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Evaluation of External Financing and Technology Investment Quality of Listed Manufacturing Companies in Nigeria

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Abstract

Purpose: This study examined the effects of external financing on technology investment quality of listed manufacturing firms in Nigeria. ***Design/Methodology/Approach:*** The study employed *ex-post facto* research design. 44 listed manufacturing firms on NGX as at 31st December, 2023 form the study population while 43 firms were selected as the sample using census sampling technique. Data were collected from annual audited financial reports and subjected to multiple regression analysis. ***Findings:*** The findings from the analysis revealed that long term debt has positive significant effect on research and development but insignificant negative effect on return on investment and operational efficiency. Also, it was found that short term debt has positive significant effect on return on investment but negative insignificant effect on operational efficiency and research and development. ***Practical Implication:*** The study concluded that finance from short term debt is crucial for manufacturing firms to earn optimum returns from their innovative investment. It is therefore recommended that management of manufacturing firms strategically align their external finances with investment in capital technology. ***Originality/Value:*** The originality of this study is such that, it may emerge as one of the pioneer studies to investigate the effect of external financing on the quality of technological investment within the Nigerian manufacturing sector.

Keywords: long-term debt, short-term debt, return on investment, research and development, operational efficiency

1. Introduction

In today's rapidly evolving technological landscape, the quality of technology investments is increasingly recognized as a critical factor influencing firm performance and competitive advantage. Market dominance, monopoly and goodwill are not being created by organizational value and capital base only, but also by technological innovations, as revealed by developed nations such as China, Japan, USA categorized by special tag "the Big manufacturing Hub Nations" (Gao *et al.*, 2023). Technology investment quality is multifaceted, involving the effectiveness, efficiency, and impact of these investments on business outcomes. This shows that to ensure a high-quality technology investment, businesses must evaluate how well the technology meets its intended objectives, optimizes resource utilization, and contributes to overall business success. By understanding and balancing these dimensions, companies can make informed decisions about their technology investments and maximize their strategic value (Novotna *et al.*, 2021; Supratiwi *et al*., 2023). However, existing metrics and

evaluation frameworks often fall short in capturing the multifaceted nature of technology investments.

Recently, firms, such as Procter & Gamble (P&G), GSK Plc, Unilever, International Breweries Limited, Scoa Foods Limited, Vitamalt Plc and Deli Foods Limited had gone to extinction in Nigeria (Taoheed, 2023; Ogunyemi, 2021) mostly as a result of low performance that can be attributed to technological inadequacies. Kaplan and Norton (2022) opined that alignment of technological investments with broader strategic goals is crucial for achieving desired outcomes. However, many firms struggle to ensure that their technological investments align with their strategic objectives, leading to suboptimal outcomes. This underscores the challenges that organizations face in effectively integrating their technological investments with their overall strategic direction, which might hinder organizations to maximize the value and impact of their investments.

Wang *et al.* (2023) identified the rise of emerging technologies, such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT), which introduces new opportunities and challenges for technological investments. Evaluating the quality of investments in these emerging technologies requires updated frameworks and methodologies to address their unique characteristics and potential impacts. Additionally, technological investments are inherently subject to high levels of uncertainty and risk, including the rapid pace of technological change, market volatility, and implementation challenges. This uncertainty complicates the assessment of investment quality and makes it difficult for firms to predict returns and manage risks effectively (Chen *et al*., 2021). One of the most pressing issues surrounding technological investment is financing. Without adequate financing, firms may struggle to undertake the necessary investments in research and development (R&D), acquire cutting-edge technologies, and integrate sophisticated information systems. Financing which encompasses a range of funding sources including internal or external sources, venture capital, private equity, and debt financing, plays a crucial role in enabling firms to undertake substantial technological investments (Santos *et al*., 2024).

In today's business landscape, external funding is crucial for empowering companies to pursue substantial technological investments, which are vital for improving productivity, and sustaining competitive advantage (Farida & Setiawan, 2022). However, the impact of external financing on the quality of technological investments remains underexplored and inadequately understood (Piao & Lin, 2020; Wang *et al.*, 2021), particularly within specific contexts such as the manufacturing sectors in developing economies like Nigeria. External financing encompasses various sources, including bank loans, trade credit, and bond financing. While these financial resources can provide the capital necessary for technological advancements, they also introduce complexities related to financial management and strategic decision-making (Nylund *et al*., 2019). The challenges lie in understanding how different forms of external financing influence the quality of technology investments, which includes the effectiveness, efficiency, and outcomes of these investments.

Existing literature had been written on relationship between external financing and technological investment. Kim *et al*. (2023) examining external financing, technological changes and employee's productivity was able to infer that seasoned equity offerings (SEOs), which is a means of raising external equity financing, influenced research and development and employee's productivity in China firms. Kokot-Stępień (2022) also observed that in Poland businesses, the utilization of external finances by SMEs is still insufficient and often restricted mainly to European Union (EU) funds. In the study from 35 developed countries by Zhang *et al*. (2019) on the effects of equity financing and debt financing on technological innovation, it was discovered that debt financing as a form of external financing has little or no capacity to promote technological innovations. Unlike previous studies such as Wang (2022), Bhattacharya *et al*., (2019), have examined commercial credit, long-term loan, and focused on the whole listed private and public companies, however, there exist the need to explore both the short-term debt and long-term debt aspect of external financing on return on investment, operation efficiency and research and development investment.

Furthermore, some previous studies on external financing evaluated external financing, measured by seasoned equity, bank debt, straight non-bank debt, and convertible issues and bank loans, on technological investment (Liu *et al*., 2019; Grundy & Verwijmeren, 2020), yet the findings are uneven and conflicting. Despite efforts in these previous studies, previous research in Nigeria has not yet focused on the quality of technological investments, particularly within the listed manufacturing companies, despite this sector being heavily driven by technological innovations. As a result of this, there exists a gap in understanding the broader implications of external financing on technological investment quality in diverse contexts.

The broad objective of the study is to investigate the influence of external financing on technological investment quality of listed manufacturing companies in Nigeria with specific focus on long-term debt and short-term debt financing. The choice of listed manufacturing is premised on the capital structure and size, as well as technological investment drive. The study limited its external financing scope to long-term debt and short-term debt, while return on investment, operational efficiency and research and development investment were used to measure technological investment quality.

This study is divided into five sections. The first part provides an overview of the study. Part two discusses the conceptual, theoretical, and empirical assessments of the literature. Part three focuses on the methodology. Part four includes data analysis, hypothesis testing, and discussion of findings. Finally, part five contains the summary, conclusion, and recommendations.

2. Literature Review

2.1 Conceptual Review

2.1.1 Technology Investment Quality

Technology Investment Quality is defined as the effectiveness and strategic alignment of technology investments with an organization's long-term goals and competitive strategies (Boulding & Christen, 2022). This involves how well technological investments contribute to innovation, enhance firm capabilities, and integrate into existing systems to improve operational efficiency. According to Garcia and Lee (2024), the quality of technological investments reflects their ability to achieve high performance and strategic objectives within specific sectors, suggesting that successful technological deployment also includes user adoption and market expansion through new products and services.

Tonkova *et al.* (2019) highlight the importance of dynamically allocating investments between high and low technologies, ensuring that they are not only innovative but also practical and cost-effective. This underscores a flexible approach to managing technological investments strategically. The study further defines technology investment quality as the effectiveness and efficiency in utilizing funds for innovative projects that yield tangible results, like new product development and process improvements. It emphasizes both achieving investment goals and optimizing resource utilization, reflecting the alignment of technology investments with strategic objectives and their long-term performance impact.

2.1.2 Research and Development Investment

Luo and Liu (2022) characterize research and development (R&D) investment as an organization's systematic commitment to generating new knowledge and applying it to develop innovative solutions that yield future advantages. This dual-faceted approach emphasizes both the creative processes involved in understanding new knowledge and the practical application of this knowledge for long-term organizational benefits. Their study indicates that R&D investment significantly enhances debt financing efficiency for small and medium-sized enterprises (SMEs), suggesting that innovative firms tend to secure better loan terms due to improved financial performance and credibility with lenders.

R&D investment not only fosters innovation and technological advancements but also aids firms in lowering production costs, boosting productivity, and enhancing export performance. These improvements can stimulate new demand, contributing to national economic growth (Soltanisehat & Alizadeh, 2019). Thus, R&D is integral to achieving competitive advantages and increasing overall economic activity, with potential spillover effects that promote broader economic development. The study defines R&D investment as a financial commitment, measured by the ratio of R&D spending to total assets, highlighting its role in fostering innovation and economic benefits for firms and the wider economy.

2.1.3 Return on Investment

Dadd and Hinton (2022) define return on investment (ROI) as a financial metric that evaluates the additional profits generated from a specific investment relative to its cost. This measure helps companies make informed decisions about which investment opportunities to pursue by providing a straightforward way to assess profitability. ROI serves as a benchmark for performance and a comparative tool for different investment options, enabling businesses to identify those that yield the highest profit (Hassanzadeh & Bigdeli, 2019). Sinebe and Henry (2023) further emphasize that ROI analysis originates from financial investing and is crucial for evaluating investment efficiency and aligning decisions with financial goals. By measuring returns against investment costs, firms can determine whether an investment is profitable and compare varying investment opportunities effectively. The study also describes ROI in the context of technology investments, measuring the financial returns generated as a percentage of the investment cost, reinforcing its role in supporting decision-making and resource allocation.

2.1.4 Operational Efficiency

Operational efficiency is a critical focus for both researchers and industry professionals in the manufacturing sector. Osazefua (2019) defines it as the effective utilization of resources — such as time, money, and labor — to achieve maximum output with minimum input. This concept is fundamental to a company's strategic objectives, encompassing cost reduction, competitive advantage, and resource optimization (Dilshani *et al*., 2019). Operational efficiency is measured by the ratio of outputs to inputs, reflecting how effectively resources are transformed into results (Handoyo *et al*., 2023). Enhanced operational efficiency can lead to improved

performance, reduced costs, and a stronger market position. External financing plays a vital role in this regard, providing the capital needed for process improvements, technology upgrades, and resource optimization. Efficient use of these funds not only boosts financial performance but also increases the organization's attractiveness to prospective investors (Tanjung, 2019). However, balancing efficiency with quality and innovation is essential for sustainable growth. This study conceptualizes operational efficiency as the increase in output and decrease in costs, measured by the value of cost reductions achieved through technological investments.

2.1.5 External Financing

Cheratian *et al*. (2023) define external financing as the funds available to corporate entities from sources outside their ownership, aimed at addressing funding challenges. This financing contrasts with owners' equity and internal financing sources, meaning it does not dilute owners' control but can reduce their returns. Brealey *et al*. (2023) further explain that external financing includes loans, equity investments, venture capital, or grants, which support operations, growth, or development. In this context, various forms of external financing — such as bank loans, debentures, trade credit, and government grants — are utilized to drive business activities without selling controlling rights. However, the need for external financing, particularly debt repayment, can create pressure on management to meet short-term financial targets, potentially leading to earnings management. Ultimately, the effectiveness of external financing in enhancing or hindering technological investment quality depends on how well it aligns with a company's innovation objectives. For the purpose of this study, external financing will be viewed as long-term debt financing and short-term debt financing.

2.1.5.1 Long-Term Debt Financing

Ebe *et al*. (2024) define long-term debt financing as capital acquired from lenders for business operations, with repayment periods of two years or more, particularly emphasizing its application for substantial, tangible investments. Shikumo *et al*. (2020) further elaborate that this type of financing is typically secured by collateral, often asset-based, and is used for significant projects that take longer to yield returns, highlighting the relationship between debt and the organization's assets through metrics like the debt ratio. Recent studies have produced varied insights on long-term debt financing. For instance, Sukma *et al*. (2022) found that the long-term debt ratio significantly affects return on equity, suggesting that excessive debt can diminish owner returns due to fixed interest payments. Conversely, Bui *et al*. (2023) argue that long-term debt does not impact firm value, asserting that a firm's value is more influenced by its assets and operational profitability rather than its financing methods, aligning with the Modigliani-Miller theorem. This study conceptualizes long-term debt financing as debt secured by asset-based collateral within a long-term framework, reflecting a company's financial health. High debt levels may lead to increased capital costs, posing challenges for raising funds for technological investments (Bhattacharya *et al*., 2019).

2.1.5.2 Short Term Debt Financing

Asiedu *et al*. (2021) defines short-term debt as a crucial indicator of a firm's short-term liquidity, essential for managing immediate financial needs and meeting obligations. Kose *et al*. (2022) further describe it as debt that provides liquidity, bridging temporary cash flow gaps for operational expenses, inventory management, and seasonal revenue fluctuations. This study defines short-term debt financing as obligations to fund day-to-day operations that must be repaid within one year or within the operating cycle, encompassing short-term loans, trade credit, and lines of credit, also referred to as current liabilities. Research presents differing opinions on short-term debt. Pradana and Imelda (2023) argue that short-term debt does not negatively affect company performance, suggesting that effective financial management is crucial for optimizing long-term performance. Conversely, Abdulrahman (2021) points out that short-term debt carries higher liquidity risks due to its frequent repayment requirements, which can constrain cash flow. This liquidity risk may hinder research and development investments, as firms with high short-term debt ratios might prioritize immediate financial health over long-term innovation potential.

2.2 Theoretical Review

This study explored trade-off theory and real option theory as the theoretical basis for its investigation.

2.2.1 Trade-off Theory

The trade-off theory, introduced by Modigliani and Miller in 1958, posits that there is an optimal capital structure for a company that balances the benefits of debt (like tax shields and lower capital costs) against its costs (such as financial distress and agency costs). This theory suggests that firms strive to maximize their value or minimize their cost of capital by determining the right mix of debt and equity financing, taking into account factors like organizational risk and future cash flows (Grundy & Verwijmeren, 2020; Nazir *et al*., 2021). Research indicates that firms with lower debt ratios may invest more in research and development (R&D), as they have the financial flexibility to allocate resources towards innovation without the burden of high debt

servicing costs.

Conversely, excessively low debt levels may signal underinvestment in R&D, as firms may prioritize financial stability over long-term growth. However, debt financing can also incentivize innovation by providing the necessary capital for risky projects (Kim & Sorensen, 2020). Despite its foundational role in corporate finance, the trade-off theory has faced criticism for its oversimplifying assumptions, such as the existence of perfect capital markets and static tax environments. In reality, these conditions rarely hold true, leading to discrepancies between theoretical predictions and actual outcomes (Hengjie *et al*., 2021).

2.2.2 Real Option Theory

Real option theory originated mainly from the works of Myers (1977) but expanded in scope by McDonald and Siegel (1986). The theory assumes that investments in real assets (such as technology) can be treated like financial options. This means that firms have the flexibility to make decisions over time, similar to the way option holders have the right (but not the obligation) to buy or sell a financial asset or to abandon a project if it becomes unprofitable. By treating technology investments as real options, firms can use external financing as a tool to optimize resource allocation, adapt to market conditions, and ensure that technological initiatives contribute to strategic growth. This approach allows firms to manage risk and maximize the potential benefits of both technology and financing, leading to higher-quality investments (Christian & Bart, 2022).

Real Option Theory's focus on flexibility, timing, and managing uncertainty plays a crucial role in enhancing both the quality of technology investments and the strategic use of external financing. By treating technology investments as options, firms can optimize their financial decisions, securing the right amount of external capital at the right time, and ensuring that resources are deployed toward the most promising technological innovations. Real Option Theory (ROT) offers insights into investment flexibility but has notable limitations, especially in technology investment quality and external financing. Its reliance on uncertainty modeling and overemphasis on flexibility diminish its relevance in fast-paced, capital-constrained environments like the tech-sector. Additionally, the disconnect between ROT's theoretical framework and the practical expectations of external financiers can lead to funding difficulties, making it less applicable in real-world situations (Adegbie *at al*., 2019).

2.3 Empirical Review

Relevant research works related to external finances and technological innovation investment quality were examined in this study in accordance to the specific objectives while the research hypotheses were thereafter developed.

2.3.1 Long-Term Debt Financing and Technology Investment Quality

Xin *et al*. (2019) investigated the impact of debt financing on technological innovation among 225 listed computer and telecommunication equipment firms in China, finding that debt financing positively influences both radical and incremental innovations. This finding aligns with Piao and Lin (2020), who found a significant positive effect of long-term borrowing on technological innovation efficiency across various firms in the internet industry in China. In contrast, research by Zhang *et al*. (2019) using data from 35 high-income countries indicated a significant negative correlation between bank debt financing and technological innovation, suggesting that bank debt does not effectively support innovation due to its low tolerance for uncertainty and potential failure. Supporting this perspective, Wang and Zhu (2023) reported a negative relationship between digital transformation and debt financing costs, indicating that technological advancements can help reduce these costs.

Bessonova *et al*. (2021) examined long-term financing in Russia, finding a significant positive relationship between long-term bank loans and innovation among 4,220 private sector firms. However, research by Wang *et al*. (2021) revealed mixed results regarding the impact of financing on technological innovation at different stages, with loans negatively affecting the maturity stage of innovation. While some studies have explored the relationship between debt financing and technological innovation in various sectors, there is limited research specifically focusing on the manufacturing sector. This study aims to fill this gap by examining how external financing influences the quality of technological innovation investments in listed manufacturing firms in Nigeria. The study hypothesizes the influence of long-term debt financing on technological investment quality as thus:

$H_{01:}$ *Long-term debt financing has no significant effect on research and development investment of listed manufacturing companies in Nigeria.*

$H_{02:}$ *Long-term debt financing has no significant effect on return on investment of listed manufacturing companies in Nigeria.*

H_{03}: Long-term debt financing has no significant effect on operational efficiency of listed manufacturing companies in Nigeria.

2.3.2 Short Term Debt Financing and Technology Investment Quality

Liu *et al.* (2019) conducted a study on the impact of bank loans on technological innovation among A-share listed enterprises in China from 1990 to 2017. They analyzed data from 2,208 companies using a two-stage generalized moment estimation (GMM) method, revealing a positive relationship between bank loans and technological innovation. This suggested that short-term debt can effectively stimulate innovation in businesses. However, contrasting findings emerged from Zhang *et al.* (2019), which highlighted a significant influence of both debt financing and bank loans on technological innovation in Chinese firms. Nykvist and Maltais (2020) examined the finance sector's role in sustainability transitions in Sweden, finding that demand for credit had minimal impact on sustainable innovation. Their study indicated that financing alone does not drive innovation without the influence of external factors, such as government intervention. In a different context, Ruiz-Palomo *et al*. (2022) analyzed how financial constraints affect technological and management innovation in Spanish SMEs, discovering that restricted access to debt financing significantly impairs innovation.

Yuan *et al*. (2021) reported mixed results in their study of financial innovation and green innovation across OECD countries. They found that stronger environmental regulations positively influenced the relationship between financial innovation and green innovation, while the opposite was true in countries with lax regulations. Conversely, Asiedu et al. (2021) established that bank financing and trade credit positively influenced innovation in Africa. While previous studies, including those by Liu et al. and Zhang et al., focused on debt financing's role in technological innovation, there remains a gap in research regarding how external financing, particularly short-term debt, affects the quality of research and development investments in the manufacturing sector. This study aims to address that gap by positing a hypothesis concerning the influence of short-term debt financing on technology investment quality in listed manufacturing firms in Nigeria as:

H_{04}: Short-term debt financing has no significant effect on research and development investment of listed manufacturing companies in Nigeria.

H_{05}: Short-term debt financing has no significant effect on return on investment of listed manufacturing companies in Nigeria.

H_{06}: Short-term debt financing has no significant effect on operational efficiency of listed manufacturing companies in Nigeria.

2.4 Conceptual Framework

Figure 1 shows the interactions between the independent variable (External Financing) and the dependent variable (Technology Investment Quality)

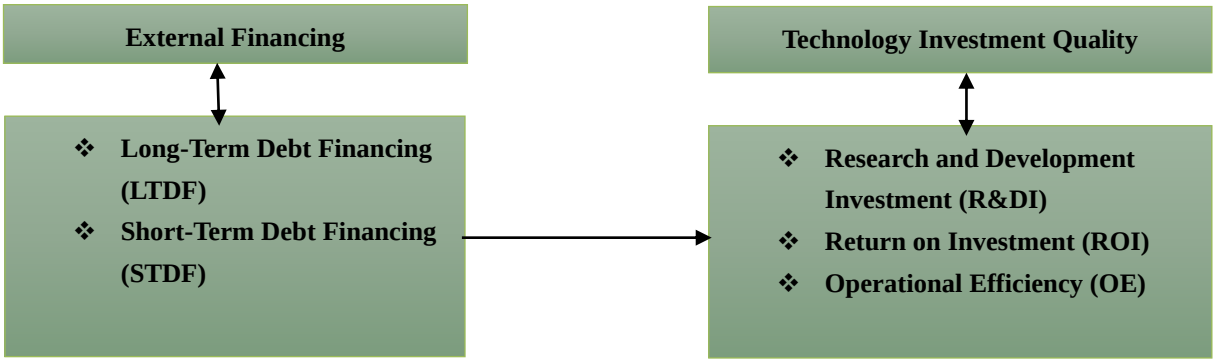

Figure 1. Conceptual Framework

Source: Researchers' Design (2024).

3. Methodology

The study employed *ex-post facto* research design. The study population was made up of 44 manufacturing companies which comprises of 13 Industrial goods manufacturing firms and 21 Consumer goods manufacturing firms listed on Nigeria Exchange Group (NGX) as at 31st December, 2023. The reason for focusing on manufacturing sector is because the sector is considered to be highly technologically driven. However, 43 firms

were selected using census sampling with exclusion of a firm that has incomplete financial report as a result of listing period. Data on key variables were extracted from the annual audited reports and financial statements of the sampled firms.

The study covered a 10-year financial period from 2014 to 2023. This period is appropriate for the study as it covers period of significant technological advancement in the nation, most importantly the manufacturing sector. And it is a period when regrouping and reclassification of firms and restructuring of Nigeria Exchange Group (NGX) from Nigeria Stock Exchange (NSE) took place. Multiple regression models were used to assess the influence of external financing on technology investment quality. This study adheres to ethical research practices by ensuring data confidentiality and anonymity. All data used in the study is publicly available and does not contain any personal or sensitive information.

3.1 Model Specification

The econometric function for the study was developed as a model to accommodate variables of the study. The function is formulated as:

$$TIQ = f(LTDF, STDF) \quad \text{……..…… 1}$$

Various scenarios were evaluated based on the dependent variables, which were divided into three separate models. Based on the above functional relationship, the models were as stated below:

Model 1 (Research and Development Investment)

$$RDI = \beta 0 + \beta_1 LTDF + \beta_2 STDF + \epsilon \quad \text{…….…. 2}$$

Model 2 (Return On Investment)

$$ROI = \beta 0 + \beta_1 LTDF + \beta_2 STDF + \epsilon \quad \text{…….……. 3}$$

Model 3 (Operational Efficiency)

$$OE = \beta 0 + \beta_1 LTDF + \beta_2 STDF + \epsilon \quad \text{…….. 4}$$

Dependent variable

Research & Development Investment (R&DI), Return on Investment (ROI), Operational Efficiency (OE).

Independent variable

Long-Term Debt Financing (LTDF), Short-Term Debt Financing (STDF)

$\beta 0$ = Intercept

β_1 β_2 β_3 β_4 = unexplained variable coefficients

ϵ = Error Term

The explanatory variables and the explained variable are predicted to have a positive connection, as shown by the a-priori expectation = β_1 $\beta_2 > 0$.

3.1.1 Operationalization of Variables

Table 1 shows the description, measurement, data source, and literature evidence of the investigated variables.

Table 1. Measurement and Description of Research Variables

S/N	Variable	Description	Measurement	Data Source	Literature Evidences
1	Dependent Variable:				
	Research and Development Investment (R&DI)	This refers to the firm's commitment to developing innovative technologies and products.	To be measured as the ratio of research and development (R&D) investment to total assets	Annual Financial Reports.	Liu *et al.* (2019), Nhung Do *et al.* (2023)
	Return On Investment (ROI)	This can be described as the value of profit derived from investment	To be measured as percentage of financial returns generated from technology investments to the cost or NPV of technology investments	Annual Financial Reports.	Sunaryo (2020)

	Operational Efficiency (OE)	This refers to the improvement or increase in output and decrease in cost or time as a result of technology investment.	To be measured as value of decrease in operational cost brought about by technology investments	Annual Financial Reports.	Tanjung (2019)
2	Independent Variables:				
	Long-Term Debt Financing (LTDF)	This refers to the firm's leverage and reliance on long term external financing	To be measured as the proportion of total long term debt to total assets	Annual Financial Reports	Xin *et al.* (2019), Piao & Lin, (2020)
	Short Term Debt Financing (STDF)	This refers to the firm's short-term liquidity position and reliance on short-term financing.	It is measured as the proportion of short-term debt to total assets	Annual Financial Reports	Pradana & Imelda (2023), Asiedu *et al.* (2021)

Source: Researcher's Compilation (2024).

4. Data Analysis and Discussion of Findings

4.1 Descriptive Statistics

The descriptive analysis of variables is reported in Table 2. The results shows that research & development investment (RDIV) on the average is 0.32 percent with standard deviation of 0.964 and this indicate that most of the surveyed manufacturing firm has high variability when it comes to research and development investment quality and it is of low quality as most of the R&D cost are expenses as they don't meet the criteria of intangible assets and they form small percentage of the total assets. Manufacturing firm with the minimum research and development investment (RDIV) has no R&D investment having 0 and the maximum research and development investment (RDIV) during the period is 4.4 percent. The data is positively skewed and has abnormal distribution.

From Table 2, it is observed that returns on investment (ROIV) for the selected firms on the average, is -1.438 with standard deviation of 13.93. The standard deviation value shows that there is high variability in the returns on capital investment made across the sampled firms while the standard error of mean implied that the sample mean is a reflection of the actual population having a small value compared to the mean 0.6722. Manufacturing firms with the least returns on investment (ROIV) has -66.24 while the maximum is 14.7248 and the total sum of returns on investment (ROIV) represents -618.41. This indicates that many manufacturing firms in the sample are struggling to generate positive returns from their investments. The data is negatively skewed and abnormally distributed.

Furthermore, on Table 2, it is observed that operating efficiency (OPEF) for analyzed firms on the average is 26.85 with standard deviation of 39.050. The standard deviation value shows that there is moderate variability in the cost efficiency (COEF) across the sampled manufacturing firms while the standard error showed the value of 1.8832. Manufacturing firms with the least operating efficiency (OPEF) has 0 while the maximum operating efficiency (OPEF) is 201.151 and the total sum of the operating efficiency represents 11549.64. The implication is that the operating efficiency effort of the studied manufacturing firms is average and the operating cost to the revenue is of high percentage in ration to their revenue. The data is positively skewed and abnormally distributed.

More so, long term debt (LGDBT) for surveyed manufacturing firms on the average is 6.0182 with standard deviation of 2.1923. The standard deviation value shows that there is high variability in the external financing through long term debt (LGDBT) during the period covered while the standard error of mean implied that the sample mean is a reflection of the actual population having a small value compared to the mean 0.1057. Manufacturing firms with the least long term debt (LGDBT) have 0 implying no borrowings were made during a particular year while the maximum long term debt (LGDBT) is 9.4872 and the total sum of the long term debt (LGDBT) represents 2587.85. The data is negatively skewed and abnormally distributed.

Short-term debt (SHDBT) for studied firms on the average is 5.6345 with standard deviation of 1.9894. The standard deviation value shows that there is high variability in the external financing through short-term debt (SHDBT) during the period covered while the standard error of mean implied that the sample mean is a reflection of the actual population having a small value compared to the mean 0.0959. Manufacturing firms with the least short term debt (SHDBT) has 0 implying no short term borrowings was made during a particular year while the maximum Short-term debt (SHDBT) is 9.4105 and the total sum of the Short-term debt (SHDBT)

represent 2422.86. The data is negatively skewed and abnormally distributed.

Table 2. Descriptive Statistics

Stats	RDIV	ROIV	OPEF	LGDBT	SHDBT
Mean	0.3278	-1.438	26.8596	6.0182	5.6345
S.D.	0.9646	13.9383	39.050	2.1923	1.9894
Se(mean)	0.0465	0.6722	1.8832	0.1057	0.0959
Min	0.00	-66.24	0.00	0.00	0.00
Max	4.430298	14.7248	201.151	9.4872	9.4105
Sum	140.992	-618.41	11549.64	2587.85	2422.86
Skewness	3.473	-3.871	3.377	-1.714	-1.484
Kurtosis	14.134	18.195	14.595	5.5926	5.0752

Note: Results of mean, median, minimum, maximum, skewness and kurtosis of each variable from analysis of study data are shown above table.

Source: Researcher's Computation (2024).

4.2 Correlation Analysis

In Table 3, the data revealed a direct but insignificant relationship between research & development investment (RDIV) and long term debt (LGDBT), as evidenced by the coefficient value of 0.0697 and probability of 0.1492. Furthermore, it is demonstrated that for sampled manufacturing firms, there is an inverse correlation between research & development investment (RDIV) and short term debt (SHDBT) but the relationship is insignificant as the p-value of 0.0886 is higher than 5 percent level of significance. Furthermore, it is observed that returns on investment (ROIV) and operating efficiency (OPEF) has positive and significant relationship with long term debt (LGDBT) and this imply that one time increase on long-term debt, returns on investment will increase by 11.64 percent. Also, one time increase in short term debt (SHDBT) will lead to 23.63 percent increase returns on investment and this is evidence by coefficient value of 0.2363 and p-value of 0.0000 imply a significant relationship. More so, the correlation result shows that operating efficiency is negatively influenced by external financing both short term and long term debt. The table shows that one time increase in long term debt (LGBDT) will decrease the operating efficiency (OPEF) by 10 percent. And one time increase in short term debt (SHDBT) will cause the operating efficiency to reduce by 18.29 percent. The overall implication of these relationships is that all external financing has mixed effect on quality technological investment in manufacturing firms. It is further observed from Table 3 that the relationships between the independent variables are not strong in a way that depicts multicollinearity.

Table 3. Correlation Analysis of External Financing and Technological Investment Quality

Variables	Pairwise Correlation	RDIV	ROIV	OPEF	LGDBT	SHDBT
RDIV	Coefficient	1.0000				
	Sig.	-				
ROIV	Coefficient	0.0545	1.0000			
	Sig	(0.2591)	-			
OPEF	Coefficient	0.2207*	-0.4495*	1.0000		
	Sig.	(0.0000)	(0.0000)	-		
LGDBT	Coefficient	0.0697	0.1146*	-0.1000*	1.0000	
	Sig.	(0.1492)	(0.0174)	(0.0383)	-	
SHDBT	Coefficient	-0.0822	0.2363*	-0.1829*	0.5170*	1.0000
	Sig.	(0.0886)	(0.0000)	(0.0001)	(0.0000)	-

Note: Results of a pairwise correlation coefficient test of relationships amongst variables of the study are shown in above table.

Source: Researchers' Computation (2024).

4.3 Estimation Tests

4.3.1 Pre-Estimation Tests

4.3.1.1 Panel Unit Root Test of the Variables

The results of unit root tests were displayed in Table 4. It shows that all the variables are integrated of order zero that is 1(0) which is significant at 5 percent level of significance. Therefore, we reject the null hypothesis and conclude that the series is stationary. Therefore, it is not necessary to conduct the co-integration test in order to determine the long run relationship among the variables. The panel least square is capable of estimating an efficient model and that is less spurious.

Table 4. Panel Unit Root Test

	Levin-Lin-Chu unit-root test	
Variable	z-statistics	P-value
RSID	-11.8217	0.0000
ROIV	-4.7446	0.0000
OPEF	-13.7159	0.0000
LGDBT	-4.3304	0.0000
SHDBT	-15.5868	0.0000

Note: Results of unit root tests of variables from analysis of study data are presented above.

Source: Researcher's Computation (2024).

4.3.2 Post-Estimation Tests

The summary of post estimation test results was presented in Table 5. The multicollinearity test shows the absence of collinearity among the independent model as the mean vif is less than 10 and 1/vif for the variables is less than 0.10. Data for the study revealed that the residuals of the dependent variables are not independent of each other having probability of 0.000 which is less than 5 percent level of significance and this imply that there is no need to separate the regression, hence the study progress to perform the multivariate regression. The Hotelling T2 value was statistically significant, therefore the null hypothesis of that all mean are the same is rejected as the result shows that there is mean difference. The test for covariance shows non-diagonal and the normality of the residual shown by doornick reveals that the distribution data is abnormal.

Table 5. Summary of Post Estimation Test Results

Tolerance and VIF Value		
Null Hypothesis	VIF	Mean VIF
There is no multicollinearity among the variables (1/VIF >0.10)	-	1.36
Breusch-Pagan test of Independence		
Null Hypothesis	Chi2 Statistics	Probability
Residuals of the dependent variables are independent of each other (P>0.05)	99.886,	0.0000
Hotelling T^2		
Null Hypothesis	Statistics- F(4,426)	Probability
No joint mean difference (P>0.05)	164.64	0.0000
Multivariate test of covariance		
Null Hypothesis	LR chi2(10)	Prob > F
covariance matrix is diagonal	302.72	0.0000

Test for multivariate normality		
Null Hypothesis	Chi2 Statistics	Probability
Doornik-Hansen	36086.005	0.0000

Note: Results of tolerance and variance inflation factor test, multivariate normality test, hoteling test and test of independence of all variables of the study with their significance effect at 0.05 levels are shown above.

Source: Researchers' Computation (2024).

4.4 External Financing on Technological Investment Quality of Listed Manufacturing Companies in Nigeria

The tests for the overall model showed Table 6 implied that the model is statistically significant at 5 percent and this is evidenced by the significance of the f-statistics for research and development investment (RSIV), return on Investment (ROIV) and operating efficiency (OPEF) showing 0.0057, 0.0000 and 0.0007 respectively. The R-square shows that external financing can influence research and development investment (RSIV) by 2.39 percent; return on Investment (ROIV) by 12.64 percent and operating efficiency (OPEF) by 7.4 percent. The R-square shows that returns on investment (ROIV) is the highest measure of investment quality because as it is the most productive measure that reflects the innovation and how economically funds obtained are being used. The overall result shows that short term debt (SHDBT) is the most significant influencer of investment quality because it is of significance to all measures of investment quality. The implication of this is that manufacturing firms should consider leveraging short-term debt for financing investments, as it significantly influences all aspects of investment quality.

The result of the individual regression result shows that long term debt (LGDBT) has positive and significant effect on research and development investment (RSIV) having t-statistics of 2.74 and p-value of 0.006, hence, the hypothesis that long-term debt financing has significant effect on research and development investment of listed manufacturing companies in Nigeria is hereby rejected. On the other hand, short term debt (SHDBT) has negative and significant effect on research and development investment (RSIV) having t-statistics of -2.89 and p-value of 0.004, therefore, the hypothesis that short-term debt financing has significant effect on research and development investment of listed manufacturing companies in Nigeria is rejected.

Table 6 also shows that long term debt has negative and insignificant effect on returns on investment (ROIV) having t-statistics of -0.19 and p-value of 0.852, leading to the rejection of the hypothesis that long-term debt financing has no significant effect on return on investment of listed manufacturing companies in Nigeria. In contrast, short term debt has positive and significant effect on returns on investment (ROIV) having t-statistics of 4.40 and p-value of 0.073 greater than 0.005, hence the null hypothesis is accepted**, i**mplying that short-term debt financing has positive significant effect on return on investment of listed manufacturing companies in Nigeria.

Lastly on the Table 6, it is shown that long term debt (LGDBT) has negative and insignificant effect on operating efficiency (OPEF) having t-statistics of -0.13 and p-value of 0.895, hence the hypothesis that long-term debt financing has significant effect on operational efficiency of listed manufacturing companies in Nigeria is rejected. Also, short term debt has negative and significant effect on operating efficiency (OPEF) having t-statistics of -3.22 and p-value of 0.001. The hypothesis is thereby rejected, indicating that short-term debt financing has no significant effect on operational efficiency of listed manufacturing companies in Nigeria.

Findings above imply that sourcing finance from external sources will affect research and development investment but taking long term debt will positively influence the quality of research & development and this may be because of large cost and period attached to achieving research goals and it is long term debt that can perfectly sponsor the goals. Also, the results imply that if the manufacturing firms want higher returns on investment, the best financing to go for is the short term debt (SHBDT). The negative effect of the long term debt (LGDBT) means that the manufacturing firms do not usually pursue highly tangible investments that are financed by long term debt; hence assets are mainly financed with low level of debt. This means that when the manufacturing firms want to enhance their performance, reduce costs, and better position them in the market, they source for finance by taking short term.

The findings of this study align with previous research, such as Xin *et al.* (2019) and Liu *et al*. (2019), which both demonstrated a positive relationship between debt financing and technological innovation, particularly in China's A-share enterprises. Similarly, the study supports Piao and Lin (2020), who found that long-term borrowing significantly enhances technological innovation efficiency in China's internet industry, and Bessonova *et al.* (2021), who observed a positive link between long-term loans and innovation in Russian businesses. Additionally, it echoes Zhang *et al.* (2019), which highlighted the significant impact of both debt financing and bank loans on technological innovation in China. In contrast to the empirical review, where

short-term debt is generally associated with fostering innovation (Liu *et al.*, 2019), the findings suggest that short-term debt has a negative and significant effect on research & development investment (RSIV). The findings also contradict Wang *et al*. (2021) who found that long-term debt has a positive and significant impact on research & development but a negative and insignificant effect on return on investment (ROIV) and operating efficiency.

Table 6. Multivariate Regression Table

	Research & Development Investment			**Returns on Investment**			**Operating Efficiency**		
R-sq	0.0239			R-sq	0.0559		R-sq	0.0335	
F-stat	5.235			F-stat	12.642		F-stat	7.399	
P-value	0.0057			P-value	0.0000		P-value	0.007	
Obs	430			Obs	430		Obs	430	
	Coeff.	T	P>|t|	Coeff.	Z	P>z	Coeff.	T	P>|t|
LGDBT	0.3675	2.74	0.006	-0.2032	-0.19	0.083	-0.1311	-0.13	0.895
SHDBT	-0.426	-2.89	0.004	5.2780	4.40	0.073	-3.3515	-2.53	0.001
_cons	1.019	1.21	0.228	-35.380	-5.16	0.000	47.458	7.61	0.000

Note: Results of the regression of all variables of the study with their significance effect at 0.05 levels are shown above.

Source: Researcher's Computation (2024).

4.5 Discussion of Findings

The findings of this study can be closely related to the Trade-off Theory and Real Option Theory which form the basis of the study. Trade-off theory posits that firms must balance the tax benefits of debt with the costs of financial distress. The analysis reveals that Nigerian manufacturing firms benefit from short-term debt in terms of return on investment, aligning with the theory's suggestion that debt can improve financial efficiency when optimally used (Grundy & Verwijmeren, 2020). However, the negative impact of long-term debt on operational efficiency supports the argument that excessive reliance on long-term debt can lead to inefficiencies, perhaps due to the burden of interest payments or financial constraints. The findings also indicate that while long-term debt positively influences research and development investment, firms might not be utilizing this financing optimally to enhance short-term return on investment and operational performance, suggesting an imperfect balance in capital structure, which is a core consideration in trade-off theory (Nazir *et al.*, 2021). The implication of the findings should influence the managers to reconsider their leverage position and make proper matching of which external finance will match the investment they are making to achieve better quality of returns in order to step-up their game of been the most efficient cost management in the manufacturing industry.

Also, Real Option Theory (ROT) emphasizes flexibility in investment decisions, particularly in research and development projects. The positive impact of long-term debt on research and development investment aligns with ROT's principles, as it allows firms to pursue risky innovation projects with long-term potential (Christian & Bart, 2022). However, the negative effect of short-term debt on research and development investment implies that firms may face limitations in leveraging short-term financing to foster long-term innovation, which contradicts the flexibility advocated by ROT. The results suggest that while firms may view long-term debt as an enabler of strategic investments (such as research and development), short-term financing is more suited for immediate gains, reinforcing the idea that the timing and nature of debt matter significantly in maximizing investment quality.

The significant positive impact of short-term debt on returns on investment (ROIV) in the study aligns with the theory's assertion that debt can provide financial leverage to improve firm performance (Grundy & Verwijmeren, 2020). The finding that long-term debt positively affects research and development investments, supporting the idea that firms can use debt to fund long-term, high-cost projects, such as innovation and technological advancements. This is in line with the theory, as debt financing, particularly long-term, offers the financial capacity to invest in risky, innovation-driven projects that might otherwise be underfunded (Nazir *et al*., 2021). The implication of the findings should influence the managers to reconsider their leverage position and make proper matching of which external finance will match the investment they are making to achieve better quality of returns in order to step-up their game of been the most efficient cost management in the manufacturing industry.

The findings closely address the issues and challenges raised as regards managing the risks and uncertainties

associated with debt financing, particularly in the context of innovation-driven investments (Chen *et al.*, 2021). The negative impact of long-term debt on operating efficiency, for instance, suggests that firms must carefully weigh the risks of financial distress and inefficiency that may arise from leveraging long-term debt, even if it supports innovation. The findings underscore the importance of selecting the right mix of financing options, particularly short-term and long-term debt, to align with both immediate and long-term strategic objectives of organization, specifically, manufacturing companies (Nylund *et al*., 2019). Ultimately, the results from the survey bridges the gap identified in the study by offering empirical evidence on how external financing influences technological investment quality in the manufacturing sector of a developing economy like Nigeria.

The study confirms that the lack of alignment between financing sources and investment needs is a key challenge for manufacturing firms. As Kaplan and Norton (2022) pointed out, ensuring alignment between technology investments and broader strategic goals is crucial for achieving positive outcomes. When firm's financing sources are not aligned with its investment strategy, the company risks diluting the effectiveness of both the investments and the financing. Misaligned financing can lead to higher debt servicing costs, lower returns, and, in the case of technology investments, slower or poorer innovation outcomes. The study's finding that short-term debt significantly improves the quality of technology investments highlights a practical solution to this challenge, offering a strategic path for firms to optimize their financing decisions and enhance their competitive advantage. The manufacturing firms should also have a policy to bring a balance on acquisition of technology including tangible research and development in order to consistently gain maximum returns with lesser cost.

By focusing on both long-term and short-term debt, the current study sheds light on how these financing options affect return on investment, operational efficiency, and research and development, offering practical insights for optimizing technology investment strategies. These are consistent with existing literature, particularly studies that highlighted the positive link between long-term borrowing and technological innovation. For instance, Piao and Lin (2020) demonstrated that long-term borrowing enhances technological innovation efficiency in China's internet industry by allowing firms to pursue extensive research and development projects. Similarly, Bessonova *et al*. (2021) showed that long-term bank loans positively influence innovation in Russian companies, supporting the idea that such debt provides financial stability for riskier, more substantial technological investments.

Findings of this study offer a more targeted exploration of short-term debt and its role in fostering high-quality technological investments in the manufacturing sector. By focusing specifically on short-term debt, the study provides greater clarity on how this financing option influences technological investment outcomes, particularly in developing economies like Nigeria. This differ from Zhang *et al.* (2019)'s observation that debt financing and bank loans significantly influence technological innovation in China, particularly in sectors where innovation is capital-intensive. However, their findings on different financing sources were mixed, suggesting that the impact of financing types, whether short-term or long-term, varies across sectors and economies. This suggests that while long-term debt may be beneficial for some industries, such as those focused on large-scale innovation projects, its effectiveness can vary depending on the specific financial needs and investment characteristics of different firms.

5. Conclusion and Recommendations

The study explored how external financing, specifically long-term and short-term debt, influences the quality of technology investments among listed manufacturing companies in Nigeria. *Ex-post facto* research design was applied, using secondary data from 43 manufacturing companies listed on the Nigerian Exchange Group (NGX) from 2014 to 2023. The findings through the use of multiple regression models showed that short-term debt has significant positive effect on returns on investment but a negative effect on research and development and operating efficiency, while long-term debt positively affects research and development, but negatively affects returns on investment and operating efficiency. And generally, external financing have positive and significant effect on investment quality of the manufacturing firms. Based on the result of the findings, it was concluded that external financing is crucial for manufacturing firms to finance their technology investments, but the choice between short-term and long-term debt depends on the specific strategic goals of the firm. Firms should consider using long-term debt for research and development investments and short-term debt for improving returns on investment**,** balancing risk and return appropriately to enhance overall performance.

It is then recommended that management of manufacturing firms in Nigeria should ensure that external financing aligns with their long-term strategic goals. Long-term debt should be used to support research and development projects, while short-term debt should be utilized for improving return on investment and managing immediate operational needs. External source of finance should be discouraged in financing the operating cost in manufacturing firms; however, short-term debt should be directed toward activities that offer quick returns, such as enhancing operational efficiency and generating immediate profits. This will help firms meet financial obligations and sustain cash flow while improving returns on investment. The Nigerian government and

financial regulators should implement policies that provide favorable conditions for technology investments, including offering lower interest rates on loans for innovation and R&D. This will ease the burden of external financing for manufacturing firms.

JEL Classification: G32, O32.

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