Governance Framework for Digital R&D Activities - Practical Experience from China

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Abstract. Digital technology is subverting the traditional corporate R&D paradigm, and China has embarked on a characteristic path in exploring digital R&D. Firstly, we sort out the connotation of digital R&D and digital R&D system, and then focus on the fields of new energy vehicles, banking sector, rare and precious metal material genetic engineering, we summarize the governance experience of China's R&D digital transformation from the aspects of organization reshaping, data governance, data empowerment, efficiency evaluation, and multi-agent collaboration, a governance framework is proposed based on these. Finally, management inspirations are given from four aspects: user value-driven agile organization reengineering, system support of data governance, digital empowerment of R&D management activities, and giving play to the leading role of the government. The research conclusions are expected to provide references for digital R&D activity managers and policymakers.

Keywords: digital R&D, China, governance framework

1 Introduction

In today's world, the great abundance of material life has spawned increasingly diverse and rapidly iterative consumer demands. The market has entered the "VUCA" era, and the traditional inefficient and high-risk corporate R&D innovation model has been unable to respond to market demands in a timely and accurate manner. In response, digital technologies represented by big data, cloud computing, artificial intelligence, and the Internet of Things are giving new connotations to R&D activities. The application of digital technology in R&D activities can not only save R&D time and cost, but also realize platform reuse and improve virtual verification capabilities, to better meet the needs of consumers. Digital R&D has become the main focus of scholars recently [1], however, the understanding of the application of digital technology in R&D activities is still in its infancy [2], and there is a lack of a systematic research framework to analyze the impact of digital transformation on the R&D process.

Data assets, digital tools, R&D center, and organizational change constitute the main content of digital R&D, and are also the governance focus of digital R&D. Data is the foundation of digital R&D. Effective collection and utilization of data will provide

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comprehensive guidance for product functional improvement, engineering improvement, and R&D process innovation. While the application of various digital tools such as design, simulation, and verification provides strong support for the efficiency improvement of R&D processes. In addition, the construction of the R&D middle platform can enable the organization to realize the accumulation of public technical capabilities, avoid the problem of repeated construction of basic technical capabilities, and further improve the organization's R&D efficiency. Finally, digital R&D involves not only technological innovation, but also the evolution of organizations. Therefore, managers should advance from a systematic point of view, implement organizational changes which match the requirements of digital R&D and shape organizational digital R&D capabilities.

Benefiting from the massive data foundation accumulated by the huge market scale, the powerful tool empowerment provided by the rich digital ecosystem, and the good innovation soil created by inclusive regulatory policies, China has explored a characteristic path in digital R&D. The "14th Five-Year Plan for the Deep Integration of Informatization and Industrialization Development Plan" pointed out that the penetration rate of digital R&D and design tools in Chinese industrial enterprises has reached 73%, and it is expected to reach 85% by 2025, at the same time, a large number of characteristic management practices have emerged in some fields. Given this, this paper analyzes cases in three fields: new energy vehicles, banks, and rare and precious metal materials genetic engineering, and summarizes the governance framework of China's digital R&D, to provide the Chinese experience of R&D digital transformation.

2 Research overview

2.1 Concept and characteristics of digital R&D

At present, the academic and industrial circles have insufficient discussions on the concept of digital R&D, and the existing definitions often emphasize the transformation of traditional R&D links by digital tools. For example, IF Smart believes that digital R&D is the use of various digital tools and software to digitally design, analyze, simulate, test/verify products, form a complete digital prototype with manufacturing conditions, and provide various product data in the manufacturing stage. IResearch believes that digital R&D is the use of digital technology to realize the transformation of the R&D process by using data flow based on shortening the R&D cycle, platformization, and virtual verification capabilities. However, digital R&D is not only reflected in the application of computer-aided technology but also involves broader organizational changes such as creating an open and parallel R&D working mechanism. Therefore, referring to the definition of digital innovation by Bharadwaj (2013) [3], This paper argues that digital R&D is the process of bringing new products or services, improving the traditional R&D process, changing the original organizational model, and changing the inherent business development model by using a combination of digital technologies in the traditional R&D process.

2.2 Digital R&D system

The application of digital technology has led to a complete change in the R&D process, and the digital R&D system is a relatively complete R&D system based on digital technology, which is formed by comprehensively reconstructing demonstration, design, simulation, test, manufacturing, management, standards, and specifications to adapt to this change [4]. The digital R&D system was first proposed by Boeing in the 1990s and applied to the product R&D process, its core elements include digital R&D, information management, and knowledge reuse. With the in-depth application of digital technology in R&D activities, the participants in innovation activities are becoming more diverse, and the boundaries between innovation processes and results are increasingly blurred. These impacts will enrich the content of the digital R&D system.

2.3 Difficulties and trends of R&D model innovation

R&D activities have inherent characteristics of VUCA, and these characteristics are more complex in the digital context. Combining the concept of digital R&D and the characteristics of the digital R&D system, the difficulties and trends of digital R&D model innovation can be summarized in the following aspects: The first aspect is organizational and cultural challenges. For example, large organizations have complex organizational structures, and the process of implementing R&D model changes is often slow, while small organizations are more flexible but have limited resources, which limits their capabilities for large-scale technology businesses. The inherent risk-averse culture also steers organizations away from exploring technologies with high-priority and potentially high-value. In addition, resistance to change may also come from the R&D team itself, because the introduction of new models and new technologies has changed their work habits and challenged their work skills. Developers will decide whether to adopt new technology through a comprehensive trade-off between perceived usefulness and perceived ease of use [5]; The second aspect is the challenge of human resource management of the R&D activities, an innovative R&D model must clarify issues such as the performance evaluation of the R&D team, the individual performance evaluation, and the gap of R&D management talent [6]. In the digital context, these problems have become more serious: while managers can use digital technology to evaluate teams in a more objective and quantitative way, it may become a game with front-line R&D personnel, causing the tools to fail. In addition, digital R&D puts forward higher requirements on the capacities of R&D managers. R&D managers not only need to complete the transformation from production thinking to user thinking but also need to have a multidisciplinary knowledge background; The third aspect is R&D collaboration management challenges. Collaboration is a typical feature of digital R&D. The collaboration of digital R&D is often characterized by multi-agent, cross-border, and non-linearity, which requires organizations to formulate sound management norms and systems for product R&D collaboration.

3 China's experience in digital R&D governance

Under the influence of the market, technology, economic system, and other factors, China has gradually explored a characteristic path of R&D digital transformation. Considering industry differences, this paper summarizes the leading practices of digital R&D transformation in the fields of new energy vehicles, banking, and Genetic engineering of rare and precious metal materials according to the hierarchy of manufacturing sector, service sector, and basic research (Table 1), and extracts the typical characteristics of China's R&D digital transformation by industry.

Table 1. China's digital R&D governance practices

Governance Focus	New Energy Vehicle (Manufacturing Sector)		Banking (Service Sector)		Basic Research
	WM Motor	NIO	Bank of Shanghai	Minsheng Bank	Rare and Precious Metal Materials Genetic Engineering
Data Governance	Establish data governance committee; build comprehensive data governance framework; build collaborative working mechanism between the data governance department and business departments; set up data security department	—	Build operation and management data information platform	Set up the "Data Management Department"; build seven platforms including big data platform and AI platform; establish a data stewardship mechanism	Established the first database of basic parameters of new materials covering 11 types of rare and precious metals in China
Organization	The first in the industry to introduce the C2M process and realize the "user-defined car"	Network-based organization integrating product, R&D, and operation; "Vision-Action-Upgrade" target management method; PLM adaptive reengineering	Virtual tribe	Established the "Ecological Finance Department",	Collaborative innovation alliance; "Revealing the list and Domination"; "Military Order"
R&D Process	—	Digital twin, virtual reality	Visualization and quantification of personnel, requirements, and the whole R&D process; daily stand-up meeting mechanism	Self-construction of the data center; introduction of RPA	Build the first high-throughput computing platform, high-throughput preparation and characterization platform for rare and precious metal materials

Efficacy Evaluation	—	Emphasis on achieving goals in a manner consistent with company values	Use Agilean's "greater, faster, better, satisfied" R&D efficiency measurement index system	Automatic collection of R&D data; build a comprehensive index library, and build rich quality-efficiency analysis models.	—
Multi-agent Collaboration	Cooperate with Dell to build a big data platform; cooperate with Shanghai Unicom on digital services;	Introduce digital tools such as Siemens PLM system and simulation software	Use Agilean's digital tools	Cooperate with universities to cultivate digital talents; cooperate with Huawei to establish a joint innovation laboratory	Build computing platforms, research platforms, and carry out innovation cooperation under the coordination of the government

"—" indicates that there are no relevant reports

3.1 New energy vehicles: comprehensive data governance and scaled agile organization reshaping

Data is the cornerstone of digitization, and the quality of the data determines the quality of the R&D output. The automotive industry is a highly complex and systematic project with a huge data scale and extremely difficult governance. Given this, China's new energy vehicle companies pay special attention to comprehensive data governance: The first is the top-down governance of data. At the group level, set up a data governance committee composed of executives from various departments to strengthen departmental collaboration and avoid "data silos"; The second is to clarify the content of data governance. By formulating a data governance framework, the management of the whole process of data collection, processing, and utilization can be realized. Once again, new energy vehicle companies in China emphasizes collaborative governance with business departments. Data cannot only be governed on the technical level, the ultimate purpose of data governance is to empower businesses. Therefore, data governance personnel need to go deep into the business and jointly formulate data standards and data application processes with business personnel.

In addition, the R&D digital governance of new energy vehicles also focuses on scale agile organizational remodeling. In the digital age, besides using digital tools such as digital twins and virtual simulations to improve R&D efficiency, Chinese new energy vehicle companies pay more attention to the construction of agile organizations that match digital technologies. The essence of the agile organization of new energy vehicle companies is the integration of R&D, products, and operation oriented by user needs. Through the aggregation of various functional roles such as PO, TO, SM, and development engineers, the agile team actually constitutes a self-organizing unit. In this organizational model, technical personnel can break through the user communication barriers existing in the linear R&D model, directly connect with users' demand feedback, and achieve value delivery and update iterations in a team collaborative manner.

3.2 Banking sector: digital empowerment of R&D process and R&D efficiency evaluation

The digital R&D of Chinese banking sectors focus on the digital empowerment of the R&D process and efficiency evaluation. The digital empowerment of the R&D process is reflected in the promotion of transparency in the R&D process, the accumulation of R&D capabilities, and the substitution of transactional activities. First, the banking department uses the Kanban tool to achieve end-to-end transparency in R&D, and introduces a daily stand-up meeting mechanism to analyze the blockage and slow progress in the R&D process to ensure the coordinated advancement of the R&D activities; Second, the construction of the data center enables the banking sector to realize the precipitation of R&D capabilities, and it also makes enterprises avoid repetitive R&D resource expenditures. Finally, the introduction of RPA technology in process management realizes the automation of business process processing, and greatly reduces the time spent by the R&D team on finance and procurement.

In terms of R&D efficiency evaluation, the banking department has completed the digital empowerment of the whole evaluation process by using digital tools to automatically collect R&D efficiency data, build a comprehensive indicator warehouse, establish data analysis models, and conduct in-depth data mining. Data-driven R&D efficiency evaluation solves a series of problems in the software development process of the banking sector: poor visualization, data islands, "Goodhart's curse", isolated analysis of local and global indicators, and weak rationality of easily available indicators. In addition, it can help to enhance the R&D personnel's perception of procedural fairness and result fairness, realize a more rational evaluation of efficacy and facilitate the improvement of efficacy.

3.3 Yunnan rare and precious metal materials genetic engineering: government-led R&D collaboration of multiple subjects

The digital transformation of basic research has the characteristics of large investment, high risk and long payback period, so that a single enterprise does not have the strength to undertake it independently. By acting as deployers, facilitators, and coordinators in basic research, government can play an important role in top-level design, strategic planning, policy formulation, and market guidance, and rapidly improve innovation capabilities in key areas. The science and technology project of “Yunnan Rare Metal Material Genetic Engineering” is a paragon of government-led multi-subject collaborative digital R&D. On the one hand, the government guides through "blood transfusion". In the process of implementation, the government invested 500 million funds and compiled the "Yunnan Province Rare and Precious Metal Materials Genetic Engineering Construction Plan (2018-2030)", which provided funds and policy support for the development of projects. On the other hand, the government strengthens the "hematopoietic" function through innovative ecological construction. Under the organization of Yunnan Academy of Science and Technology, more than 30 high-level innovation institutions and downstream user units have been united to form a national collaborative innovation alliance around the digital R&D of rare and precious metal materials.

Through the aggregation of R&D resources, various innovative entities in the alliance have built the country's first high-throughput computing platform, high-throughput preparation and characterization platform, data platform for rare and precious metal materials, and have built a number of professional R&D institutions, which provides platform foundation and intellectual support for the development of the industry. Through the combination of "blood transfusion" and "hematopoiesis", Yunnan has been at the forefront in terms of technology and production capacity of rare and precious metal materials.

3.4 Governance framework of digital R&D in China

Based on the foregoing analysis, China's digital R&D governance framework mainly includes four aspects: data governance, organizational transformation, data empowerment, and multi-agent collaboration, which can be summarized as the structure shown in Figure 1. Among them, user needs are the orientation, which represents the starting point and purpose of digital R&D activities; Data governance is the premise and the primary task; data empowerment is the path and the focus of digital R&D construction; The agile organization is the guarantee, providing a matching organizational model for digital R&D; and multi-agent collaboration is the support, providing required resources for digital R&D activities.

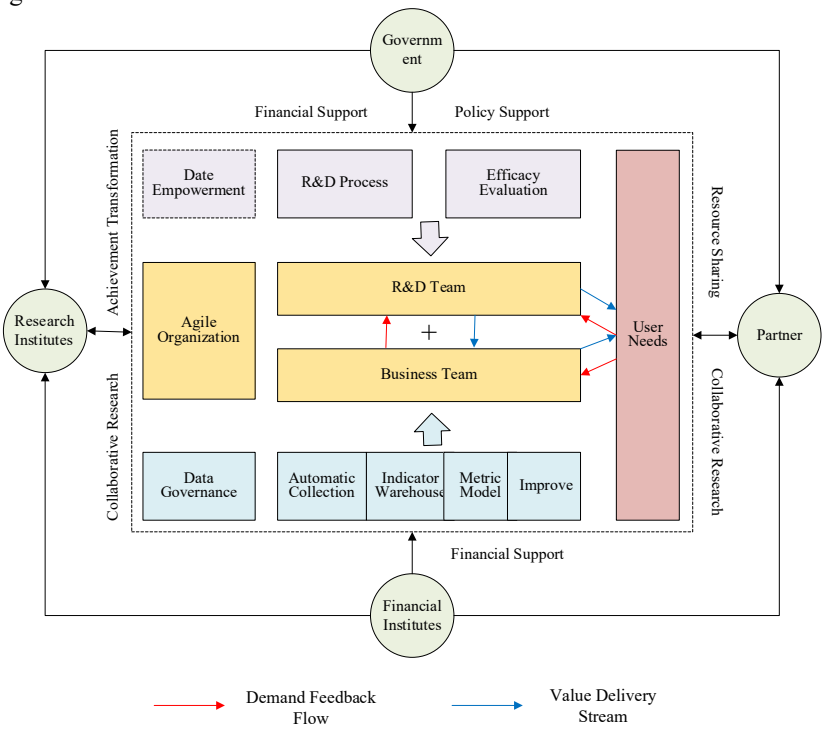

Fig. 1. The governance framework of China's digital R&D

4 Research conclusions and implications

At present, the digital transformation of R&D worldwide is in the exploratory stage and not yet mature. Leading practices from China's new energy vehicle, banking sector, and rare and precious metal material genetic engineering fields can provide novel governance inspirations: First, the system support for data governance must be strengthened. Enterprises conducting data governance should focus on top-level design and establish departments such as the Data Governance Committee to promote relevant work from top to bottom, break through the "data islands" between various departments, and moreover, enterprises should also comprehensively consider the data standard system, quality system, master data platform building, control rules, and regulations, etc; Second, it is necessary to establish an agile organization driven by user value, by exploring the form of deep integration between the R&D team and the business team, the agile organization can effectively support product iteration and meet consumer needs continuously and rapidly; The third is to realize the digital empowerment of the R&D process and R&D efficiency evaluation. Digital tools can make the process and results of R&D transparent and quantifiable, thus providing support for personnel collaboration in the R&D process and improvement of R&D efficiency; The fourth is to pay attention to the leading role of government departments, for basic research that requires a lot of resources in the early stage, the government can lead the R&D digital transformation through policy tools and special funds, and can also lead the establishment of innovation alliances to encourage resource sharing and capacity collaboration among innovative subjects.

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