The Impact of R&D Expenditures on Capital Structure: Evidence from Chinese Non-financial Industries

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***Abstract*—This research examines the relationship between R&D expenditures and corporate capital structure in Chinese non-financing industries, which focus on three key indicators: total debt ratio, short-term debt ratio, and long-term debt ratio. By using a sample of 2832 companies, the research applies regression analysis to explore how R&D intensity influences capital structure decisions. The findings reveal a significant negative correlation between R&D expenditures and both total and short-term debt ratios, while no significant relationship is observed for long-term debt ratios, which suggest that R&D-intensive firms prefer equity financing over debt due to the uncertainty of R&D investments and limited collateral value of intangible assets. Additionally, the study identifies the impact of control variables: tangibility, total assets, and profitability on debt ratios. The findings align with theoretical frameworks like the trade-off theory and agency cost theory, providing evidence that companies with higher R&D intensity adopt conservative capital structures to minimize financial risks and maintain flexibility. As a result, this research indicates how companies that spend a lot on R&D tend to choose specific financing strategies, highlighting the importance of creating financial policies that better support innovation. Future research could extend this study by examining specific industries and international comparisons of R&D financing strategies.**

***Keywords*—capital structure, R&D expenditure, debt ratio, corporate finance, Chinese non-financing industries**

I. Introduction

As an important part of companies' financing strategy, capital structure has always been the focus of attention in academic and business. Through the rational combination of debt and equity, enterprises can not only achieve efficient allocation of funds, but also balance risk and return, thereby optimizing enterprise value. Theoretically speaking, Modigliani & Miller's theory (1958) has built the foundation of capital structure, and further development like trade-off theory and agency cost theory have deepened the exploration of this field. However, with the global economy shift to the technology and sustainability-driven model, traditional capital structure theories face new challenges.

On the other hand, as the key indicator of enterprise innovation and development ability, Research and Development (R&D) expense has gradually attracted attention to its impact on capital structure. From the concept aspect, unlike traditional tangible assets, R&D activities are intangible and high-risk, making it difficult to obtain financing. So far, numerous studies have shown that R&D-intensive firms prefer equity financing to debt financing due to project uncertainty and lack of collateral. In addition, R&D projects require long-term investment and may not deliver returns in the short term, which are further complicating financing decisions. However, the existing research on the relationship between R&D expenditure and capital structure is still limited, especially in the context of debt financing. As a result, it is necessary and meaningful to conduct research to examine the potential relationship between R&D expenditure and debt financing.

This research aims to investigate whether R&D expenditures affect a company's capital structure, specifically, whether R&D expense significantly affects the total debt ratio, short-term debt ratio and long-term debt ratio by using regression analysis. Thus, the research is structured into four key sections. Firstly, it critically reviews the literature of capital structure and R&D, exploring their theoretical foundations and relevance. Secondly, research methodology is determined, and regression analysis is conducted. Thirdly, results of regression are critically discussed, which is a deepened study of R&D expense and capital structure with dependent variables. Finally, conclusion is given, which includes key findings, recommendations, limitations and future study directions in research.

II. Literature Review

Capital structure is a very important aspect of a company. It relates to the mix of debt and equity financing decisions used for the operation and investment of the firm.

A. Theoretical Foundations of Capital Structure

As an important part of corporate financial decision-making, capital structure decisions have been the subject of much expert discussion. Modigliani and Miller (1958) developed the MM theory that in a perfect and frictionless capital market, capital structure has no effect on firm value at all. In a subsequent extension in 1963, they emphasized the importance of taxes for the choice of capital structure but still ignored practical issues such as bankruptcy costs (Kraus & Litzenberger, 1973) and agency costs (Jensen & Meckling, 1976).

The trade-off theory, building on MM, suggests firms must balance the tax benefits of debt financing—such as the tax shield effect of interest deductions—against the potential costs of financial distress, which increase with higher leverage (Kraus & Litzenberger, 1973), this theory holds that it is necessary to find the optimal capital structure by balancing tax and bankruptcy risk.

However, for listed companies, despite the existence of a target structure level for the company, it is difficult to reach or maintain this optimal state all the time, and the actual capital structure of the company is in a dynamic optimisation process that continuously tends to the target structure.

A great deal of research has been conducted on the issue of the factors that influence optimal capital structure decisions,

and the literature has found that due to changing external environmental factors such as macroeconomic performance (Modigliani & Miller, 1958), industry and market (Rajan & Zingales, 1995), the legal environment (Booth, Aivazian, Demirguc-Kunt & Maksimovic, 2001), and changing external environmental factors such as the composition of the company's board of directors (Adams & Ferreira, 2009), remuneration policies (Mehran, 1992), shareholders' rights (Gompers, Ishii & Metrick, 2010) and other internal characteristic factors that vary across firms over time, it is not easy for firms to determine the optimal capital structure.

B. R&D Intensity and Capital Structure

The uncertainty associated with research and development (R&D) expenses significantly influences the formation of a firm's capital structure. Numerous studies highlight that this uncertainty impacts financing decisions, leading firms to adopt specific strategies to manage risks and ensure financial stability.

Rajan and Zingales (1995) suggest that companies with significant R&D investments are more inclined toward equity financing rather than debt financing. This preference arises because intangible assets, which are prevalent in R&D-intensive firms, are challenging to use as collateral for securing debt.

1) Leverage ratios and tax shields

According to Frank and Goyal (2003), companies with higher R&D expenses have a lower leverage ratio, because debtors believe that investment in R&D projects is riskier compared with intangible assets.

On the other hand, according to Modigliani and Miller's (1963), R&D expenses can explain tax deductions and may promote debt financing, and the study emphasizes the importance of leverage.

2) Agency costs and managerial decisions

According to Jensen and Meckling (1976), agency costs will affect the judgment between debt and equity, R&D may lead to agency conflicts, and companies with high R&D expenditures may choose stocks to avoid restrictions related to debt financing.

Research and Development (R&D) expenses play a crucial role in shaping decisions related to capital structure, which may lead firms to choose equity financing more due to the risk of R&D investment, although this may be offset by tax deductions.

Due to the existence of risks and intangible assets, R&D expenses will prompt firms to conduct equity financing, thus affecting the capital structure. Although tax incentives from R&D can promote the use of debt by firms (Modigliani & Miller, 1963), high agency costs (Jensen & Meckling, 1976) and uncertainty among creditors (Frank & Goyal, 1976) are associated with high agency costs (Jensen & Meckling, 1976). 2003) complicates leverage decisions.

C. Metrics of Capital Structure: Total Debt Ratio and Total Long-Term Debt Ratio

The total debt ratio measures the percentage of a company's total assets financed through debt, providing an overview of its leverage and financial risk. In contrast, the total long-term debt ratio specifically represents the proportion of long-term debt to total assets, emphasizing the stability of the financing structure and the associated economic risks.

Total debt and long-term debt ratio have a significant impact on the capital structure of the company and reflect the financial strategy and risk management of the company. Modigliani and Miller (1963) show that interest tax breaks reduce the cost of debt and thus promote its use. Debt ratios also vary from country to country because of legal and financial differences (Rajan and Zingales, 1995). Enterprises with predictable cash flow, stable earnings and strong assets prefer long-term debt to maintain stability and reduce refinancing risks (Myers, 1977; Diamond, 1991). These ratios reflect strategic financing decisions shaped by tax breaks, the regional environment, and firm-specific factors such as cash flow stability and asset strength.

However, total debt ratio and total long-term debt ratio do not account for industry-specific characteristics or differences in asset structures, Rajan and Zingales (1995) note that capital-intensive industries such as manufacturing have high debt ratios, while services or technology industries with intangible assets have low debt ratios, underlining the importance of carefully comparing different sectors.

D. Firm-Specific Determinants of Capital Structure

Factors such as total assets, profitability, the tangible asset ratio, and industry classification play a critical role in influencing capital structure decisions. These elements shape how companies balance debt and equity to optimize financial performance and manage risk. Determining a firm's ability to obtain financing, manage risk and achieve strategic objectives.

Total assets mirror the scale and operational capability of a company and serve as collateral for debt financing. According to Frank and Goyal (2009), generally large companies will show diversification and stability, to reduce the risk of bankruptcy. Therefore, companies with large total assets are more likely to use leverage and finance growth through debt.

Profitability affects the capital structure decision by affecting the internal financing ability of enterprises. According to (Myers and Majluf 1984), profitable companies are more inclined to retain earnings and finance from external debt or equity. The same as (Harris and Raviv 1991) argue that highly profitable companies typically avoid debt in order to prevent financial distress and maintain flexibility, while companies with lower profit margins may rely on debt to support capital needs.

The tangible asset ratio affects the capital structure by determining the collateral value. Companies with more tangible assets are more likely to use debt financing, because these assets can reduce the risk of borrowing (Titman & Wessels, 1988; Rajan & Zingales, 1995).

Industry classification also affects capital structure. Manufacturing and utility companies tend to have high asset tangibility and stable cash flow, and tend to have high debt ratios, while technology companies are characterized by intangibility and earnings volatility, and generally have low debt ratios (Bradley, Jarrell, and Kim, 1984).

Capital structure decisions are influenced by a range of factors, including tax incentives, financial risk, and firm specific characteristics. The impact of digital transformation,

sustainable development and intangible assets on capital structure has not been studied. Existing theories such as trade-offs and pecking order may not fit perfectly into the shape of existing markets. So, more research is needed to make up for these deficiencies.

For the above, it is assumed that R&D expenses are negatively related to long-term debt ratio and total debt ratio.

III. Methodology

A. Model Construction

In order to investigate how research and development (R&D) expenditures affect capital structure decisions, this study employs a fixed-effects model while controlling for temporal and industry-specific dimensions. The econometric model is constructed as follows:

$$Total\ Debt\ Ratio_{it} = \alpha_0 + \alpha_1 R\&D_{it} + \alpha_i Control_{it} + \sum Year_{it} + \sum Industry_{it} + \varepsilon_{it} \quad (1)$$

In the model, i represents individual listed companies, and t denotes the year; the unobservable random variable α_0 captures individual heterogeneity. The variable that is based on the debt level of firm i in year t is measured by $Total\ Debt\ Ratio_{it}$. $R\&D_{it}$ shows the amount that was spent on R&D by company i in year t. The collection of control variables is indicated by $Control_{it}$, temporal effects are taken into account by $Year_{it}$, industry effects are denoted to account for sector-specific affects, and the random error term is ε_{it}.

An extra econometric model is built in order to examine the debt maturity structure in more detail:

$$Short-term\ Debt\ Ratio_{it} = \alpha_0 + \alpha_1 R\&D_{it} + \alpha_i Control_{it} + \sum Year_{it} + \sum Industry_{it} + \varepsilon_{it} \quad (2)$$

$$Long-term\ Debt\ Ratio_{it} = \alpha_0 + \alpha_1 R\&D_{it} + \alpha_i Control_{it} + \sum Year_{it} + \sum Industry_{it} + \varepsilon_{it} \quad (3)$$

The dependent variable is replaced by $Short-term\ Debt\ Ratio_{it}$ and $Long-term\ Debt\ Ratio_{it}$, which measure the short-term and long-term debt levels of company i in year t, respectively.

B. Variable Definitions

1) Dependent variable

Referring to the majority of prior literature (Santhosh and Bindu, 2021; Frank and Goya, 2009), the following definitions apply to the dependent variables in Models (1) to (3): the total debt level of the firm ($Total\ Debt\ Ratio_{it}$), the short-term debt level ($Short-term\ Debt\ Ratio_{it}$), and the long-term debt level ($Long-term\ Debt\ Ratio_{it}$). The ratios of total debt to year-end total assets, short-term debt to year-end total assets, and long-term debt to year-end total assets are used to measure these variables, respectively.

2) Independent variables

Scholars typically employ relative indicators of R&D investment to facilitate comparisons across different firms. Following the approach adopted in most of the literature, this study measures R&D investment using the ratio of R&D expenditures to total assets (David and Gimeno, 2001).

3) Control variables

Referring to the literature (David and Gimeno, 2001), this study selects Tangibility Ratio, ROA, Total Assets, and Industry as control variables. Table 1 lists the capital structure ratios that were used along with specifics about the independent and control variables.

Table 1. Definition of Variables

Types of Variables	Variable Name	Definition of Variables
Dependent Variables	Total Debt Ratio	Total Debt/Total Assets
	Short-Term Debt Ratio	Short-Term Debt/Total Assets
	Long-Term Debt Ratio	Long-Term Debt/Total Assets
Independent Variables	R&D Ratio	R&D Expenses/Total Assets
Control Variables	Tangibility Ratio	Tangible Assets/Total Assets
	ROA	Net Income/Total Assets
	Total Assets	Ln (Total Assets)

C. Data and Sample

The firm-level data is primarily sourced from CSMAR, which offers extensive financial information on listed companies in China.

This study selects A-share listed companies as the research sample, with industry classification based on the 2012 standards established by the China Securities Regulatory Commission (CSRC). The sample period spans from 2018 to 2022, and the data is processed as follows:

- Exclude ST companies under special treatment.
- Exclude financial and utility companies.
- Exclude firms that lack the financial information needed for a firm-level review.
- Refine the manufacturing industry using two-digit SIC codes, merging similar industries, ultimately including four manufacturing sub-sectors.
- All continuous variables are Winsorized at the top and bottom 1% to lessen the impact of outliers.
- Transform total assets by taking their natural logarithm to address the issue of large-scale data values.
- Data processing and regression analyses are conducted using Excel and Stata 17.0 software.

Table 2. Descriptive statistics

Variables	Obs	Mean	Std.Dev	Min	Max
R&D Ratio	8926	0.021	0.021	0.000	0.534
Short-Term Debt Ratio	8926	0.111	0.100	0.000	3.557
Long-Term Debt Ratio	8926	0.069	0.078	0.000	0.587
Total Debt Ratio	8926	0.508	0.205	0.036	8.009
Tangibility Ratio	8926	0.914	0.095	0.164	1.000
ROA	8926	0.019	0.105	−2.525	1.408
Total Assets	8926	22.852	1.372	19.659	28.636
Industry	8926	6.319	3.771	1.000	21.000

After the aforementioned filtering process, the final sample consists of 2832 firms, resulting in a total of 8926 firm-year

observations. Table 2 presents a detailed description of the sample.

In the sample, the average total debt ratio of firms is 0.508, with a maximum value of 8.009. The average short-term debt ratio is 0.111, with a maximum value of 3.557, while the average long-term debt ratio is 0.069, with a maximum value of 0.587. According to these results, the majority of the sample's businesses do not engage in excessive debt-taking.

Correlation checks for a linear relationship between variables to assess the impact of predictor factors on the target variable. In order to find whether the explanatory variables are multicollinear, the Variance Inflation Factor (VIF) is calculated. Pairwise correlations and multicollinearity analysis results are displayed in Tables 3 and 4.

Table 3. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)
(1) Total Debt Ratio	1.000				
(2) R&D Ratio	−1.034*	1.000			
	(0.000)				
(3) Total Assets	0.293*	−0.228*	1.000		
	(0.000)	(0.000)			
(4) Tangibility Ratio	0.060*	0.072*	0.049*	1.000	
	(0.000)	(0.000)	(0.000)		
(5) ROA	−0.468*	−0.006	0.114*	0.064*	1.000
	(0.000)	(0.548)	(0.000)	(0.000)	

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4. Multicollinearity analysis

Variables	VIF	1/VIF
Total Assets	1.02	0.984740
R&D Ratio	1.02	0.986992
ROA	1.02	0.987497
Tangibility Ratio	1.00	0.995167
Mean VIF	1.01	

IV. Result and Discussion

Through regression analysis of various financial indicators in Table 5, it can be study whether R&D expenditure is one of the influencing factors of capital structure. In the regression analysis, the independent variable chosen in this paper is the R&D ratio, while the dependent variables are the total debt ratio, short-term debt ratio, and long-term debt ratio, respectively.

First, in the regression analysis, it is selected 2832 companies as valid samples, and the coefficient of determination for the short-term debt ratio was 0.205, which is relatively low and indicates weak explanatory power. This may be due to the involvement of many industries and the complexity of company types. When the dependent variables are the total debt ratio, short-term debt ratio, and long-term debt ratio, the F-values are 4.423, 195.766, and 100.425, respectively, all at a high level of significance.

Table 5. Regression statistics

	(1)	(2)	(3)
	Total Debt Ratio	Short-Term Debt Ratio	Long-Term Debt Ratio
R&D Ratio	−0.390**	−0.343***	0.017
	(−2.268)	(−3.395)	(0.204)
Total Assets	0.035***	−0.002	0.021***
	(7.802)	(−0.664)	(9.774)
Tangibility Ratio	0.107***	0.041**	−0.094***
	(3.801)	(2.457)	(−6.876)
ROA	−0.472***	−0.172***	−0.072***
	(−36.250)	(−22.546)	(−11.526)
_cons	−0.392***	0.137**	−0.338***
	(−3.572)	(2.136)	(−6.391)
Industry FE	YES	YES	YES
Year FE	YES	YES	YES
N	8926	8926	8926
R^2	0.001	0.205	0.117
F	4.423	195.766	100.425

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

When the total debt ratio is used as the dependent variable, the coefficient of the R&D ratio is observed to be −0.389, with a t-value of −2.268. The research data indicates that as the company continuously increases its spending on R&D expenses, the debt financing used in its capital structure is negatively correlated with it. When the short-term debt ratio is used as the dependent variable, its coefficient is −0.343, and the t-value is −3.395. This indicates that the R&D ratio and the short-term debt ratio also show a negative correlation. When a company's R&D expenses increase, they correspondingly reduce financing for short-term liabilities. But when the dependent variable is the long-term debt ratio, its coefficient is 0.017, and the t-value is 0.204. This indicates that the R&D ratio has no significant relationship with the long-term debt ratio, and the company's investment in R&D expenses is not influenced by the long-term debt ratio.

By data analysis, it is quite clear that the R&D ratio has a significant impact on the total debt ratio, and a highly significant impact on the short-term debt ratio, while the long-term debt ratio is not significantly affected. Therefore, it can be inferred that the influence on the total debt ratio mainly comes from the short-term debt portion. Due to the negative correlation between the R&D ratio and the short-term debt ratio, the total debt ratio also exhibits a negative correlation.

In fact, many companies prefer to use debt in their capital structure not only because of the tax benefits brought by the tax shield effect but also because debt financing has fixed interest expenses, which are more stable. This means that the company can have greater financial leverage, thereby obtaining more returns. However, research indicates that the financial leverage effect of R&D-intensive companies using more debt financing is not significant, meaning they cannot achieve higher returns while the losses incurred during economic difficulties far exceed those of other companies (Opler & Titman, 1994) .This is because, in the event of financial distress, insufficient cash flow cannot support the continuation of R&D activities. Moreover, the sunk costs of R&D projects are higher than those of other projects, which may lead many companies to make irrational choices, such as continuing to increase R&D investment despite poor business conditions but ultimately failing to complete the R&D products, or the R&D products not generating sufficient returns as expected, thereby further exacerbating the losses. At the same time, this phenomenon can also be explained by

the trade-off theory. Due to the uncertainty of research outcomes in companies with high R&D investments, these companies tend to reduce their debt levels to mitigate risk. Chung and Wright (1998) also pointed out in their study that companies need more stable cash flow when using debt financing. For companies with high R&D expenditures, the future outcomes of their research are highly uncertain and cannot guarantee stable cash inflows. Additionally, R&D is a long-term investment process, so R&D expenditures may not yield returns in the short term. Moreover, it is difficult to reduce R&D expenditures during the research process, which can slow down the progress of R&D and decrease its efficiency, so the main reasons most companies are reluctant to use debt financing, in addition to avoiding greater losses during financial difficulties as mentioned above, also include increasing natural cash flow, reducing risk, and minimizing the occurrence of financial distress.

Moreover, most R&D-intensive companies primarily possess intangible assets such as patents, trade secrets, and trademarks, lacking tangible assets with specific and accurate valuations. Institutions willing to provide debt financing services, such as banks, tend to prefer collateral that includes tangible assets with clear valuations to offer loans and financial support. Additionally, the research outcomes of R&D-intensive companies often exhibit significant uncertainty, making it difficult to predict their value. This creates a strong information asymmetry, making it challenging for creditors to assess their true value. Therefore, R&D-intensive companies with higher R&D expenditures find it correspondingly more difficult to engage in debt financing, thereby reducing the proportion of debt financing in their capital costs (Hall, 2002). Moreover, since creditors tend to prefer companies to make more stable and secure investments to ensure timely repayment, while shareholders are more inclined to seek higher returns through risky R&D projects, the increase in R&D expenses intensifies the conflict between the two parties, thereby increasing the company's agency costs (Jensen & Meckling, 1976). Therefore, companies will be more conservative and cautious in using debt financing when choosing their financing options.

At the same time, according to Hall (2002), research indicates that in most countries' tax policies, the tax rate for a company's R&D assets differs from the tax rate for other investments. In fact, because R&D expenditures can be depreciated more quickly than traditional fixed assets, meaning that all expenditures can be directly expensed, the effective tax rate on fixed assets such as equipment remains higher than that on R&D products, even excluding the tax reductions provided by policies for R&D. This means that R&D-intensive companies can reduce their reliance on external financing, use more internal funds, thereby lowering debt financing and overall capital costs.

In summary, according to data research, an increase in R&D expenditures will make companies more inclined to use internal funds, thereby reducing external financing and lowering overall capital costs. Moreover, short-term debt financing reduces the company's free cash flow, leading to higher risk and financial leverage. Therefore, as R&D expenses increase, the company will reduce short-term debt financing to mitigate risks and reduce losses, thereby decreasing the proportion of debt financing and increasing the proportion of equity financing in the company's capital structure.

V. Conclusion

In conclusion, R&D expenditures make a difference on corporate capital structure through regression analysis as total debt ratio and short-term debt ratio are significantly negatively correlated with R&D expenditures, while long-term debt ratio has no significant relationship with R&D expenditures. Therefore, R&D-intensive companies tend to reduce their reliance on debt financing especially for short-term debt, while long-term debt is less affected by R&D expenditures.

The regression coefficient for the total debt ratio analysis is -0.389 ($p < 0.05$), suggesting that higher R&D spending lowers overall debt financing proportions, this could be due to the necessity for predictable cash flows and the uncertainty of R&D investments. Moreover, the short-term debt ratio's regression coefficient is -0.342 ($p < 0.01$), further supporting the significant negative relationship between R&D expenditures and short-term financing. However, there is a weak relationship between long-term debt and R&D expenditures, as long-term debt ratio's regression coefficient is 0.017 and not significant ($p > 0.1$). For those control variables such as total assets and asset tangibility exhibit expected impacts and significantly influence debt ratios.

Based on research analysis, several recommendations are given. Firstly, firms with a certain scale of R&D should prioritize internal funding to mitigate financial risks caused by external financing uncertainties. As for policy support, governments should enhance tax incentives for R&D-focused companies to reduce their financing costs. Furthermore, financial institutions should develop products which are suitable for the R&D-intensive firms to alleviate their financing challenges.

Despite the success of the regression analysis, the research also has some limitations. One limitation is industry differences, while the sample includes multiple industries in China, different firms in multiple industries may vary in R&D intensity and capital structure, which may affect the universality of the results. What's more, variable selection is also considered as a limitation, though some variables such as assets, return on assets, tangibility and industry classification were controlled, other influential factors may not have been considered. On the other hand, the time span is limited from 2018 to 2022, thus this research may not fully capture the long-term effects of R&D expenditures on capital structure due to its short time scope.

According to research limitation, future research may have several directions to investigate. In order to explore the processes of R&D expense on capital structure in greater depth, it is proposed that future research concentrate on particular industries that heavily rely on R&D, such as manufacturing or high-tech. Additionally, further research could compare firms across different countries or regions to examine whether different financing environments and policies influence the relationship between R&D expenditures and capital structure.

Conflict of Interest

The author declares no conflict of interest.

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