Capital Misallocation and Earnings-based Borrowing *

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Abstract

Existing literature in capital misallocation and credit markets typically explains capital misallocation by the asset-based borrowing constraint: firms can only borrow up to a fraction of the value of their assets. In practice, the majority of U.S. corporate debt is constrained by earnings, not assets. This paper studies how earnings-based borrowing shapes capital allocation and efficiency. Using the Enron–Arthur Andersen accounting scandal as the first natural experiment on earnings-based financial frictions, I find causal evidence that a 10-percentage-point decline in a firm's share of issued earnings-based borrowing increases the firm's marginal revenue product of capital (MRPK) growth by about 6.6 percentage points more for the high-MRPK than the low-MRPK firms. A simple model formalizes the mechanism: earnings-based borrowing channels funds toward more productive firms and compresses the dispersion of MRPK, as productive firms tend to have higher earnings. In a calibrated quantitative general equilibrium heterogeneous-firm model, the Enron shock reduces aggregate TFP by about 0.45% through the tightening of the earnings-based borrowing constraint. In contrast, a comparable tightening of the asset-based borrowing constraint would lower TFP by only about 0.1%. Taken together, the evidence highlights earnings-based borrowing as a key credit margin that supports allocative efficiency and limits misallocation.

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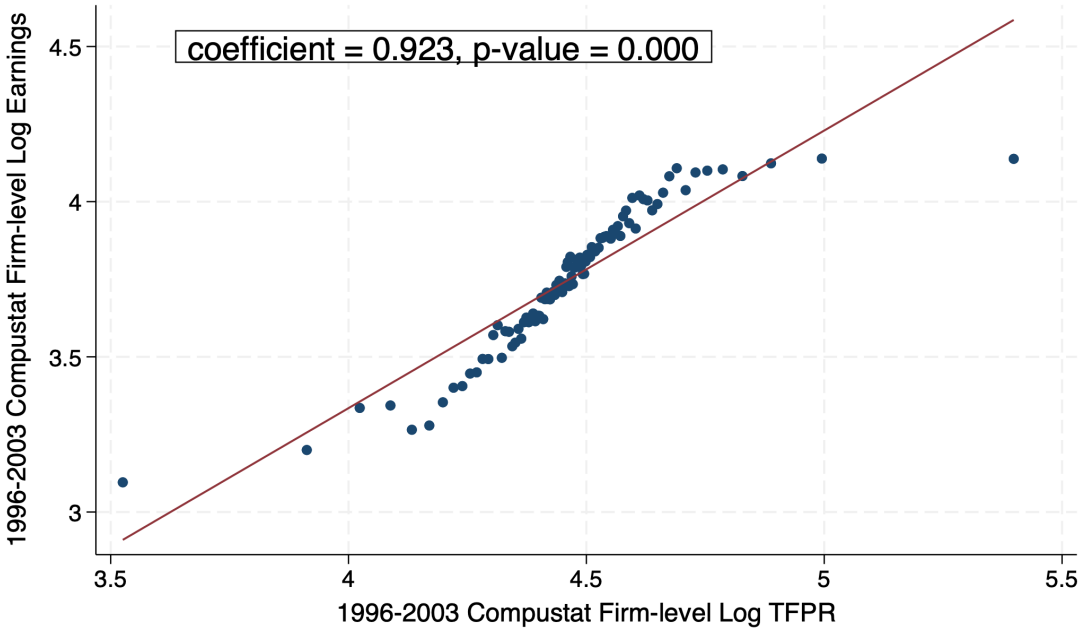
1 Introduction

Higher aggregate total factor productivity (TFP) allows an economy to produce more output with the same resources. Misallocation of resources, such as capital, reduces the aggregate TFP by breaking the alignment between where resources are available and where they are most productive. Intuitively, more productive firms generate higher earnings. Figure 1 documents a strong positive association between firm-level productivity and earnings, where a 1% increase in total factor revenue productivity (TFPR) is associated with a 0.92% increase in earnings. Moreover, the strong positive association is robust: (i) The estimated productivity is derived from the standard approach to estimate production functions in the literature — the control function approach. (ii) The firm fixed effect and the year fixed effect are included in the empirical specification. Firms' earnings, which are highly correlated with firm TFPR, set borrowing limits for earnings-based borrowing. It dominates the US corporate debt market, accounting for 80% of US corporate debt (Lian and Ma, 2021). This leads to my research question: What is the contribution of financial frictions to capital misallocation when financial frictions are earnings-based?

To answer this question, the first objective of this article is to causally identify the effects of earnings-based borrowing constraints on capital misallocation. The causal identification via a solid natural experiment is important and challenging. It is important for many reasons. First, in the data, earnings-based borrowing is pervasive in US corporate debt, yet no study has identified the effects of earnings-based financial frictions causally. Second, mitigating misspecification concerns, a natural experiment delivers a causal effect estimate for earnings-based financial frictions with fewer assumptions about functional forms and calibration. By contrast, a structural model typically imposes more structures, increasing the risk of misspecification. Third, in policymaking, because aggregate comparisons obscure the specific sources of misallocation, policymakers lack clear levers to address and reduce misallocation. A good natural experiment provides a clear source of misallocation. Understanding the source of misallocation is especially important given the salient gap amid the broad slowdown in productivity growth across advanced economies (Fernald, Inklaar and Ruzic, 2025).

It is also challenging because firms face both earnings-based and asset-based borrowing constraints, and a natural experiment on earnings-based borrowing should exogenously shock earnings-based financial frictions separately from asset-based financial frictions. Asset-based borrowing means that the borrowing limit of the corporate debt is proportional to the liquidation value of the collateralized assets. Existing natural experiments on financial frictions do not distinguish an exogenous tightening of earnings-based

Figure 1 Log TFPR and Log Earnings



Notes: This figure plots firm-level log earnings against firm-level log TFPR. Log TFPR is constructed as the residual of subtracting the product of elasticity on capital and log capital, and the product of elasticity on labor and log labor from log sales, where the output elasticities on capital and labor are estimated using the control-function approach of Olley and Pakes (1992). Labor is treated as the variable input, capital as the predetermined state variable, and firm-level investment as the proxy for productivity. Earnings are measured as EBITDA, earnings before interest, taxes, depreciation, and amortization, from Compustat. Under earnings-based lending, borrowing limits are proportional to EBITDA (Lian and Ma, 2021). The sample is the merged Compustat–SDC Platinum panel from 1996 to 2003, which is used in the main empirical analysis. Firm and year fixed effects are included. The reported coefficient and p-value are based on robust standard errors.

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, 2000; Richardson and Troost, 2009; Ziebarth, 2013; Huber, 2018), the 2008–09 financial crisis (Chodorow-Reich, 2014), and sovereign debt crises (Schnabl, 2012).

The most significant contribution of this article is to provide the first natural experiment on earnings-based financial frictions and to conduct empirical tests for the effects of earnings-based borrowing constraints on capital misallocation. The fact that earnings-based borrowing relies on the credibility of earnings from the income statement allows me to overcome the difficulty of separately identifying earnings-based financial frictions from asset-based financial frictions by exploiting the Enron-Arthur Andersen accounting scandal as the natural experiment. Benmelech, Kumar and Rajan (2024) documents that the decline of asset-based borrowing and the rise of earnings-based borrowing can be partly attributed to improvements in accounting, which boost the verifiability of earnings. Inspired by this, I exploit the Enron-Arthur Andersen accounting scandal as an exogenous shock to earnings-based financial frictions. The accounting scandal undermines confidence in Arthur Andersen auditees' income statements—especially earnings before interest, taxes, depreciation, and amortization (EBITDA), the basis for earnings-based borrowing. So the treatment group—Arthur Andersen–audited firms—faces tighter earnings-based financial frictions as a result of the Enron–Arthur Andersen accounting scandal. On March 14, 2002, the U.S. Department of Justice indicted Arthur Andersen LLP for obstruction of justice over the destruction of Enron-related documents. Because Andersen was no longer in a position to consent to the inclusion of its audit reports after the indictment, firms audited by Andersen could not recover against the auditor in security issuance in 2002 under Section 11 of the Securities Act of 1933.

By contrast, asset-based borrowing is largely insulated from the scandal because asset-based credit relies on the liquidation value of assets, as determined by independent third-party collateral appraisals, which are required by industry practice and the US Office of the Comptroller of the Currency. Liquidation values are derived from third-party appraisals that employ current and forward-looking methods, distinct from the historical book values in auditor-certified statements (M&E Appraisal Associates, Inc., 2025). In line with SEC auditor-independence guidance, auditors' availability to be these evaluators is severely limited (Independence Standards Board, 1999).

Building on the causal identification, my next two steps are to specify the regression equations and to study the mechanism through which earnings-based financial frictions shape capital allocative efficiency, in comparison with the existing literature on capital

misallocation and credit markets. The long-standing literature on capital misallocation and credit markets formulates financial frictions as an asset-based borrowing constraint subject to a fraction of assets (Moll, 2014; Midrigan and Xu, 2014; Catherine et al., 2022). In these models, high-productivity firms that lack assets are unable to finance efficient capital levels, resulting in capital misallocation and lower aggregate productivity.

To motivate the regressions and clarify the mechanism, I present a simple static general equilibrium model with heterogeneous firms, which allows for the study of how earnings-based borrowing affects capital allocative efficiency. First, earnings-based borrowing leads to higher aggregate productivity than asset-based borrowing because earnings are better proxies for productivity than assets. In general equilibrium, low-wealth and high-productivity firms can face a considerably more relaxed borrowing constraint due to the availability of earnings-based borrowing. These firms are highly constrained by asset-based borrowing in the model, but they can generate relatively high earnings due to their high productivity. Earnings-based borrowing consequently relaxes their borrowing constraint to a large extent. Second, when the Enron shock, an exogenous negative earnings-based financial shock in the model, occurs, larger increases in the marginal product of capital (MPK) are experienced by high-MPK firms than by low-MPK firms, because the high-MPK firms are affected more by the Enron shock due to their higher reliance on earnings-based borrowing: higher productivity results in higher MPK and earnings. As a result, the gap between the MPKs of high-MPK and low-MPK firms widens, increasing MPK dispersion and aggravating capital misallocation.

Guided by the model's prediction that tightening the earnings-based borrowing constraint raises capital misallocation by increasing the marginal revenue product of capital (MRPK) of high-MRPK firms, I estimate the corresponding empirical specifications. My identification exploits variation between the treated firms and the control firms. The treated firms are firms who were audited by Arthur Andersen before the accounting scandal, and the control firms are those who were not. The treatment status is "as good as random" because: i) The treatment status is predetermined. ii) There was no anticipation of the accounting scandal. By the nature of an accounting scandal, the crime is designed to be hidden and unexpected to the public until it breaks out. iii) The parallel trends assumption is likely to be satisfied, as confirmed by the event studies. Arthur Andersen was a legitimate accounting firm as one of the Big Five. Healy and Palepu (2003) also did not find that Arthur Andersen auditees systematically restated their financial reports differently from other firms. For robustness, I conduct a battery of robustness checks on my identifying assumptions, including exclusion restrictions, the parallel trends assumption, and the Stable Unit Treatment Value Assumption (SUTVA). I also conduct placebo tests

for concurrent shocks.

The main empirical findings are as follows. First, the two-stage least squares panel regression specification shows that, for high-MRPK firms, the growth of MRPK is 6.6 percentage points higher for treated firms per 10-pp exogenous decline in a firm's share of issued earnings-based borrowing. Second, the event studies complete the empirical analysis by revealing the mechanism. The difference-in-differences (DiD) event study reveals that the Enron shock resulted in a 9.9 percentage point reduction in the share of issued earnings-based borrowing. Furthermore, high-MRPK firms became more constrained, with capital declining by 9.0 percent more than the low-MRPK firms. The event study specifications also indicate that for high-MRPK firms, MRPK increases by 8.7 percent more, and the growth in MRPK is 6.4 percentage points higher than those of low-MRPK firms. These results from the event studies are consistent with the results from the panel two-stage least squares regression.

Having empirically established the effects of earnings-based borrowing on capital misallocation, I then demonstrate the importance of earnings-based borrowing by quantitatively comparing the TFP losses caused by a tightening of the earnings-based borrowing constraint with those resulting from a commensurate tightening of the asset-based borrowing constraint. The quantitative general equilibrium heterogeneous-firm model is calibrated to target the moments of the firm-level micro data. For model validation, I re-estimate the two-stage least-squares (2SLS) specification on model-simulated data and compare the implied coefficients with the corresponding estimates in the data. In the quantitative exercise, the Enron shock—modeled as a tightening of earnings-based financial frictions while holding asset-based financial frictions fixed—reduces TFP by 0.45%. By contrast, a counterfactual tightening of the asset-based financial frictions of comparable magnitude, holding earnings-based financial frictions fixed, reduces TFP by only 0.1%. The intuition for the larger TFP loss under tighter earnings-based frictions is that this tightening binds high-productivity firms disproportionately. Because these firms have higher earnings, they rely more on earnings-based borrowing; when this constraint tightens, their access to borrowing—and thus to capital—shrinks, worsening capital misallocation.

Overall, compared to asset-based borrowing, earnings-based borrowing enhances capital allocative efficiency by collateralizing productivity via earnings. The policy implication is twofold: First, when taking an earnings-based borrowing limit, credit market policy can mitigate capital misallocation more than an asset-based borrowing limit. Earnings-based credit market policy financing high-earning and low-wealth firms can increase efficiency because these firms are productive but constrained by traditional asset-

based borrowing constraints. Second, more caution should be warranted when setting restrictions on the debt-to-earnings ratio than on the debt-to-asset ratio in macroprudential regulations. A lower earnings-based borrowing limit can have a considerably larger negative impact on aggregate TFP than the asset-based borrowing limit.

Literature. The main contribution of this article is to provide the first natural experiment for earnings-based financial frictions by exploiting the Enron-Arthur Andersen accounting scandal. Lian and Ma (2021) points to new venues for modeling firms' borrowing constraints by documenting that borrowing limits are frequently tied to firms' earnings rather than their assets, and that this earnings-based borrowing accounts for about 80% of U.S. corporate debt. They discover the changes in an accounting rule (SFAS 123(r)) as the natural experiment contributing to an exogenous variation in operating earnings (EBITDA). Before this rule was adopted, firms could exclude stock option compensation expenses from operating earnings. The new rule instead requires these expenses to be recognized through operating earnings. My natural experiment, which exploits the Enron–Arthur Andersen accounting scandal, isolates earnings-based financial frictions rather than exogenous variation in EBITDA itself. After Arthur Andersen was indicted for obstruction of justice in 2002 and subsequently exited the auditing business, it could no longer consent to the inclusion of its audit reports, thereby tightening earnings-based financial frictions for Andersen-audited firms. Focusing on macroeconomic fluctuations, Drechsel (2023) shows that earnings-based borrowing amplifies firms' responses to investment shocks and raises the contribution of supply shocks to output fluctuations. Ottonello and Winberry (2024) studies how financial frictions shape the allocation of investment and innovation, and as a robustness exercise, replaces the standard asset-based borrowing constraint in the model with an earnings-based constraint. Finally, Li et al. (2025) documents the fact that borrowing constraints shape markups: within industries, firms that are less financially constrained charge higher markups, especially in sectors where borrowing depends more on earnings than on collateral, and these sectors also display greater markup dispersion. They develop a model that accounts for both patterns.

A large literature studies financial frictions as a source of capital misallocation, building on a common premise: borrowing constraints linked to assets distort the allocation of capital (Banerjee and Moll, 2010; Moll, 2014; Midrigan and Xu, 2014; Buera and Moll, 2015; Gopinath et al., 2017). Buera, Kaboski and Shin (2011) allows borrowing limits to depend on a combination of capital and earnings through an enforcement constraint. However, that approach does not model earnings-based borrowing as a distinct financing technology; instead, earnings enter as part of a reduced-form repayment or enforcement condition. They show that sectors operating at a larger scale have more financing needs

and are therefore disproportionately affected by financial frictions.

This paper is most closely related to Li (2022). That paper is the first to study the role of earnings-based borrowing for aggregate productivity in a dynamic heterogeneous-firm model. A key implication of Li (2022) is that, among constrained firms, capital demand is increasing in productivity, because the borrowing limits expand in productivity due to the positive pledgeability of earnings. Relative to Li (2022), my paper makes two contributions. First, in a parsimonious static heterogeneous-firm environment, I derive an explicit analytical mapping from constrained firms' capital choices to productivity when borrowing capacity depends positively on earnings. Second, I clarify why earnings-based borrowing improves capital allocation relative to purely asset-based borrowing: by allowing low-wealth, high-productivity firms to borrow against earnings, it relaxes their borrowing constraints, enables them to access capital, and lowers their marginal product of capital relative to an economy with only asset-based borrowing.

Li (2022) is also the first to quantify the relevance of earnings-based borrowing. Her counterfactual exercises show that, with aggregate debt-to-capital as target, the implied TFP loss from financial frictions is much larger when firms cannot borrow against earnings than when earnings and capital are assumed to be equally pledgeable. This comparison highlights that quantitative inference about misallocation is highly sensitive to the assumed composition of borrowing capacity. Importantly, when aggregate TFP falls, aggregate output declines given aggregate endowment. As a result, fixing the debt-to-output ratio also implies a proportional decline in aggregate debt. This makes it difficult to disentangle changes in the amount of aggregate borrowing from changes in the allocation of borrowing. To isolate the allocation channel of earnings-based borrowing, I conduct a quantitative exercise that differs from the comparison in Li (2022). To focus instead on the allocative role of earnings-based borrowing, I first calibrate the model to pre-scandal firm-level moments and then consider two counterfactuals.

In Case 1, I hold fixed the asset-based borrowing friction and tighten the earnings-based borrowing friction to match the average debt-to-EBITDA ratio of treated firms at the peak of the scandal in 2002. In Case 2, I hold fixed the earnings-based borrowing friction and instead tighten the asset-based borrowing friction so as to replicate the general-equilibrium interest rate in Case 1. Matching the equilibrium interest rate makes the two counterfactuals directly comparable, because it implies the same amount of aggregate borrowing in the economy. With a frictionless labor market, firms' labor demand is linear in capital demand, with the factor of proportionality determined in general equilibrium by the interest rate and the wage. Hence, for a given interest rate and aggregate supplies of capital and labor, the equilibrium wage is pinned down.

Conditional on the interest rate and the wage, the cutoff separating lenders from borrowers is identical across the two cases. It follows that the same firms lend in equilibrium and that, for a given joint distribution of firm wealth and productivity, aggregate lending and borrowing are also identical. The two counterfactuals therefore differ only in the allocation of capital, not in the aggregate quantity of capital or credit. Any difference in aggregate TFP between them thus isolates the allocative consequences of the two borrowing frictions.

The quantitative exercise shows that tightening the earnings-based borrowing friction generates substantially larger TFP losses than tightening the asset-based borrowing friction. The reason is that a tighter earnings-based constraint disproportionately restricts high-productivity firms, which rely more heavily on borrowing against earnings. As a result, capital is reallocated away from firms with the highest marginal returns, leading to a larger decline in allocative efficiency.

The article proceeds as follows. In Section 2, I describe the simple model, showing that earnings-based borrowing collateralizes borrowing via earnings and explaining why the empirical analysis tests the treatment effect on the MRPK of the high-MRPK firms for capital misallocation. Section 3 describes the Enron-Arthur Andersen scandal as the natural experiment, identification strategy, and 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 and empirical relevance. 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; $\theta_e \cdot zk^{\alpha} > \theta_a k$ correspond to the case where the constrained firm chooses earnings-based borrowing; $\theta_e \cdot zk^{\alpha} < \theta_a k$ are the case when asset-based borrowing is preferred.

2.3 Individual Behavior

Entrepreneurs maximize the value of utility from consumption (1) subject to the budget constraint (3). Their production and saving decisions separate conveniently. 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 choice $k = k(a,z)$ is weakly increasing in productivity z, and is given by*

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

where the productivity cutoff is

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

Here, for a given wealth level a, $\mathcal{K}^{-1}(a,z)$ denotes the inverse (in k) of

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

Moreover, for any fixed a:

1. *The mapping $z \mapsto \mathcal{K}^{-1}(a,z)$ is strictly increasing.*
2. *The mapping $z \mapsto \mathcal{K}^{-1}(a,z)$ is convex.*

In particular, at the cutoff $z = \tilde{z}(a)$, I have $\mathcal{K}^{-1}(a,\tilde{z}(a)) = \frac{a}{1-\theta_a}$, so the piecewise definition of $k(a,z)$ is continuous in z.

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 productivity lower than $\tilde{z}(a)$ issue asset-based borrowing, and those with productivity higher than $\tilde{z}(a)$ 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. The threshold of $\tilde{z}(a)$ for firms switching from asset-based to earnings-based raises due to the lower θ_e. As a result, the average share of earnings-based borrowing in the economy shrinks.

Lemma 2 *Fix a productivity level z and consider a constrained firm. The firm's optimal capital choice $k = k(a, z)$ is strictly increasing in own wealth a, and is given by*

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

where the cutoff $\tilde{a}(z)$ is

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

For a given productivity level z, the function $\mathcal{A}^{-1}(a,z)$ denotes the inverse (with respect to k) of

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

Moreover, for any fixed z:

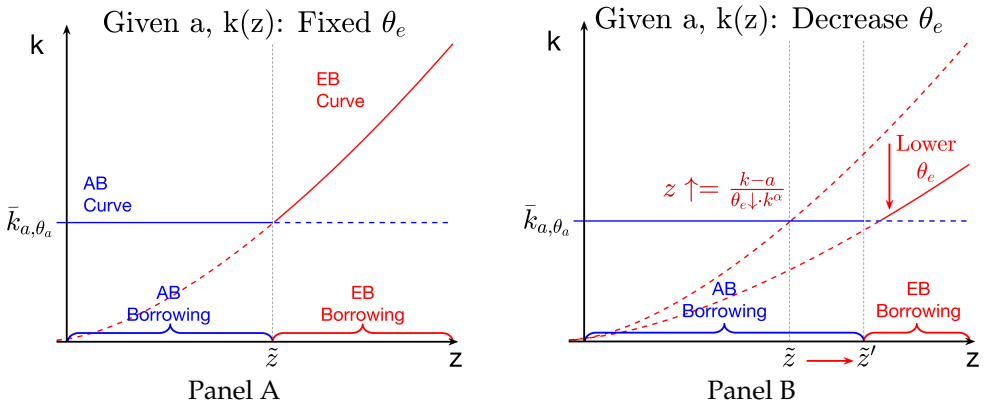


Figure 2 Constrained Firms' Capital on Productivity

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. Firms with productivity lower than $\tilde{z}$ choose asset-based borrowing, as the solid part of the blue asset-based curve. Productive firms with productivity above $\tilde{z}$ issue earnings-based borrowing, as shown by the solid part of the red earnings-based 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 curve, which is solid after the new threshold $\tilde{z}'$.

1. *The mapping $a \mapsto \mathcal{A}^{-1}(a,z)$ is strictly increasing.*

2. *The mapping $a \mapsto \mathcal{A}^{-1}(a,z)$ is concave.*

Finally, the policy $k(a,z)$ is continuous at the cutoff: at $a = \tilde{a}(z)$,

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

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

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

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 wealth $a < \tilde{a}(z) = (1-\theta_a)\left(\frac{\theta_e \tilde{z}}{\theta_a}\right)^{\frac{1}{1-\alpha}}$ issue earnings-based borrowing, and firms with wealth a higher than $\tilde{a}(z)$ issue asset-based borrowing. A negative shock to θ_e would shift the earnings-based curve lower and diminish the

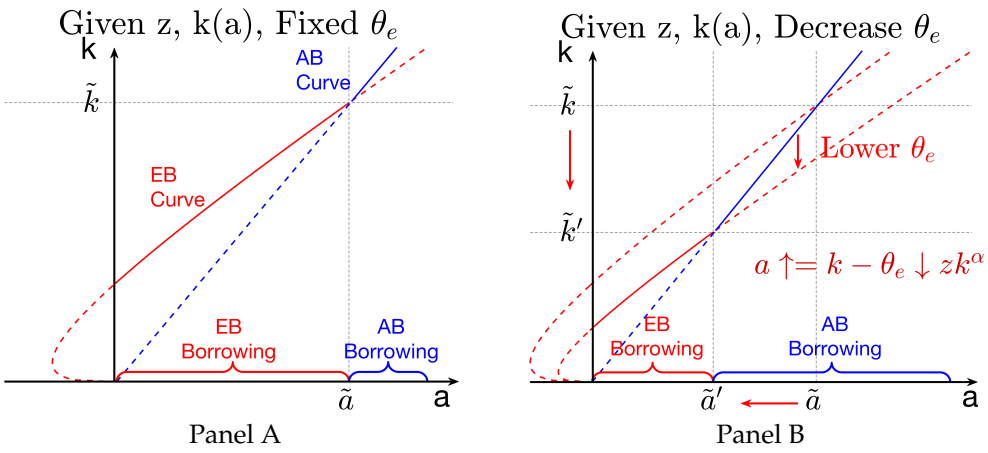


Figure 3 Constrained Firms' Capital on Wealth

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 wealth less than $\tilde{a}_1$ choose earnings-based borrowing, as the solid part of the red earnings-based curve. Firms with more wealth than $\tilde{a}_1$ 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. As a result, the threshold between EB firms (red curly bracket) and AB firms (blue curly bracket) shifts down from $\tilde{a}_1$ to $\tilde{a}_2$.

threshold $\tilde{a}(z)$. Consequently, the negative shock to θ_e decreases the average share of earnings-based borrowing in the economy.

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. Left to 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. Right to 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 switch to 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 equilib-

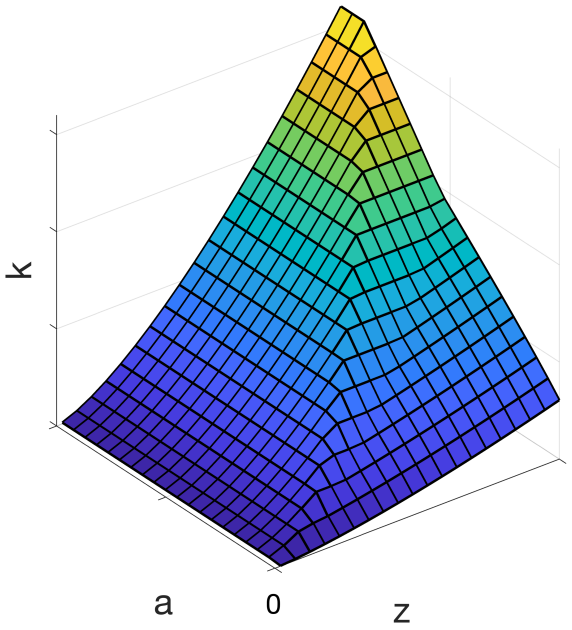


Figure 4 Policy Function of Capital

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. Left to the ridge are the unconstrained firms with relatively high wealth a and relatively low productivity z. Right to the ridge are the constrained firms, which have relatively low wealth a and high productivity z.

rium 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. This sections focus on the mechanism between tightening the earnings-based financial frictions and the deteriorated capital allocative efficiency.

Lemma 3 *Fix the firm's wealth, a, and consider constrained firms. Let $mpk(a,z)$ denote the marginal product of capital evaluated at the firm's optimal capital choice. Then, holding a fixed, $mpk(a,z)$ is strictly increasing in firm 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. Since firms switch from asset-based to earnings-based borrowing as productivity increases, this implies that the firms issuing earnings-based borrowing are also high-MPK firms. 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 switch to earnings-based borrowing; relative to the asset-based counterfactual, the relaxed constraint raises k and therefore lowers MPK, as shown by the red solid curve versus the blue dashed curve. The proof of Lemma 3 (Appendix C.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 *For constrained firms, fix wealth a and consider the piecewise capital policy $k(a,z;\theta_a)$ and MPK policy $mpk(a,z;\theta_a)$ with threshold $\tilde{z}$ separating the asset-based region ($z \le \tilde{z}$) and the earnings-based region ($z > \tilde{z}$). A decrease in the earnings-based parameter θ_e diminishes the capital inputs k and raises the MPK pointwise on the high-z branch.*

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. Smaller firms, in the sense of 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, the smaller firms at the same productivity z still receive less capital and therefore have higher MPKs (Figure 6). When earnings-based financial frictions θ_e worsen, smaller firms that have high MPKs become more constrained and have higher MPKs because of their reliance on the earnings-based borrowing.

Lemma 4 *For any unconstrained firm, the optimality condition implies that its marginal product of capital equals the rental rate of capital:*

$$mpk = r.$$

In general equilibrium, the rental rate $r = r(\theta_e)$ is increasing in the earnings-based borrowing parameter θ_e. Hence, when θ_e falls, r falls, and the marginal product of capital of unconstrained firms decreases.

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 this result, the empirical strategy examines the dispersion of logged MPK by focusing on the Enron shock's impact on the logged MPK of high-MPK firms.

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.

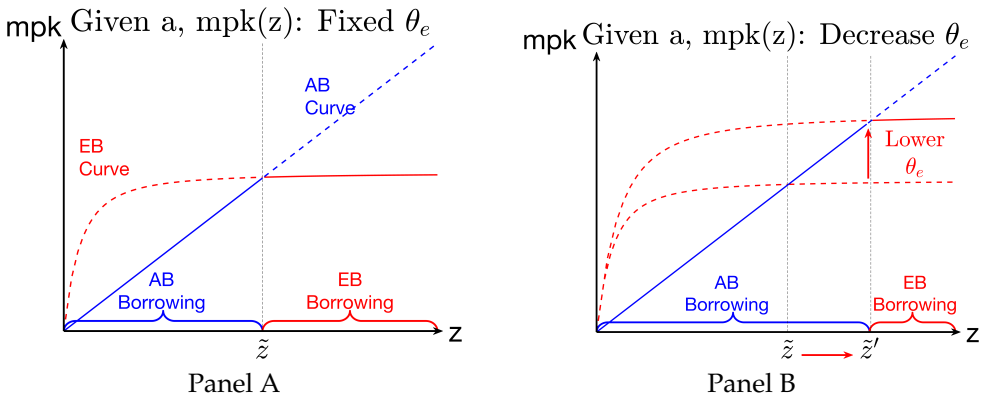


Figure 5 Constrained Firms' MPK on Productivity

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.

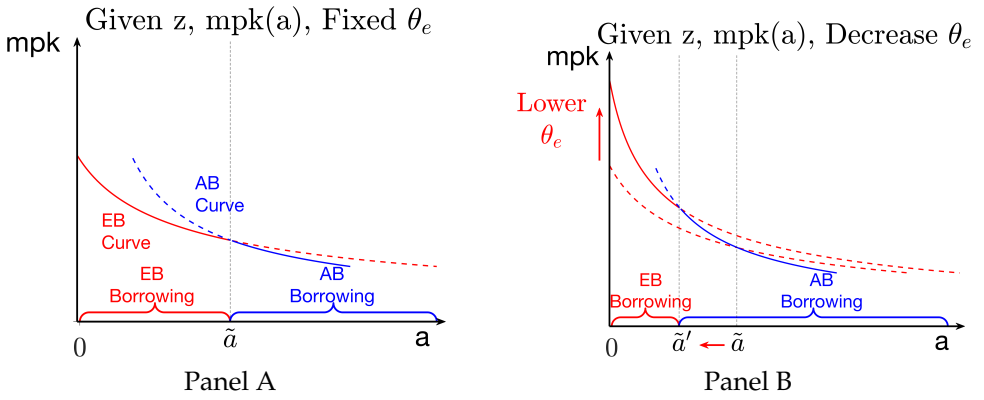


Figure 6 Constrained Firms' MPK on Wealth

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.

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 empirical 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 Scandal in 2001, as it is common practice to require the financial reports of the most recent three years when conducting financial analysis (Latham & Watkins and KPMG, 2025). 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 7,000 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 Appendix C.6. In a static model, all variables are determined simultaneously, as if time does not evolve. Therefore, the model outcomes can be directly compared to flow variables measured over a representative period. In particular, the borrowing b in the model can be interpreted as the borrowing issued relative to the firm's wealth a. So, I match the share of earnings-based borrowing in the model to the share of issued earnings-based borrowing 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 marginal revenue product of capital 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 marginal revenue product of capital (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

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

where $\hat{\theta}_{st}$ is the elasticity 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 (De Loecker, Eeckhout and Unger, 2020). 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 pro-

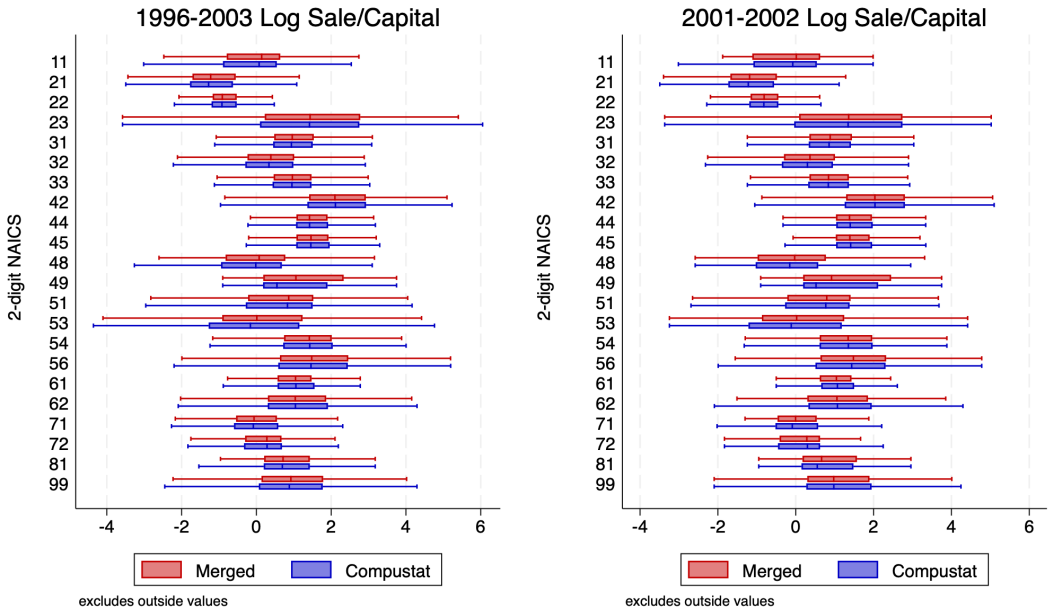


Figure 7 Summary Statistics on Sales-to-capital ratio by Industry

Notes: This figure shows the box plot of sales-to-capital ratio by industry (2-digit NAICS). The left panel focuses on the period from 1996 to 2003, which is the full sample in the empirical analysis. The right panel focuses on the period from 2001 to 2002, which is the years of the Enron Scandal. The blue represents the full Compustat sample. The red represents the merged dataset in the main analysis.

duction 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. 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.

3.1.2 Summary Statistics

This section demonstrates that the merged sample closely aligns with the population of publicly listed firms in Compustat North America from 1996 to 2003, and particularly during the Enron–Arthur Andersen episode (2001–2002). The comparison centers on the sales-to-capital ratio and its annual log change.

Moments of the annual firm-level sales-to-capital ratio (Figure 7) and of the annual change in log sales-to-capital (Figure 8) are tightly aligned across the merged sample and Compustat: means and medians coincide, dispersion and the distributional shapes overlap, indicating that the merged dataset is representative for the period of interest.

The left panel of Figure 7 presents box plots of log sales-to-capital ratio by 2-digit

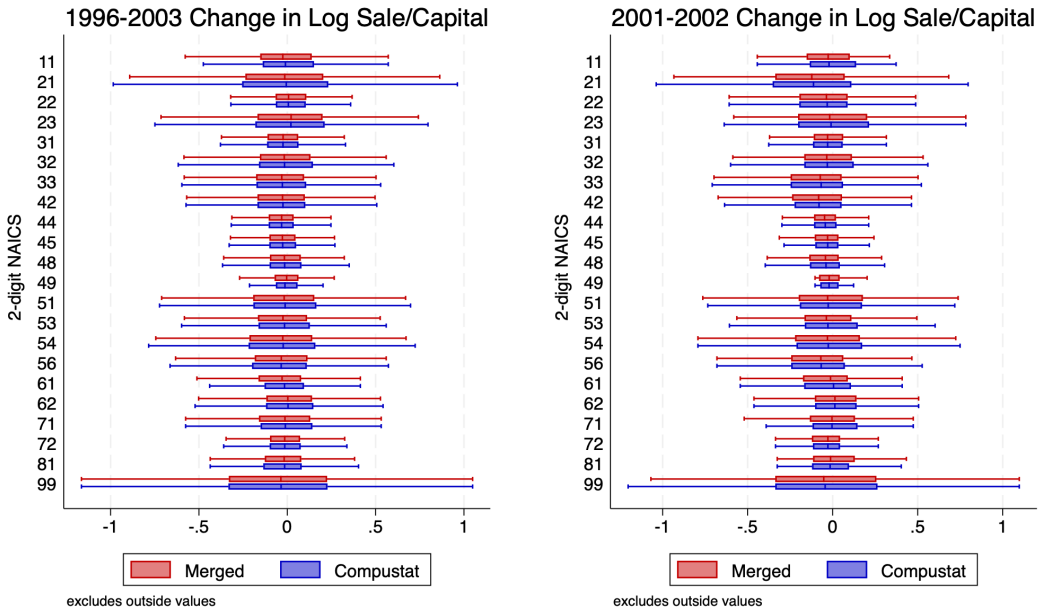


Figure 8 Summary Statistics on the Change in the Log Sales-to-Capital Ratio by Industry

Notes: This figure shows the box plot of the change in log sales-to-capital ratio by industry (2-digit NAICS). The left panel focuses on the period from 1996 to 2003, which is the full sample in the empirical analysis. The right panel focuses on the period from 2001 to 2002, which is the years of the Enron Scandal. The blue represents the full Compustat sample. The red represents the merged dataset in the main analysis.

NAICS for 1996–2003. Over this window, for example, the highest industry median is Wholesale Trade (NAICS 42) at 2.11, and the lowest is Mining, Quarrying, and Oil and Gas Extraction (NAICS 21) at −1.27. The right panel focuses on 2001–2002, which is the Enron–Arthur Andersen period. The same industries remain at the extremes, with Wholesale Trade at 2.03 and Mining, Quarrying, and Oil and Gas Extraction at −1.21. That the maxima and minima are attained by the same industries in both the merged and Compustat samples in both the full period and the scandal period underscores that the merged sample mirrors Compustat's cross-industry distribution of log sales-to-capital ratio.

The left panel of Figure 8 displays box plots of the change in log sales-to-capital ratio by 2-digit NAICS for both the merged dataset and Compustat over 1996–2003. In the merged sample, industry medians range from −3.37% in Administrative and Support and Waste Management and Remediation Services (NAICS 56) to 2.16% in Construction (NAICS 23); in Compustat, similar to the merged dataset, the corresponding medians are −3.43% and 2.08% in the same industries. The right panel focuses on 2002–2003 (the Enron–Arthur Andersen period). Again, the distributions are similar across datasets: For example, Mining, Quarrying, and Oil and Gas Extraction (NAICS 21) exhibits the lowest

median, −12.28% in the merged dataset and −11.29% in Compustat, whereas Health Care and Social Assistance (NAICS 62) exhibits the highest, 1.33% and 1.31%, respectively. The fact that the minima and maxima are attained by the same industries in both samples—and at very similar magnitudes—indicates that the merged sample mirrors Compustat's cross-industry distribution of changes in log sales-to-capital ratio.

In sum, the matched SDC-Compustat sample is representative of the publicly listed firms in Compustat during the sampling period. I rely on the matched dataset for the subsequent analysis. Table 1 reports the summary statistics for the merged firm-level sample used in my main analysis.

Table 1 Summary Statistics

	Obs	Mean	SD	p25	p50	p75	Min	Max
Share of Issued Earnings-based Borrowing	8203	0.35	0.41	0.00	0.11	0.76	0.00	1.00
Sales/Capital	57153	5.46	66.96	0.95	2.27	4.60	0.00	15203.60
Log Sales/Capital	56596	0.72	1.35	-0.05	0.82	1.53	-10.04	9.63
Change in Log Sales/Capital	52164	-0.02	0.46	-0.16	-0.02	0.11	-2.00	2.00
Capital (Million USD)	57562	1357.90	4831.20	9.39	57.66	428.93	0.00	83496.37
Change in Log Capital	52740	0.11	0.40	-0.01	0.06	0.21	-2.00	2.00
Total Amount of Issued Borrowing (Million USD)	57562	128.58	5944.79	0.00	0.00	0.00	0.00	1000000.00
Employment (Thousand)	57562	5.45	16.79	0.12	0.61	3.20	0.00	321.52
Change in Log Employment	52740	0.04	0.38	-0.08	0.02	0.17	-2.00	2.00
Intangible Assets (Million USD)	51414	243.64	2271.57	0.00	1.77	40.95	-0.42	172264.48
Change in Log Intangible Assets	30174	0.12	0.89	-0.15	-0.03	0.34	-2.00	2.00
Firm Age (Years)	4761	37.48	29.73	12.00	28.00	63.00	-21.00	103.00

Notes: This table shows the summary statistics for firms in my analysis, using the merged dataset of Compustat North America and SDC Platinum from 1996 to 2003. 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 of the firm. The change in the log sales-to-capital ratio is the annual change in the logged ratio of sales to capital for the firm. Capital is the total book value of property, plant, and equipment of the firm. The change in log capital refers to the annual change in logged capital. The total amount of issued borrowing refers to the total amount of borrowing that has been issued by the firm. Employment is the number of workers at the firm. The change in log employment represents the annual change in the logged employment. Intangible assets are the firm's book value of intangible assets. The change in log intangible assets represents the annual change in the logged intangible assets. Firm age is the difference between the current year and the year the firm was founded. The founding year is from SDC Platinum. Columns represent the total observations, means, standard deviations, 25th percentile, 50th percentile, 75th percentile, and maximum and minimum at the firm level. All monetary values are deflated by a US GDP deflator using 2017 as the base year

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 a positive association across the conditional distribution: more productive firms allocate a larger fraction of their new

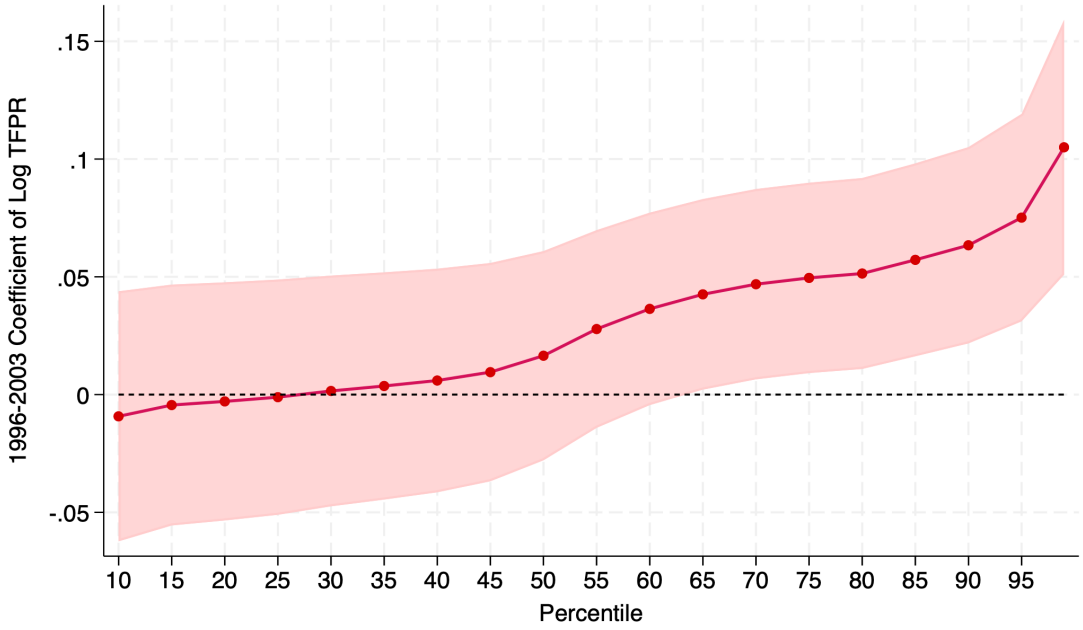


Figure 9 Quantile Regression Results for % Issued Earnings-based Borrowing on Log TFPR

Notes: This figure shows the quantile regressions of share of issued earnings-based borrowing on logged TFPR as equation (17) using the merged dataset of Compustat and the SDC Platinum from 1996 to 2003. The Robust standard errors are used. The confidence band is on the 95% level.

borrowing to earnings-based instruments. Second, the regressions of log total borrowing on interactions between wealth-quantile indicators and the earnings-based share indicate that, among low-wealth firms, 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.

Figure 9 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 estimated the Log TFPR as the residual of the sales from inputs, which are capital and employment. The elasticities of capital

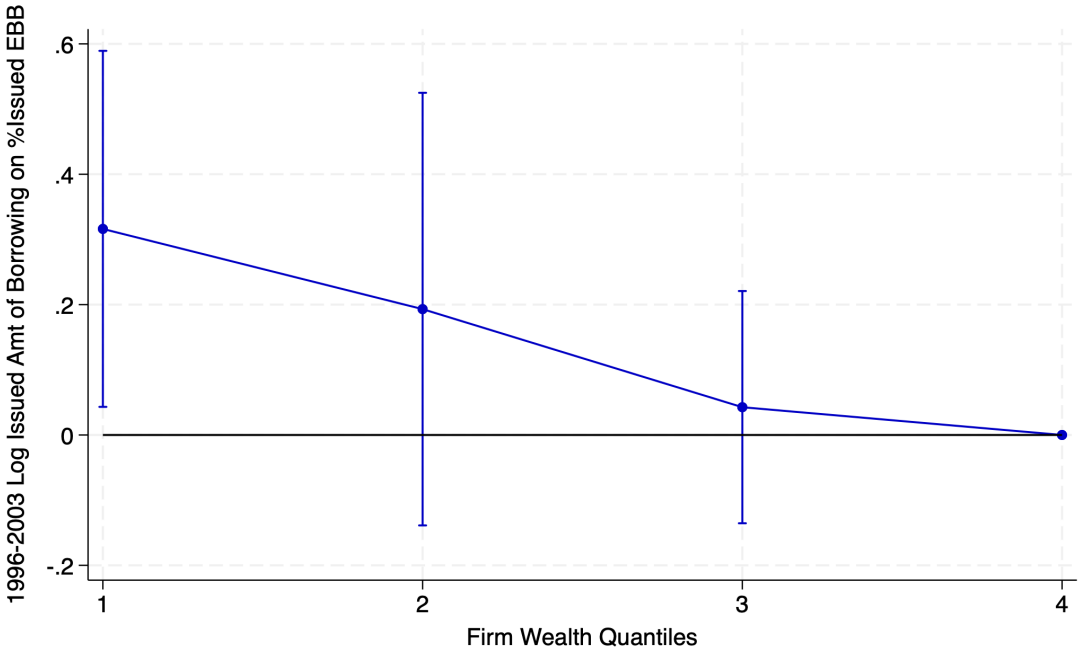


Figure 10 Regression Results for Log Total Issued Amount of Borrowing on the Interaction of Wealth Dummy and % Issued Earnings-based Borrowing

Notes: This figure presents the regression results for log total issued amount of borrowing on the interaction of wealth dummy and the share of issued earnings-based borrowing as equation (18) using the merged dataset of Compustat and the SDC Platinum from 1996 to 2003. Robust standard errors are used. The error bars are at the 95% confidence level.

and labor are estimated using the control function approach of Olley and Pakes (1992), with investment as a proxy for TFP. Following Olley and Pakes (1992), the production function is assumed to be of the Cobb-Douglas form with inputs of capital and labor. The elasticities are estimated from Compustat data covering the period from 1996 to 2000, prior to the Enron-Arthur Andersen Scandal. Figure 9 shows that the positive association between the share of issued earnings-based borrowing and TFPR strengthens toward the upper part of the TFPR distribution: the slope is steeper at higher percentiles. Intuitively, more productive firms rely more heavily on earnings-based borrowing, consistent with Lemma 1 in Section 2.3.

Figure 10 shows the quantile 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. 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. The coefficients on the interaction of the low wealth dummy and the share of issued earnings-based borrowing are positive and decrease across quantiles as shown in Figure 10. This indicates that access to earnings-based borrowing improves the availability of borrowing for low-wealth firms. The figure also shows a downward trend in the coefficients across quantiles. This implies that when earnings-based borrowing is less accessible, the marginal effect of increasing accessibility has a relatively large impact on the amount of borrowing to low-wealth firms, as shown in 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, such as omitted-variable bias. For example, Benmelech (2024) documents operational flexibility concerns: firms are reluctant to collateralize assets because asset restructuring on collateral requires lender approval. This harms the firm's profitability, which is correlated with sales. 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. In another example, the asset-based financial frictions may lead to downward biases in the estimation. A more relaxed asset-based borrowing constraint could imply greater access to capital and, in turn, relatively lower sales-to-

capital ratios. In the meantime, fewer asset-based financial frictions could imply a lower share of issued earnings-based borrowing. The endogeneity concerns necessitate an instrument for earnings-based financial frictions.

3.3.1 A Natural Experiment

I employ the Enron and Arthur Andersen 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 and Arthur Andersen 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. Income statements contain earnings before interest, taxes, depreciation, and amortization (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 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 (M&E Appraisal Associates, Inc., 2025): (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 immune to the accounting scandal.

   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 issued debt through special-purpose entities to avoid recognizing additional debt on its books. In other 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 many assumptions (Deloitte, 2025*a*,*b*), such as the ability of market participants to enter into transactions. 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. 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)[1].

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 (Appendix C.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

[1]To restore public confidence in the accounting sector, the US government enacted the Sarbanes-Oxley Act on 30 July 2002, which mandated annual auditor 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.

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. 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 Bau and Matray (2023)

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

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 industry s is higher than the yearly medium 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. Firstly, 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 1575 observations. The natural experiment concluded in 2003 with the implementation of the Sarbanes-Oxley Act. This act mandates auditor rotation, which restored public confidence in accounting firms and ended my natural experiment. Secondly, the dependent variable, the sales-to-capital ratio is a proxy for $MRPK$, because i) I assume the Cobb-Douglas production function $MRPK_{ist} = Output\ Elasticity\ on\ Capital_{st} \cdot \frac{Sale_{ist}}{Capital_{ist}}$. 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. 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 NACIS 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 0.171, with heterogeneity across firms. The standard deviation is 0.377, and the interquartile range is 0. I only keep observations in 2001 and 2002 because the Enron-Arthur Andersen scandal is a one-off event. The enactment of the Sarbanes-Oxley Act restored public confidence in the accounting profession and ended my natural experiment.

4. *Identification Conditions*. IV consistency requires instrument relevance, which means treatment $Treat_{is}$ and χ_{ist} are correlated, and instrument validity, which means

Table 2 Summary Statistics on the Treatment Dummy

	Mean	Standard Deviation	Interquartile Range
	0.171	0.377	0.000
N Total		13756	
N Industry (3-digit NAICS)		96	

Notes: The table reports the statistics on the treatment dummy using the merged dataset of Compustat and the SDC Platinum from 1996 to 2003. The treatment dummy is 1 if the firm is audited by Arthur Andersen from 1998 to 2000, and 0 otherwise.

$Treat_{is}$ 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, firstly, 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. Secondly, confounders are also not likely to have effects on the treatment dummy because: i) No anticipation of treatment before the Scandal. Enron was ranked 18th on the Fortune 500 list in 2000 (Fortune, 2000). When Bethany McLean, the author of *The Smartest Guys in the Room: The Amazing Rise and Scandalous Fall of Enron* interviewed the financial professionals on Wall Street in early 2001 before the scandal surfaced, the financial professionals said: Enron is 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) does 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 balance checks in Appendix B.2 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 include tests on the "zero earnings-based borrowing" firms for robustness in the next section.

The natural experiment may be subject to criticism over the Stable Unit Treatment Value Assumption (SUTVA). For example, Compustat North America and the SDC Platinum do not provide information on the supply chain between firms. The spillovers from treated firms to the control over the supply chain depend on the enforceability of their contracts. I will discuss SUTVA further in the results section.

5. *Exclusion Restriction and SUTVA: 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, it is not solid to conclude that the natural experiment violates the exclusion restrictions. This test on the "zero earnings-based borrowing" firms also partly addresses concerns over SUTVA. The insignificant and close-to-zero estimates of coefficients cannot validate that there is interference between units.

3.3.2 Results

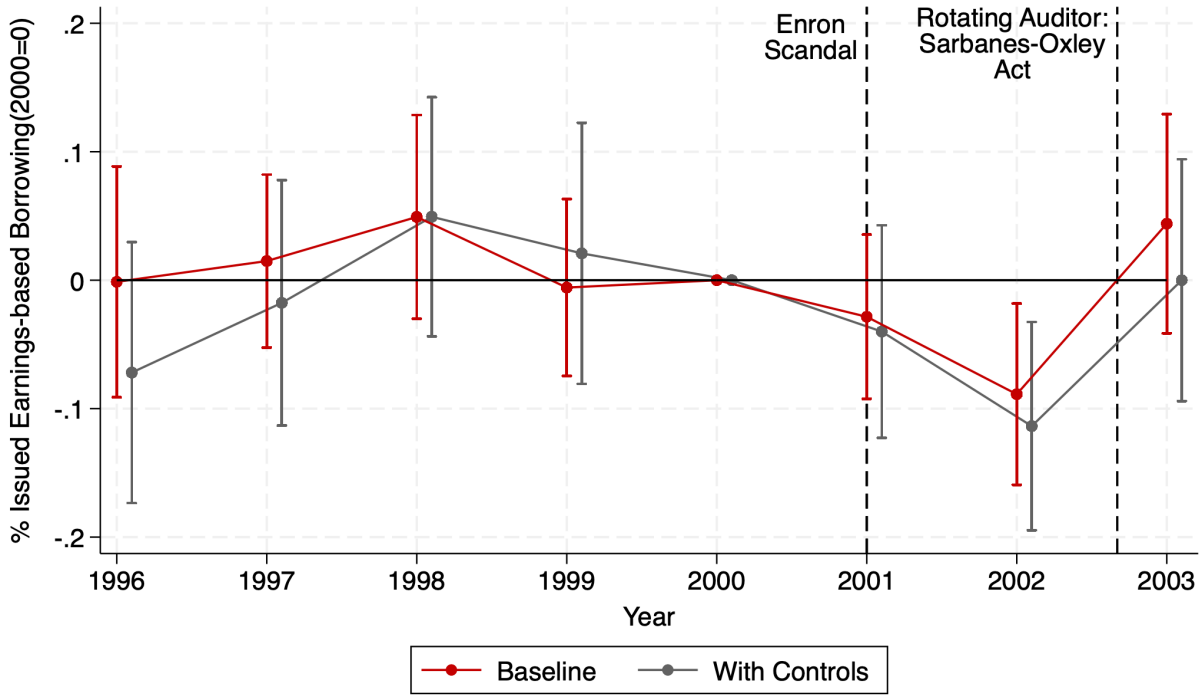
1. *Event Study Estimates of the First Stage*. A key step in my analysis is to identify the change in the endogenous variable due to the treatment. Using data on firm i in industry s over years t, I first present the results of event study specifications for the share of issued earnings-based borrowing.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

Figure 11 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 (33) using the merged dataset of Compustat and the SDC Platinum. The control variables are logged employment, logged intangible assets, and firm age. Standard errors are clustered by auditor × year. The error bars are at the 95% confidence level.

the share of issued earnings-based borrowing in year τ; $Treat_{i,s}$ is the treatment dummy; α_i is the firm fixed effects; $\delta_{s,t}$ is the industry-year fixed effect; $v_{i,s,t}$ is the error term, clustered by auditor $\times$ year.

Figure 11 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 9.9 percentage points. For robustness, I also examine the treatment's effects on the ratio of earnings-based borrowing to EBITDA in Appendix B.3.

2. *Reduced-form Event Study Estimates*. To understand the mechanism of how earnings-based financial frictions affect capital misallocation, I estimate the following event study specification:

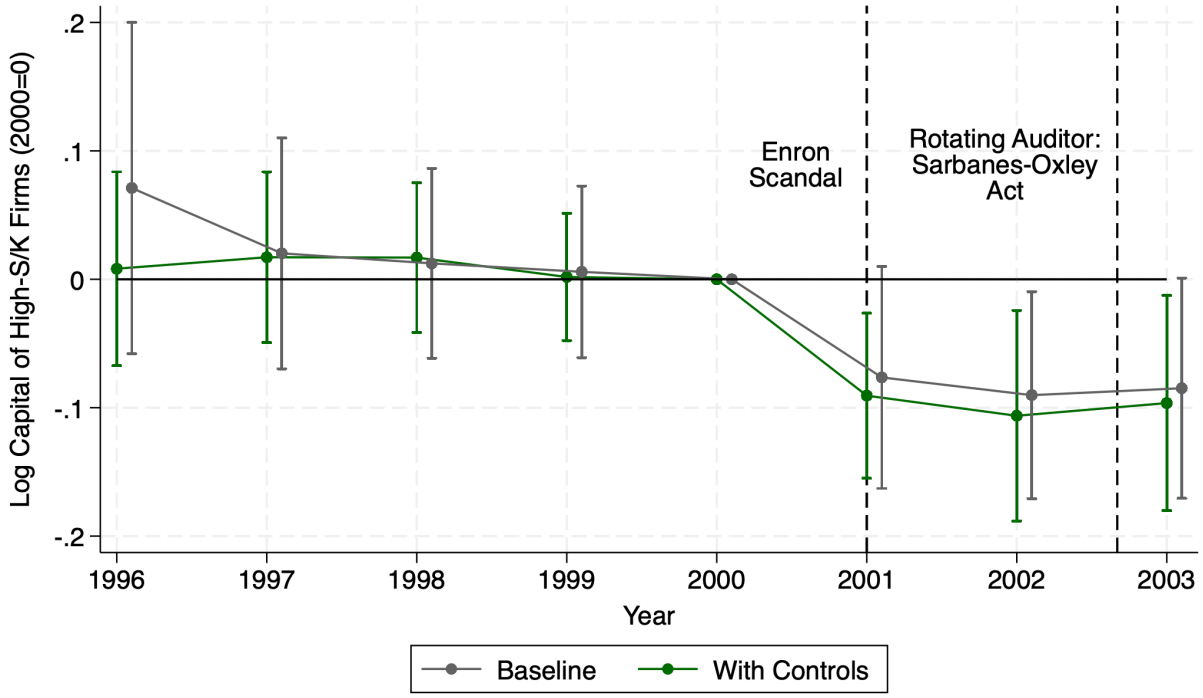
$$\begin{aligned} Y_{i,s,t} = &\sum_{\tau \neq 2000} \tilde{\beta}_\tau \mathbb{1}_{i,s}^{High\ S/K} \cdot \mathbb{1}^{t=\tau} \cdot Treat_{i,s} \cdot \\ &+ \sum_{\tau \neq 2000} \tilde{\gamma}_{1\tau} \mathbb{1}^{t=\tau} \cdot Treat_{i,s} \\ &+ \sum_{\tau \neq 2000} \tilde{\gamma}_{2\tau} \mathbb{1}^{t=\tau} \cdot \mathbb{1}_{i,s}^{High\ S/K} \\ &+ \tilde{\gamma}_3 \mathbb{1}_{i,s}^{High\ S/K} \cdot Treat_{i,s} + \tilde{\alpha}_i + \tilde{\delta}_{s,t} + u_{i,s,t}, \end{aligned} \tag{22}$$

where the firm is indexed by i, the industry is indexed by s, and the year is indexed by t; $Y_{i,s,t}$ is the output variables, including the logged capital $\log k_{i,s,t}$, the logged MPK proxied by $\log \frac{Sale_{i,s,t}}{Capital_{i,s,t}}$ and the change in logged MPK proxied by $\Delta \log \frac{Sale_{i,s,t}}{Capital_{i,s,t}}$; $\mathbb{1}^{High\ S/K}$ is the high-sales-to-capital-ratio dummy, such that each $\tilde{\beta}_\tau$ represents the treatment effects of the Enron shock on the output variables for the high-sales-to-capital-ratio firms; $\tilde{\alpha}_i$ is the firm fixed effects; $\tilde{\delta}_{s,t}$ is the industry $\times$ year fixed effects; $u_{i,s,t}$ is the error term.

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 12, I plot the coefficient $\tilde{\beta}_\tau$, the percentage points difference in capital owned by the high-sales-to-capital-ratio firms between the treatment group

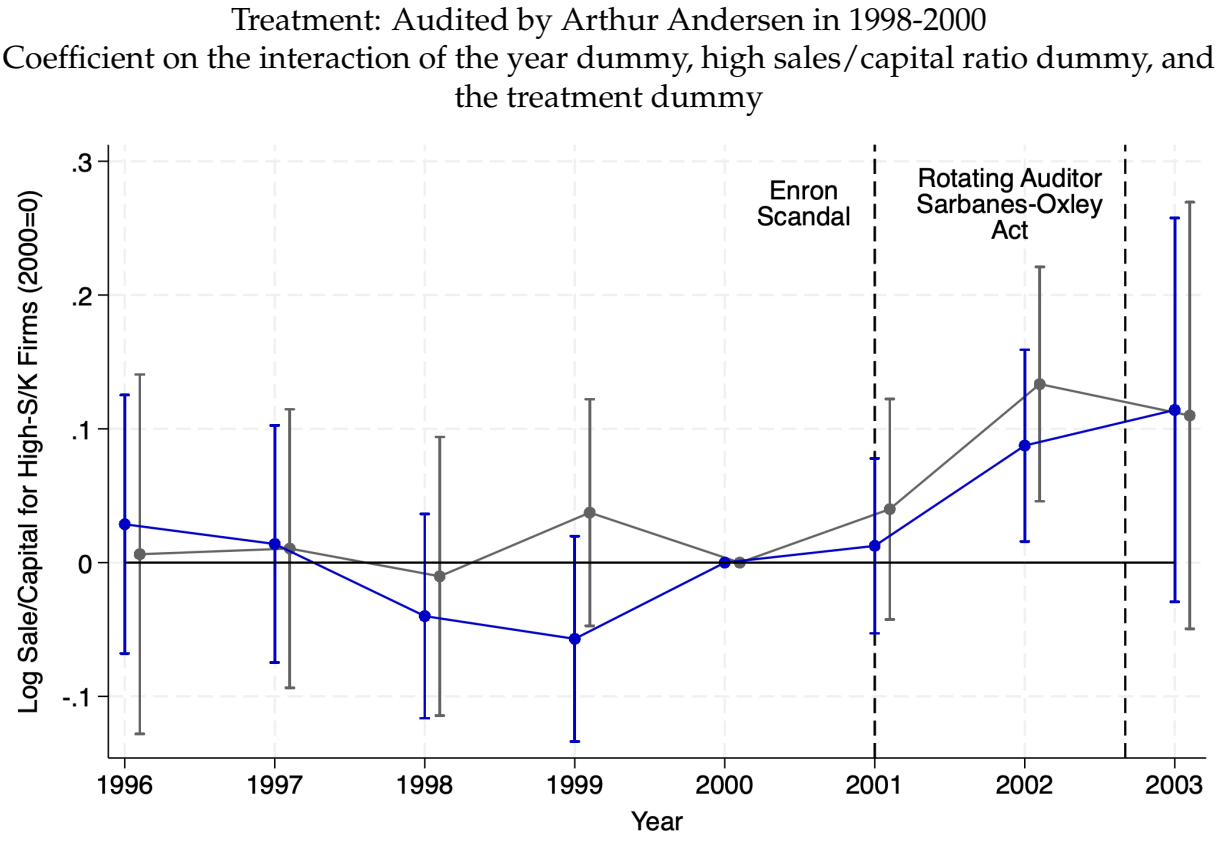
Figure 12 Event Study on the Logged Capital for High Sale/Capital Ratio Firms

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



Notes: This figure plots the estimates of coefficient $\tilde{\beta}_\tau$ 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 control variables are logged employment, 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.

Figure 13 Event Study on the Logged Sale/Capital Ratio for High Sale/Capital Ratio Firms



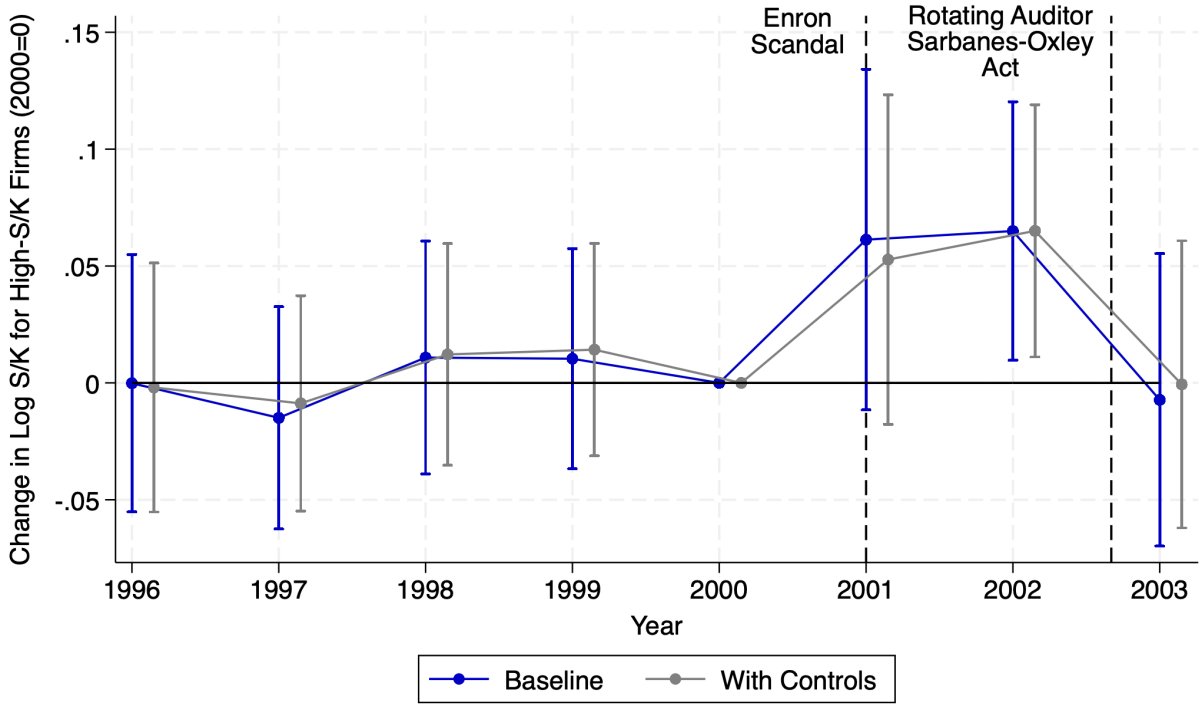
Notes: This figure plots the estimates of coefficient $\tilde{\beta}_\tau$ on the interaction of the year dummy, the high sales-to-capital ratio dummy and the treatment dummy when the outcome variable $Y_{i,s,t}$ is the logged sales-to-capital ratio in equation (22). The control variables are logged employment, 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.

and the control group relative to 2000, and the 95% confidence intervals. The pre-trends before 2000 satisfy the parallel trends assumption with coefficients $\hat{\beta}_\tau$ close to zero and statistically insignificant. Figure 12 shows a statistically significant, persistent decline of 9.0 percentage 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.

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

Figure 14 Event Study on the Growth of Sale/Capital Ratio for High Sale/Capital Ratio Firms

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



Notes: This figure plots the estimates of coefficient $\tilde{\beta}_\tau$ 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. To provide a measure of capital misallocation caused by the treatment, Figure 13 plots the coefficient $\tilde{\beta}_\tau$, 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 8.7 percent higher sales-to-capital ratio without control variables and a 13.0 percent higher ratio with control variables compared to the control group in 2002.

For robustness of the main specification, Figure 14 plots the estimates of $\tilde{\beta}_\tau$, the difference of the change in logged sales-to-capital ratio across treatment status in the

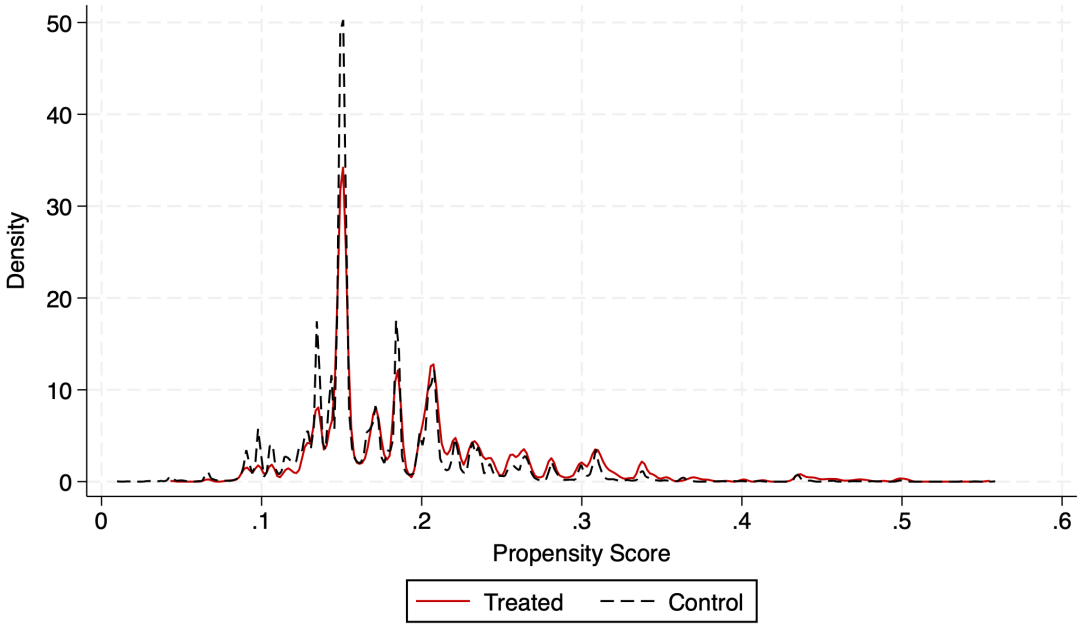


Figure 15 Kernel Density of Propensity Scores

Notes: This figure shows the kernel density of the propensity scores of firms across the treatment group and the control group. The covariates include employment, intangible assets, selling, general and administrative expense, costs of goods sold, total debt, common equity, and the industry (3-digit NAICS) fixed effect.

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 $\tilde{\beta}_\tau$ 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 6.4 percentage points.

It is suggested by the pre-trends in the event studies in this sectioin, the balance tests in Appendix B.2, and the propensity score distributions in Figure 15 that the treatment group and the control group are comparable prior to the Enron shock. Figure 15 shows the propensity score distributions of the treatment group and the control group. The graph reveals no systemic impact of the covariates on treatment status in 2000, prior to the scandal. The covariates include employment, intangible assets, industry fixed effects, and so on. First, I estimate a logit model of the propensity to be treated before the scandal, conditional on the covariates. Then, I plot the kernel densities of firm-level propensity scores by firms' treatment status. As Figure 15 shows, the densities of the treatment group and the control group do not differ materially. The reduced-form event study specifications show no pretrends, and

the estimates of the balance checks in Appendix B.2 are close to zero and insignificant. Intuitively, this suggests no evidence that the treatment and control groups differ before the Scandal, so the control is a reasonable counterfactual for the treatment. Overall, it is reasonable to claim that this Scandal is an exogenous shock to other firms, including Arthur Andersen and its confounders, that can affect capital misallocation.

I present results from event studies on zero-earnings-based borrowing firms to address concerns about exclusion restrictions and the SUTVA in Appendix B.1. I estimated equation (22) on a sample of zero-earnings-based borrowing firms. Figure 19 shows that the difference in the change in the logged sales-to-capital ratio for the high sales-to-capital-ratio firms between the treatment group and the control group is close to zero and insignificant. The difference in the logged capital for the high sales-to-capital-ratio firms between the treatment group and the control group is also small and insignificant, as shown in Figure 20. The reduced-form event studies with firms of zero exposure to earnings-based borrowing provide no evidence that the natural experiment violates the exclusion restriction or that there is interference between units, contradicting the SUTVA.

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 controls for employment growth and lagged employment growth to address potential concerns about absorbing unobserved firm heterogeneity. 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 2 reports regression results for the first-stage relationships and the IV estimates. Panel *A* reports the first stage: there are two clear negative relationships: i) the treat and the share of issued earnings-based borrowing; ii) the interaction of the treat 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). The column (1) in Panel A and Panel B of Table 3 presents the baseline results. In the baseline results, I controlled for firm size, represented by employment and lagged employment.

Table 2, Panel B reports the IV estimates. A 1-percentage-point decrease in the share of issued earnings-based borrowing leads to a 0.66-percentage-point increase in the growth of the sales-to-capital ratio, with high-sales-to-capital-ratio firms in the treatment group showing a larger increase than those in the control group. 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 2 reports a set of robustness checks. Panel A presents the stability of the IV estimates as control variables are added one at a time to the IV specification. Column (2) focuses on the firm age, and column (3) focuses on the change in log intangible assets. The magnitude of the treatment effects remains stable over the specifications. The treatment reduces the share of issued earnings-based borrowing by about 9.5 percentage points across specifications in Panel A. The coefficients on the interaction of the treatment and the high-sales-to-capital-ratio dummy are also stable at around 5.5 percentage points. The statistical significance of the coefficients on the treatment dummy for the share of issued earnings-based borrowing remains stable at 1%. The significance of coefficients on the interaction of the treatment dummy and the high-sales-to-capital dummy for the interaction of the share of issued earnings-based borrowing and the high-sales-to-capital dummy is also stable at 10%. The Sanderson-Windmeijer F statistics remain around 20 in Panel A.

   Table 2, Panel B shows the IV estimates across specifications of controls. With firm age and the percentage change in intangible assets separately (columns (2) and (3)) and jointly (column (4)) as controls, the coefficients on the interaction of the share of issued earnings-based borrowing and the high-sales-to-capital dummy remain sizable and stable at around -0.65 and statistically significant at the 10% level.

   The Appendix B.4 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.

Table 3 Changes on the Share of Issued Earnings-based Borrowing: the Enron shock

Panel A — First Stage

Panel A: First Stage

	% Issued Earnings-based Borrowing$_{i,t}$			
	(1)	(2)	(3)	(4)
Treat$_{i,s}$	-0.094***	-0.095***	-0.096***	-0.096***
	(0.020)	(0.021)	(0.021)	(0.021)
Treat$_{i,s}$×High S/K Pre the Scandal$_{i,s}$	0.043	0.042	0.046	0.045
	(0.040)	(0.040)	(0.040)	(0.040)
Controls				
$\Delta \log emp_{i,s,t}$	✓	✓	✓	✓
Lagged $\Delta \log emp_{i,s,-1 \text{ to } -3}$	✓	✓	✓	✓
Firm Age		✓		✓
Δ log Intangible Assets			✓	✓
Industry × Year FE	✓	✓	✓	✓
Observations	1573	1573	1573	1573
Sanderson-Windmeijer F	22.46	21.58	20.75	20.09

Notes: This table reports the results from the 2SLS framework in Section 3.3.1, using the merged Compustat and SDC Platinum datasets from 2002 to 2003. Standard errors are clustered by auditor × year. Column (1) reports baseline estimates controlling for employment growth and its lag. Columns (2) - (4) are robustness checks when firm age and growth of intangible assets are included as controls. All specifications are controlled for industry × year fixed effects. Panel A reports the first stage regression results as equation (20). Panel B reports the IV regression results as equation (19). The * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2 Continued

Panel A — Continued: First Stage

	% Issued Earnings-based Borrowing$_{i,t}$ × High S/K (pre-Scandal)$_{i,s}$			
	(1)	(2)	(3)	(4)
Treat$_{i,s}$	0.004	0.004	0.003	0.002
	(0.007)	(0.007)	(0.007)	(0.007)
Treat$_{i,s}$×High S/K Pre the Scandal$_{i,s}$	-0.056*	-0.057*	-0.054*	-0.055*
	(0.024)	(0.024)	(0.024)	(0.024)
Controls				
$\Delta \log emp_{i,s,t}$	✓	✓	✓	✓
Lagged $\Delta \log emp_{i,s,-1 \text{ to } -3}$	✓	✓	✓	✓
Firm Age		✓		✓
Δ log Intangible Assets			✓	✓
Industry × Year FE	✓	✓	✓	✓
Observations	1573	1573	1573	1573
Sanderson-Windmeijer F	21.83	22.32	20.17	19.32

Table 2 Continued

Panel B: IV	(1)	(2)	(3)	(4)
% Issued Earnings-based Borrowing$_{i,t}$	-0.020	-0.021	-0.027	-0.029
	(0.269)	(0.267)	(0.260)	(0.258)
% Issued Earnings-based Borrowing$_{i,t}$×High S/K Pre the Scandal$_{i,s}$	-0.664*	-0.669*	-0.649*	-0.654*
	(0.345)	(0.340)	(0.361)	(0.356)
Controls				
$\Delta \log emp_{i,s,t}$	✓	✓	✓	✓
Lagged $\Delta \log emp_{i,s,-1 \text{ to } -3}$	✓	✓	✓	✓
Firm Age		✓		✓
Δ log Intangible Assets			✓	✓
Industry × Year FE	✓	✓	✓	✓
Observations	1573	1573	1573	1573

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; and (iii) a borrowing constraint, the limit of which equals the sum of an asset-based component and an earnings-based component. This section outlines the key adapted ingredients.

Joint distribution of firm wealth and productivity $G(a, z)$ has material implications in 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, the correlation between log TFPR and log EBITDA is statistically significant at 0.923, but the correlation between log TFPR and log wealth is only 0.45 in Table 1. 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). The budget constraint of the entrepreneur becomes

$$c = f(z, k, \ell) - rk - w\ell - (1+r)a. \tag{24}$$

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. To generate fractional shares of issued earnings-based borrowing in the model, I assume that the firm's units of capital input k is the sum of the firm's earnings-based borrowing b_e, asset-based borrowing b_a, and wealth a,

$$k = b_e + b_a + a. \tag{25}$$

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

$$b_e \leq \theta_e[f(z, k, l) - wl], \tag{26}$$

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

$$b_a \leq \theta_a k. \tag{27}$$

Entrepreneurs still maximize the value of utility from consumption (1) subject to the budget constraint (24). Define the profit function

$$\tilde{\Pi}(a, z) = \max_{k,\ell} \left\{ f(z, k, \ell) - rk - w\ell \text{ s.t. } k - a \leq \theta_e[f(z, k, \ell) - w\ell] + \theta_a k \right\} \tag{28}$$

The budget constraint (24) can be rewritten as

$$c = \tilde{\Pi}(a, z) + (1+r)a. \tag{29}$$

Lemma 5 *For any parameterization of financial frictions (θ_e, θ_a), conditional on the interest rate $r = \bar{r}$, aggregate labor supply, and the aggregate endowment of firm wealth, the general-equilibrium wage rate is uniquely pinned down at $w = \bar{w}$.*

In the absence of labor market frictions, and under the CES production technology, each firm's labor demand is proportional to its capital demand, with the proportionality factor pinned down by the equilibrium interest rate and wage. It follows that aggregate labor demand is proportional to aggregate capital demand. In general equilibrium, market clearing implies that aggregate capital demand equals the aggregate endowment of firm wealth, while aggregate labor demand equals the fixed aggregate labor supply. Therefore, for a given interest rate and given aggregate supplies of labor and firm wealth, the equilibrium wage is uniquely determined.

Proposition 2 *For any parameterization of financial frictions (θ_e, θ_a), given the interest rate $r = \bar{r}$, aggregate labor supply, the aggregate endowment of firm wealth and the joint distribution firm wealth and productivity $G(a, z)$, aggregate borrowing is pinned down at $B = \bar{B}$.*

Lending firms are those whose endowment of firm wealth a exceeds the unconstrained optimal capital choice,

$$k^*(z, r, w) = \left(\frac{\eta \, \Phi_1(z, r, w)}{\Phi_2(r, w)} \right)^{\frac{1}{1-\eta}} < a, \tag{30}$$

where $\Phi_1(r, w) = z\left[\alpha^{1+\rho} + (1-\alpha)\alpha^{\rho}\left(\frac{w}{r}\right)^{\frac{\rho}{1+\rho}}\right]^{-\frac{\eta}{\rho}}$, $\Phi_1(r, w) = r\left[\frac{1-\alpha}{\alpha}\left(\frac{w}{r}\right)^{\frac{\rho}{1+\rho}} + 1\right]$. Hence, for given factor prices (r, w), the cutoff $k^*(z, r, w)$ divides firms into lenders and borrowers: firms with $a \geq k^*(z, r, w)$ are lenders, whereas firms with $a < k^*(z, r, w)$ are borrowers. It follows that, holding $r = \bar{r}$ and $w = \bar{w}$ fixed, aggregate lending in general equilibrium is pinned down at

$$\bar{B} = \int_0^{+\infty} \int_{k^*(z, \bar{r}, \bar{w})}^{+\infty} a \, g(a, z) \, da \, dz. \tag{31}$$

Given the joint distribution of firm wealth and productivity, equilibrium factor prices determine the cutoff between lenders and borrowers and, therefore, the set of firms that lend in equilibrium.

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, 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 equilibrium to data in the year 2000 and the new mid-scandal equilibrium 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 NACIS) × 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 $\mu_{\log a} \approx 0$ and standard deviation $\sigma_{\log a} = 2.24$ of log firm wealth, mean $\mu_{\log z} \approx 0$ and standard deviation $\sigma_{\log z} = 0.99$ of log firm TFP, and the correlation $\rho = 0.45$ between log firm wealth and log firm TFP (Table 6).

Production Function. According to the literature, the capital share is equal to $\alpha = 1/3$. I use the estimates of elasticity of substitution from Acemoglu and Restrepo (2018) to calibrate $\sigma = 0.7$, 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).

Financial Frictions. Literature usually sets the financial friction parameters to the average leverage ratios from firm-level microdata, assuming that all firms are constrained. However, 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. To avoid this issue, 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 5.62 from Compustat North America in 2000 is the targeted moment to calibrate the asset-based financial frictions $\theta_a = 0.6$, because I measure firm wealth to align 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, $\theta_e = 1.3$, 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 $\Delta\theta_e = -1.1$ is set such that earnings-based financial frictions during the shock $\theta_e + \Delta\theta_e = 0.2$ can replicate the average firm-level debt-to-EBITDA ratio for the treated Compustat firms in 2002.

Table 6 Estimated Parameters

Parameter	Interpretation	Target/Source	Value
Panel A: Internally Calibrated Parameters			
θ_e	Earnings-based financial frictions	Average firm-level debt/EBITDA ratio in 2000 (Compustat North America)	1.3
$\Delta\theta_e$	Enron shock to earnings-based financial frictions	Average firm-level debt/EBITDA ratio of the treated in 2002 (Compustat North America)	-1.1
θ_a	Asset-based financial frictions	Average firm-level debt/wealth ratio in 2000 (Compustat North America)	0.6
Panel B: Externally Calibrated Parameters			
Distribution of firm wealth a and productivity z			
$\mu_{\log a}$	Mean of log firm wealth	Compustat North America in 2000	0
$\sigma_{\log a}$	Standard error of log firm wealth	Compustat North America in 2000	2.24
$\mu_{\log z}$	Mean of log firm TFP	Compustat North America in 2000	0
$\sigma_{\log z}$	Standard error of log firm TFP	Compustat North America in 2000	0.99
ρ	Correlation between log firm wealth and log TFP	Compustat North America in 2000	0.45
Production function			
α	Capital share		1/3
σ	Elasticity of substitution	Acemoglu and Restrepo (2018)	0.7
η	Span-of-control parameter	Midrigan and Xu (2014)	0.85

Notes: This table reports the estimated parameters in the quantitative model.

4.3 Model's Fit

While the natural experiment in Section 3 delivers an exogenous tightening of earnings-based borrowing, its implications for the allocative efficiency of capital remain unclear without a disciplined comparison to a commensurate tightening of the asset-based borrowing constraint in a quantitative model. In the calibrated version of the model, I demonstrate that it can quantitatively reproduce the empirical findings from the two-stage least squares (2SLS) main specification, namely, stronger earnings-based financial frictions due to the Enron shock and the consequent greater capital misallocation.

Table 7 reports the coefficients from the 2SLS specification, both in the data and in the model, indicating a good fit between the data and the model. The quantitative model closely matches the extent of capital misallocation induced by the Enron shock. As shown in the first row of Table 7, the model yields an IV coefficient on the interaction between the share of earnings-based borrowing issuance and a high sales-to-capital indicator of -0.67, very close to the -0.64 estimated in the data. As suggested by Proposition 1, the greater earnings-based financial frictions disproportionately constrain the high-MPK firms and consequently increase their MPK more than the low-MPK firms.

The model also reproduces the decline in the share of earnings-based borrowing issuance caused by the Enron shock. In the second row of Table 7, the first-stage coefficient of the share of issued earnings-based borrowing on the treatment indicator of the share of issued earnings-based borrowing is -0.091 in the model, closely matching the -0.094 estimated in the data from the first-stage regression in (20). That is to say, the Enron shock reduced the share of issued earnings-based borrowing by approximately 10 percentage points for the low-MPK firms. According to the summary statistics in Table 1, the mean share of issuance accounted for by earnings-based borrowing is 0.36 and the standard deviation is 0.41, so a reduction of about 9–10 percentage points associated with the Enron shock is economically meaningful.

The model also reproduces the heterogeneous decline in the share of earnings-based borrowing among high-MPK firms following the Enron shock. In the first-stage regression (20), the coefficient of the interaction between the share of issued earnings-based borrowing and the high sales-to-capital ratio dummy on the interaction between the treatment indicator and the high sales-to-capital dummy is -0.026 in the model, matching the negative sign in the data and remaining of comparable magnitude to the empirical estimate of -0.056 (see Table 7). Relative to the mean and standard deviation of the share of issued earnings-based borrowing (Table 1), this reduction for high-MPK firms is non-trivial in economic terms.

Table 7 Nontargeted Moments: Model versus Data

2SLS coefficients	Data	Model
IV coefficient on share of issued EBB × high sale/capital ratio	-0.64	-0.67
1st stage coefficient on treatment dummy	-0.094	-0.091
1st stage coefficient on treat dummy × high sale/capital ratio	-0.056	-0.026

4.4 The Experiments on the Tightness of Borrowing Constraints

I now reproduce the Enron shock in earnings-based financial frictions using my economic model and demonstrate the economic implications of a comparable change in asset-based financial frictions.

Experiment Design. The model has a unique equilibrium. Different equilibria are reached only when parameter values are adjusted. The economy is the pre-scandal equilibrium in 2000. To start with, the Enron shock tightens the earnings-based borrowing constraint and pushes the economy into the mid-scandal equilibrium in 2002 by reducing the value of earnings-based financial frictions θ_e from 1.3 to 0.2. Building on my natural experiment in Section 3, the asset-based financial frictions are unaffected and remain at the pre-scandal level. Earnings-based financial frictions and asset-based financial frictions are fundamentally different by definition. To make the tightening on the earnings-based and asset-based borrowing comparable, in the counterfactual exercise, I set the asset-based financial frictions so that the new equilibrium generates the same rental rate r as the equilibrium under the Enron shock. The intuition is the following: since the aggregate capital is fixed by the aggregate endowment of firm wealth in general equilibrium, the equal rental rate makes the steady states comparable in the sense that unconstrained firms would share the equal $MPK = r$.

Results. Figure 16 shows the TFP loss caused by the Enron shock and the TFP loss incurred by a comparable tightening of the asset-based borrowing constraint. The red curve in Figure 16 presents the TFP loss caused by the Enron shock to earnings-based financial frictions θ_e when asset-based financial frictions are constant at the pre-scandal level of 0.6. The θ_e decreases from 1.3 to 0.2 due to the Enron shock, leading to the TFP loss of 0.45%. The blue curve in Panel B illustrates the TFP loss resulting from a comparable tightening of the asset-based borrowing constraint, while holding earnings-based frictions at the pre-scandal level of 1.3. The comparable tightening of the asset-based constraint only results in a 0.1% loss in TFP.

Implications. The main lesson from my model is that a tightening of the earnings-

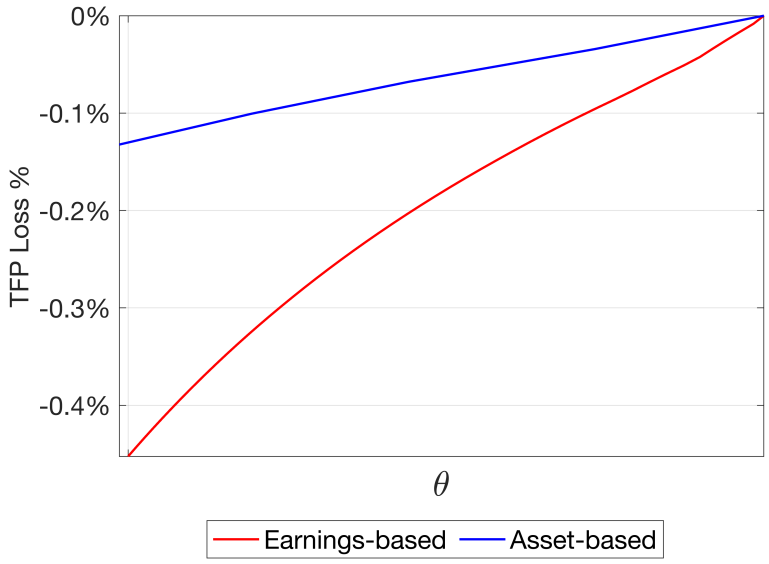


Figure 16 TFP Loss from Tightening Borrowing Constraints

Notes: This figure compares the TFP losses caused by a tightening of the earnings-based borrowing constraint calibrated to the Enron shock and a comparable tightening of the asset-based borrowing constraint. The red curve in Figure 16 presents the TFP loss caused by the Enron shock to earnings-based financial frictions θ_e when asset-based financial frictions are constant at the pre-scandal level of 0.6. The θ_e decreases from 1.3 to 0.2 due to the Enron shock, leading to the TFP loss of 0.45%. The blue curve in Panel B illustrates the TFP loss resulting from a comparable tightening of the asset-based borrowing constraint, while holding earnings-based frictions at the pre-scandal level of 1.3. The tightening of the asset-based borrowing constraint and the earnings-based constraint are comparable in that the economy has the same rental rate in general equilibrium. The comparable tightening of the asset-based constraint only results in a 0.1% loss in TFP.

based borrowing constraint generates larger efficiency losses than a comparable tightening of the asset-based borrowing constraint. Deterioration in earnings-based financial frictions leads to greater TFP losses because high-productivity firms are disproportionately affected. High-productivity firms have higher earnings and, therefore, more relaxed earnings-based borrowing limits. When the earnings-based borrowing constraint is tightened, high-productivity firms must reduce borrowing and, consequently, capital, while low-productivity firms do not respond as significantly due to their limited earnings. As a result, capital is more misallocated. This conclusion has implications for policy design. A government that aims at improve capital misallocative efficiency by credit market policies should recognize that (i) an earnings-based borrowing policy will allocate funds more efficiently as earnings tracks productivity well (Figure 1), and (ii) channeling funds to firms with high earnings and low wealth will generate more efficiency because these firms are more constrained and have higher MPK.

5 Conclusion

Earnings-based borrowing dominates the US corporate debt market. The main contribution of this article is to provide the first natural experiment on earnings-based financial frictions, utilizing the Enron-Arthur Andersen scandal. My key finding is that the Enron shock diminishes the share of issued earnings-based borrowing by 10 percentage points for the treated firms that were audited by Arthur Andersen before the scandal, and the change in the log MRPK of the high MRPK firms increases by 6.6 percentage points more than the low-MRPK firms, causing more dispersion to MRPK in the economy. The Enron shock led to a significant deterioration in capital allocative efficiency. For future research, the natural experiment on earnings-based financial frictions is a rare event that can be used to study the effects of the earnings-based borrowing, which dominates the US corporate debt market, on other economic variables.

The simple model contributes to the literature by showing how earnings-based borrowing collateralizes productivity via earnings. The intuition is that high-productivity firms generate higher earnings, thereby relaxing the earnings-based borrowing constraint. As a result, high-productivity firms have access to more funds and, consequently, more capital due to the relaxation of the earnings-based borrowing constraint. The quantitative model suggests that tightening the earnings-based borrowing constraint yields greater TFP losses than a comparable tightening of the asset-based borrowing constraint. The TFP loss is exacerbated by deteriorating earnings-based financial frictions, as high-productivity firms that have high earnings disproportionately lose access to capital as

the earnings-based borrowing constraint tightens. More immediately, the model can be used to analyze the efficiency implications of the Enron shock. The Enron shock results in a 0.45% TFP loss for the US economy, primarily due to its earnings-based credit shock, whereas a comparable asset-based credit shock causes only a 0.1% TFP loss.

Taking a broader view, the research also provides guidance on the future effects of credit policies on misallocation. First, an earnings-based credit allocation rule will lead to more efficiency in the economy than an asset-based rule. Indeed, I show that earnings-based borrowing channels funds to high-earning firms, which are also more productive. Second, earnings-based credit market policies should target high-earning and low-wealth firms. The firm's low wealth suggests it is more constrained by a traditional asset-based borrowing constraint. Given that high earnings are indicators of high productivity, an earnings-based credit market policy can channel funds to productive firms, thereby improving capital allocative efficiency. Third, policymakers should be more careful when setting a cap on the debt-to-earnings ratio than on the debt-to-capital ratio in the corporate debt market. Although managing the leverage ratios is crucial to macroprudential regulations, a lower earnings-based borrowing limit will have a considerably larger impact on TFP and the aggregate economy than the asset-based borrowing limit.

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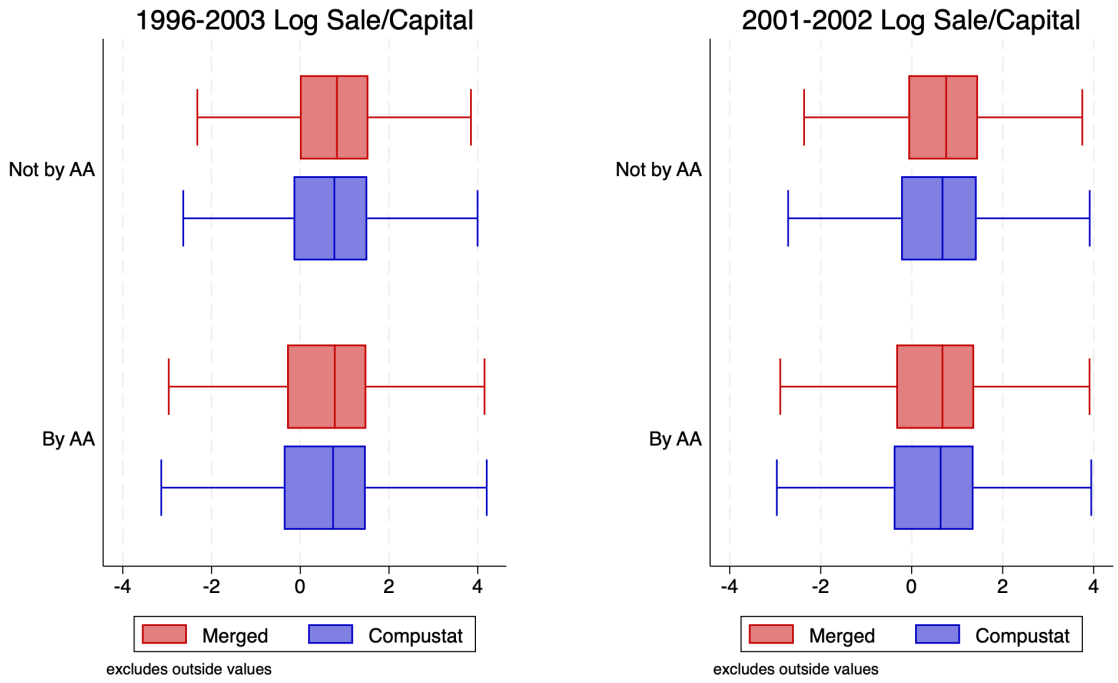


Figure 17 Summary Statistics on Sales-to-capital ratio by Auditor

Notes: This figure shows the box plot of the log sales-to-capital ratio by engagement with Arthur Andersen in auditing. Not by AA means firms that were not audited by Arthur Andersen. By AA, I mean firms that were audited by Arthur Andersen. The blue represents the full Compustat sample. The red represents the merged dataset in the main analysis.

A Appendix: Summary Statistics

Figure 17 and Figure 18 also show similar patterns of the firm-level sales-to-capital ratio and the firm-level change in log sales-to-capital ratio across auditors between the merged dataset and Compustat. Compustat is useful for my natural experiment because it provides the names of firms' primary auditors on an annual basis. *By AA* means firms audited by Arthur Andersen before the Enron Scandal, and *Not by AA* means firms not audited by Arthur Andersen before the Scandal in Figure 17 and Figure 18. The medians of the log sales-to-capital ratio and the change in the log sales-to-capital ratio remain similar in both figures.

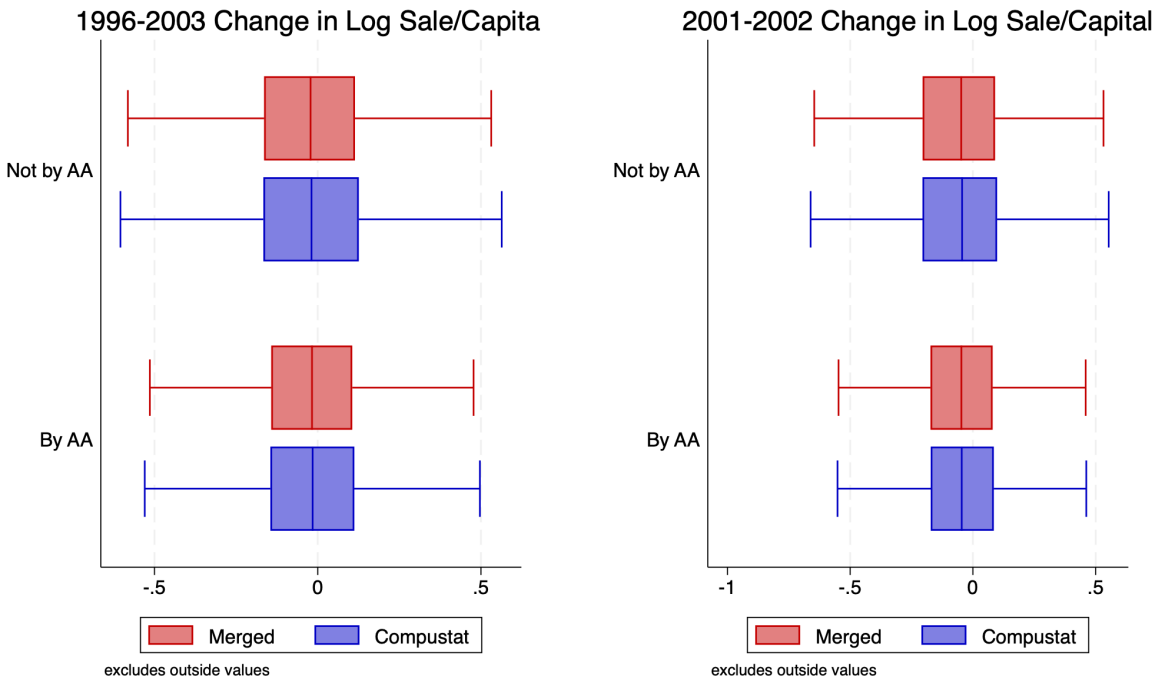
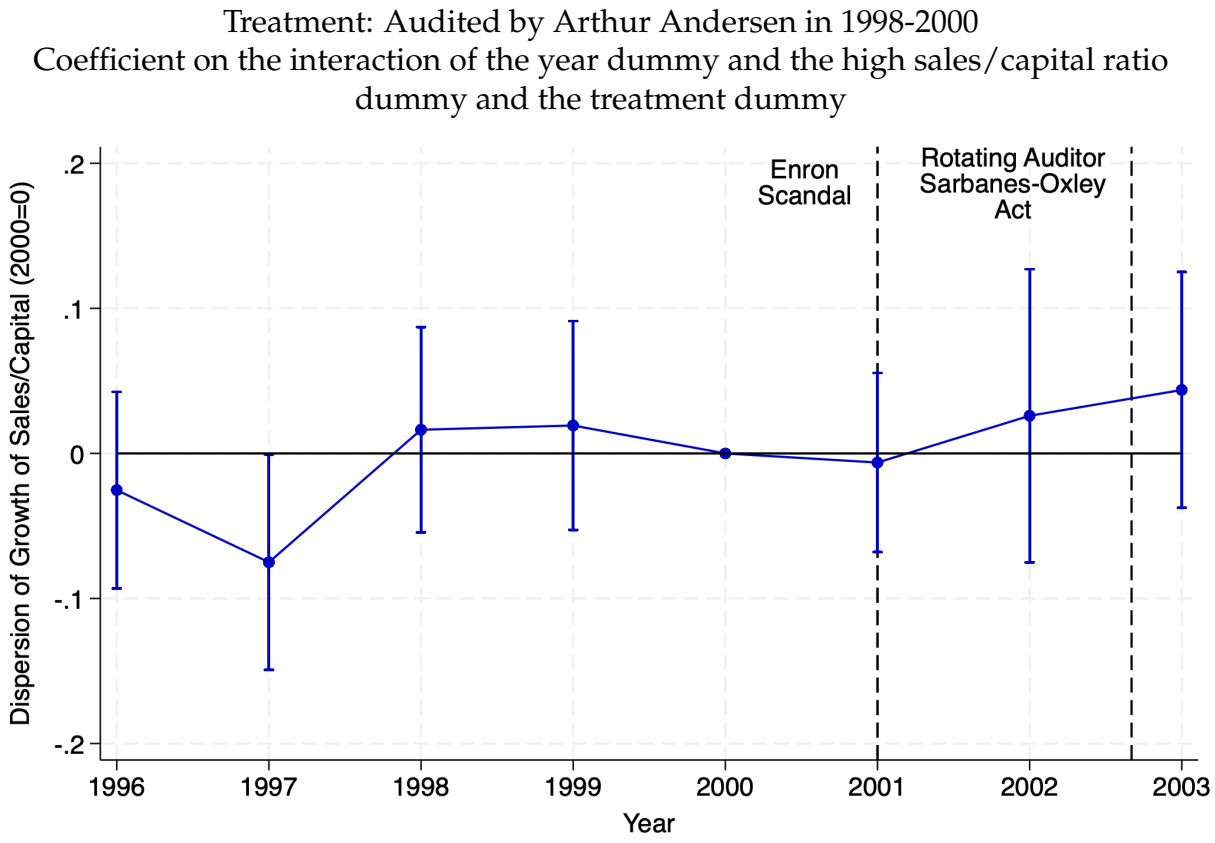


Figure 18 Summary Statistics on the Change of the Log Sales-to-Capital Ratio by Auditor

Notes: This figure shows the box plot of the change in log sales-to-capital ratio by engagement with Arthur Andersen in auditing from 1996 to 2003. Not by AA means firms that were not audited by Arthur Andersen. By AA, I mean firms that were audited by Arthur Andersen. The blue represents the full Compustat sample. The red represents the merged dataset in the main analysis.

Figure 19 Event Study on the Growth of Sale/Capital Ratio for High Sale/Capital Ratio Firms with Zero Earnings-based Borrowing



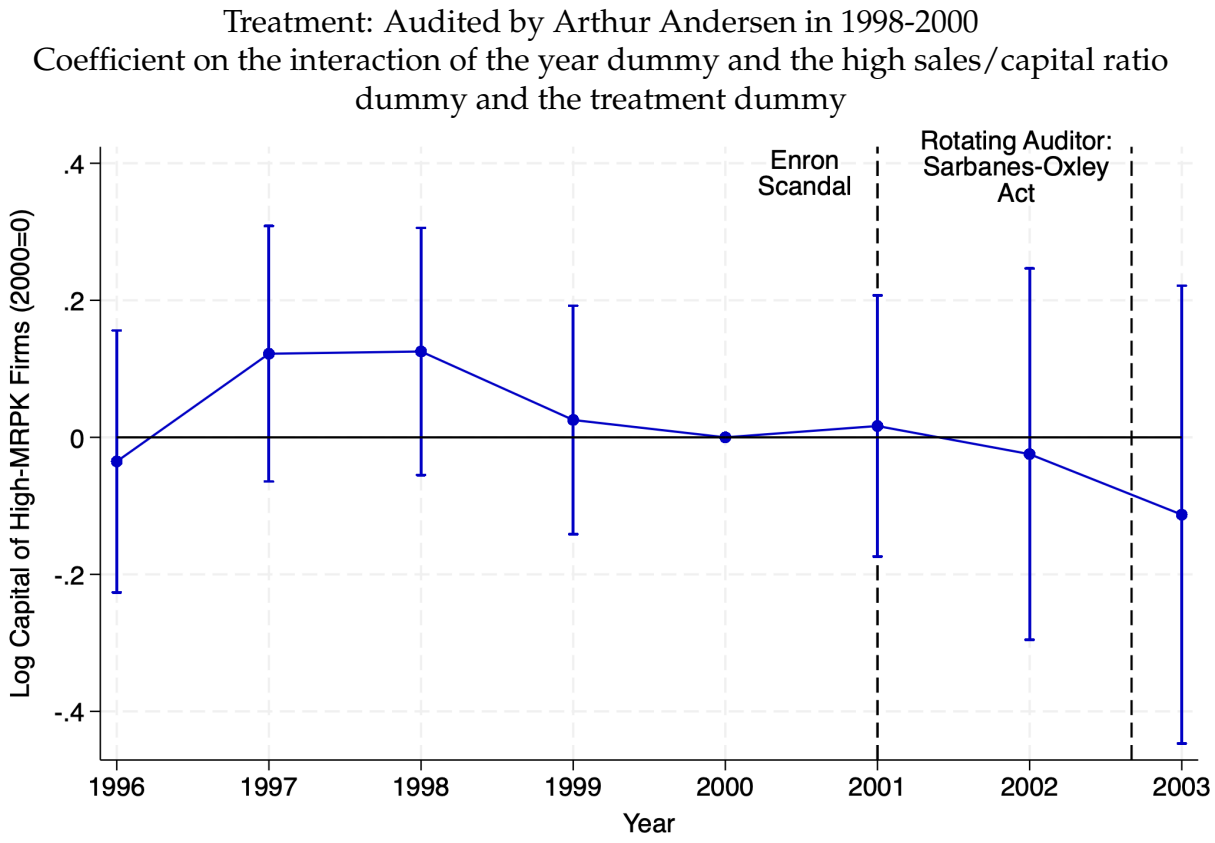
Notes: This figure plots the estimates of coefficient $\tilde{\beta}_\tau$ on the interaction of the year dummy, the high sales-to-capital ratio dummy and the treatment dummy when the outcome variable $Y_{i,s,t}$ is the change in logged sales-to-capital ratio in equation (22). The sample is a merged 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.

B Appendix: Robustness Tests

B.1 Tests of Exclusion Restrictions and SUTVA

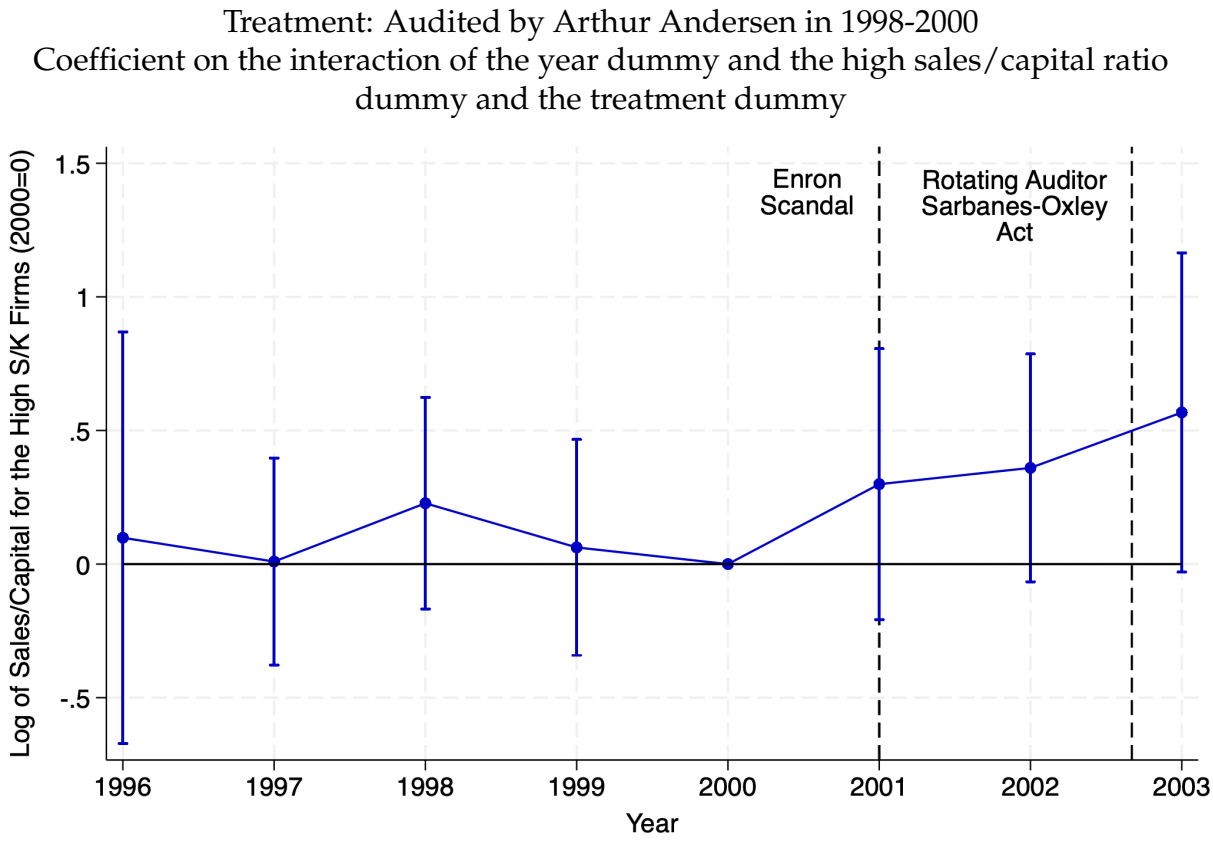
This section conducts the event studies on the "never-earnings-based" firms to test for the exclusion restrictions and the validity of SUTVA. The event study empirical specification is equation (22). The results are presented in Figure 19 and Figure 20. As Figure 19 and Figure 20 show, the MRPK and the capital inputs for the high-sales-to-capital-ratio firms of the "never-earnings-based" are unaffected by the treatment. The coefficients of the interaction of the year dummy, the high sales-to-capital ratio dummy, and the treatment dummy remain close to zero and insignificant.

Figure 20 Event Study on the Logged Capital for High Sale/Capital Ratio Firms with Zero Earnings-based Borrowing



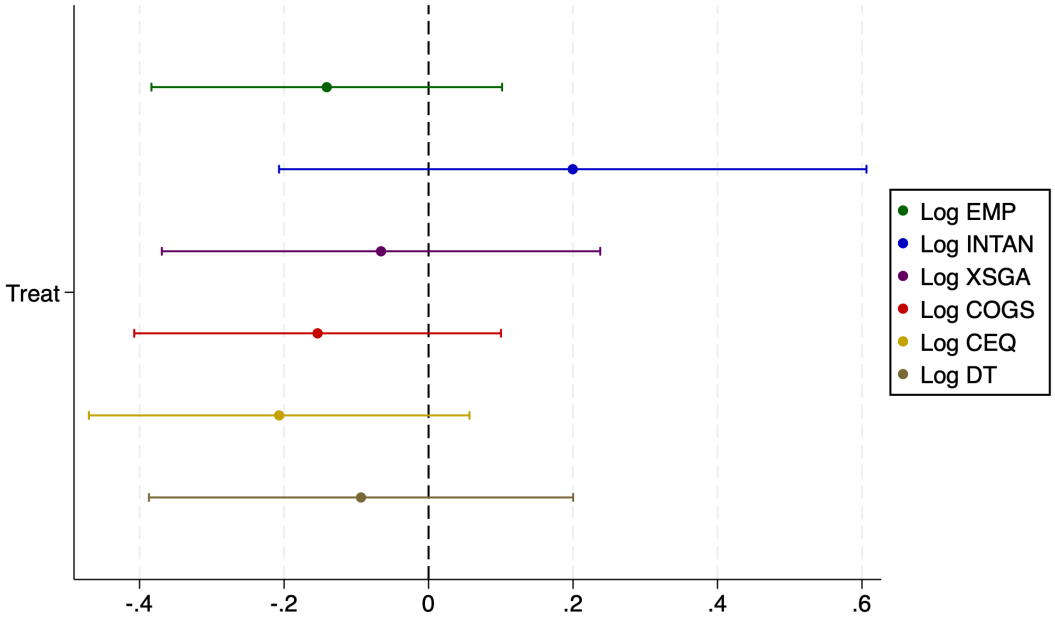
Notes: This figure plots the estimates of coefficient $\tilde{\beta}_\tau$ on the interaction of the year dummy, the high sales-to-capital ratio dummy and the treatment dummy when the outcome variable $Y_{i,s,t}$ is the logged capital in equation (22). The sample is a merged dataset of Compustat and 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 21 Event Study on the Log Sale/Capital Ratio for High Sale/Capital Ratio Firms with Zero Earnings-based Borrowing



Notes: This figure plots the estimates of coefficient $\tilde{\beta}_\tau$ 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 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 22 Balance Checks



Notes: This figure shows the results from the balance checks by the empirical specification in (32).

B.2 Balance Check

This section presents the balance check between the treatment and the control in 2000, prior to the Enron-Arthur Andersen scandal. The empirical specification is as follows for firm i in industry s in year 2000:

$$Y_{is} = \beta Treat_{is} + \alpha_s + \epsilon_{is}, \tag{32}$$

where Y_{is} is the outcome variable, including log cost of goods sold, log firm wealth, log employment, log intangible assets, log selling, general and administrative expense, and log debt; $Treat_{is}$ is the treatment variable; α_s is the industry fixed effect.

The results are presented in Figure B.2, which shows that the treatment and control do not differ in the outcome variables. The estimates of the coefficient β on the treatment dummy $Treat_{is}$ are close to zero and insignificant.

B.3 Event study of the ratio of the amount of issued earnings-based borrowing to EBITDA

This section estimates the coefficient for the regression of the ratio of issued earnings-based borrowing to EBITDA on the interaction of the treatment dummy and the year dummy for each year, relative to 2000. I estimate the following,

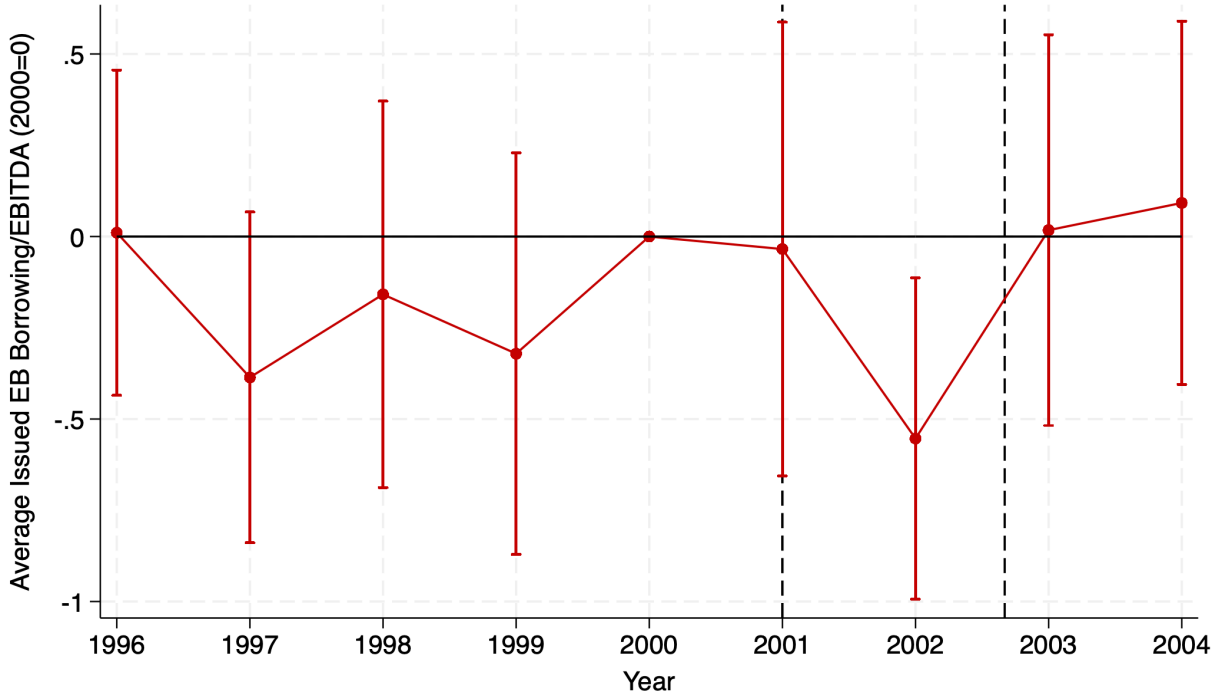
$$\frac{b^{+}_{e,i,s,t}}{EBITDA_{i,s,t}} = \sum_{\tau \neq 2000} \beta_\tau \mathbb{1}^{t=\tau} \cdot Treat_{i,s} + \alpha_i + \delta_{s,t} + \nu_{i,s,t}, \tag{33}$$

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

Figure 23 presents the coefficient estimates of β_τ when the outcome variable is the ratio between issued earnings-based borrowing and EBITDA of firm i in industry s in year t. The coefficient estimates declined significantly for the treatment group in 2002. The result shows that earnings-based financial frictions worsen due to the Enron shock, which is robust to Section 3.3.2.

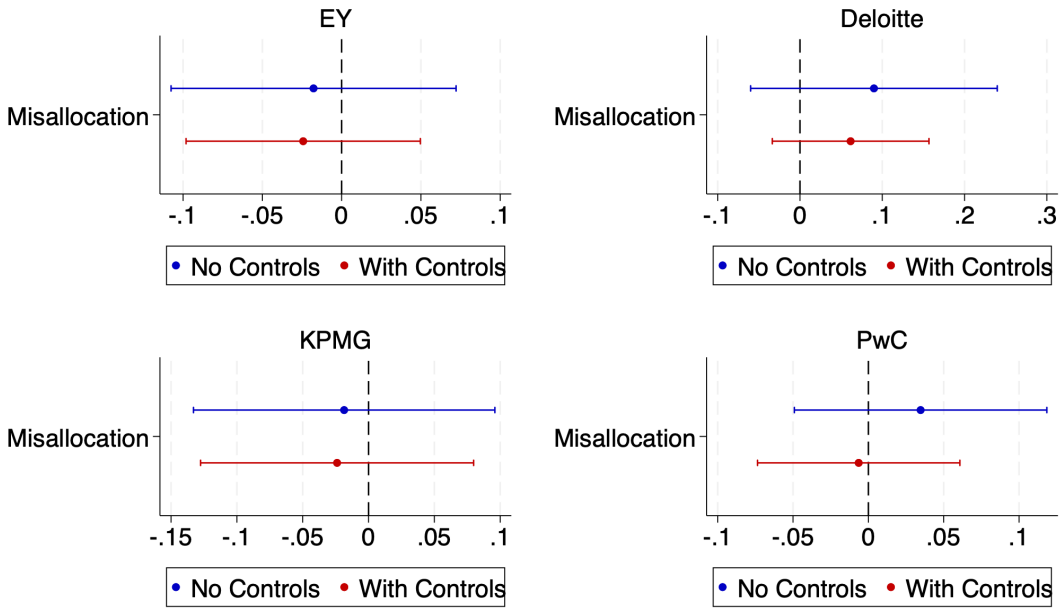
Figure 23 Event Study on the Issued Amount of Earnings-based Borrowing/EBITDA

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 coefficient β_τ on the interaction of the year dummy and the treatment dummy when the outcome variable is the ratio of the amount of the earnings-based borrowing to EBITDA $\frac{b^+_{e,i,s,t}}{EBITDA_{i,s,t}}$. 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 24 Placebo Tests with the "Big Four"



Notes: This figure presents the placebo tests when the treatment dummy $Treat_{is}$ is equal to 1 if the firm i in industry s is audited by EY, Deloitte, KPMG, and PwG, respectively. The empirical specification follows the two-stage least squares regression (20) and (19). The estimates of the coefficient β on the interaction of the treatment dummy and the high-sales-to-capital-ratio dummy are plotted in the figures. The placebo tests indicate that the effects of the fake treatments on misallocation are close to zero and insignificant.

B.4 Placebo Tests with Other Auditors

This section presents the placebo tests for the main specification when firms audited by other auditors, namely the "Big 4", are assigned as the treatment. Figure 24 presents the placebo tests when the treatment dummy $Treat_{is}$ is equal to 1 if the firm i in industry s is audited by EY, Deloitte, KPMG, and PwG, respectively. The empirical specification follows the two-stage least squares regression (20) and (19). The estimates of the coefficient β on the interaction of the treatment dummy and the high-sales-to-capital-ratio dummy are plotted in the figures. The placebo tests indicate that the effects of the fake treatments on misallocation are close to zero and insignificant.

C Appendix: Proofs

C.1 Proof of Lemma 1

$$
\begin{aligned}
z(k) = \frac{k-a}{\theta_e k^{\alpha}} = \frac{1}{\theta_e}(k^{1-\alpha-ak^{-\alpha}}),\ k>0,\\
z'(k) = \frac{1}{\theta_e}\Big[(1-\alpha)k^{-\alpha}+\alpha a k^{-\alpha-1}\Big] > 0,\\
z''(k) = \frac{1}{\theta_e}\Big[-\alpha(1-\alpha)k^{-\alpha-1}-(1+\alpha)\alpha a k^{-\alpha-2}\Big] < 0,\\
k\to 0,\ -ak^{-\alpha}\to-\infty,\ z(k)\to-\infty
\end{aligned}
\tag{34}
$$

So, $z(k)$ is increasing in k. $z'(k)$ is decreasing in k, so $z(k)$ is concave in k.

Since the piecewise function $k(z)$ is continuous respectively on $z<\tilde{z}$ and $z>\tilde{z}$, and by definition of threshold, when $z=\tilde{z}$, $\mathcal{K}^{-1}(a,\tilde{z}(a)) = \frac{a}{1-\theta_e}$. So, the policy function $k(a,z)$ is continuous in z.

C.2 Proof of Lemma 2

When $a\to 0$, the asset-based borrowing limit approaches 0 such that

$$
k = \frac{a}{1-\theta_a} \to 0. \tag{35}
$$

The earnings-based borrowing limit can be rewritten as

$$
a = k - \theta_e z k^{\alpha}. \tag{36}
$$

The first-order derivative is

$$
a' = 1-\alpha\theta_e z k^{\alpha-1}, \tag{37}
$$

and the second-order derivative is

$$
a'' = \alpha(1-\alpha)\theta_e z k^{\alpha-2} > 0, \tag{38}
$$

such that the first-order derivative a' is monotonically increasing in k. The $a'=0$ when

$$
k = (\alpha\theta_e z)^{\frac{1}{1-\alpha}}. \tag{39}
$$

Therefore, the firm wealth a is decreasing in capital k when $k < (\alpha\theta_e z)^{\frac{1}{1-\alpha}}$ and increasing in capital k when $k \geq (\alpha\theta_e z)^{\frac{1}{1-\alpha}}$. When $a = 0$, there are two roots for k:

$$k_1 = 0, k_2 = (\theta_e z)^{\frac{1}{1-\alpha}}. \tag{40}$$

Profit maximization implies that when $a \to 0$, given z, firm chooses $k = (\theta_e z)^{\frac{1}{1-\alpha}} > 0$ to earn positive profits.

Since the piecewise function $k(a)$ is continuous respectively on $a < \tilde{a}$ and $a > \tilde{a}$, and by definition of threshold, $\mathcal{A}^{-1}(z, \tilde{a}(z)) = \frac{\tilde{a}(z)}{1-\theta_e}$. So, the policy function $k(a, z)$ is continuous in a.

C.3 Proof of Lemma 3

Given a, for the asset-based-borrowing constrained firms,

$$MPK = \alpha z\left(\frac{a}{1-\theta_a}\right)^{\alpha-1}, \tag{41}$$

which is monotonically increasing in z given a. Rewriting capital k as a function of MPK such that

$$k = \left(\frac{\alpha z}{mpk}\right)^{\frac{1}{1-\alpha}}. \tag{42}$$

Substitute into equation (34),

$$\begin{aligned}
z(mpk) &= a^{1-\alpha}\left(\frac{mpk}{\alpha}\right)^{\alpha}\left(\frac{\alpha}{mpk} - \theta_e\right)^{\alpha-1}, \\
z'(mpk) &= a^{1-\alpha}\alpha(\frac{mpk}{\alpha})^{\alpha-1}\left(\frac{\alpha}{mpk} - \theta_e\right)^{\alpha-1} \\
&\quad + a^{1-\alpha}\left(\frac{mpk}{\alpha}\right)^{\alpha}(\alpha-1)\left(\frac{\alpha}{mpk} - \theta_e\right)^{\alpha-2}\left(-\frac{\alpha}{mpk^2}\right) \\
&= a^{1-\alpha}mpk^{\alpha-2}\left(\frac{\alpha}{mpk} - \theta_e\right)^{\alpha-2}\left[mpk\left(\frac{\alpha}{mpk} - \theta_e\right) + (1-\alpha)\right] > 0,
\end{aligned}$$

Set $x = mpk\left(\frac{\alpha}{mpk} - \theta_e\right) > 0$, such that

$$z'(x) = a^{1-\alpha}\alpha^{1-\alpha}x^{\alpha-2}(x + 1 - \alpha)$$

The second order derivative wrt to mpk is

$$\begin{aligned} z''(mpk) &= \frac{dz'(x)}{dx}\frac{dx}{dmpk} \\ &= \left[(\alpha-2)a^{1-\alpha}\alpha^{1-\alpha}x^{\alpha-3}(x+1-\alpha) + a^{1-\alpha}\alpha^{1-\alpha}x^{\alpha-1}\right]\left(\frac{\alpha}{mpk} - \theta_e - \frac{\alpha}{mpk}\right) \\ &= -\theta_e(\alpha a)^{1-\alpha}x^{\alpha-3}\left[(\alpha-2)(1-\theta_e mpk) + (\alpha-\theta_e mpk)^2\right], \end{aligned}$$

Posive $z = a^{1-\alpha}\left(\frac{mpk}{\alpha}\right)^{\alpha}\left(\frac{\alpha}{mpk} - \theta_e\right)^{\alpha-1}$ requires $\frac{\alpha}{mpk} - \theta_e > 0$, so

$$1 > \alpha > \theta_e mpk > 0.$$

Therefore,

$$0 < \alpha - \theta_e mpk < 1.$$

With reasonable parameterization,

$$\alpha - 2 < -1,$$

and

$$1 - \theta_e mpk > \alpha - \theta_e mpk.$$

So,

$$(\alpha-2)(1-\theta-empk) + (\alpha-\theta_e mpk)^2 < 0,$$

$$z''(mpk) = -\theta_e(\alpha a)^{1-\alpha}x^{\alpha-3}\left[(\alpha-2)(1-\theta_e mpk) + (\alpha-\theta_e mpk)^2\right] > 0$$

So, $z(mpk)$ is monotonically increasing in mpk. $z'(mpk)$ is increasing in mpk, so $z(mpk)$ is convex in mpk.

C.4 Proof of Proposition 1

From the previous section,

$$z = a^{1-\alpha}\left(\frac{mpk}{\alpha}\right)^{\alpha}\left(\frac{\alpha}{mpk} - \theta_e\right)^{\alpha-1}. \tag{43}$$

For a given a and mpk, when θ_e decreases z should also decrease since z is monoton-

ically increasing in θ_e, such that

$$\frac{dz}{d\theta_e} = (1-\alpha)a^{1-\alpha}\left(\frac{mpk}{\alpha}\right)^{\alpha}\left(\frac{\alpha}{mpk}-\theta_e\right)^{\alpha-2} > 0. \tag{44}$$

Therefore, on Figure 5, the red earnings-base curve shifts up with z on the x-axis and mpk on the y-axis. As a result, the MPK of the earnings-based firms which are among the high-MPK firms increases.

C.5 Proof for Lemma 4

Capital market clearing implies that the aggregate wealth A is equal to the aggregate capital demand, such that

$$A = \int_{\underline{z}}^{\overline{z}}\int_{\underline{a}}^{\tilde{a}} k_e(a,z)g(a,z)dadz + \int_{\underline{z}}^{\overline{z}}\int_{\tilde{a}}^{a^*}\frac{a}{1-\theta_e}g(a,z)dadz + \int_{\underline{z}}^{\overline{z}}\int_{a^*}^{\overline{a}}\left(\frac{\alpha z}{r}\right)^{\frac{1}{1-\alpha}}g(a,z)dadz. \tag{45}$$

Applying the Lebniz rule, such that

$$\int_{\underline{z}}^{\overline{z}}\int_{\underline{a}}^{\tilde{a}}\frac{dk_e(a,z)}{d\theta_e}g(a,z)dadz = \frac{dr}{d\theta_e}\frac{1}{1-\alpha}r^{\frac{\alpha-2}{1-\alpha}}\int_{\underline{z}}^{\overline{z}}\int_{a^*}^{\overline{a}}(\alpha z)^{\frac{1}{1-\alpha}}g(a,z)dadz. \tag{46}$$

Therefore,

$$\frac{dr}{d\theta_e} = (1-\alpha)r^{\frac{2-\alpha}{1-\alpha}}\frac{\int_{\underline{z}}^{\overline{z}}\int_{\underline{a}}^{\tilde{a}}\frac{dk_e(a,z)}{d\theta_e}g(a,z)dadz}{\int_{\underline{z}}^{\overline{z}}\int_{a^*}^{\overline{a}}(\alpha z)^{\frac{1}{1-\alpha}}g(a,z)dadz} < 0, \tag{47}$$

since $\frac{dk_e(a,z)}{d\theta_e} < 0$.

C.6 Share of Earnings-based Borrowing

Lemma 6 *Share of earnings-based borrowing $\chi \in [0,1]$ is a monotonically increasing mapping in earnings-based financial frictions θ_e:*

$$\chi = \int_0^{+\infty}\int_{\tilde{z}(a)}^{+\infty} g(a,z)dzda. \tag{48}$$

In Lemma 6 and Figure 25, I study the average share of earnings-based borrowing in the economy χ on the coordinate of (a,z). The gray area in Figure 25 is an illustration of χ. The solid black curve in the figure is the threshold between the asset-based firms and

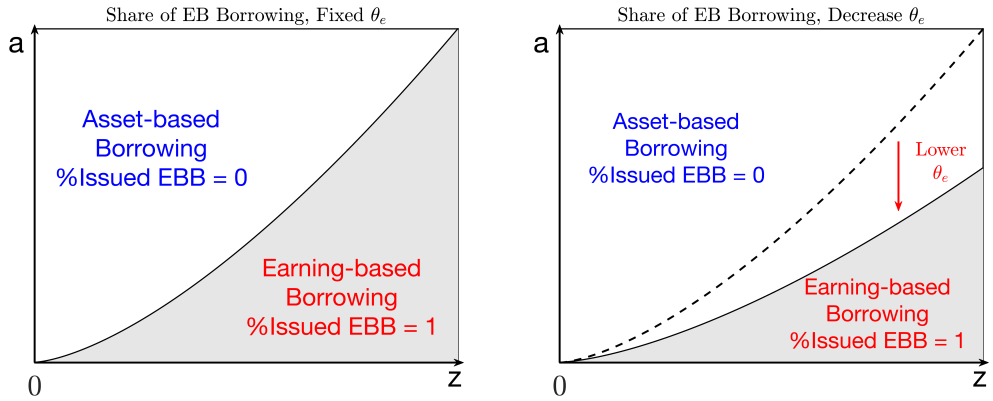


Figure 25 Share of Earnings-based Borrowing

Notes: Panel A of Figure 25 shows the share of earnings-based borrowing in the economy on the coordinates of wealth a and productivity z. The black curve shows the threshold between earnings-based borrowing firms and asset-based borrowing firms. The gray area illustrates the share of earnings-based borrowing. Panel B of Figure 25 shows that the share of earnings-based borrowing shrinks when the earnings-based constraint tightens.

earnings-based,

$$\tilde{z}(a) = \frac{\theta_a}{\theta_e}\left(\frac{a}{1-\theta_a}\right)^{1-\alpha} \Leftrightarrow \tilde{a}(z) = (1-\theta_a)\left(\frac{\theta_e z}{\theta_a}\right)^{\frac{1}{1-\alpha}}. \tag{49}$$

$\tilde{z}(a)$ is the threshold between the asset-based firms and earnings-based firms given wealth a as Figure 2. $\tilde{a}(z)$ is the threshold given productivity z as Figure 3. For firms with productivity z higher than $\tilde{z}(a)$ at a given wealth a and wealth a lower than $\tilde{a}(z)$ when productivity z is held constant, the firm-level share of earnings-based borrowing equals 1 because they issue earnings-based borrowing. The firm-level share of earnings-based borrowing equals 0 when firms have productivity z below than $\tilde{z}(a)$ and wealth a over $\tilde{a}(z)$.

A negative shock to θ_e would lower the average share of earnings-based borrowing in the economy χ as shown in Figure 25. After a negative shock to θ_e, the threshold $\tilde{a}(z)$ between asset-based firms and earnings-based firms would tilt clockwise, shrinking the average share of earnings-based borrowing in χ.