical power.

Table 7 Robustness: Controlling for Firms' Pre-Enron Debt-Stock Share

	(1)	(2)	(3)	(4)	(5)
Panel A: First Stage. Dependent variable: $\%EBB_{i,t}$					
$Treat_{i,s}$	-0.105***	-0.104***	-0.106***	-0.105***	-0.108***
	(0.022)	(0.022)	(0.023)	(0.023)	(0.026)
$Treat_{i,s}\times$ High $S/K_{i,s}$	0.056	0.054	0.057	0.056	0.048
	(0.044)	(0.043)	(0.043)	(0.043)	(0.047)
Sanderson–Windmeijer F	23.59	24.40	23.01	22.46	29.02
Panel B: First Stage. Dependent variable: $\%EBB_{i,t}\times$ High $S/K_{i,s}$					
$Treat_{i,s}$	0.004	0.005	0.003	0.004	0.010
	(0.004)	(0.004)	(0.005)	(0.005)	(0.007)
$Treat_{i,s}\times$ High $S/K_{i,s}$	-0.061**	-0.062**	-0.061**	-0.061**	-0.077***
	(0.029)	(0.029)	(0.028)	(0.029)	(0.030)
Sanderson–Windmeijer F	36.85	28.32	28.28	24.89	11.53
Panel C: IV. Dependent variable: $\Delta\log(Sales/Capital)_{i,t}$					
$\%EBB_{i,t}\times$ High $S/K_{i,s}$	-0.765*	-0.775*	-0.782*	-0.752*	-0.623
	(0.427)	(0.428)	(0.432)	(0.432)	(0.359)
Wild bootstrap p-value	0.025	0.049	0.069	0.064	0.286
$\%EBB_{i,t}$	0.040	0.043	0.049	0.044	0.003
	(0.146)	(0.147)	(0.146)	(0.152)	(0.142)
Wild bootstrap p-value	0.257	0.930	0.862	0.849	0.604
log Common $\text{Equity}_{\text{pre}}\times$ Year FE		✓	✓	✓	✓
log Intangible $\text{Assets}_{\text{pre}}\times$ Year FE			✓	✓	✓
log $\text{Employment}_{\text{pre}}\times$ Year FE				✓	✓
Earnings-Based Share of $\text{Debt Issuance}_{\text{pre}}\times$ Year FE					✓
Industry × Year FE	✓	✓	✓	✓	✓
Observations	1724	1724	1724	1724	1289

Notes. This table reports the first-stage and 2SLS regressions underlying Table 4, augmented with a control for firms' pre-Enron share of earnings-based debt issuance interacted with year fixed effects. $\%EBB_{i,t}$ denotes the share of firm i's debt issuance in year t classified as earnings-based, and High $S/K_{i,s}$ indicates a sales-to-capital ratio above the annual median in 2000. Panels A and B report the two first-stage regressions in equation (20); Panel C reports the IV estimates from equation (19). Column (1) reports the baseline specification. Columns (2)–(4) sequentially add the same predetermined controls as in Table 4. Column (5) further adds firms' pre-Enron share of earnings-based debt issuance interacted with year fixed effects; the smaller sample reflects the additional data required for this control. All specifications include industry × year fixed effects. Standard errors, clustered by auditor × year, are in parentheses; wild bootstrap p-values adjusted for the small number of clusters are reported for Panel C. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.