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The Impact of Corporate Debt on Corporate Innovation Behavior: Evidence from China

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Abstract: This article uses data from Chinese A-share listed companies from 2002 to 2018 and employs a fixed-effects model to identify the impact of corporate leverage on corporate innovation behavior. The results show that corporate leverage significantly hinders corporate innovation behavior. After conducting robustness tests, the conclusion remains valid. Further research reveals that state-owned enterprises exacerbate the impact of corporate leverage on corporate innovation behavior, while external supervisory mechanisms mitigate this effect.

1. Introduction

Innovation is of great significance for both the long-term development of a country and its enterprises. Innovation can enhance a company's competitive advantage and is also a crucial driver of national economic growth (Solow, 1957)[1]. As our country's economy enters the "new normal," traditional competitive advantages continue to weaken, and economic growth is at a critical juncture of transitioning from being driven by factors and investments to being driven by innovation. Innovation promotes industrial and technological upgrades, fosters the development of emerging industries, continuously improves various aspects of the industrial chain, and generates diverse effects on associated industries, thereby providing a steady stream of momentum for the upgraded version of China's economy. Micro-level innovation efficiency is high and cost-effective, making it the driving force behind the entire nation's innovation efforts.

Over the past decade, a central issue explored has been how to effectively incentivize innovation in companies, which differs significantly from incentivizing routine tasks. Holmstrom (1989) points out that unlike conventional tasks that follow traditional techniques and yield rapid returns, innovation is a long-term, adventurous, and unique process that requires immense patience, a spirit of adventure, and a willingness to try new, unexplored methods[14][18].

Manso (2011) argues that tolerance for failure is crucial for fostering innovation[12] [15]. If one wants to innovate, one must be willing to tolerate failures. His core theory suggests that innovation contracts should be formulated in a way that allows short-term tolerance for failures, permits trial and error, while rewarding long-term success. For instance, shareholders could design mechanisms that better incentivize innovation within management.

Tian and Wang (2014) examined whether strong tolerance for failure in venture capital (VC)

investments promotes corporate innovation, using companies that underwent Initial Public Offerings (IPOs) between 1985 and 2006 as their sample [9]. They constructed a measure of failure tolerance based on the investment patterns of VC firms in poorly performing startups in their portfolios. The findings reveal that IPO companies supported by VC firms with higher failure tolerance tend to generate more patents, and these patents are cited more frequently in the future. This effect is particularly stronger for companies facing high failure risks.

Kortum and Lerner (2000) conducted a study on 20 industries in the U.S. manufacturing sector from 1965 to 1992, and for the first time, they documented a positive relationship between venture capital investment and patent output [7]. They employed instrumental variable methods and controlled for research and development (R&D) expenses to address concerns related to omitted variables, such as technological opportunities. The results indicated that during the period from 1983 to 1992, although the average proportion of venture capital investment to R&D spending was less than 3%, its contribution to industry innovation was approximately 8%.

Since ongoing financial investments are typically required for corporate R&D, especially in the form of long-term loans rather than short-term ones, seeking rent through credit may suppress corporate R&D expenditure, thereby exacerbating the restrictive impact of financing constraints on corporate innovation. Hence, it is believed that a company's leverage ratio can influence its innovation behavior.

Compared to previous literature, this article's potential contributions are as follows: First, it examines the impact of corporate leverage (assessing enterprise risk and risk resistance) on corporate innovation behavior from a new perspective. Second, a company's leverage ratio can influence its normal business operations and even generate cascading effects, affecting the normal functioning of upstream and downstream companies. How to formulate relevant policies and regulations to supervise the behavior of listed companies is a concern for regulatory authorities, and this article provides theoretical references for regulatory bodies to establish relevant policies and maintain market order. Third, our research enriches the literature on the economic impact of corporate innovation.

The remaining part of this article is structured as follows: In Section Two, we propose research hypotheses on the impact of corporate leverage on corporate innovation based on a review of relevant literature. Section Three introduces the research design, sample, and descriptive statistics of relevant variables. Section Four reports the basic empirical results and robustness test results. In Section Five, we analyze the influencing mechanisms. Finally, Section Six presents the research conclusions.

2. Materials and methods

2.1. Background of the study area

Faced with an ever-changing market competition, companies must rely on innovation to achieve high-quality development (Dang et al., 2015). According to a report by the Organization for Economic Cooperation and Development (OECD, 2015), innovation (including technological progress embodied in physical capital, investment in knowledge capital, multifactor productivity growth, and creative destruction) accounts for approximately 50% of a country's total GDP growth, with its impact depending on the level of economic development and the stage of the economic cycle. Economists estimate that 85% of a country's economic growth can be attributed to technological innovation (Rosenberg, 2004) [23]. Chang et al. (2016) demonstrated that a one standard deviation increase in the patent stock per capita leads to a 0.85% increase in GDP growth [13]. Therefore, it is evident that capital (including financial and human capital) is crucial for fostering innovation within companies.

From the perspective of financing availability, Chava et al. (2013) found that state-level relaxation of regulations on intrastate banking enhanced the local market power of banks, leading to a negative impact on innovation in private enterprises [24]. Amore et al. (2013) discovered that interstate banking deregulation in the 1980s and 1990s increased the quantity and quality of corporate innovation output, particularly for firms heavily reliant on external capital and located in proximity to banks [25]. They attributed this effect to the ability of deregulated banks to disperse credit risk geographically. Brown et al. (2009) found that the availability of internal and external (public equity) financing significantly influences a company's initial R&D expenditure [7] [21].

According to the trade-off theory, if the benefits obtained from debt financing outweigh the cost of capital, then excess returns can be achieved. However, higher leveraged companies face a greater risk of bankruptcy, leading to higher direct and indirect bankruptcy costs and, consequently, higher financing costs.

From the perspective of CEO compensation schemes and incentive measures, Ederer and Manso (2013) found that incentive plans that include tolerance for early-stage failures and rewards for long-term success are most effective in motivating exploratory (i.e., innovative) actions compared to fixed wages or standard compensation plans. Mao and Zhang (2018) discovered that CEO risk-taking motivation induced by compensation structures has a positive causal relationship with a company's innovation activities. Acharya and Xu et al. (2017) found that CEOs with longer contract terms pursue more influential and diversified innovations, and this phenomenon is not driven by changes in compensation structure [26][8]. They believe that longer contracts allow managers to focus less on short-term performance metrics. Jia et al. (2018) focused on team-based compensation design and studied the impact of executive collaborative incentives on corporate innovation performance [2][11]. In addition to providing appropriate incentives for innovation to senior executives, department managers, and ordinary employees, shareholders can directly influence the company's innovation activities in terms of scale and scope by altering the functional attributes of the board, playing a crucial role in monitoring and governance.

Existing literature discusses how to support corporate technological innovation from various perspectives, including financial development, policy support, human capital, and incentives (Yi et al., 2015; Seyoum et al., 2015). Research has found that different characteristics of companies can influence the incentives for managers or ordinary employees to participate in innovation. For example, institutional investor shareholding (Aghion et al., 2013) [27], venture capital (Chemmanur et al., 2014) [28], private equity (Bernstein, 2015) [29], tolerance for failure (Ederer & Manso, 2013; Tian & Wang, 2014) [30][11], analyst "neglect" (He & Tian, 2013) [31], and non-CEO executive tournament rewards (Jia et al., 2016) can all stimulate managerial enthusiasm for innovation and drive them to engage in long-term innovation activities for the company [22].Some studies have also explored employee incentives and found that employee shareholding is beneficial for corporate innovation (Chang et al., 2015), while the expansion of union power reduces corporate innovation (Bradley et al., 2016). It is evident that both managers and employees play a crucial role in creating corporate value and bear different responsibilities in the process of innovation.

According to the agency theory perspective, companies with higher leverage are more likely to choose high-risk projects, aiming to maximize shareholder wealth rather than maximizing corporate value. At the same time, their managers tend to reject investment projects with positive net present value that only benefit creditors, exhibiting short-sighted investment behavior that is detrimental to long-term company profitability. Additionally, technology innovation theory suggests that higher leverage in companies has a stronger inhibitory effect on innovation investment, which hinders the improvement of corporate competitiveness. Dang et al. (2013), using data from Chinese listed companies from 2003 to 2010, found that companies with different debt levels exhibit varying capital structure adjustment speeds, with companies having higher debt levels adjusting their capital

structure relatively quickly. These research findings indicate that companies with higher leverage have faster capital structure adjustments (downward), and deleveraging is more favorable for reducing losses caused by high leverage, leading to a more significant positive impact on company performance. Therefore, this study proposes the following hypothesis:

The leverage ratio of a company will have an impact on its innovation behavior.

The above findings provide strong theoretical support and methodological inspiration for exploring a series of issues arising from the relationship between "corporate leverage and corporate innovation." In the context of the rapid development of big data and artificial intelligence, in-depth research on this issue holds significant practical value and provides insightful perspectives for interdisciplinary studies.

3. Research Design

3.1. Data Source and Processing

Our initial sample includes all A-share listed companies that were listed on the Shanghai and Shenzhen Stock Exchanges during the period from 2002 to 2018. Relevant financial information and measurement indicators were obtained from databases such as the China Stock Market and Accounting Research (CSMAR) database and Wind database. Following previous literature, we excluded financial firms because these companies differ significantly from other industries in terms of accounting and reporting rules and financing policies. We also removed companies with a total number of patent applications less than 1. Additionally, we excluded companies with "ST," "ST*," or "PT" in their stock abbreviations, and performed a winsorization at the upper and lower 1% tails for the main continuous variables.

3.2. Model Specification and Variable Definition

3.2.1 Variable Definition

Referring to Wu et al. (2016) and Li et al. (2020), the innovation indicator of the company is represented by the proportion of total R&D expenses to total assets, denoted as RD asset. R&D expenses can only reflect a specific observable quantitative input (Aghion et al., 2013) and may not capture the different dimensions of corporate innovation strategies (Manso et al., 2017). Moreover, R&D measures are highly sensitive to accounting standards, for example, whether R&D expenses should be capitalized or expensed (Acharya and Subramanian, 2009). On the other hand, the company's leverage is represented by the asset-to-liability ratio, denoted as Lev.

3.2.2 Model Specification

Drawing on the work of Pan et al. (2015) and Wu et al. (2016), we construct the following regression model to analyze the impact of corporate leverage on corporate innovation behavior:

$$Innovation_{i,t} = \beta_0 + \beta_1 Lev_{i,t-1} + \beta_j Controls_{i,t} - 1 + Year + Firm + \varepsilon_{i,t}$$

Regarding the selection of control variables, following the practices in the aforementioned literature, this study mainly controls for company financial characteristics, corporate governance characteristics, and regional economic levels that may affect innovation. Specifically, the company financial characteristics include: leverage ratio (Lev, the ratio of total liabilities to total assets), cash asset ratio (Cflow Asset, the ratio of cash and cash equivalents to total assets), return on assets (ROA, the ratio of earnings before interest and taxes to total assets), tangibility (the ratio of fixed

assets to total assets), market-to-book ratio (MB, the ratio of market value of assets to book value of assets), and firm size (Size, the natural logarithm of total assets). The corporate governance characteristics include: institutional ownership ratio (INSThold, the ratio of shares held by institutional investors to total shares), management ownership ratio (Mngshrate, the ratio of shares held by management to total shares), company age (AGE, the natural logarithm of years since establishment plus one), and ownership type (gov, taking the value of 1 for state-owned enterprises and 0 otherwise). The regression model also controls for time fixed effects.

3.2.3 Descriptive Statistics

Table 1 presents the basic statistical characteristics of the main variables. Regarding the innovation measurement indicator, due to some companies not having R&D expenses, there are missing values for the RD_asset and RD_sale indicators related to R&D expenditures. Robustness tests were conducted by replacing the innovation measurement indicator RD_asset with RD_sale in the regression analysis.

Table 1: Presents the basic statistical characteristics of the main variables.

Variable	N	Mean	p50	Min	Max	SD
RD asset	22000	0.0120	0.00500	0	0.0790	0.0160
RD sale	22000	0.0240	0.00800	0	0.201	0.0350
Lev	34000	0.440	0.440	0.0510	0.883	0.205
Cflow Asset	34000	0.0440	0.0440	-0.190	0.249	0.0740
ROA	34000	0.0370	0.0360	-0.215	0.186	0.0560
Tangibility	34000	0.239	0.204	0.00200	0.739	0.174
MB	33000	1.200e+10	4.700e+09	6.200e+08	1.800e+11	2.500e+10
SIZE2	34000	21.87	21.70	19.59	25.79	1.250
Mngshrate	33000	0.108	0	0	0.686	0.190
AGE	33000	2.539	2.639	1.099	3.367	0.491
QFIIhold	34000	0.00100	0	0	0.139	0.00500
INSThold	34000	0.236	0.152	0	1.257	0.234
gov	33000	0.452	0	0	1	0.498
Big4	34000	0.0610	0	0	1	0.240
Big10	29000	0.470	0	0	1	0.499

4. Empirical Analysis

4.1. Baseline Regression

Table 2: Baseline regression.

	(1)
VARIABLES	
Lev	-0.006***
	(-9.61)
Cflow_Asset	0.012***
	(7.95)
ROA	0.027***
	(11.98)
Tangibility	-0.007***
	(-12.06)
MB	0.000***
	(5.05)
SIZE2	-0.002***
	(-14.62)

Mngshrate	0.010***
	(16.80)
AGE	-0.005***
	(-19.53)
Constant	0.069***
	(24.40)
Observations	20,711
R-squared	0.253
year FE	YES

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2 presents the baseline regression. To mitigate the interference of unobservable time-related factors, this study employs a time fixed-effects model to analyze the impact of corporate leverage on corporate innovation. The specific model is as follows: The results indicate that higher corporate leverage has an inhibitory effect on corporate innovation behavior.

4.2. Robustness Test

Table 3 presents the robustness test. This study uses the method of variable replacement to test the robustness of the model. As shown in the figure below, the empirical results remain robust.

Table 3: Robustness test.

	(1)
VARIABLES	reghdfe
Lev	-0.040***
	(-29.84)
Cflow_Asset	0.012***
	(3.87)
ROA	-0.037***
	(-7.70)
Tangibility	-0.025***
	(-18.84)
MB	0.000***
	(5.09)
SIZE2	-0.003***
	(-9.49)
Mngshrate	0.030***
	(23.73)
AGE	-0.010***
	(-18.59)
Constant	0.129***
	(21.45)
Observations	20,721
R-squared	0.307
incode FE	YES
year FE	YES

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Heterogeneity Analysis

5.1. Heterogeneity

In order to gain a deeper understanding of the causal relationship, this study will examine the relationship between corporate leverage and corporate innovation behavior from a heterogeneity perspective. Existing research indicates that ownership type and external monitoring significantly influence the quality of corporate innovation. Therefore, the next analysis will focus on the heterogeneity of the relationship between corporate leverage and corporate innovation from these two aspects.[20]

5.1.1 Property Rights Nature or Property Ownership Nature

Table 4: Property Rights Nature or Property Ownership Nature.

	(1)
VARIABLES	
Lev_gov	0.008***
	(7.57)
Lev	-0.009***
	(-12.21)
Cflow_Asset	0.012***
	(7.89)
ROA	0.028***
	(12.15)
Tangibility	-0.007***
	(-11.65)
MB	0.000***
	(4.54)
SIZE2	-0.002***
	(-13.81)
Mngshrate	0.008***
	(13.17)
AGE	-0.005***
	(-19.09)
Constant	0.069***
	(24.04)
Observations	20,711
R-squared	0.256
incode FE	YES
year FE	YES

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

State-owned enterprises are mostly monopolistic and face less intense industry competition compared to non-state-owned enterprises (Liu et al., 2016). Moreover, the government has high expectations for the development of state-owned enterprises, aiming for them to become globally competitive world-class companies [6][17]. As a result, state-owned enterprises may have weaker demand and necessity for low-quality innovation. Ferreira et al. (2014) studied the impact of listing and private ownership structures on firms' innovation incentives through a theoretical model [5]. They argued that the former is more conducive to firms utilizing existing ideas, while the latter is more favorable for firms exploring new ideas. Privately held entrepreneurial firms face fewer conflicts of interest and have more capability to protect their confidential information and trade secrets, which may motivate them to engage in long-term and high-risk innovation projects. Empirical results indicate that state-owned enterprises intensify the impact of leverage on corporate

innovation behavior [19].Table 4 presents the property rights nature or property ownership nature.

5.1.2 External Supervision or External Monitoring

Given the increasing importance of institutional investors in corporate governance and decision-making, exploring how different types of institutions shape the innovation process is a natural and worthwhile endeavor. Moshirian et al. (2016) found that foreign institutional investors have a significant positive impact on corporate innovation [3][16]. Possible channels for this impact include supervision, insurance, and knowledge spillover. Li et al. (2017) identified three potential channels through which foreign institutional investors promote corporate innovation: active supervision, higher tolerance for failure, and knowledge spillover from highly innovative economies [4][10]. We focus on two monitoring mechanisms: the Big Four auditors and institutional ownership. The hiring of Big Four auditors is measured as a binary variable, where 1 indicates a company employing one of the international Big Four audit firms and 0 otherwise. Institutional ownership is measured by the proportion of institutional holdings. The results indicate that companies employing Big Four auditors intensify the impact of leverage on corporate innovation behavior, while higher institutional ownership weakens this intensifying effect of leverage on corporate innovation behavior. Table 5 presents the external supervision or external monitoring.

Table 5: External Supervision or External Monitoring.

	(1)	(2)
VARIABLES		
Lev_Big4	0.009***	
	(4.07)	
Big4	-0.003**	
	(-2.48)	
Lev_INSThold		-0.008***
		(-3.97)
INSThold		0.007***
		(6.29)
Cflow_Asset	0.012***	0.011***
	(7.84)	(7.53)
ROA	0.028***	0.026***
	(12.21)	(11.21)
Tangibility	-0.007***	-0.008***
	(-11.96)	(-12.34)
MB	0.000***	0.000***
	(2.98)	(4.87)
SIZE2	-0.002***	-0.002***
	(-14.43)	(-14.88)
Mngshrate	0.010***	0.012***
	(16.59)	(18.20)
AGE	-0.005***	-0.005***
	(-19.50)	(-19.59)
Constant	0.069***	0.068***
	(24.19)	(24.01)
Observations	20,711	20,711
R-squared	0.254	0.255
incode FE	YES	YES
year FE	YES	YES

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. Conclusions

With the development of China's capital markets, the role of accounting information in promoting optimal resource allocation and reducing information asymmetry has become increasingly important. However, due to deficiencies in information disclosure and regulation of listed companies, some companies' internal control systems fail to function effectively, leading to a growing trend of financial fraud in listed companies. This not only harms the interests of investors but also threatens market fairness. How to manage corporate leverage, incentivize corporate innovation, and enhance corporate competitiveness are issues that regulatory authorities should consider.

In this study, we use data from Chinese A-share listed companies between 2002 and 2018 and employ a time fixed-effects model to identify the impact of corporate leverage on corporate innovation behavior. The results show a significant negative association between corporate leverage and corporate innovation behavior. After conducting robustness tests, the conclusion remains valid. Further research reveals that state-owned enterprises exacerbate the impact of leverage on corporate innovation behavior, while external monitoring mechanisms alleviate this effect of leverage on corporate innovation behavior.

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