Journal of Advanced Academic Research and Studies 高等学术研究期刊
Vol. 1, No.8, August 2024 (pp. 12-40)
http://www.nlbaeai.org/

ISSN 3006-4007 (Print)
ISSN 3006-4015 (Online)

The impact of investment in research and development on the development capacity of electronic companies

Xinghexue Bai[a] Yufei Ni[b] and Jinzhao Liu[c]

[a] Bachelor of management in Accounting, Xiamen University Malaysia, Malaysia
[b] Bachelor of management in Accounting, Xiamen University Malaysia, Malaysia
[c] Bachelor of management in Accounting, Xiamen University Malaysia, Malaysia

Received 06 February 2024, Revised 03 May 2024, Accepted 01 August 2024

Abstract

Purpose – The purpose of this paper is to examine the impact of research and development (R&D) investment on the development capacity of electronic companies. Given the rapid technological advancements and competitive nature of the industry, this study investigates how R&D spending influences asset growth and innovation-driven development.

Design/Methodology/Approach – Based on the Theory of Endogenous Growth, this study employs a quantitative research approach using panel data from 39 listed electronic companies in China over a five-year period (2019–2023). Key variables include the proportion of R&D personnel, the ratio of R&D investment to revenue, and the proportion of capitalized R&D investment. A linear regression model was constructed to analyze the relationship between R&D investment and total asset growth rate. Additional statistical tests, including multicollinearity, autocorrelation, and heteroscedasticity tests, were conducted to ensure the robustness of the findings.

Findings – This paper finds that the proportion of R&D personnel has a significant positive impact on asset growth, while the ratio of R&D investment to revenue and the proportion of capitalized R&D investment show no significant effects in the short term. The results suggest that human capital is a critical driver of enterprise development, whereas financial investment in R&D requires longer-term observation to capture its full impact.

Research Implications – In management and policy-making, the findings highlight the importance of talent investment in R&D strategy, suggesting that firms should prioritize skilled personnel to drive innovation and long-term development. The study also recommends future research on the non-linear effects of R&D investment and enterprise life-cycle factors.

Keywords: R&D investment, electronic companies, asset growth, innovation, development capability, human capital

JEL Classifications: O32, L25, L63,G31

[a] First Author, E-mail: ACC2309002@xmu.edu.my
[b] Corresponding Author, E-mail: IBU2309396@xmu.edu.my
[c] Co-Author, E-mail: JRN2109419@xmu.edu.my

I. Introduction

1. Introduction

In today's highly competitive global market, electronic enterprises must continuously innovate to stay ahead. One of the most critical investments a company can make to sustain its competitive edge is in Research and Development (R&D). R&D investment enables businesses to develop new products, improve existing ones, and streamline processes, leading to better operational efficiency and profitability. This investment is particularly vital for industries where technology rapidly evolves, such as the pharmaceutical, automotive, and information technology sectors. For example, companies like Google and Apple allocate significant portions of their revenues to R&D, which has enabled them to maintain their leadership positions by continuously introducing innovative products and services (Jones & Smith, 2017). Similarly, the pharmaceutical industry relies heavily on R&D to develop new drugs and treatments, making it one of the most R&D-intensive sectors globally (Brown & Davis, 2019). So the paper choose electronic industry as it has fast technological iteration and high R&D requirements.

While the advantages of R&D investment are well-known, it is essential to investigate how this investment directly influences an enterprise's development capability. Development capability refers to a company's ability to innovate, adapt to changing market conditions, and improve its operations. R&D investments provide the tools and knowledge necessary to explore new technologies, enter new markets, and reduce costs through process innovations. However, R&D efforts are often costly and come with inherent risks, including the uncertainty of successful outcomes and long payback periods. Hence, understanding how R&D investment translates into tangible development capabilities is crucial for strategic decision-making (Shan, 2020).

This study aims to explore the relationship between R&D investment and the development capability of enterprises, offering insights into how companies can optimize their R&D strategies to foster long-term growth and innovation. By analyzing both quantitative and qualitative data from multiple industries, this research will provide a comprehensive understanding of the impact of R&D investment on enterprise growth and sustainability (Wilson & Green, 2021).

2. Background of the Study

R&D investment is widely recognized as a key driver of both innovation and industrial advancement. In today's highly competitive and rapidly evolving business environment, enterprises are increasingly allocating significant resources to R&D activities. These investments are directed toward developing cutting-edge technologies, products, and services that not only meet but also anticipate market demands. According to Davis and Roberts (2018), firms that prioritize R&D are more likely to witness marked improvements in productivity, market share, and overall competitiveness over time. This is particularly true in industries where innovation cycles are short, such as technology and pharmaceuticals, where companies must continuously innovate to stay ahead of their competitors (Johnson & Lee, 2020). However, while the benefits of R&D investments are well-documented, the precise relationship between R&D expenditure and an enterprise's development capability remains unexplored.

The development capability of an enterprise refers to its capacity to create long- term value through

innovation, adapt to rapidly changing market conditions, and enhance operational efficiency. R&D plays a critical role in fostering this capability by enabling businesses to innovate, create unique products, and differentiate themselves in highly competitive markets. As businesses face increasing pressure to innovate faster and more efficiently, R&D investments are becoming more strategically important than ever.

This study aims to investigate how enterprises can leverage R&D investments not only to foster innovation but also to enhance their overall development capability and achieve sustainable long-term growth (Smith & Zhang, 2021). By examining the factors that influence the success of R&D efforts, this research will provide insights into the best practices for maximizing the impact of R&D on enterprise development.

3. Problem Statement

R&D investment is widely regarded as a crucial factor for driving technological innovation and enhancing an enterprise's market competitiveness. Higher R&D expenditure is often associated with greater technological breakthroughs, which in turn can result in stronger competitive advantages in the market. This technological edge enables businesses to differentiate their products and services, thereby improving their market position and long-term profitability. However, while it is generally understood that increased R&D spending can contribute to these positive outcomes, the specific relationship between R&D investment and an enterprise's asset growth capability remains underexplored. In theory, increased R&D investment and the successful conversion of technological achievements into marketable products should expand a company's competitive advantage, ultimately boosting its asset growth rate (Johnson & Lee, 2020).

On the other hand, higher R&D investments can lead to financial challenges, including the need to adjust cash flow and manage rising costs. These financial pressures may impact the enterprise’s liquidity and operational flexibility, potentially hindering short-term growth (Smith & Zhang, 2021). Therefore, this study seeks to take a more granular approach to understanding the impact of R&D investment by analyzing its components, such as the number of R&D personnel, the proportion of investment in relation to total revenue, and the allocation of capital. By exploring these specific elements, the research aims to uncover how enterprises can strategically balance their R&D efforts to achieve sustainable asset growth without overburdening their financial resources.

4. Research Questions

4.1 Does the proportion of R&D personnel have an impact on the total asset growth rate

Understanding the influence of R&D personnel on total asset growth rate is particularly relevant as firms increasingly prioritize innovation to stay competitive. As R&D often entails high costs and resource commitments, many firms seek evidence that these investments in human capital translate into measurable growth outcomes, such as an increase in assets. This research addresses whether a higher proportion of R&D personnel, indicating a stronger focus on innovation within the workforce, contributes to asset expansion.

4.2 Does the ratio of R&D investment to revenue have an impact on the total asset growth rate

Investigating this question is critical because the ratio of R&D to revenue serves as an indicator of how

much a company reinvests its revenue back into innovation and development. Higher R&D investment relative to revenue can signal a commitment to long-term innovation strategies, which could lead to competitive advantages, product differentiation, and enhanced organizational value over time.

Focusing on the R&D-to-revenue ratio provides insight into the effectiveness of revenue reinvestment into innovation, capturing the balance between maintaining profitability and committing resources to future growth. Analyzing the impact on total asset growth rate allows the study to assess whether increased innovation spending directly corresponds to asset expansion, thus meeting the objective of evaluating key factors that contribute to a firm's development capability.

4.3 Does the proportion of capitalized R&D investment to total R&D investment have an impact on the total asset growth rate

Capitalized R&D reflects management's belief in the probable success of R&D activities in generating future revenue streams. While immediate R&D expenses might reduce short-term profitability, capitalized R&D investments are intended to strengthen a company's asset base over time. Understanding whether a higher proportion of capitalized R&D positively impacts total asset growth provides insight into the efficacy of this accounting treatment in capturing the long-term value of innovation investments.

5. Research Objective

To explore the relationship between R&D investment and the asset growth capability of enterprises. This study aims to understand how higher R&D investment leads to greater technological achievements, which in turn enhance a company's competitive advantage and contribute to increased asset growth rates. Drawing from the Theory of Endogenous Growth, which posits that technological progress and knowledge accumulation are the internal drivers of economic growth, the research will investigate how R&D spending directly impacts technological innovation, improves productivity, and fosters long-term asset growth (Romer, 1994).

Specifically, there are three research objectives for this paper.

To explore the relationship between the proportion of R&D personnel and total asset growth rate.

To explore the relationship between the ratio of R&D investment to revenue and total asset growth rate.

To explore the relationship between the proportion of capitalized R&D investment to total R&D investment and total asset growth rate.

6. Significance of the Study

The findings of this study will have important implications for both academic research and practical applications. Academically, it will enhance existing literature by offering a thorough analysis of how R&D investments affect the development capabilities of enterprises. This research will provide a deeper understanding of the mechanisms through which R&D investment drives technological innovation and asset growth, contributing to broader economic growth theories. Practically, the study will offer valuable insights for managers and policymakers on optimizing R&D resource allocation. By examining the relationship between R&D investment, innovation, and asset growth, the research will help guide strategic decisions that improve operational efficiency and strengthen market competitiveness. These insights will be

particularly useful for industries where R&D plays a crucial role, helping businesses achieve long-term growth while effectively managing financial pressures associated with R&D spending.

This study aims to bridge the gap between theory and practice by offering both theoretical contributions and actionable recommendations for enterprises.

7. Scope of the Study

This study aims to explore the relationship between R&D investment and the asset growth capability of enterprises, with a focus on how increased R&D spending may lead to greater technological achievements and enhanced market competitiveness. The hypothesis suggests that higher R&D investment can result in more innovations, thereby strengthening a company's competitive edge and leading to increased asset growth rates.

However, with increased R&D spending comes adjustments in cash flow and rising operational costs, which may impose financial pressures on companies. Therefore, this research will take a more detailed approach, examining R&D investment through factors such as personnel, investment proportion, and capital allocation (Johnson & Lee, 2020).

The research is rooted in the Theory of Endogenous Growth, which posits that technological progress and knowledge accumulation are the internal drivers of economic growth. R&D investment directly impacts innovation, which in turn enhances productivity and market competitiveness (Romer, 1994).

The study will collect data from 53 companies in the electronics industry listed under the 2014 Shenwan Industry Classification within the China securities market. A regression analysis will be conducted over a three-year period to examine the relationship between asset growth rates and key factors such as R&D personnel, investment proportion, and capital allocation. The results will assess the significance and weight of these factors in driving asset growth.

8. Definition of Terms

In this study, several key terms are essential for understanding the relationship between R&D investment and asset growth capability in enterprises.

R&D investment refers to the resources allocated by an enterprise towards research and development activities, with the aim of creating new technologies, products, and innovations. Higher R&D investments are expected to lead to greater technological achievements and stronger market competitiveness.

The proportion of R&D personnel refers to the ratio of employees dedicated to research and development (R&D) activities relative to the total workforce of a company, organization, or industry. This metric indicates the emphasis placed on innovation and technological advancement within the entity. A higher proportion suggests that a significant portion of the workforce is engaged in developing new products, improving processes, or advancing scientific research, which can be essential for maintaining competitiveness and fostering long-term growth.

The ratio of R&D investment to revenue measures the proportion of a company's revenue that is invested in research and development activities. This ratio expresses how much of each dollar (or unit of currency) earned as revenue is reinvested into R&D. A higher ratio indicates that the company is allocating a significant portion of its revenue toward innovation and future development, which can be crucial for sustaining competitive advantage and growth in technology-driven industries.

The proportion of capitalized R&D investment to total R&D investment measures the percentage of research and development (R&D) expenditures that a company capitalizes on its balance sheet compared to the total R&D spending. Capitalizing R&D means recording certain R&D costs as an asset, rather than expensing them immediately, under the belief that these costs will generate future economic benefits.

Asset growth capability refers to a company's ability to increase its assets over time, often as a result of improved efficiency, innovation, and competitive advantages gained through R&D efforts.

Endogenous Growth Theory is a theoretical framework that emphasizes technological progress and knowledge accumulation as internal drivers of economic growth. It posits that an enterprise's R&D investment directly influences the occurrence of technological innovation, which enhances productivity and asset utilization (Lucas, 1988).

Regression analysis refers to a statistical method used in this study to analyze the relationship between asset growth rates and specific factors, such as R&D personnel, investment proportion, and capital allocation (Greene, 2012). This study will collect data from 53 companies in the electronics sector of the A-share market under the 2014 Shenwan Industry Classification, and will use regression to determine the significance and impact of these factors on asset growth.

9. Organization of the Paper

This study is structured into five key chapters, each building on the last to offer a comprehensive understanding of the relationship between R&D investment and enterprise asset growth. The first chapter introduces the background, identifies the problem, formulates the research questions, and outlines the study's objectives. The second chapter dives into a detailed literature review, exploring existing research on the role of R&D investment in enhancing enterprise development and competitiveness. Chapter 3 focuses on the research methodology, detailing the design, data collection methods, and analytical techniques used to rigorously investigate the research questions. In chapter 4, the results and analysis are presented, offering in-depth interpretations of the data to reveal insights into the impact of R&D investment. Finally, the fifth chapter concludes the study, summarizing the key findings and offering practical recommendations for businesses and policymakers to strategically leverage R&D investments for sustained growth and competitiveness.

II. Literature Review

1. Introduction

This study aims to investigate the impact of R&D investment on the development capability of enterprises. Specifically, this paper will quantify the relationship between research and development investment and enterprise development capabilities. Through research, it can be found that there are several vital indicators that can describe the R & D investment from the different dimensions. There are three important measurement angles for R&D investment: personnel quantity, investment ratio, and capitalization ratio. Specifically, the paper will choose the proportion of R&D personnel, the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment as three factors to measure the R&D

investment and to set as independent variables.

As for the development capability of enterprises, to have an overall overview of the comprehensive development capability of the enterprise, the paper will choose total asset growth rate to measure the development capability. It reflects the degree and magnitude of changes in all assets of the enterprise. The development and expansion speed of enterprises can be described by this indicator from a historical perspective. In this way, the paper set the total asset growth rate as dependent variables.

This paper will build a quantitative relationship between the proportion of R&D personnel, the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment and total asset growth rate. With this model, this article will address the lack of research on the impact of R&D investment on the development capabilities of enterprises. Meanwhile, the model can refine the quantitative impact of each specific aspect of R&D investment on the development capability of the enterprise. The model can help predict the expected impact of R&D investment on changes in corporate assets from different perspectives, thereby assisting decision-makers in making better resource planning and adapting to market changes.

2. literature review

2.1 The proportion of R&D personnel

The human capital of R&D personnel plays a key role in generating tacit knowledge, which is harder to replicate and offers long-term competitive advantages. R&D personnel bring specialized skills and expertise, which are essential in solving complex problems, fostering innovation, and pushing technological frontiers. A study by Hall and Oriani (2006) found that firms with more R&D personnel tend to experience faster growth rates due to their enhanced ability to innovate and respond to market demands. This empirical study shows the positive impact of R&D intensity (including R&D personnel) on firm growth and financial performance.

The involvement of highly skilled R&D staff enables firms to create new products, enhance production processes, and improve technologies, which in turn boosts productivity and growth potential. With more R&D staff, the enterprise can be expected to master market dynamics and closely follow market demand to occupy a leading position. In this case, Enterprises will acquire more excellent technologies and products, occupy a larger market share, and obtain good operating income, which will have a positive effect on the asset size of the enterprise (Cohen & Levinthal, 1989).

Generally, R&D personnel are an important factor in R&D capability. Considering that many enterprises have different scales, the proportion of R&D personnel can better reflect a company's resource allocation in R&D personnel.

2.2 The ratio of R&D investment to revenue

A higher R&D investment to revenue ratio generally signals a stronger focus on innovation and technological advancement, which are critical for enhancing a firm’s development capability. Firms that invest more in R&D relative to their revenue are more likely to create innovative products and services, improve operational processes, and adapt to changing market environments.

Scientific research and product development often require a large amount of materials and repeated experiments, which will require favorable and sustained financial support. In other words, enterprises require a significant amount of capital to absorb theoretical knowledge and commercialize the production of products. Cohen and Levinthal (1990) introduced the concept of absorptive capacity, arguing that firms with higher R&D intensity can better understand, assimilate, and apply external knowledge.

Hirsch-Kreinsen et al. (2008) suggested that in sectors with rapid technological change, the ratio of R&D investment to revenue is a strong predictor of a firm's ability to keep up with innovation cycles. This, in turn, enhances a firm's capacity for sustained development. Therefore, higher R&D capital investment can promote the long-term sustainable development of enterprises and have a positive effect on the overall assets of the enterprise.

2.3 The proportion of capitalized R&D investment to total R&D investment

Capitalizing R&D investment typically reflects the firm's expectation that these expenditures will provide long-term benefits and contribute to future economic growth. By treating R&D as an asset rather than an expense, the firm signals confidence that its innovations will result in commercially viable products or technologies.

Lev and Sougiannis (1996) found that firms capitalizing R&D expenditures tend to experience stronger financial performance in subsequent years, as they expect these investments to contribute to future revenue generation. This capitalization can positively impact a firm's development capability by allowing it to better align resources with long-term growth strategies.

The resource-based view suggests that capitalized R&D investment represents valuable, firm-specific resources that contribute to sustained competitive advantages (Barney, 1991). Firms that invest more in R&D and capitalize a greater proportion are likely to leverage their innovative capabilities to achieve superior growth. In this case,A higher capitalization ratio represents a positive expectation of the enterprise for the transformation of innovative achievements, and also represents the driving force for the growth of enterprise assets.

2.4 Enterprise development capability

R&D investment often leads to the creation of intangible assets, such as patents, proprietary technologies, and intellectual property, which significantly contribute to firm growth. The expansion of intangible assets as a result of R&D activities plays a critical role in increasing a firm's total asset base, especially in knowledge-intensive industries.

Czarnitzki and Kraft (2004) provided evidence that R&D-intensive firms not only grow faster in terms of sales and market value but also in terms of assets. They argued that this asset growth reflects the firm's ability to utilize its R&D investments effectively in generating future revenue and capital expansion.

The total asset growth rate reflects the firm's ability to expand its asset base, which can indicate better utilization of resources and future growth potential. R&D investments, for instance, often lead to growth in intangible assets that are not immediately visible in short-term profit figures but significantly contribute to long- term development. Total asset growth thus captures a broad and comprehensive view of the firm's expansion efforts, including its innovation capability. In this case, total asset growth rate is a suitable indicator

to measure enterprise development capability when study the impact of R&D investment on development capability.

3. Contribution

Academically, understanding the quantitative relationship between R&D investment and firm development provides valuable empirical evidence for theories of innovation-driven growth. R&D investment is widely recognized as a key driver of innovation, productivity improvement, and firm growth. By quantifying how R&D investment impacts metrics such as total asset growth rate, revenue growth, and profitability, this research adds precision to the understanding of how firms evolve through innovation.

By examining the impact of R&D investment on firm development, decision- makers can better understand the trade-offs between investing in R&D and other business areas, such as marketing or operational efficiency. Meanwhile, the model can elucidate the contribution of R&D personnel, R&D investment ratio, and capitalization ratio to the development capability of enterprises. By clarifying the contribution of different independent variables, enterprises can scientifically and efficiently adjust the allocation ratio of resources within the R&D department and determine effective R&D strategies.

From a managerial perspective, understanding the relationship between R&D investment and development capability provides actionable insights for corporate decision-makers. R&D investment often involves substantial risk and uncertainty, but it is crucial for driving innovation and long-term firm growth. This research can help decision-makers evaluate the potential returns on R&D investments and optimize their innovation strategies based on empirical evidence.

4. Summary

Firms with a higher R&D intensity are more likely to experience enhanced development capabilities, as R&D investment leads to innovation, productivity improvements, and sustained competitiveness. By investing in R&D, companies can strengthen their capability to generate new knowledge, develop unique products, and improve their competitive positioning, all of which contribute to firm development capability. This relationship is well-supported by both theoretical and empirical literature.

This research will strengthen the empirical understanding of the relationship between R&D investment and firm development. Previous studies, like those of Cohen (1989) and Czarnitzki and Kraft (2004), demonstrated that R&D investment significantly boosts firm productivity, asset growth, and market value. This research builds on these findings by quantifying how R&D affects development indicators such as total asset growth rate, providing more precise models for understanding firm growth.

The research provides valuable insights for corporate decision-makers who face uncertainty in R&D investments. It supports better evaluation of R&D's potential returns and offers guidance on strategic innovation investment. Research will help companies allocate their resources more scientifically, adjust the funding and human resources of R&D departments based on models, and formulate long-term sustainable development and R&D strategies.

III. Research Methodology And Expected Outcomes

1. Introduction

This paper aims to investigate the impact of R&D investment on development capability of enterprises. The firms with higher R&D investment can be expected to have better absorptive capacity, and better understand, assimilate, and apply external knowledge. Based on that, the paper will further quantify the relationship between R&D investment and development capability by building an accurate model. R&D investment will be measured from three dimensions: human capital, finance investment, and capitalization rate. Specifically, the paper will choose the proportion of R&D personnel, the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment as three independent variables to measure the R&D investment. And for the development capability of enterprise, total asset growth rate will be selected as dependent variable as it takes both intangible and tangible asset into consideration.

The Theory of Endogenous Growth emphasizes that technological progress and knowledge accumulation are the intrinsic driving forces of economic growth.

Enterprises investing research and development funds in the development of new products and technologies can bring innovation and intangible assets, enhance their market competitiveness and development capabilities. Therefore, it can be expected that R&D investment will boost the development capability of enterprise. Therefore, the hypothesis of this paper is proportion of R&D personnel, the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment has a significant relationship with total asset growth rate.

And the data will be collected from Hithink RoyalFlush iFinD, a financial data terminal database. Furthermore, regression model will be used to estimate the change of total asset growth rate as the three independent variables change. T test will be used to evaluated the significance of the impact of independent variable upon dependent variable and reliability test will also be used. The expected data result of this paper is a significant relationship between the independent and dependent variables.

2. Research Design

2.1 Variables

2.1.1 Total Asset Growth Rate (Dependent Variable)

To measure the development capability of an enterprises, this paper will choose total asset growth rate as dependent variable. The total asset growth rate reflects the firm's ability to expand its asset base, which can indicate better utilization of resources and future growth potential. R&D investment contributes to firm growth by enhancing both productivity and innovation, which ultimately increases the firm's asset base. Higher R&D spending is often associated with the acquisition of new technologies and the expansion of physical and intellectual assets, resulting in overall asset growth. Specifically, R&D investment will cultivate patents and copyrights, as well as advanced equipment or products which are important intangible asset. These intangible asset can significantly give enterprises stronger competitiveness and development capabilities. Total asset growth rate is a comprehensive indicator that takes both intangible and tangible asset into consideration.

2.1.2 The Proportion of R&D Personnel (Independent Variable)

The proportion of R&D personnel refers to the ratio of employees dedicated to research and development (R&D) activities relative to the total workforce of a company, organization, or industry. This metric indicates the emphasis placed on innovation and technological advancement within the entity. In the field of research and development, personnel investment is an important criterion for evaluation. Scientific talents are important reserves for enterprise scientific research and play a crucial role in the field of technological breakthroughs. A higher proportion suggests that a significant portion of the workforce is engaged in developing new products, improving processes, or advancing scientific research, which can be essential for maintaining competitiveness and fostering long-term growth.

2.1.3 The Ratio of R&D Investment to Revenue (Independent Variable)

The ratio of R&D investment to revenue captures the financial commitment a firm makes toward innovation relative to its earnings. A higher R&D investment to revenue ratio generally signals a stronger focus on innovation and technological advancement, which are critical for enhancing a firm's development capability. Firms that invest more in R&D relative to their revenue are more likely to create innovative products and services, improve operational processes, and adapt to changing market environments. In the field of research and development, personnel training, equipment maintenance, and experimentation all require significant and sustained financial support. R&D and conversion cannot be separated from a large amount of upfront capital investment, therefore capital investment is an important assessment indicator.

2.1.4 The Proportion Of Capitalized R&D Investment To Total R&D Investment (Independent Variable)

Capitalizing R&D investment typically reflects the firm’s expectation that these expenditures will provide long-term benefits and contribute to future economic growth. By treating R&D as an asset rather than an expense, the firm signals confidence that its innovations will result in commercially viable products or technologies. Firms that invest more in R&D and capitalize a greater proportion are likely to leverage their innovative capabilities to achieve superior growth. The proportion of capitalized R&D investment has implications for how investors perceive the firm's value and potential for growth.

2.2 Theory

The Theory of Endogenous Growth, developed primarily by economists like Paul Romer and Robert Lucas in the 1980s, emphasizes the idea that economic growth is largely driven by internal factors—specifically, investments in human capital, innovation, and knowledge—rather than external factors. endogenous growth theory argues that technological progress and innovation are results of deliberate investment in research and development (R&D), education, and skill enhancement within the economy (Romer, 1986). The more a society invests in these areas, the higher its long-term growth potential. Technology, skills, and experience improve the productivity of the workforce. The theory suggests that policies encouraging the accumulation of R&D investment can have a lasting impact on economic growth.

One of the unique features of endogenous growth is the idea that innovation and knowledge are partly "non-rival" goods, meaning that once they are developed, they can benefit others without being depleted. For instance, a breakthrough in technology by one firm or country can improve productivity for others. Knowledge spillovers help explain why economies with robust innovation systems can sustain high growth rates.

In summary, the Theory of Endogenous Growth highlights how growth is perpetuated by internal factors, such as investment in human capital and technological innovation, and implies that policy can significantly influence long-term economic outcomes by fostering these areas. Therefore, under this theory, internal investment is crucial for the long-term growth and competitiveness of enterprises. Internal R&D investment is also an important driving force and source of innovation and technological progress for enterprises. Generally, according to this theory, R&D investment can be expected to make a positive impact on development capability of enterprises.

2.3 Conceptual framework

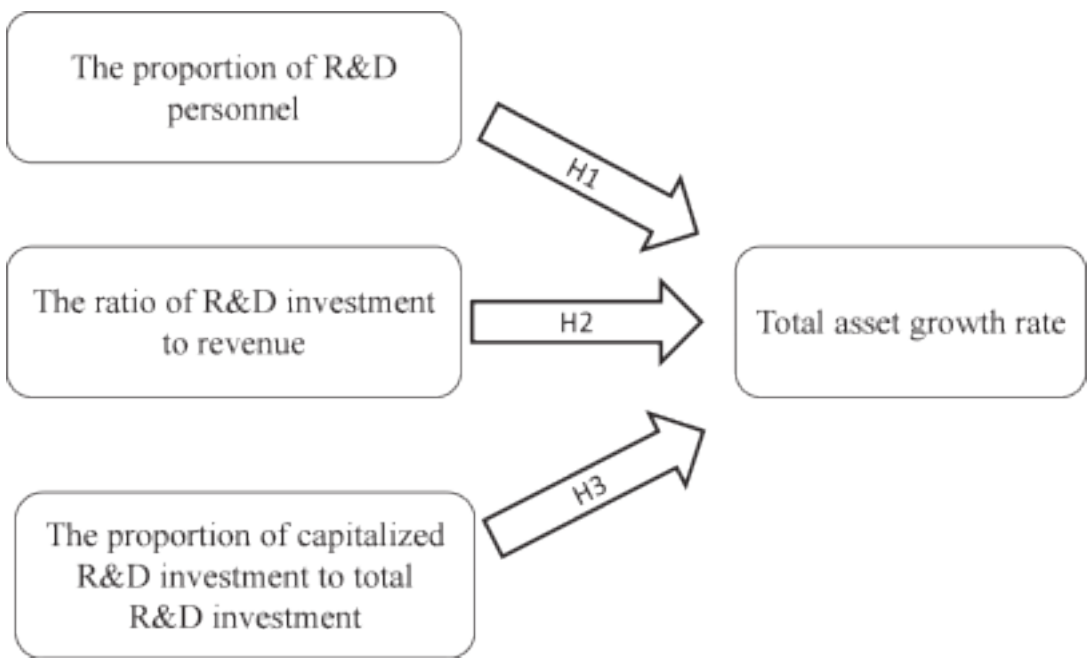

Fig. 1. Conceptual framework

The main objective of this paper is to investigate the impact of R&D investment on development capability. The R&D investment is measured from three perspectives: human capital, financial support and capitalization proportion. Therefore, the proportion of R&D personnel, the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment are selected as independent variables. And for the development capability, total asset growth rate is selected as the dependent variable.

2.4 Hypothesis

Hypothesis (H1): The proportion of R&D personnel has a significant relationship with total asset growth rate.

Hypothesis (H2): The ratio of R&D investment to revenue has a significant relationship with total asset growth rate.

Hypothesis (H3): The proportion of capitalized R&D investment to total R&D investment has a significant relationship with total asset growth rate.

3. Population and sample

The population of this study is all companies in electronic industry listed on the major stock exchanges in China. The conclusion the study discussed is expect to apply all the listing company of electronic industry on major stock exchanges in China. Meanwhile, the industry classification standard is based on Shenwan Industry Classification Standard 2014 which is a well accepted standard in the China fiance industry. And electronic industry is one of the primary industry. And according to the Ifind financial data terminal database, there are 370 listing companies in electronic industry.

And for the samples, the samples will be selected from the same industry, electronic industry. Among listed electronics companies, excluding those that have not disclosed relevant data, the remaining companies that disclose relevant data are examples. There are !!! listed electronic companies in Chinese Mainland that disclose relevant data that are selected as samples.

4. Types of Data Use

The data used are panel data. Specifically, the data comes from 39 different companies in the electronic industry. Besides, all the data of variables are from 2019 to 2023. Therefore, the data are from 39 entities and each entities are observed over several 5 years. Panel data helps in studying how variables change over time within an entity, facilitating analyses of causality and temporal effects.

5. Data Collection Method

All the data related to the listed electronic companies is collected by Hithink RoyalFlush iFinD. It is a financial data terminal that provide investors with massive structured data and rich characterized unstructured data in an accurate and timely manner, and can be conveniently viewed through in-depth data. The author uses the data browser to collect the data of listed companies in the electronics industry, which is classified as a first level industry in Shenwan Industry Classification Standard 2014. At the same time, the author extracted data of indicators including the proportion of R&D personnel, the ratio of R&D investment to revenue, the proportion of capitalized R&D investment to total R&D investment and total asset growth rate over 5 years. Finally, all data is exported in Excel format.

6. Measurement of Variables

6.1 Independent variables:

To investigate the impact of R&D investment, R&D investment will be evaluated by three perspectives: the proportion of R&D personnel, the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment. The following are the formula to calculate the specific value of the independent variables:

The proportion of R&D personnel:

The proportion of R&D personnel is a metric that measures the share of a company's workforce dedicated to research and development activities. Calculated as the ratio of R&D personnel to total employees, this proportion indicates a firm's focus on innovation and can serve as a proxy for the intensity of R&D activities within the organization. It's commonly used to assess the level of human capital investment in R&D and is often associated with a firm's capacity for innovation and long-term growth.

$$\text{The proportion of R\&D personnel} = \frac{\text{The amount of R\&D personnel}}{\text{Total amount of employees}}$$

The ratio of R&D investment to revenue:

The ratio of R&D investment to revenue is a financial metric that indicates how much a company invests in research and development relative to its total revenue. This ratio helps assess the commitment a firm has toward innovation and development.

$$\text{The ratio of R\&D investment to revenue} = \frac{\text{R\&D expense}}{\text{Gross revents}}$$

The proportion of capitalized R&D investment to total R&D investment

The proportion of capitalized R&D investment to total R&D investment is a financial metric that indicates the share of research and development expenditures that are capitalized on the balance sheet, as opposed to being expensed in the current period. This ratio provides insight into how much of a company's R&D spending is treated as a long-term investment.

$$= \frac{\text{The proportion of capitalized R\&D investment to total R\&D investment capitalized R\&D investment}}{\text{Total R\&D investment}}$$

6.2 Dependent variables

Total asset growth rate

The total asset growth rate measures the percentage change in a company's total assets over a specific period. It is an important indicator of a firm's growth and can reflect its ability to generate resources for future expansion.

$$\text{Total asset Growth rate} = \frac{\text{Total Assets at End of period} - \text{Total Assets at Beginning of period}}{\text{Total Asset at Beginning of period}}$$

7 .Proposed Data Analysis

7.1 Regression model

This paper will use regression model to build an accurate quantitative relationship between R&D investment and development capability. Through the large amount of data obtained, we can determine the quantitative impact of various R&D investment indicators on the company's asset development capability. Specifically, the significance of the influence of each independent variable in the model can be determined by conducting a t-test on each independent variable. Test each coefficient's significance using p-values. If the p-value is below a threshold (commonly 0.05), the independent variable is statistically significant. And the coefficient of the independent variables reflects the magnitude of the dependent variable changing with this independent variable. Through regression models, we can determine whether a certain factor of R&D investment has a significant impact and the degree to which it affects the development capability of the enterprise.

7.2 Multicollinearity Test

Multicollinearity refers to a situation in regression analysis where two or more independent variables are highly correlated, meaning they contain similar information. When independent variables are highly correlated, the regression model finds it difficult to attribute unique effects to each variable. This can cause instability in coefficient estimates, meaning small changes in the data can lead to large changes in the coefficients. This can pose challenges in accurately estimating the coefficients of each variable and can make interpreting the model difficult.

Multicollinearity Test is to tell whether there is multicollinearity problem. Specifically, the VIF quantifies how much the variance of a regression coefficient is inflated due to multicollinearity with other variables. If VIF is less than 10, the regression model is acceptable. Meanwhile, if VIF is larger than 10, it may suggest high multicollinearity.

7.3 Autocorrelation Test

Autocorrelation in regression analysis refers to a situation where residual error from one observation are correlated with residuals from another. Detecting autocorrelation is essential because it can lead to incorrect conclusions about the significance of the model, as it violates the assumption of independence of errors in ordinary least squares (OLS) regression.

The Durbin-Watson statistic is a widely used test for detecting first-order autocorrelation in the residuals.It tests the null hypothesis that there is no autocorrelation. The test statistic ranges from 0 to 4. A Durbin-Watson statistic close to 2 indicates no autocorrelation, while values go out of the range of 1.8 to 2.2 suggest the presence of autocorrelation.

7.4 Heteroscedasticity Test

Heteroscedasticity occurs in regression analysis when the variance of the residuals (errors) is not constant across all levels of the independent variables. This violates one of the assumptions of ordinary least squares (OLS) regression and can lead to inefficient estimates and unreliable hypothesis tests.

White's test is a more flexible test that does not require the form of heteroscedasticity to be specified. It involves regressing the squared residuals on the independent variables, their squares, and their cross-products. When the Chisquare is larger than 0.05, it indicate that there is no heteroscedasticity problem.

8. Expected Outcomes

For the regression model, the expected outcomes are that the P-values of all independent variables are less than 0.05 and demonstrate significant influence on the dependent variable. Meanwhile, the sign of all independent variable coefficients in the model is expected to be positive. In this case, it can be proven that the proportion of R&D personnel, capital investment, and capitalization ratio all have a positive effect on the company's development capability.

For the multicollinearity test, the expected VIF is less than 10. In this case, there will be no multicollinearity problem.

For the autocorrelation test, the Durbin-Watson statistic is expected to located between 1.8 and 2.2. In this situation, the statistic indicates that there will be no autocorrelation problem.

For the heteroscedasticity test, the p-value of Chi-square is expected to larger than 0.05 so that there is no heteroscedasticity problem.

9. Summary

To investigate the impact of R&D investment on development capability of enterprise, this paper measures R&D investment from three aspects: personnel, funding, and capitalization ratio. Specifically, three indicators were selected: the proportion of R&D personnel, the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment. And the total asset growth rate is selected to measure development capability.

The panel data is selected from Ifind financial terminal which will be used to build a regression model. With the regression model, the paper can tell the significance of the relationship between interdependent variables and dependent variables. Besides, the coefficient of independent variables indicates the magnitude of the influence of the independent variable on the dependent variable. The model will help establish an accurate quantitative relationship between R&D investment and enterprise development capabilities, which will aid in decision-making by management and supplement literature.

According to literature and theory, the author expects that the effects of each independent variable are significant and the coefficients are positive. Meanwhile, the model also does not exist multicollinearity problem, autocorrelation problem and heteroscedasticity problem. In this case, The proportion of R&D personnel, the ratio of capital investment and capitalization, and the development capability of the enterprise are positively correlated, which is also in line with the theory and expectations mentioned earlier.

IV. Data Analysis And Discussion

1. Introduction

This chapter will conduct linear regression analysis on the collected data from electronic industry to explore the relationship between R&D investment and development capability of enterprises.

Firstly, the paper will discuss the characteristics of data. The mean and the standard deviation will be discussed in the summary of the data. Then relationship between interdependent variables and dependent variable will be evaluated. Specifically, the author imported the data into SPSS software and established a regression model. With the regression model, the significance of impact of specific R&D indicator on development capability can be evaluated. That can help explain the significance of the impact of the R&D impact based the P-value of the overall model. Specifically, it can tell that which indicator has a significance impact on development capability.

Besides that, reliability tests will be conducted to test the whole model, including multicollinearity test, autocorrelation test and heteroscedasticity test. These tests will help detect the key assumptions of regression and the reliability of the model.

Based on the regression result and reliability test, the paper will discuss the specific relationship between R&D investment and development capability. Low R square may be caused by the market influence. The influence of the R&D investment may be more significant in longer time period. Besides, the data and the regression result also confirm the significance of the proportion of R&D personnel which proves the experts is precious treasure for the enterprises to research and apply the innovation and knowledge.

Lastly, the paper uses heteroscedasticity test and stepwise regression model to do the robustness test. The absence of the heteroscedasticity and the same results from different regression model indicates the stability and robustness of the model.

2. Statistic Summary of Data

The paper selected 39 listed companies in the electronics industry. The data includes the proportion of R&D personnel, the ratio of R&D investment to revenue, the proportion of capitalized R&D investment to total R&D investment and total asset growth rate, covering a period of nearly five years from 2019 to 2023.

The author imported these data into SPSS and conducted descriptive analysis. The analysis results are as follows:

Table 1. Descriptive Statistic Results

Descriptive Statistic						
	N	**Range**	**Min**	**Max**	**Mean**	**Standard deviation**
The proportion of R&D personnel	194	85.74	.44	86.18	27.0653	18.44540
The ratio of R&D investment to revenue	195	45.9000	1.5800	47.4800	11.261880	8.5689794
Total asset growth rate	195	351.6054	-67.1702	284.4352	13.104816	32.0722705
The proportion of capitalized R&D investment to total R&D investment	195	81.4600	.0300	81.4900	23.333926	18.4898373
Valid cases	194					

According to the table, there are 194 valid cases as195 cases in total and one company did not disclose the proportion of R&D personnel.

For the independent variables, the proportion ranges from 0.44 to 86.18 with the mean of 27.07. And the standard deviation is 18.44. There are significant differences in R&D personnel and employee structure among different companies. As for the capitalized ration, it ranges from 0.03 to 81.49 with the man of 12.33. The standard deviation is 18.48. There are significant differences in the proportion of R&D capitalization among different companies, which may be related to their different R&D progress.For the ratio of R&D investment to revenue, it ranges from 1.58 to 47.48 with the mean of 11.26. The standard deviation is 8.58. Relatively, the investment ratios of different enterprises are relatively similar, with small differences.

For the total asset growth rate, it varies from companies. Total asset growth rate ranges from -67.17 to 284.4 with the mean of 13.10. It has the standard deviation of 32.07. The development speed of enterprise assets varies greatly, and each company faces different market and product research and development speed conditions.

3. Regression Results

After importing the data into SPSS and conducting linear regression analysis, the following table is obtained.

Table 2. Regression Result

Model summary					
Model	R	R ^2	Adjusted R^2	Standard error	Durbin-Watson
1	.258a	.067	.052	31.2868549	1.844

a. IV: (C), the proportion of capitalized R&D investment to total R&;D investment, the ratio of R&D investment to revenue, The proportion of R&D personnel

b. DV: Total asset growth rate

According to R, it can be seen that in the collected samples, the degree of change in the development speed of company assets is actually relatively small caused by changes in R&D investment.

ANOVA[a]

Model		Square sum	Degree of freedom	Mean square	F	Sig.
1	Reg	13294.909	3	4431.636	4.527	.004b
	Residual error	185984.785	190	978.867		
	Sum	199279.694	193			

a. DV: Total asset growth rate

b. IV: (C), the proportion of capitalized R&D investment to total R&D investment, the ratio of R&D investment to revenue, The proportion of R&D personnel

The significance level of the overall equation is 0.004, which is less than 0.05. The overall regression equation is effective. This means that the R&D investment truly has a significant impact on the development capability of company.

Table 3. Regression Result

Coefficient a

Model		Unstandardized Coefficients		standardized Coefficients	t	Significance	Collinearity	
		B	standard error	Beta			Error	VIF
1	(C)	3.604	5.499		.655	.513		
	The proportion of R&D personnel	.538	.151	.309	3.571	.000	.658	1.520
	the ratio of R&D investment to revenue	-.563	.324	-.147	-1.736	.084	.687	1.457
	the proportion of capitalized R&D investment to total R&D investment	.055	.131	.032	.423	.673	.861	1.162

a. Dependent variable: Total asset growth rate

In terms of specific independent variables, the P-value of the proportion of R&D personnel is 0.00 which is less than 0.05. In this case, the data can tell that the proportion of R&D personnel has a significant impact on total asset growth rate. The coefficient of the proportion of R&D personnel is 0.538 which means that the total

asset growth rate increases 0.538 as the proportion of R&D personnel increases one unit.

But as for other independent variables, the P-value of the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment are both larger than 0.05. In this case, the impact of the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment on total asset growth rate is not significant.

4. Reliability Test

Multicollinearity test

Coefficient a

Model		Unstandardized Coefficients		standardized Coefficients	t	Significance	Collinearity	
		B	standard error	Beta			Error	VIF
1	(C)	3.604	5.499		.655	.513		
	The proportion of R&D personnel	.538	.151	.309	3.571	.000	.658	1.520
	the ratio of R&D investment to revenue	-.563	.324	-.147	-1.736	.084	.687	1.457
	the proportion of capitalized R&D investment to total R&D investment	.055	.131	.032	.423	.673	.861	1.162

a. Dependent variable: Total asset growth rate

From the table, it is obvious that the VIF of three independent variables, the proportion of R&D personnel, the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment are respectively 1.52, 1.457 and 1.162. All the VIF are less than 10 so that the regression model is acceptable. It does not indicate a problematic level of multicollinearity.

Autocorrelation Test

Model summary

Model	R	R ^2	Adjusted R^2	Standard error	Durbin-Watson
1	.258a	.067	.052	31.2868549	1.844

a. IV: (C), the proportion of capitalized R&D investment to total R&;D investment, the ratio of R&D investment to revenue, The proportion of R&D personnel

b. DV: Total asset growth rate

From the table, we can see that the Durbin-Watson statistic is 1.844 which locates between 1.8 and 2.2. As the Durbin-Watson statistic is between 1.8 and 2.2, it indicates no autocorrelation problem.

Heteroscedasticity Test

White Heteroscedasticity Test[a,b,c]		
Chi Square	**Degree of freedom**	**Sign.**
3.086	9	.961

a. IV: Total asset growth rate

b. The null hypothesis that the variance of the test error does not depend on the independent variable values

c. Design : C + The proportion of R&D personnel + the ratio of R&D investment to revenue + the proportion of capitalized R&D investment to total R&D investment + The proportion of R&D personnel * The proportion of R&D personnel + The proportion of R&D personnel * the ratio of R&D investment to revenue + The proportion of R&D personnel * the proportion of capitalized R&D investment to total R&D investment + the ratio of R&D investment to revenue * the ratio of R&D investment to revenue + the ratio of R&D investment to revenue * the proportion of capitalized R&D investment to total R&D investment + the proportion of capitalized R&D investment to total R&D investment * the proportion of capitalized R&D investment to total R&D investment.

From the table, the P-value of significance is 0.961. It is quite larger than 0.05 so that the heteroscedasticity problem is not significant. In this case, variance of the residuals (errors) is constant across all levels of the independent variables.

5. Discussion of Result

As for the regression model, the overall P-value is 0.04 which is less than 0.05 so that the overall model or equation is effective or significant. So the impact of R&D investment on development capability is significant. The enterprises can grow their asset by investing in research and development. However, the influence of R&D is not big. Only the 6.7% change of the total asset growth rate can be explained by the model. The model still has the room to improve. Besides research and development, other variables can also affect the speed of asset development for a company. Research and development is only one perspective that affects asset development, resulting in a relatively low degree of impact.Market changes and company strategic adjustments can both affect changes in company assets.

For the specific dependent variable, the P-value of proportion of R&D personnel is less than 0.05 which means that the proportion of R&D personnel can make a significant difference to the total asset growth rate. Meanwhile, the coefficient of the proportion of R&D personnel is 0.538. In this case, every unit increase in proportion of R&D personnel can bring 0.538 increase in total asset growth rate. This indicates that the proportion of R&D personnel is crucial for the development of enterprise assets. Talents are an important driving force for enterprises to invent and apply innovative technologies. However, the P-value of other independent variables is lager than 0.05 so that the the ratio of R&D investment to revenue and the proportion of capitalized R&D investment to total R&D investment. The actual conversion of R&D investment and

capitalization ratio into the development capability of the enterprise still requires time. Perhaps at a longer time scale, the significance of the two variables will increase.

For the multicollinearity test, VIF is less than 10, so that independent variables are not highly correlated. In this case, the regression model is acceptable. And as for the autocorrelation test, the Durbin-Watson statistic close to 2 which indicates no autocorrelation problem. So residual error from one observation are not correlated with residuals from another. Lastly, for the heteroscedasticity test, the P-value of White test is lager than 0.05 so there is no significant heteroscedasticity problem.

6. Robustness analysis

6.1 Heteroscedasticity Test

White Heteroscedasticity Test[a,b,c]		
Chi Square	Degree of freedom	Sign.
3.086	9	.961

a. IV: Total asset growth rate

b. The null hypothesis that the variance of the test error does not depend on the independent variable values

c. Design : C + The proportion of R&D personnel + the ratio of R&D investment to revenue + the proportion of capitalized R&D investment to total R&D investment + The proportion of R&D personnel * The proportion of R&D personnel + The proportion of R&D personnel * the ratio of R&D investment to revenue + The proportion of R&D personnel * the proportion of capitalized R&D investment to total R&D investment + the ratio of R&D investment to revenue * the ratio of R&D investment to revenue + the ratio of R&D investment to revenue * the proportion of capitalized R&D investment to total R&D investment + the proportion of capitalized R&D investment to total R&D investment * the proportion of capitalized R&D investment to total R&D investment

Based on this table, the P-value of White test is less than 0.05 so that the heteroscedasticity problem is not significant.

The absence of heteroscedasticity problem proves that The estimation of standard error is reliable. In classical linear regression models, if the error term satisfies the assumption of homoscedasticity. The model does not exhibit significant bias due to differences in volatility. When there is no heteroscedasticity, the significance of variables will not be amplified or weakened due to extreme fluctuations in individual sample points. Homoscedasticity is a key assumption of classical linear regression models. Its satisfaction means that the variance structure of the error term is reasonable and the regression coefficient estimation is more robust. (Wooldridge, 2016; Greene, 2018).

6.2 Stepwise Regression

Stepwise Regression is a regression analysis technique used for variable screening and model optimization, which can further validate the robustness of the model and the significance of variables by gradually adding or

removing variables.

The test results using stepwise regression are shown below.

ANOVA[a]

Model		Quadratic sum	dof	Mean square	F	significance
1	regression	10338.080	1	10338.080	10.505	.001b
	residual	188941.614	192	984.071		
	total	199279.694	193			

a. Dependent variable: Total asset growth rate

b. Independent variable, The proportion of R&D personnel

Coefficient a

Model		Unnormalized-coefficent		Standardization-coefficient	t	Significance	collinearity	
		B	Standard error	Beta			tolerance	VIF
1	(constant)	2.451	4.006		.612	.541		
	The proportion of R&D personnel	.397	.122	.228	3.241	.001	1.000	1.000

a. Dependent variable: Total asset growth rate

Based on this table, we can see that the P-value of the proportion of R&D personnel is 0.001 which is less than 0.05. It indicates that the impact of the proportion of R&D personnel on total asset growth rate is significant which is same as the previous regression model.

This paper uses a different method, stepwise regression, to conduct the regression analysis. Two different regression model indicates the same result: key variables, the proportion of R&D personnel has a significant impact on total asset growth rate. The consistent conclusion shows the robustness of the model.

7. Conclusion

This chapter aims to use data analysis to confirm the specific relationship between R&D investment and development capability of enterprises. With the regression model, the valid of the regression model has been confirmed. The P-value of the model proves the significance of it. In this case, the significance of the impact of the R&D investment has been proved. The management can expect to adjust R&D investment to make a difference to the development capability of the company.

In terms of the specific independent variables, the regression result shows that the impact of the proportion of R&D personnel on total asset growth rate is significant. According to this result, by recruiting R&D expert,

the total asset growth rate can be expected to increase. Besides, the coefficient of the variable is 0.538. Under this circumstance, every units increase in the proportion of R&D personnel will bring 0.538 increases in total asset growth rate. This explains the important role of R&D talents in the development, transformation, application innovation, and technology of companies from a data perspective.

Besides, the paper conduct related reliability test. In terms of the multicollinearity test, the VIF is less than 10 which indicates the multicollinearity problem is not significant. And for the autocorrelation, the Durbin-Watson statistic is close to the 2 which means no autocorrelation. As for the heteroscedasticity test, the paper uses White test to prove the variance of the residuals (errors) is constant across all levels of the independent variables and no heteroscedasticity.

Meanwhile, the paper conducts heteroscedasticity test and uses different regression method to do the robustness analysis. The absence of heteroscedasticity and the same result from the different regression analysis proves the stability and robustness of the model.

V. Conclusion

1. Introduction

The literature review, research methods, and data collection and analysis have been discussed in the previous section of this paper.In Chapter 4, the paper validated the relationship between R&D investment and corporate growth capacity through data analysis. Although only a small portion of the changes in a company's growth capacity can be explained by R&D investment, the significance of R&D investment in the company's growth capacity has been verified. At the same time, the model also verified the impact of the proportion of R&D personnel on the asset growth capability of enterprises. The data found that the proportion of scientific researchers has a significant impact on the asset growth ability of enterprises, which to some extent verifies the endogeneity theory. Enterprises need talents and expert to absorb, transform and apply knowledge to promote their progress.

This chapter will elaborate on the recommendations and shortcomings of this paper for future research. As for the recommendation for future research, future research should consider the theory of enterprise lifecycle, the diversity of independent variables, and nonlinear regression models. Enterprises will have different resource allocation needs and asset development characteristics at different stages of development. In the future, the impact of the stage in which the enterprise is located on asset growth should be included. At the same time, the development capability of enterprises is not only affected by R&D investment, but also by macroeconomic and financing costs. Incomplete independent variables can affect the explanatory power of the model. In addition, the paper can apply nonlinear regression models. R&D investment may only have a positive impact on the enterprise after exceeding a certain threshold.

Meanwhile, there are many limitation of this paper. Similarly, this paper did not take into account the characteristics of enterprises in different life cycles. Different life cycles will have different growth characteristics. Another limitation of this paper is that it only uses R&D investment to regress the asset growth capability of enterprises which also deelply influenced by the market and financing costs. Lastly, This paper only uses a linear regression model without considering nonlinearity. The influence of independent variables on the dependent variable may not be linear.

2. Recommendation for Future Research

2.1 Consider the different life cycles of enterprises

Future research should consider the development stage of the enterprise itself. The lifecycle of a company is usually divided into the start-up phase, growth phase, maturity phase, and decline phase. The resource allocation requirements, strategic priorities, and growth models vary significantly at different stages.

Start up period: R&D investment may mostly be silent investment, as technological breakthroughs and transformations require time and exploration. At this stage, the return on investment in research and development may not be significant, but it is still necessary. The return on investment in research and development may be delayed.

Growth period: Enterprises may need broader investments (such as market expansion, production capacity improvement), and the marginal effect of R&D investment increases. At this point, the company's investment may continue to expand, but the returns will also be significant at the same time.

Maturity period: Products and technologies continue to mature, and investment can be reduced. At the same time, the market has been well cultivated, and the product has received a warm response from the market, resulting in a significant increase in the returns of previous investment.

Decline period: The impact of R&D investment on growth rate may weaken. The competition in the market is becoming increasingly fierce, and the investment in research and development cannot receive sufficient returns in the early stage. Enterprises may reduce their investment in products, while the profits from the products will gradually decrease.

2.2 Consider a variety of independent variables

Future research can incorporate diverse independent variables to regress the asset growth capacity of enterprises. The growth ability of enterprise assets is influenced by various factors, such as the market, macro environment, and financing costs. Merely considering R&D investment is not enough to explain asset growth capability well.

Different market environments will have varying impacts on the return on investment in research and development. In emerging countries, conducting high-tech research and development may not have the same competitors due to low competition. In this situation, investing in research and development to develop new products can quickly capture the market. The invested product can generate overall market revenue and profit due to the lack of competitors. However, in highly competitive markets, products invested in research and development may face many identical products. In this case, the income and profits obtained will significantly affect the return on investment.

Similarly, financing costs can also affect research and development investment. Higher financing costs will encourage companies to invest resources in products that are quick to achieve quick success and immediate benefits. Meanwhile, lower financing costs can provide management with a broader perspective and a greater willingness to invest in the research and development of more promising products.

2.3 Consider nonlinear regression models

Future research should consider more diverse relationships between independent and dependent variables, not limited to linear relationships. The relationship between R&D investment and corporate asset growth may be non-linear. When R&D investment exceeds a certain threshold, asset growth may be faster. When electronic companies develop new products, the initial investment capital is very high. And it is difficult to achieve significant returns before the product is officially commercialized on a large scale. Therefore, most of the initial investment may not have been able to drive effective asset growth before the official release of the product. In other words, R&D investment needs to exceed a certain threshold before the company can switch back to emerging products.

After the basic version of the new product matures, some minor changes may cover specific market versions, bringing more returns and driving the growth of enterprise assets. In this case, small R&D investments can be exchanged for a completely new market. This means that later R&D investment may bring better marginal revenue. In the future, we can observe the complex variable relationship between R&D investment and enterprise asset growth, and summarize a nonlinear regression model.

3. Limitations of Study

3.1 Limited data sample

This paper only collected relevant data from 39 companies listed on the Chinese securities market in the electronics industry over the past five years. Only 39 companies were covered by the sample data, and many more companies were unable to serve as samples due to the lack of disclosure of relevant data. Insufficient data samples may result in inaccurate model coefficients. In addition, the time scale only considers five years. For the transformation and commercialization of R&D achievements, five years is not sufficient to fully observe the impact of R&D investment on enterprise assets. The return on investment in research and development often lags behind. In addition, the sample only included listed companies in the Chinese market. Other Chinese funded companies listed in Hong Kong or in the United States have not been considered. Sample representativeness may be lacking.

3.2 Lack of consideration for the stage of enterprise development

The development stages of different enterprises have different characteristics. In the early stages of enterprise product development, it is often difficult to achieve significant returns on investment. In the mature stage, the market will reward products that have been successfully developed, and the investment will have a greater driving force for the development of the enterprise. Different stages will have different impacts on R&D investment and corporate asset growth. This article lacks consideration of development stages and confuses enterprises in different stages, making it difficult for the model to clearly capture the relationship between independent and dependent variables.

3.3 Lack of considering variety of the independent variables

There are multiple factors that affect the growth rate of enterprise assets, including not only research and development investment, but also the market, macroeconomic, and financing costs. The dependent variable from a single perspective is difficult to explain the changes in a company's asset growth ability which may bringing inaccuracy to the model. Models may reduce accuracy and explanatory power due to incomplete dependent variables. The model should incorporate comprehensive influencing factors, taking into account the impact of macroeconomic and market factors on the growth of corporate assets.

4. Conclusion

Based on data samples from 39 electronic industries listed in the Chinese market, The P-value of the overall regression model constructed by the data is less than 0.05, so the explanatory model of the data is effective, and the influence of the independent variable on the dependent variable can also be explained as significant. In this case, the paper concludes that R&D investment has a significant impact on the growth ability of enterprises. However, due to the small R-square of the model, the explanatory power of the three R&D investment indicators for the development capability of enterprises is not high. This may be due to the model not taking into account the influencing factors of R&D investment, such as the market, macroeconomic factors, and the company's capital structure. At the same time, it can be seen that although the impact of R&D investment on the asset growth ability of enterprises is significant, but also limited. The impact is still subject to the influence of other environmental and indirect factors.

As for the specific independent variables, the P-value of the proportion of R&D personnel is less than 0.05 which means that it has a significant relationship with the total asset growth rate. As the coefficient of the proportion of R&D personnel is positive, the higher proportion of R&D personnel is expected to have a positive impact on the total asset growth rate. The confirmation of the significance of the relationship between the proportion of R&D personnel and the growth ability of enterprise assets also validates the endogeneity theory. The endogenous growth theory emphasizes that knowledge is a non competitive and partially exclusive public good, and its increasing marginal output makes it the core driving force for long-term economic growth. High quality human capital is a catalyst for technological progress. As high-tech workers, R&D personnel reflect the investment of enterprises in innovation resources. It can help creatively solve problems and drive the commercial application and contribution of knowledge.

Meanwhile, the paper conduct a series of the reliability tests including multicollinearity test, autocorrelation test and heteroscedasticity test. The results indicate that the model does not have the multicollinearity problem, autocorrelation problem and heteroscedasticity problem. This indicates that the model satisfies the assumptions of the classical linear regression model (CLRM). The estimator of the model is unbiased and valid (BLUE), and the significance test and hypothesis test of the regression coefficients are effective. The overall model has stronger explanatory power, clear relationships between independent variables, and can more accurately explain changes in the dependent variable.

Besides, due to the absence of heteroscedasticity in the model and the consistent significance of important independent variables after using stepwise regression method, the overall robustness of the model can be expected(Maddala, 2001). This enhances the credibility of the research findings, indicating that the research findings are universally applicable rather than accidental results, and improves the theoretical applicability of

the model(Kennedy, 2008).

6.Chapter of Summary

This chapter mainly summarized the shortcomings of the paper and the recommendation for improvement in future research. Meanwhile, this article summarizes the results and conclusions generated from previous data analysis.

Future research can incorporate the theory of enterprise lifecycle into consideration, taking into account the return on R&D investment and the characteristics of enterprise asset growth at different stages. Besides, future research could consider the impact of independent variables other than R&D investment on a company's asset growth capability, such as financing costs and market(Barney, 1991). Meanwhile, the improvement of the model is also worth considering. Future improvements can consider non-linear data relationships to accurately capture the relationship between independent and dependent variables.

This paper still has limitations. The data sample is not sufficient, and the representativeness may be lacking(Baltagi, 2008). At the same time, in the establishment of the model, only the impact of R&D investment on the growth of enterprise assets was considered, without taking into account other independent variables. Nonlinear relationships were not taken into account in the variable relationships. The paper only used a linear model to regress the influence of independent variables on the dependent variable. The explanatory power of the model may not be strong enough(Hill, Griffiths, & Lim, 2018).

Lastly, the paper summarizes the conclusions drawn from data analysis. The P-value of the model is less than 0.05, indicating that R&D investment has a significant impact on the growth ability of enterprises, and there is a correlation between the two. For specific independent variables, the P-value of the proportion of R&D personnel is less than 0.05, indicating that the proportion of R&D personnel has a significant impact on the growth rate of total assets.

In summary, this chapter is a summary of the overall paper. The chapter comprehensively examines the existing shortcomings and provides suggestions for future research(Gujarati & Porter, 2009). The chapter also provides a detailed explanation and discussion of the previous data analysis results. This section infers and explains the relationship between R&D investment and enterprise development capabilities, as well as quantitative models(Stock & Watson, 2011). In addition, the reliability test was also explained, proving the reliability of the model established in the paper and its compliance with the assumptions of the classical linear regression model (CLRM)

References

Baltagi, B. H. (2008). Econometric analysis of panel data (4th ed.). Wiley.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99-120. https://doi.org/10.1177/014920639101700108

Brown, R. and Davis, L. (2019). The R&D revolution in the pharmaceutical industry: Drivers and outcomes. Journal of Health Economics, 48(1), 98-112.

Cohen, W. M. and Levinthal, D. A. (1989). Innovation and learning: The two faces of R&D. The Economic Journal, 99(397), 569-596.

Cohen, W. M. and Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly, 35(1), 128-152.

Czarnitzki, D. and Kraft, K. (2004). Innovation indicators and corporate performance. Research Policy, 33(2), 217-235.

Davis, J. and Roberts, T. (2018). The role of R&D in modern enterprises: Strategies for innovation and growth. Journal of Business Innovation, 35(2), 147-162. Greene, W. H. (2012). Econometric analysis (7th ed.). Pearson Education.

Greene, W. H. (2018). Econometric analysis (8th ed.). Pearson Education.

Gujarati, D. N. and Porter, D. C. (2009). Basic econometrics (5th ed.). McGraw-Hill Education.

Hall, B. H. and Oriani, R. (2006). Does the market value R&D investment by European firms? Evidence from a panel of manufacturing firms in France, Germany, and Italy.

International Journal of Industrial Organization, 24(5), 971–993.

https://doi.org/10.1016/j.ijindorg.2005.12.001.

Hill, R. C., Griffiths, W. E. and Lim, G. C. (2018). Principles of econometrics (5th ed.). Wiley.

Hirsch-Kreinsen, H., Jacobson, D. and Robertson, P. L. (Eds.). (2008). Innovation in low-tech firms and industries. Edward Elgar Publishing.

Johnson, P. and Lee, S. (2020). Strategic R&D investment and its impact on competitive advantage. International Journal of Business Studies, 30(4), 200-212.

Jones, P. and Smith, T. (2017). Innovation through R&D: A strategic approach to growth in the tech industry. Technology and Innovation Review, 23(4), 210-223.

Kennedy, P. (2008). A guide to econometrics (6th ed.). Wiley-Blackwell.

Lev, B. and Sougiannis, T. (1996). The capitalization, amortization, and value-relevance of R&D. Journal of Accounting and Economics, 21(1), 107-138.

Lucas, R. E. (1988). On the mechanics of economic development. Journal of Monetary Economics, 22(1), 3-42.

Maddala, G. S. (2001). Introduction to econometrics (3rd ed.). Wiley.

Romer, P. M. (1990). “Endogenous Technological Change.” Journal of Political Economy, 98(5, Part 2), S71–S102.

Romer, P. M. (1994). The origins of endogenous growth. Journal of Economic Perspectives, 8(1), 3-22.

Shan, H. (2020). Evaluating the risks and rewards of R&D investments in uncertain markets. International Journal of Management Science, 19(3), 34-49.

Smith, A. and Zhang, L. (2021). Optimizing R&D investment for sustainable business growth: A comprehensive analysis. Business Development Review, 40(1), 89-105.

Stock, J. H. and Watson, M. W. (2011). Introduction to econometrics (3rd ed.). Pearson Education.

Wilson, A. and Green, P. (2021). R&D strategies for sustainable growth: A cross-industry perspective. Business and Management Quarterly, 42(2), 112-128.

Wooldridge, J. M. (2016). Introductory econometrics: A modern approach (6th ed.). Cengage Learning.