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Corporate Leverage Ratio and Total Factor Productivity: Promotion or Inhibition? Empirical Evidence of the Role of Shareholding Concentration

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Abstract: In the context of China's high-quality economic development, enhancing Total Factor Productivity (TFP) is of great importance. Employing data from 799 non-financial companies listed on the Shanghai and Shenzhen main boards from 2007 to 2024, this study investigates the impact of corporate leverage ratio on TFP and its underlying mechanism. Using fixed-effects models and mediation effect tests, we find that leverage significantly promotes TFP. Shareholding concentration plays a partial mediating role between leverage and TFP, though its indirect effect is negative. These results remain robust after estimating TFP using both the Olley-Pakes and Levinsohn-Petrin methods, as well as multiple robustness checks. The study suggests that moderate leverage helps alleviate financing constraints and supports innovation, yet excessive ownership concentration may inhibit governance efficiency. It is advised to optimise ownership structure while pursuing deleveraging, so as to enhance TFP and achieve sustainable growth.

Keywords: Total Factor Productivity; Debt leverage ratio; Shareholding concentration; Mediating effect

1. Introduction

Total Factor Productivity (TFP) is a metric for assessing the efficiency with which an enterprise generates total output from a given set of factor inputs over a specific period. It captures the portion of output growth unexplained by increases in factor inputs, which can commonly be attributed to technological progress, managerial innovation, or optimised resource allocation.

Corporate investment activities serve as the core driver of technological innovation, profoundly influencing the level of Total Factor Productivity (TFP). By developing novel technologies and processes, capital resource allocation directly impacts the production function, constituting the foundation for enhancing TFP. However, investment does not automatically translate into TFP improvement. Management effectiveness plays a critical role in this process.

Existing research demonstrates that management practices, acting as the core operational mechanism of microeconomic entities, play a pivotal role in shaping investment efficiency and ultimately driving TFP growth (Chu *et al*., 2016). This dynamic holds true even within the complex economic and institutional transformation contexts of emerging economies.

Since management determines the scale, allocation, and sustainability of funding, its strategic vision directly influences the technological frontier-breaking potential of R&D activities and their contribution to TFP (Leute *et al*., 2023). R&D activities rely on continuous capital investment, often necessitating external financing, such as debt leverage, to supplement internal funds (Liu & Yang, 2013). The leverage ratio formed by financing decisions exerts a highly complex and context-dependent influence on R&D and, ultimately, TFP, making management's balancing capability crucial in this domain. Leverage itself does not determine technology or TFP levels (Mallick & Nemlioglu, 2021); the core determinant is whether management quality can effectively utilise leverage instruments and optimise the entire operational process.

On the one hand, moderate leverage and debt financing can effectively alleviate corporate financing constraints, providing the necessary capital for R&D activities, thereby supporting investment in innovation and knowledge accumulation, and laying the groundwork for TFP enhancement. Sound corporate governance, such as supervision by multiple major shareholders, can strengthen management's long-term orientation and safeguard R&D resource allocation (Tang & Tian, 2019).

However, excessive leverage increases interest burdens, crowds out cash flow, and amplifies financial risks, compelling management to curtail high-risk, long-cycle R&D investments—particularly exploratory innovation (Fan & Hu, 2019). If compounded by phenomena such as major shareholder tunnelling or controlling shareholders' equity pledges, these short-termism actions directly deplete R&D resources or force management to abandon long-term technological accumulation, severely inhibiting the potential for TFP improvement (Li & Al, 2022).

Existing research indicates that an inverted-U-shaped relationship often exists between corporate leverage ratios and TFP outcomes for many firms, with the inflexion point contingent on management capability (Tao & Ang, 2018). Highly effective management can more precisely calibrate the optimal degree of leverage, achieving the optimal balance between the benefits of eased financing constraints and the costs of financial risk, thereby maximising the efficiency with which R&D investment translates into TFP gains (Mallick & Nemlioglu, 2021).

In conclusion, while capital allocation acts as the engine for TFP growth, the realisation of its efficacy is highly dependent on management practices. As strategic decision-makers, resource allocators, and risk balancers, management capability directly determines a firm's ability to utilise financial leverage effectively to support sustained gains in Total Factor Productivity.

The significance of this research lies in its timely and targeted investigation of how listed companies in China—crucial agents of technological progress—can overcome their institutional and financial constraints to translate operational investments more effectively into the productivity gains (TFP) that underlie high-quality development. The study provides both theoretical insights and practical tools with substantial implications for investment decisions and corporate strategy.

This study selected a sample of 799 non-financial, non-ST (Special Treatment) companies from the Shanghai and Shenzhen Stock Exchanges. The purpose of this research was to examine the impact of financial factors on corporate total factor productivity and to identify their potential mechanisms. By conducting robustness checks, this study ensured the validity of the analysis results and the accuracy of their economic implications. The mediating role of large shareholder concentration in corporate financial decisions and productive development offers empirical evidence for relevant policy formulation and corporate strategic planning.

The first part of the article presents the literature review and background introduction, the second part puts forward research hypotheses, the third part outlines the research design and variable selection, the fourth part analyses and compares the empirical results, and finally, the article concludes with recommendations.

2. Theoretical Analysis and Research Hypotheses

Theoretical analysis and empirical evidence suggest that a company's capital structure and financial condition influence its investment in research and development (R&D), as well as the output of its R&D activities. Total Factor Productivity (TFP) is adopted as the output measurement metric in this study. Corporate R&D innovation activities are characterised by high uncertainty and capital intensity. Without sufficient and stable funding, companies may be unable to support the continuous R&D activities, thereby inhibiting technological advancements. Debt financing through leverage increases the capital a company can control, providing sustained support for TFP improvement.

Based on this, we proposed Hypothesis 1:

The leverage ratio has a significant positive effect on the company's TFP.

Modern companies, especially listed ones, have their financing activities, capital structures, and fund utilisation controlled and supervised by shareholders. When the share concentration level is high, major shareholders have the motivation and ability to supervise management, reducing agency problems, improving the efficiency of resource allocation, increasing investment in R&D, and thus enhancing overall corporate productivity. However, excessive control may lead to conservative and rigid behaviour among management, having an over-supervision effect. Within the company, there may even be not only be tunnelling and short-sighted behaviour but also profit management and financial leverage level manipulation, thus undermining its ability to enhance productivity and masking the company's true operational status. Overall, one of the channels through which a company's capital structure and financial condition affect its TFP is through the decisions and actions of shareholders.

Therefore, we proposed Hypothesis 2:

The intermediary variable through which a company's leverage ratio affects its TFP is the concentration level of major shareholder holdings.

3. Research Design

3.1. The Research Sample

Excluding financial firms and ST (Special Treatment) companies, the research sample comprises data on 799 companies listed on the Shanghai and Shenzhen Stock Exchanges from 2007 to 2024. Given that the Ministry of Finance issued the Accounting Standards for Business Enterprises in 2006, 2007 was chosen as the starting point of the research period.

The software used for data processing is Stata15 and Python3.

3.2. Variables and Theoretical Model

In this study, the dependent variable is Total Factor Productivity (TFP). TFP serves as a key indicator of economic efficiency, capturing the contribution of technological progress, managerial improvements, and similar factors to output. Traditional estimation typically employs a production function approach based on the Cobb-Douglas specification. However, Ordinary Least Squares (OLS) estimation suffers from endogeneity and sample selection bias. To address these limitations, this study utilises semi-parametric methods: the Levinsohn-Petrin (LP) and Olley-Pakes (OP) methods.

The OP method (Olley & Pakes, 1996) employs firm investment as a proxy for unobserved productivity shocks. This approach treats investment decisions

as endogenous and responsive to contemporaneous productivity shocks. Consequently, investment serves as an effective proxy variable for identifying production function parameters and computing TFP.

The LP method (Levinsohn & Petrin, 2003) addresses a primary limitation of the OP approach: its stringent requirement for continuous investment data. The LP method, therefore, utilises intermediate inputs such as raw materials and energy consumption as proxies for productivity shocks.

For robustness checks, TFP estimates derived from both the OP and LP methods serve as the dependent variable in this study.

The key explanatory variable is corporate leverage (LEV), measured by the equity multiplier. The formula for calculating the equity multiplier is total assets divided by total shareholders' equity. A higher equity multiplier indicates that shareholders' equity accounts for a smaller proportion of the company's total assets, reflecting a higher reliance on financial leverage, i.e., the company uses more debt financing to sustain its operating activities.

The control variables include return on assets (ROA), current ratio (CUR), and institutional shareholding ratio (ISH). The intermediary variable is the shareholding ratio of the top ten shareholders (SH).

The variable table is shown below:

Table 1: Explanatory Variables

	Variable Symbol	*Variable Name*
Independent	LEV	leverage ratio (equity multiplier)
Control	ROA	return on assets
	CUR	current ratio
	ISH	institutional shareholding ratio
Mediating	SH	shareholding ratio of the top ten shareholders

Note: The data are sourced from iFind.

3.3. Model Specification

To investigate the effect of corporate leverage on TFP, a regression model was constructed as shown in Equation (1):

$$TFP_{it} = \alpha_{it} + \beta LEV_{it} + Control'\delta + lt + \mu_i + \xi_{it} \quad (1)$$

In the equation, TFP_{it} is the dependent total factor productivity, with *Control* representing the matrix of control variables, and δ denoting the coefficient vector. The disturbance term is composed of $\lambda_t + \mu_i + \xi_{it}$, where μ_i represents the time-invariant individual heterogeneous intercept, i.e., the individual fixed effect, while λ_t is the time fixed effect that varies over time but not across individuals. Robust standard errors are clustered at the company level.

4. Empirical Analysis

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics for each variable.

Table 2: Descriptive Statistics of Variables

	count	*mean*	*std*	*min*	*1%*	*50%*	*99%*	*max*	*skewness*	*kurtosis*
TFP	12718	9.54	1.21	6.72	6.72	9.49	12.44	12.44	0.13	-0.16
LEV	12718	2.92	2.1	1.1	1.1	2.29	14.63	14.64	3.05	11.85
ROA	12718	4.91	6.51	-18.43	-18.42	4.44	26.18	26.18	-0.05	2.98
CUR	12718	1.67	1.35	0.26	0.26	1.31	8.9	8.9	2.92	10.82
ISH	12661	44.63	20.45	1.38	1.38	44.86	86.98	87	-0.1	-0.65
SH	12718	52.51	15.43	20.71	20.71	52.41	87.43	87.43	0.1	-0.6

To mitigate the influence of outliers on analytical outcomes, the dataset underwent a 1% winsorisation.

Total Factor Productivity (TFP) demonstrates a mean of 9.54 with a standard deviation of 1.21, indicating minimal dispersion around the central tendency and high data concentration.

Leverage ratio (LEV) presents a mean of 2.92 and a standard deviation of 2.10, reflecting substantial heterogeneity relative to the central value. Its significant right-skewed distribution (skewness = 3.05, kurtosis = 11.85) reveals that while most enterprises maintain moderate leverage, a subset employs exceptionally high financial leverage.

Return on Assets (ROA) registers a mean of 4.91% (SD = 6.51%), suggesting considerable volatility. The alignment between its mean and median (4.44%) denotes a symmetric distribution pattern.

Current ratio (CUR) exhibits a mean of 1.67 (SD = 1.35) with pronounced dispersion. Its right-skewed (skewness = 2.92), leptokurtic distribution (kurtosis = 10.82), and median value of 1.31 indicate that over half of sampled firms operate below the 1.5 safety threshold, signalling prevalent short-term solvency challenges. This distribution further implies that while most enterprises experience liquidity constraints, a minority maintain excessively high current ratios.

Joint implications of LEV and CUR distributions: The coexistence of elevated leverage ratios and depressed current ratios among substantial enterprise subsets suggests heightened exposure to financial risk and short-term debt servicing pressures.

Institutional shareholding (ISH) displays a median value of 45%, confirming extensive participation of institutional investors in listed enterprises.

Shareholding concentration of top 10 shareholders (SH) demonstrates a mean of 52.51% (SD = 15.43%), reflecting moderate dispersion. The median value of 52.41% confirms high ownership concentration, with a symmetric distribution spanning from 20.71% to 87.43%.

4.2. Regression

After the Hausman test, this study is suitable for the entity fixed-effects model. This model is appropriate for addressing individual effects in panel data and can effectively resolve endogeneity issues. The benchmark regression results are presented in Table 3.

Table 3: Regression Results of the Model

(Fixed Effects Estimations)

	TFP as the dependent variable	*explanatory X+ CUR_squared (explanatory X and mediator M's influence on dependent Y)*	*Mediator SH as the dependent variable*
LEV	0.0485***	0.0505***	-0.1771***
	(0.0036)	(0.0036)	(0.0507)
ROA	0.0154 ***	0.0131***	0.1674***
	(0.001)	(0.0009)	(0.0133)
CUR	-0.0251 ***	0.045***	0.3526*
	(0.0059)	(0.014)	(0.199)
CUR_squared		-0.0081***	-0.046**
		(0.0015)	(0.0217)
ISH	0.0104 ***	0.0119***	0.1934***
	(0.0006)	(0.0004)	(0.0049)
SH	0.0118 ***	0.0105***	
	(0.0004)	(0.0006)	
Firm	Yes	Yes	Yes
Year	No	No	No
No. Obs	12661	12661	12661
Entities	799	799	799
F-statistic (robust)	466.14***	390.09***	351.96***

SH 95% confidence interval for the mediation effect

direct effect

LEV (0.002986, 0.017181)

ROA (0.006715, 0.010948)

CUR	(-0.023838, -0.002514)
ISH	(0.009013, 0.010977)
SH confidence interval for the sum of indirect effects: (-1.5014e-05, 0.0099)	
SH confidence interval for the sum of indirect effectsÿwithout winsorisation: (0.0020–0.0053)	
SH's indirect effects for LEV confidence interval: (-0.003218, -0.000749)	

Notes:

1. The numbers in the table represent the estimated coefficients with the standard errors clustered at the firm level in parentheses below.
2. The asterisks *, **, *** indicate significance levels of 0.1, 0.05, and 0.01, respectively. The same applies hereinafter.
3. The 95% confidence interval for the direct effect is calculated using the bootstrap method with 1000 resamples with replacement.

The regression results indicate that LEV, ROA and ownership concentration (SH/ISH) exhibit significant positive effects on TFP. The current ratio (CUR) initially showed a negative linear relationship with TFP, prompting the inclusion of a quadratic term for CUR to investigate potential nonlinear dynamics. After eliminating outliers and introducing the nonlinear specification, the model demonstrates improved alignment with economic realities.

According to the regression results, the key variable leverage ratio (LEV) demonstrates statistically significant positive impacts on corporate TFP. This implies that for A-share listed companies, enhancing leverage ratios to expand debt-financed capital under the control of the company evidently supports corporate development.

ROA maintains a significantly positive correlation with TFP, indicating that firms with higher profitability generally possess superior resource allocation efficiency. These firms can reinvest profits into R&D, technological upgrades, or production optimisation, thereby enhancing TFP. This underscores financial health as a foundational element for technological efficiency.

CUR exhibits a statistically significant inverted U-shaped relationship with TFP. At lower CUR levels, the association is positive: increased current assets theoretically provide a thicker "safety cushion" for short-term debt obligations, alleviating financing constraints to ensure continuous R&D and production, thus fostering TFP growth. However, excessively high liquidity may indicate idle cash or inventory overstock, reflecting suboptimal capital deployment into productive operations or investments. This reduces capital efficiency and profitability, potentially signalling overly conservative, risk-averse management. The negative coefficient of the CUR squared term confirms diminishing marginal returns beyond a threshold. The relationship $\Delta TFP = 0.045 \times CUR - 0.0081 \times CUR^2$ reveals a TFP peak at CUR = 2.78 (derived by setting the first derivative to zero).

Thus, TFP increases with rising CUR when CUR < 2.78 but declines when CUR > 2.78.

Both institutional ownership (ISH) and top 10 shareholder concentration (SH) significantly promote TFP. Institutional investors enhance corporate governance and strategic decision-making through specialised oversight, while their stable, long-term capital supports technology investments that drive efficiency gains. Major shareholders possess strong incentives to monitor management, reducing agency costs and facilitating long-term technological investments. Concentrated ownership also lowers coordination costs in decision-making, accelerating technology adoption and optimal resource allocation.

After controlling for mediating effects, concentrated shareholding by major shareholders inhibits the channelling of debt leverage into R&D investments, thereby reducing corporate total factor productivity.

A detailed explanation of these seemingly contradictory or confusing results is presented in the subsequent section.

4.3. Mechanism Analysis

In Table 3 results, besides the core explanatory variable LEV, the top ten shareholders' ownership (SH) also shows statistically significant effects. According to management theory, shareholders, particularly major ones, play a pivotal role in corporate resource allocation as company owners. Consequently, leverage's impact on TFP may be mediated through major shareholders' control. Testing for mediating effects is therefore critical.

Using a two-step method and bootstrap resampling (1,000 replications with replacement), we derived the mediation regression equations and 95% confidence intervals for direct and indirect effects, as shown in Table 3. The data reveal that after controlling for mediator SH, the direct effect of leverage (LEV) on TFP is 0.0505. The indirect effect is calculated as 0.0105 × (-0.1771) = -0.00186, resulting in a total effect of 0.0486. The indirect (mediating) effect accounts for 3.8% of the total effect.

The regression equation for the explanatory variable's impact on the mediator SH is as follows:

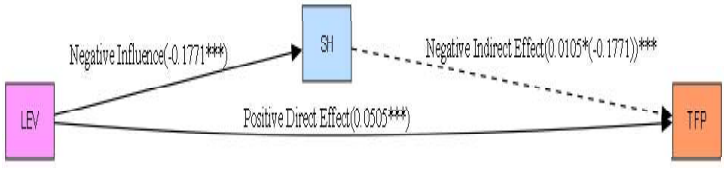

Figure 1: Mediation effect of LEV on TFP through SH

$$SH = (-0.1771)^{*}LEV+0.1674^{*}\text{ROA} + 0.3526 * CUR+(-0.0460) * \text{CUR}^2+ 0.1934^{*}\text{ISH} + \varepsilon_1 \quad (2)$$

The regression equation for the influence of the explanatory variable and the mediating variable on the dependent variable TFP is:

$$TFP = 0.0505 * LEV + 0.0131 * ROA + 0.0450 * CUR + (-0.0081) * CUR^2+ 0.0119^{*}ISH + 0.0105^{*}SH + \varepsilon_2 \quad (3)$$

Substituting equation (2) into equation (3) yields the total effect equation:

$$RTFP = 0.0505 * LEV + 0.0131 * ROA + 0.0450 * CUR+(-0.0081)^{*} CUR^2 + 0.0119 * ISH + 0.0105^{*}[(-0.1771) * LEV + 0.1674 * \text{ROA} + 0.3526 * CUR + (-0.0460)^{*}CUR^2+0.1934 * ISH + \varepsilon_1] + \varepsilon_2 \quad (4)$$

The mechanism by which large shareholders influence corporate TFP through financing structure adjustment is explained as follows:

The direct effect of 0.0505 reflects the positive impact of leverage on productivity. According to the extension of the Modigliani-Miller theorem and agency cost theory, higher leverage (LEV) implies increased available capital through debt financing, enabling investments in new technologies, R&D, or capital equipment that enhance total factor productivity (TFP). Simultaneously, debt serves as a hard constraint; its pressure compels management to optimise resource allocation efficiency to offset added costs and risks, mitigating "managerial entrenchment" issues and thereby boosting TFP—a phenomenon termed the "disciplinary role of debt" in agency theory.

The indirect effect of -0.00186 demonstrates that leverage suppresses productivity by reducing ownership concentration. A one-unit increase in leverage decreases the combined shareholding of the top ten shareholders (SH) by 0.1771 units. Given that a one-unit rise in SH elevates TFP by 0.0105 units, the LEV-induced decline in SH weakens major shareholders' active governance, ultimately generating a statistically significant drag on TFP (-0.00186), albeit economically modest. This occurs primarily because higher ownership concentration incentivises shareholders to supervise management and drive long-term investments (e.g., R&D), enhancing overall efficiency through monitoring incentives. Concentrated ownership also reduces decision-making costs and accelerates responses to technological upgrades, bolstering operational efficiency. When debt's weight in the capital structure rises, these positive governance effects are suppressed, resulting in a significantly negative net indirect effect. Bootstrap resampling further confirms that the 95% confidence interval for SH's mediating effect is (-0.003218, -0.000749), which is significantly below zero, underscoring that shareholder oversight and decision efficiency materially influence TFP. Thus,

while leverage expands available funds to promote productivity, it simultaneously undermines major shareholders' governance efficacy, rendering the net mediating effect of SH negative.

This dialectical relationship mirrors the DuPont framework, where leverage amplifies ROE while interest burdens constrain such gains.

When aggregating the total mediating effect of all explanatory variables via SH, post-1%-winsorisation yields a 95% CI of (-1.5014e-05, 0.0099), which is not statistically distinguishable from zero. Conversely, retaining extreme values reveals a significant positive aggregate mediating effect (95% CI: 0.0020–0.0053). Preserving outliers captures critical governance thresholds: observations like ROA=67.5%, SH=97.49%, and current ratio=204.7 exemplify major shareholders deploying idle capital into R&D to elevate TFP. Meanwhile, extreme leverage (e.g., LEV=-70.13)—theoretically triggering ST label by regulators—likely persists due to preemptive earnings management. Firms facing ST thresholds artificially adjust statements via non-recurring gains/losses or debt restructuring, avoiding formal labelling. Such anomalies, incompatible with sustainable operations, typically feature negative core profits, inflated non-recurring items, and qualified audit opinions. Paradoxically, these manipulations—impossible without major shareholders' involvement—highlight their operational control. When firms face financial distressÿe.g., asset sales or restructuring, shareholders' manoeuvres to evade ST create artificial linkages between LEV fluctuations, ownership adjustments (SH), and productivity declines (TFP), fabricating a spurious mediating path.

Both extreme scenarios artifactually manifest SH's positive mediating correlation with TFP.

5. Robustness Test

To verify the robustness of the data analysis results, the dependent variable was replaced with TFP calculated using the OP method for benchmark regression and mediation effect analysis. The economic interpretations of the coefficients and statistical significance remained consistent with the baseline analysis. Extending the data period to 2000–2024 and employing both LP and OP TFP with sample analysis excluding real estate-related firms from the dataset did not alter the conclusions. Therefore, the results of the data analysis demonstrate robustness.

6. Conclusions & Implication

This study provides empirical evidence on the dual role of financial leverage and ownership concentration in shaping corporate Total Factor Productivity. We

confirm that higher leverage ratios significantly enhance productivity, challenging conventional views that debt financing inherently constrains progress due to risk aversion. And concentrated ownership by major shareholders facilitates debt-financed R&D investments by mitigating managerial short-termism and alleviating financing constraints.

Regulatory authorities should adopt a nuanced approach to leverage management for listed companies. Although excessive leverage may engender increased financial vulnerability, strategically deployed debt financing can serve as a catalyst for production capacity enhancement.

Policymakers should also encourage diversified equity structures to curb overreliance on major shareholders while preserving their supervisory role in curbing short-termism.

7. Limitations and Future Research

This study focuses on listed companies, limiting generalisability to other corporates. Dynamic analyses of how liability interacts with corporate innovation cycles would deepen understanding of macro-micro linkages.

In summary, this study highlights how governance structures interact with financing and policy to shape productivity trajectories. The analysis offers a method to derive logically sound conclusions through cross-validation of empirical results and accounting interpretations, serving as a basis for assessing market conditions and risks.

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