

Research on the Influencing Factors of Green Technology Innovation in Manufacturing Enterprises

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Keywords: Green technology innovation, Environmental regulation, Technology upgrading, Innovation system, Business management, Industrial upgrading

Abstract: Under the background of innovation leading development and ecological construction, green technology innovation of manufacturing enterprises is imminent. This study summarizes and summarizes the scholars' research on green technology innovation, and discusses the influencing factors of manufacturing green technology innovation, which are divided into internal driving factors and external driving factors. The internal driving factors include the construction of green innovation culture, enterprise R&D investment and technical level, enterprise scale and redundant resources. The external driving factors include government environmental regulation policies, regional financial support, foreign technology and financial support, and market environment. This study mainly analyses the driving factors of green technology innovation of manufacturing enterprises from a qualitative perspective, and puts forward suggestions from the level of government management and enterprise development, which provides theoretical basis and practical guidance for the government to build a green technology innovation system platform and enterprises to improve their green technology innovation ability, and has reference significance for government planning and industrial upgrading.

1. Introduction

Under the background of intelligent manufacturing technology, energy crisis and technology neck problem, Chinese government put forward in the '14th Five-Year Plan' that Chinese green technology innovation system should be market demand and supply-oriented, enterprises and local governments should accelerate the action of green technology innovation under the unified deployment of the central government, trying to improve the ability of green technology innovation in China. Fossil energy locked by traditional technology of Chinese industrial enterprises is highly dependent. In industrial transformation, green technology innovation has its unique ecological and economic significance. Green technology innovation is a new technology field proposed by the economic society in the face of natural resources and ecological environment problems and the

realization of sustainable development strategy. It is a new direction of industrial change. The pursuit of green technology innovation is to achieve a win-win economic development and ecological environment, which is conducive to the elimination of 'double negative externalities'.

The realization of green technology innovation is the improvement of enterprise innovation ability, which is beneficial to improve the energy consumption of enterprises and enhance the economic benefits of enterprises, and helps enterprises to shoulder the corporate social responsibility to protect the ecological environment. The state is committed to building a green technology innovation system, which is conducive to improving Chinese green technology neck problem and breaking green technology barriers. Market green consumption measures the level of market green technology. China needs to abandon the traditional technologies and paths with high energy consumption and high ecological pollution, actively explore the influencing factors of green technology innovation, and build and improve the green technology innovation system. Green technology innovation has been a research hotspot in academia and business circles in recent years. This study explores the influencing factors of green technology innovation from different perspectives by combing the existing literature.

2. Connotation and summary of green technology innovation

2.1. The connotation of green technology innovation

Foreign scholars Brawn and Wield put forward the concept of green technology and defined it as: Green technology refers to the production technology and manufacturing process which can reduce environmental pollution and reduce the use of raw materials and energy [1]. Scholars expound their understanding of green technology innovation from different perspectives. Pedro et al. (2004) [2], Cooke et al. (2010) [3], Zhang et al. (2012) [4] and other direct definition perspective based on Brawn and wiled thought that enterprise green technology innovation is technological innovation and process innovation to reduce environmental pollution and energy consumption in the process of producing green products. Shao et al. (2008) proposed from the perspective of product life cycle, green technology innovation refers to the product life cycle process from product design stage to waste recycling stage, committed to reducing product life cycle cost of green technology innovation [5]. Grazia et al. (2017) [6], Antonio et al. (2018) [7], Pang et al. (2019) [8], drew on the dual innovation theory, divided green technology innovation into exploratory green innovation based on knowledge and information and exploitative green innovation based on product structure innovation. Yang et al. (2018) [9], Huang et al. (2019) [10], Tian et al. (2020) [11] believed that the classification of green technology innovation should focus on the innovation objects, and innovation is aimed at the structure and production process of green products. Therefore, it is divided into green product innovation and green process innovation according to different innovation objects. Green product innovation refers to the creation or transformation of products with recyclable, low pollution, low consumption and replicable green new products. Green process innovation refers to the technical innovation of transforming production technology and process to improve quality and reduce energy consumption, and it is the extension innovation of lean production.

Based on the discussion and definition of the connotation of green technology innovation by scholars, this study defines green technology innovation as follows: Green technology innovation is an innovation behaviour that transforms the product structure and optimizes the production process to reduce production costs, reduce energy consumption and environmental pollution. Green technology innovation aims to resolve the energy crisis and environmental crisis and strive to achieve technological advancement. In order to realize the green development of the whole industry of intelligent manufacturing, green technology innovation should be based on the promotion of

green consumption, green design, green manufacturing, green packaging, green supply chain and green recycling. Only in this way can the green technology competitiveness of enterprises be improved to a certain extent. At the same time, the core meaning of green technology innovation lies in the technological innovation of green nature. The realization of technological innovation is conducive to breaking technical barriers, leading the green development of Chinese manufacturing enterprises, and making Chinese green technology level stand in the forefront of the world.

2.2. Summary of Influencing Factors of Green Technology Innovation

At present, it is in a critical period of energy transformation. The key for enterprises to improve their green technology innovation ability lies in exploring the influencing factors of green technology innovation. Academic discussion on the influencing factors of green technology innovation mainly from the social network theory, resource-based theory, overall perspective, decomposition perspective, planned behavior theory, knowledge-based view and other theoretical aspects. This study classifies the scholars' research on its influencing factors, mainly including the following: Market competition, multinational technology transfer, enterprise capital investment, enterprise innovation willingness, technology knowledge coupling network, market demand, government financial support, environmental regulation, enterprise internal management, enterprise scale economy, industry structure characteristics, industrial agglomeration, enterprise ownership structure. The following is a brief description of the influencing factors that many scholars pay attention to.

Yang et al. (2018) pointed out that the advanced green technology of multinational companies mainly transfers to other enterprises through technology spillover and other means. Technology spillover is conducive to technology discussion and accelerate the realization of green technology innovation among enterprises [9].

Huang et al. (2019) [10], Tian et al. (2020) [11] and Su et al. (2021) [12] start from the perspective of enterprise R&D funds to explore the actual impact of financial support of green enterprises on enterprise green technology innovation ability and innovation achievements. The most important resource dependence in the process of technological innovation is financial support and R&D personnel input. The R&D investment of enterprises is divided into internal R&D investment, foreign investment and government financial support. The research believes that financial support has a positive effect on the improvement and promotion of enterprises' green technology innovation ability.

From the perspective of knowledge transfer, Yu et al. (2019) explored the influence mechanism of the coupling effect of innovative knowledge on green innovation of manufacturing enterprises. The study finds that most of the green technology innovation of manufacturing enterprises is through the knowledge coupling of original technology and new technology. Green technology innovation is affected by enterprise redundant resources at the same time, and the influence of redundant resources on technology innovation is not gradually increasing with the level of redundant resources. It can be found that the green technology innovation of enterprises is gradual and is the coupling development of new technology and original technology [13].

From the perspective of market demand, Peng et al. (2018) divided market demand into domestic internal market demand and foreign external market demand under the background of resource-based industry, and believes that market demand encourages manufacturing enterprises to design and manufacture green products oriented by market green demand. For a large consumer group, enterprises should actively adapt to and lead the market green demand side development, actively explore green technology innovation and seize the green consumer market [14].

Through research, Lin et al. (2019) believed that the innovation and progress of green technology and the welfare brought about by the progress of science and technology are mutually reinforcing. Green technology innovation relies on the support of government policies and behaviors, such as government funding, financial subsidies, tax incentives and other financial support for green technology innovation enterprises. At the same time, enterprises are regulated by local government environmental protection policies [15].

At present, the academic discussion on the influencing factors of green technology innovation is more intense, which is the impact of environmental regulation on green technology innovation of enterprises. Villegas-Palacio et al. (2010) [16], Noailly et al. (2015) [17], Lu et al. (2020) [18] and Zhen et al. (2021) [19] believed that the regulation of enterprises due to ecological problems can be divided into market-oriented (incentive) regulation and command-control regulation. The realization of command-control regulation mainly relies on punitive policies such as pollution tax and pollution control cost; market-oriented regulation is regulated by market demand, and actively encourage consumers' green consumption to trigger market green demand so that enterprises are active or forced to carry out green technology transformation.

Some scholars put forward the theory of large enterprise scale advantage, and some scholars put forward the theory of small enterprise advantage and 'inverted U' type relationship. Based on the discussion of enterprise scale, Zhang et al. (2020) studied the efficiency of green technological innovation of enterprises, and believed that different enterprise scales would have different degrees of influence on enterprise technological innovation. He believed that there was a threshold for the scale of enterprises that promoted green technological innovation [20].

Zhang et al. (2020) [20], Li et al. (2019) [21], Liu et al. (2018) [22], and Yang et al. (2020) [23] from the perspective of industrial agglomeration, that low industrial agglomeration, enterprises tend to low-cost strategy, enterprise development focuses on reducing resource consumption in order to survive in the market competition; the vicious market competition caused by high industrial agglomeration will stimulate the willingness of enterprises to expand market share, improve product quality and reduce energy consumption, resulting in enterprises to increase R&D investment, improve business models, change financial capital financing and other ways to improve technology R&D capabilities, and adopt product differentiation strategy to carry out market competition.

2.3. Research Hotspots of Green Technology Innovation

In recent years, the academic discussion on green technology innovation focuses on the influencing factors of green technology innovation and the influence of green technology innovation on enterprise innovation performance, financial performance and ecological performance. From the above research review of influencing factors, it can be seen that enterprises' green technology innovation practice needs to explore the influencing factors that can promote enterprises' green technology innovation ability. Next, based on Yang's decomposition perspective, this study focuses on the distinction between manufacturing and high-tech enterprises and analyzes the influencing factors of green technology innovation, in order to contribute to the practice of green technology innovation and the development of green industry in China.

3. Influential factors of green technology innovation

Based on the discussion of scholars on the influencing factors of green technology innovation, this study divides the influencing factors of green technology innovation into internal driving variables and external driving variables.

3.1. Internal driving variables

3.1.1. Green innovation culture construction

Faced with foreign technology barriers and market environment, manufacturing enterprises to carry out green technology innovation is a long-term plan, it is necessary to integrate the green concept into the corporate culture. Enterprises in the production process firmly hold green design, green production, green recycling. Employees are in the first line of design, production and sales. R&D personnel integrate green concept into product and technology research and development is the first key to reflect the practice of green concept in enterprises. Manufacturing enterprises in the face of consumers' green demands, whether employees can properly answer is very important. The inheritance of enterprise green technology innovation culture is the key to write enterprise green technology innovation into enterprise strategy. The construction of green technology innovation culture of enterprises benefits enterprises in the long run.

3.1.2. Enterprise R&D investment and technical level

In the information technology era, financial support is the most needed for enterprise technology R&D. Studies have shown that corporate R&D investment affects the salary and R&D passion of corporate R&D personnel. Therefore, the most important thing for enterprises to determine green technology innovation is R&D investment and R&D personnel investment.

Due to the threshold effect of green technology, green technology R&D is based on the existing technology of enterprises, and the purpose of innovating green technology is achieved by coupling multiple original technologies or coupling the original technology with green new technology. The original technical level of enterprises affects the green technology innovation of enterprises from the technical level.

3.1.3. Enterprise scale and redundant resources

Due to the threshold effect of firm size on green technological innovation, it is necessary to correctly examine firm size and consider redundant resources such as redundant funds. When other enterprises in the same industry seek technical cooperation units, they will measure the scale of enterprises. Most of the technical personnel with excellent technical R&D potential will choose large-scale enterprises when looking for jobs to examine whether the redundant resources of enterprises can support the R&D needs of enterprises. Therefore, enterprise scale and redundant resources directly affect the enterprise green technology innovation ability.

3.1.4. Top leader support and enterprise structure

Enterprise green technology innovation requires multi-sectoral collaboration, which requires the support of senior management. The flat and boundaryless structure of enterprises in the era of knowledge and innovation is conducive to technological innovation. Such organizational structure not only does not dissipate enterprise resources, but also enables enterprise leaders to obtain the latest R&D information in a timely manner. Enterprise R&D post R&D personnel can communicate with enterprise sales, manufacturing, logistics and other departments in time, capture consumers' green demands and explore the green products of enterprises with competitive relations, so as to combine their own situation, consumer market and competitive enterprises to adopt green product differentiation strategy.

3.2. External driving variables

3.2.1. Government environmental regulation policies

Under the pressure of ecological environment deterioration, China has paid more and more attention to ecological environment protection since the 18th National Congress. China has formulated a strict environmental regulation bill on the external pollution generated by enterprises. The pollution treatment ability of 'three wastes' and sewage discharge reflects the energy consumption of enterprise manufacturing and production, and also reflects the low practical ability of green technology. The government internalizes external pollution by means of fines and sewage taxes. Enterprises with low utilization rate of green technology may therefore pay more fees. This prompted some enterprises to judge the national development trend independently, and actively seek ways and means to improve the innovation ability and utilization rate of green technology.

3.2.2. Regional financial support

Catalysed by events such as ZTE, chip barriers and Huawei's R&D of Huawei Kirin chip, the Chinese government has actively issued preferential policies to give tax incentives to technical enterprises that are striving to develop green new technologies and explore new energy sources that have a positive role in promoting energy conservation and emission reduction, and the financial sector provides a lot of financial support for this. At the same time, the market demand has greatly affected the employment direction of college students, and the high salary in the field of green technology has also attracted a large number of excellent talents. Enterprises actively carry out green technology innovation under government support and policy guidance.

3.2.3. Foreign technology and financial support

Since the reform and opening up, a large number of foreign capital has poured into China for investment. Green technology innovation not only needs a lot of financial support, but also needs advanced technology theory as the theoretical support. Foreign capital investment and technology spillover provide financial support and technical guidance for many technical enterprises in China. Under the pressure of high energy consumption and rapid rise of raw materials, manufacturing enterprises actively abandon the traditional technology route and technology lock-in, and strive to cooperate deeply with foreign-funded enterprises with high-tech and green production technology, so as to reduce product costs and improve the technological innovation ability of enterprises.

3.2.4. Market environment

Market-oriented green technology innovation needs domestic and foreign market demand as the background. The improvement of residents' living standards promotes residents' green consumption. From green living goods to green technology products, consumers not only require green products to be pollution-free, but also pursue low pollution and low consumption in the production process, which makes enterprises with high green technology innovation ability stand out. Under the pressure of consumers, enterprises actively follow the direction of market consumption, develop green technology, adopt green technology, adopt product differentiation strategy, and produce green products.

4. Conclusions and prospects

4.1. Actively build national green innovation system

Countries should actively build international and regional green innovation systems and actively carry out green technology innovation practices under national green technology guidelines. Green technology innovation should be market-oriented, closely linked to market green demand. The state actively organizes enterprises to eliminate green technology barriers, and strengthens green technology exchange and knowledge sharing among enterprises by establishing regional technology enterprise groups such as technology exchange centers, green technology development zones and high-tech zones. Strengthen the protection of green technology innovation patents and promote patent transactions to enhance the economic benefits of national green technology innovation.

4.2. Enhancing enterprises' independent innovation capability of green technology

Enterprises should actively explore market trends, market demand-oriented green technology research and development. Increase investment in green technology R&D, protect green R&D patent, but also actively pursue the feasibility of green technology and economic and environmental benefits. After the success of green production technology research and development, it is not far to pursue the application in practice and strive to improve the transformation efficiency of technological innovation, and not pursue the green of economic and ecological benefits. Enterprises should designate green development strategy, conduct green knowledge training for enterprise employees, and improve enterprise green technology innovation ability and green product service ability from the perspective of green human resources.

4.3. Deficiency and prospects

This study only analyses the influencing factors of green technology innovation of enterprises from a qualitative perspective, and does not conduct empirical research and analysis from the micro-level data of enterprises. In the future research, we will collect the enterprise level data of these influencing factors to explore the path and mechanism of their impact on enterprise green technology innovation ability.

Acknowledgements

This work is supported by Social Science Planning Fund Project of Liaoning Province (L21AGL014).

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