



# Effectiveness Paths of R&D Investment and Digital Technology on the Ambidextrous Innovation Capability in Equipment Manufacturing Enterprises under the Digital Economy

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**Abstract.** This study examines the effectiveness of R&D investment and digital technology in enhancing ambidextrous innovation capability within equipment manufacturing enterprises in the digital economy. Focusing on both explorative and exploitative innovation, the research investigates how R&D funding and personnel drive knowledge creation and transformation into practical applications. Furthermore, digital technology, analyzed through its dimensions of data analysis, connectivity and production, is shown to optimize resource allocation, streamline operations, and promote intelligent manufacturing. Key findings indicate that adequate R&D funding and skilled personnel amplify explorative and exploitative innovation by balancing resource allocation and reducing risks. Simultaneously, digital technology shortens R&D cycles and fosters collaborative innovation with suppliers and customers, thereby broadening the boundaries of innovation. These insights highlight the need for strategic investments in R&D and digital technology to address complex market challenges, achieve sustainable growth, and enhance competitiveness. This study provides a theoretical framework and actionable implications for advancing innovation strategies under the digital economy.

**Keywords:** R&D Investment, Digital Technology, Ambidextrous Innovation.

## 1 Introduction

In the digital economy, characterized by rapid technological advancements and evolving competitive dynamics, dual innovation—comprising explorative and exploitative innovation—has become crucial for equipment manufacturing enterprises [1][2]. Explorative innovation drives the development of new technologies, while exploitative innovation enhances existing competencies [3]. Balancing these two forms of innovation enables enterprises to adapt to market changes and maintain technological leadership.

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R&D investment and digital technology have been identified as essential drivers of ambidextrous innovation capability. This study examines the roles of R&D investment and digital technology in enhancing the ambidextrous innovation capability of equipment manufacturing enterprises in the digital economy. In contrast to previous studies, this research highlights the novel integration of R&D funding, personnel, and digital technology to simultaneously foster both explorative and exploitative innovation capabilities. While previous research has largely focused on the isolated impacts of R&D investment or digital technology, our study investigates how the synergy between these factors can create a balanced innovation strategy, crucial for enterprises seeking to maintain competitiveness in rapidly changing markets.

## 2 Research Methodology

This study employs a mixed-methods approach, combining both qualitative and quantitative analyses. By systematically reviewing existing literature and incorporating theories related to ambidextrous innovation, I have developed effectiveness pathway models for R&D investment and digital technology in enhancing the ambidextrous innovation capability of equipment manufacturing enterprises. This model provides a theoretical framework and practical guidance for improving ambidextrous innovation capability in the digital economy era. The advantage of this approach lies in its ability to reveal the complex interactions between R&D investment and digital technology, offering insights for future research and practical applications in similar contexts.

## 3 R&D Investment Factors

R&D investment, comprising funding and personnel, is essential for enterprises to achieve significant innovation outcomes and enhance their independent innovation capabilities. Sufficient financial commitment to R&D is crucial for knowledge growth and innovation, with higher investment leading to improved performance [4]. According to the 2023 EU Industrial R&D Investment Scoreboard, enterprises like HUAWEI INVESTMENT & HOLDING maintain consistently high levels of R&D investment (as shown in Table 1), leveraging robust financial resources to sustain global leadership in critical technological domains. In contrast, smaller equipment manufacturers struggle with limited R&D funding, which hinders their ability to compete globally.

While R&D expenditures increase operational costs, adequate funding is necessary for designing new products, engaging in exploratory activities, and motivating R&D personnel [5]. This funding boosts patent output and facilitates the introduction of new products. Compared to exploitative innovation, explorative innovation demands significantly more resources, involves greater uncertainty, and carries higher risks. Consequently, these tensions can be mitigated by abundant R&D funding, which enables enterprises to pursue high-risk explorative projects while fostering both types of innovation, thus enhancing ambidextrous innovation capability. Profits from exploitative innovation can be reinvested into exploratory activities, creating a virtuous cycle.

**Table 1.** R&D Investment and Net Sales of the Top 10 Global Firms by R&D Expenditure.

Enterprises	R&D Investment Amount (Unit: Billion Euros)	Net Sales Revenue (Unit: Billion Euros)	R&D Intensity
1 ALPHABET	370.34	2651.75	14.0%
2 META	315.2	1093.28	28.8%
3 MICROSOFT	254.97	1986.83	12.8%
4 APPLE	246.12	3697.06	6.7%
5 HUAWEI INVESTMENT & HOLDING	209.25	862.05	24.3%
6 VOLKSWAGEN	189.08	2792.32	6.8%
7 SAMSUNG ELECTRONICS	184.35	2235.93	8.2
8 INTEL	164.34	591.17	27.8%
9 ROCHE	142.68	642.62	22.2%
10 JOHNSON & JOHNSON	136.91	890.15	15.4%

Human capital investment in R&D also plays a vital role in the competitive landscape of technological innovation. A skilled R&D workforce enhances the enterprise's knowledge base and technological capabilities, improving problem-solving skills and strengthening explorative innovation. Research highlights that innovation is fundamentally talent-driven [6]. Increased personnel investment deepens the exploration of existing technologies, boosting the effectiveness of exploitative innovation [7]. Additionally, the resource base for exploitative innovation can be enriched by the new knowledge and technologies generated through explorative innovation, maximizing its effectiveness. Thus, the size of an enterprise's R&D workforce directly determines its ability to coordinate and undertake explorative and exploitative innovation activities.

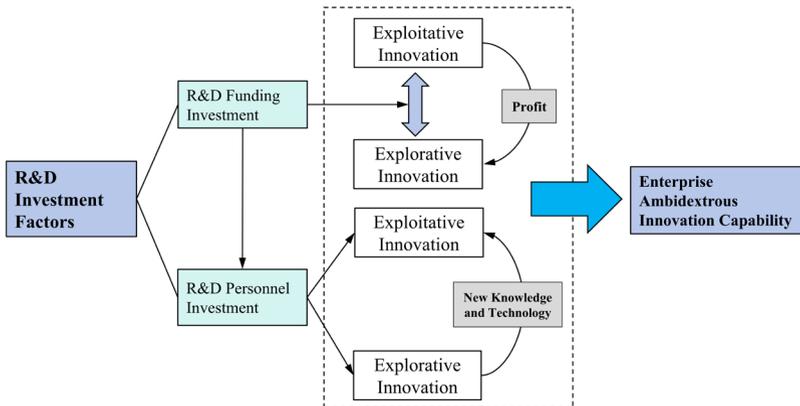
**Fig. 1.** Effectiveness path of R&D investment on the ambidextrous innovation capability in equipment manufacturing enterprises.

Fig. 1. illustrates the influence of R&D investment on the innovation pathways in equipment manufacturing enterprises, highlighting the interplay between funding, personnel, and innovation outcomes. The pathways between these nodes demonstrate the dynamic flow of resources and knowledge, with feedback loops showing how successful innovation outcomes can drive further investment in R&D.

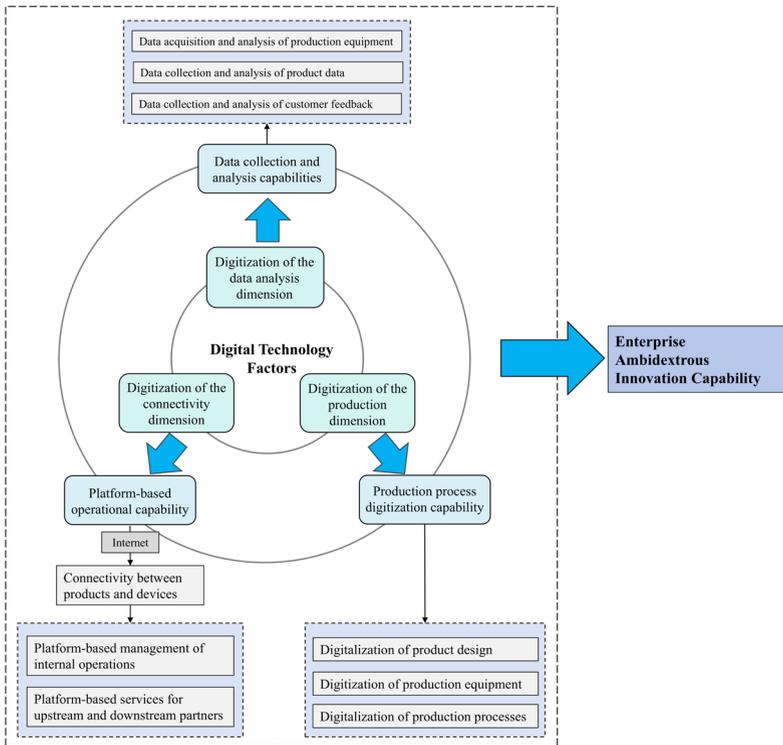
## 4 Digital Technology Factors

In the rapidly evolving era of information technology, digital technology plays a pivotal role in enhancing equipment manufacturing enterprises' ambidextrous innovation capability. On the one hand, the application of digital technologies enables enterprises to rapidly connect internal and external knowledge sources, efficiently tap into diverse resources, and accurately capture customer needs. This facilitates the exploration of relevant knowledge and technologies, allowing enterprises to deliver tailored products and services to meet customer demands, thereby significantly improving their explorative innovation capability [8]. On the other hand, digital technology also aids enterprises in uncovering and integrating existing innovation resources, which can enhance their utilization efficiency and optimizing exploitative innovation capability. Consequently, the application of digital technology has become a critical instrument for advancing innovation in equipment manufacturing enterprises.

From an internal organizational perspective, digital technology can be categorized into three dimensions: analysis, connectivity, and production [9]. For equipment manufacturing enterprises, the analysis dimension pertains to the capabilities for data collection and analysis, the connectivity dimension involves the digital platform-based management of operations, and the production dimension refers to the digitalization of production processes.

Specifically, data collection and analysis capabilities leverage the internet, databases, and big data technologies, enabling enterprises to collect, process, visualize, and interpret data related to production equipment, products, services, and feedback. This facilitates swift responses to market demand fluctuations, optimizes product structures, and improves resource allocation. Connectivity digitalization is reflected in the interconnection of products and equipment via networks and the establishment of platform-based internal operations and upstream-downstream collaborations. This allows enterprises to co-create value with customers through enhanced interactions. Production digitalization refers to the digital operation of product design, equipment control, and process management, which advances the automation and intelligence of production processes, reduces costs, and improves efficiency. These advancements create more opportunities for innovation by freeing up resources for innovative activities.

The specific effectiveness path of digital technology factors is shown in Fig. 2. There are three core dimensions: data analysis capabilities, connectivity and collaboration, and production digitalization. The relationships between these dimensions illustrate how digital technologies streamline decision-making, improve operational efficiency, and foster innovative collaborations with external partners.



**Fig. 2.** Effectiveness path of digital technology on the ambidextrous innovation capability in equipment manufacturing enterprises.

The application of digital technologies can also shorten the R&D cycle of equipment manufacturing enterprises, thereby improving their innovation efficiency [10]. With the continued penetration of digital technologies, upstream suppliers and downstream customers can actively participate in an enterprise's innovation activities, which facilitates easier access to external information and shared innovation resources. This collaboration helps to establish innovation platforms that can enable synergistic innovation, broaden the boundaries of innovation, and expand the enterprise's innovation horizons. However, under the current digital economy, phenomena such as digital disruption and the emergence of ecosystems have rendered the strategic decision-making environment more complex, so unique challenges to innovation-focused business models is posted.

## 5 Conclusions

In the digital economy era that is characterized by rapid technological advancements and the information diffusion, the competitive landscape for equipment manufacturing enterprises has undergone profound transformation [1]. Ambidextrous innovation,

comprising both explorative and exploitative innovation, has emerged as a critical capability for enterprises seeking sustainable growth and technological leadership [3]. Explorative innovation drives the pursuit of new knowledge and the development of novel technologies, while exploitative innovation focuses on refining and enhancing existing resources and competencies [4]. Balancing these two forms of innovation is pivotal for enterprises to navigate the challenges posed by rapidly changing markets and technological disruptions.

The synergy between R&D investment and digital technology aids enterprises to balance exploratory and exploitative innovation, addressing complex market challenges and fostering sustainable growth. For equipment manufacturing enterprises, strategic investments in these areas are essential to overcoming digital disruptions and leveraging ecosystem-based business models. This study provides actionable insights for firms to enhance innovation performance, expand their innovation boundaries, and achieve competitiveness in the digital economy.

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