

Study on the Impact Factors of Digital Transformation on Dual Innovation in Manufacturing Enterprises

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Abstract: Digital technology is rapidly becoming a new engine of business growth. Digital transformation of manufacturing enterprises is a must-answer question to transform production methods and promote high-quality development of manufacturing enterprises. Digital transformation can not only promote the deep application of digital technology in the whole process and field of manufacturing enterprises, cultivate new business models such as network research and development, personalized customization, and flexible production, but also improve the efficiency of resource management, thus promoting the development of exploratory innovation and utilization innovation of manufacturing enterprises. Exploratory innovation and utilization innovation differ greatly in terms of technology application, resource requirements and risks involved, and the impact of digital transformation on both of them cannot be generalized. Therefore, the analysis of the mechanism between digital transformation and dual innovation of manufacturing enterprises can not only provide practical experience for the linkage of dual innovation and digital transformation of manufacturing enterprises, but also provide suggestions for the government to improve the policy system, which has certain practical and theoretical significance.

1. Introduction

Under the traditional closed industrial system, the sales mode of manufacturing enterprises is mostly product-centered one-time sales, and the industry is also at the stage of homogeneous saturation, with certain restrictions on the value-added space. Due to its high innovation, strong penetration and wide coverage, the digital economy has become a new engine for China's high-quality economic development. Digital technology and data resources to empower internal process integration and business innovation capabilities have become an inevitable choice for traditional manufacturing enterprises to expand their value-added space. Digital transformation is gradually mapped to the production behavior of manufacturing enterprises [1], traditional manufacturing enterprises began to use digital technology to carry out all-round and whole-chain

transformation, improve total factor productivity, and play the role of digital technology to amplify, superimpose and multiply economic development. With the deepening of digitalization, single innovation behavior can no longer meet the needs of R&D and production as well as survival and development of enterprises [2], and dual innovation has become a necessary tool for industrial technology upgrading and market development [3]. The dual innovation of manufacturing enterprises includes exploratory innovation and utilization innovation, and the dual innovation of manufacturing enterprises based on digital transformation mainly includes: around quality change, digitalization drives the optimal allocation of production factors to improve product quality and energy efficiency; around efficiency change, digitalization drives the improvement of total factor efficiency and the high-speed operation of capital flow and data flow to improve the agile development capability of products and equipment; around power. Therefore, it is important to explore the influence factors of digital transformation of manufacturing enterprises on dual innovation.

Most of the studies on digital transformation in the literature have been based on the level of digital construction [4], the level of digital access [5], the level of digital application [6], and the level of digital platform construction [7] to measure the level of digital transformation in manufacturing enterprises. And most of the studies on the back-end variables of digital transformation of manufacturing enterprises are based on macro-level and micro-level. Studies at the macro level are based on employment, taxation, industrial structure, social innovation, and social equity [8]. Sovbetov (2018) used Internet penetration and credit card transaction rate to measure the level of digital transformation to study its incentive effect on female employment [9, 10]. Li (2023) found that the digital transformation of enterprises can improve the governance system of the digital economy based on the context of the "double cycle", thus optimizing the precise allocation and flexible placement of resources and ensuring the safe development of the industry [11]. Studies at the micro level are based on enterprise productivity, investment efficiency, organizational empowerment, corporate governance, and enterprise performance [8]. Gaglio (2022) analyzed micro and small enterprises in South Africa and finds that digital transformation in micro and small enterprises have a beneficial effect on labor productivity [12, 13].

The front-end variables of corporate dual innovation have been discussed in the literature in terms of the external and internal environments of firms. From the external environment, scholars have analyzed the impact of tax policies, market environment, government subsidies, and intellectual property protection on corporate dual innovation [8]. Kafouros (2015) suggested that the protection of intellectual property rights should be increased to promote the level of dual innovation by improving the R&D capability of firms [14]. Xu (2020) based on data from listed companies, showed that financial support and tax breaks have an incentive effect on both exploratory and exploitative innovation, but there are significant differences in the incentive effects [15]. In terms of internal environment, scholars have analyzed the front-end variables of dual innovation in terms of financing constraints, internal control, corporate governance, and risk taking [8]. Ayyagari (2011) showed that the diversity of financing methods and channels promotes the level of dual innovation [16].

There are comprehensive studies on the digital transformation of enterprises and the influencing factors of dual innovation of enterprises [17], but few studies have explored the impact of digital transformation on dual innovation of manufacturing enterprises based on the background of rapid changed in digital technology and the rapid development of digital economy [18,19]. Wang(2022) found that digital transformation has both "data-driven" and "capability curse" effects on the upgrading of innovation strategies, and that stakeholder governance due to performance surplus can strengthen both effects [20,21]. Xu (2022) showed that digital transformation enhances the dynamic capabilities of firms and promotes the level of dual innovation; this promotion is more significant

for capital-intensive firms and firms in competitive industries [22].

2. Factors Influencing Digital Transformation of Manufacturing Companies on Dual Innovation

2.1. Internal Factors

2.1.1. Financing Constraint

Financing refers to the monetary transaction means by which a firm raises capital to cover expenses that exceed its cash payment capacity [23], which is essentially the activity of pooling idle funds for investment with the help of financial institutions and business models [24]. The difficulty of financing has always been a problem for companies, especially in today's volatile external environment, and companies are unable to obtain sufficient funds for innovation activities, while most of the literature can argue that financing constraints can have a negative impact on companies' dual innovation activities [25]. The digital transformation of firms can alleviate the financing constraints of firms and thus facilitate their dual innovation activities, which can be discussed in the following aspects.

First, traditional manufacturing enterprises, supported by digital technology, can connect the production system and consumer Internet by building digital platforms, and reconfigure the production model, business model and operation model with the core of accurate consumer insight demand response and whole-life experience [26], so as to better meet the personalized needs of consumers and tap the long-tail market [27]. Thus the company can ensure smooth capital turnover, alleviate financing constraints, provide sufficient financial guarantee for exploratory and exploitative innovation activities, and effectively enhance the level of dual innovation.

Secondly, through the digital financial platform, manufacturing enterprises can establish interconnection with commercial banks and other institutions, so as to grasp the latest progress and project information of the dual innovation projects undertaken by enterprises in a dynamic, effective and timely manner, and effectively alleviate the cost of decision-making errors and risk costs caused by information asymmetry. At the same time, enterprises can improve their credit reports and view their credit information in a timely manner through the digital platform, reducing the cost of supervision and the moral cost of risk. Promote the integration of digital with the whole process of R&D innovation, establish innovation capability beyond traditional cognitive boundaries, and promote the innovation paradigm of R&D to data-based exploration [28], innovation bill discovery [29] and agile iterative development [30].

Finally, enterprises can make use of integrated manufacturing systems and information systems based on equipment and control processes, and also establish synergy of the whole industrial chain and value chain based on information systems to obtain financing channels and access to various proprietary innovation resources such as technology, knowledge and talents [24] and complementary innovation resources [31] by establishing links with stakeholders to maximize the utilization of enterprise resources. It also helps to ease financing constraints, enhance the conversion rate of innovation results, and provide important support for enterprises to carry out dual innovation activities.

2.1.2. Human Capital

Human capital is the carrier of knowledge creation and technological progress, and it is the key to improve the independent innovation capability of enterprises [32]. Due to its rapid development, wide range of radiation and deep influence, digital technology has gradually become an "incubator"

and "reservoir" for human capital, which continuously provides intellectual support for enterprises' dual innovation. In the process of digital transformation, manufacturing enterprises continue to release the kinetic energy of digital technology development and accumulate human capital, thus promoting exploratory innovation and utilization innovation.

On the one hand, manufacturing enterprises have gained wide attention from the government, schools and research institutes. The linkage of enterprises and universities to train talents, improve the whole chain of digital training, certification and recruitment services, and ensure a seamless match between jobs and talents, is not only important for the improvement of personal ability and long-term career planning and development, but also can form a closed loop between the supply side and demand side of technical talents [33], and build a multi-body, all-factor, industry-university-research collaborative innovation model through the effective integration of resources. On the other hand, the digital economy provides a broader structural space for human capital. As an important channel to solve employment, the number of jobs carried by enterprises will have a superimposed and cumulative effect, and this superimposed and cumulative effect will promote the full flow of labor. Manufacturing enterprises relying on digital technology development have broadened the development space due to the breakthrough of the limitations of traditional manufacturing enterprises, formed the advantages of low capital cost, low investment risk and mature operation conditions, and attracted a large number of high-quality innovative talents. Digital transformation enterprises use the platform as a carrier to integrate human, capital and other innovation elements, which stimulates the dual innovation vitality of enterprises, enriches the way of exploratory innovation and utilization innovation, and provides better support for the high-quality development of manufacturing enterprises [34].

2.1.3. Entrepreneurial Activity

Digital transformation can stimulate entrepreneurial activity through two channels: platform channel and factor channel [35]. First is the platform channel role path. In the era of digital economy, work can be refined into more processes which breeds many new entrepreneurial forms, especially the continuous innovation of artificial intelligence, Internet of Things and big data technologies have also brought certain changes to traditional industries. In this process, the radius of labor market and employment channels are broadened, the entrepreneurial space is greatly expanded, and the entrepreneurial activity is enhanced. The second is the factor channel role path. Enterprises use digital technology to complete the connection of people, equipment, systems and products of the whole element, the whole value chain and the industrial chain, and promote the high-speed circulation of data among different systems, different businesses and different processes. Based on data collaboration, we can complete the scheduling and sharing of resource elements through the Internet, thus enhancing the efficiency of resource allocation and improving entrepreneurial activity [36].

Increased entrepreneurial activity can promote dual innovation in enterprises, mainly in the following aspects: First, the core and essence of entrepreneurial activity is innovation. Startups, represented by SMEs, have strong innovation dynamics, and increased entrepreneurial activity can increase the number of startups and promote the transformation of scale innovation to scope innovation. Second, increased innovation activity can cultivate new industries and new models, build an industrial ecology with complementary advantages, efficient synergy and interactive symbiosis, drive cross-fertilization of cross-industry and cross-discipline emerging industries, and accelerate the landing of exploratory and exploitative innovation achievements of enterprises. Thirdly, the entrepreneurial activities in the region can build a multi-body innovation resource which provides a reliable path for local enterprises to obtain innovation resources, helps local enterprises to obtain external growth advantages such as technology spillover effects, creates a new

paradigm of dual innovation for enterprises, and forms a situation of mass innovation and innovation for all [35].

2.2. External Factors

2.2.1. Dynamic Competitive Environment

Studies have shown that companies can gain access to more heterogeneous resources at higher levels of dynamic competition, enhancing sustainable dual innovation capabilities and thus the ability to respond quickly to uncertainty. Companies should pay attention to market changes and adjust their digital transformation process accordingly. This paper considers the dynamic competitive environment as the environmental factor between digital transformation and dual innovation in manufacturing enterprises, specifically from the following aspects.

On the one hand, the uncertainty and chance of dynamic environment will enhance the demand of enterprises for market information, and enterprise managers need to collect enough information to reduce the cost of decision errors. Based on the perspective of dynamic capability, enterprises can complete differentiated information through digital transformation, collect user needs, improve products and services, stay ahead of competitors around customer value, continue to do well in user operation, service operation and continuously make dual innovation according to the environment so as to obtain sustainable competitive ability. From the perspective of organizational inertia, more external information can broaden the company's understanding, and multi-channel information access can reduce cognitive inertia, and the reduction of cognitive inertia can greatly reduce the obstacles related to dual innovation.

On the other hand, dynamic competitive environments are often the result of intense market changes as well as rapid technological developments. Innovations in technology and shorter production cycles have made digital technology the primary choice for manufacturing companies to reduce costs and optimize their products and services. When the dynamic competitive environment is high, companies need to invest more technology and capital to establish connections with partners in the value network to reduce risk, complete product innovation and technology iteration through exploratory innovation, and drive innovation in business philosophy, technology, organization, and management models.

2.2.2. Intellectual Property Protection

Intellectual property refers to the right to benefit from or transfer ownership of knowledge assets, such as the results of creation, to the knowledge creator. Manufacturing companies can take advantage of this multiplier effect by consolidating their technological leadership and extending the life cycle of their technologies through the exclusive use of intellectual property rights, so that they can better leverage this multiplier effect to complete their innovation and upgrade.

First, On the one hand, manufacturing companies undergoing digital transformation have a strong reliance on digital technology. Once a company invests a large amount of cost in a certain R&D area, it may be difficult to withdraw quickly due to the sunk cost, which will have a certain impact on the subsequent innovation and to a certain extent on the confidence of the company. It can help manufacturing enterprises build technological barriers to reduce the substitutability of technologies and provide technological support for exploration in frontier areas. On the other hand, due to the high risk and uncertainty of exploratory innovation, manufacturing enterprises, especially SMEs have a certain contractual governance function, which can effectively reduce the occurrence of illegal theft or forcible plundering of knowledge through a formal system to restrain the occurrence of unlawful behaviors in the market, and enterprises can use IPR protection to reduce

R&D spillover losses and thus focus on exploratory innovation. Thus, digital transformation can facilitate IP protection to further promote enterprise exploratory innovation.

Second, On the one hand, although exploitative innovation is the reuse of existing knowledge and technology, IP protection is essentially a monopoly that can suppress firms' ability to piece together and use information obtained from external sources, creating a resource dilemma for firms, which can inhibit exploitative innovation. On the other hand, IPRs can inhibit the sharing of knowledge and technology by limiting knowledge spillovers and technology diffusion. The dominant firms will not easily share their core technologies because they want to maintain their competitive advantages, while the lagging firms will not be able to obtain the latest market information due to the monopoly of knowledge, and will not be able to start R&D and production activities based on the information, thus being confined to the low-end market. Thus, intellectual property protection can inhibit exploitative innovation.

3. Conclusions

This paper analyzes the factors influencing digital transformation of manufacturing firms on dual innovation in terms of both internal and external factors. The results show that, from the perspective of internal factors, digital transformation enhances dual innovation by alleviating financing constraints and increasing human capital and entrepreneurial activity. From the perspective of external factors, digital transformation promotes dual innovation by enhancing the level of dynamic competitive environment, while intellectual property protection promotes exploratory innovation and inhibits exploitative innovation.

First, deepen the degree of cooperation between industry, university and research. Universities are gradually becoming an important force of scientific and technological innovation because of their strong scientific research and technology teams as well as scientific research platforms. In the cultivation of digital talents, the linkage between digital transformation enterprises and colleges and universities should be brought into play, giving play to both the scientific research and teaching ability of colleges and universities and the practical teaching role of digital transformation enterprises. The government should play its own guiding role, increase the depth and breadth of connection between universities and digital transformation enterprises, effectively build the bridge of school and enterprise, and enhance the ability of universities to deliver high-quality talents.

Second, the government should improve policies to provide enterprises with inclusive support. The government should precisely combine all kinds of targeted policy tools, give full play to fiscal and financial policies in the three aspects of realistic incentives, oriented signals and incentive regulation, realistic incentives through government subsidies, tax cuts and fee reductions to benefit digital transformation-related enterprises, oriented signals through the release of policy direction generation of social capital and social resources to the digital transformation field of the clustering and investment, incentive planning.

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