MULTI-DIMENSIONAL EFFECTS OF FINANCIAL DEVELOPMENT AND TECHNOLOGICAL INNOVATION ON GREEN GROWTH IN CHINA

By

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This study firstly examines the impact of financial development and technological innovation on green growth from three technical dimensions, using a sample set from 30 Chinese provinces from 2011 to 2018. Finally, this study explores and analyzes the dredging impact of the combination of financial development and technical innovation on the front and rear ends of the green growth route based on technological progress and floating population. The findings of the first objective show that the weakness of financial institutions destroys the original "dissipative structure" formed via comprehensive level of financial development and comprehensive level of technological innovation, which leads to the misallocation between the two subsystems, and this disharmony weakens the synergetic development and ultimately slows down or even degrades the evolution of the self-organizing system. When financial development exceeds a certain proportion of technological innovation, it will aggravate financial "vanishing effect". However, financial system innovation can not completely offset the harmful influence of financial overdevelopment on green growth. The empirical results of the second objective revealed that the local financial institutions' scale expansion significantly dampened green growth for the local area, while the effect is facilitated in the surrounding area. Local stock market size has a substantial beneficial role in green growth both in local and neighboring areas. Local technological innovation significantly boosts local green growth, but not significantly to surrounding areas. The adverse impact on green growth is exacerbated by the interaction between financial development and technological innovation. The results of the third objective indicated that the development of the financial institution scale will strongly contribute to green growth volatility. An increase in the stock market scale also can significantly contribute to green growth volatility. Besides, the synergies (interactions) between financial development and technological innovation can significantly moderate green growth volatility. Furthermore, financial development which is captured by the stock market indicator is shown to be substantially higher efficient in dampening green growth volatility than financial development covered by the financial institutions indicator. The fourth objective of the study indicate that the association between green growth (GG) and floating population (FP) is nonlinear when digital financial inclusion is the

threshold variable. To considerably increase green growth, output-biased technological progress needs more assistance from digital financial inclusion than input-biased technology innovation. From the point of view of "digitization + financial scale + inclusion", digital financial inclusion not only boosts the positive effect that technological innovation has on green growth, but also helps to reduce the adverse effect that green growth has on floating populations. This study has important reference significance for replacing old growth drivers with new ones, industrial structure upgrading, development model transformation and superior economic development at the present stage and offers a fresh theoretical foundation for promoting the sustainability, balance and stability of China's green growth.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN PELBAGAI DIMENSI PEMBANGUNAN KEWANGAN DAN INOVASI TEKNOLOGI TERHADAP PERTUMBUHAN HIJAU DI CHINA

Oleh

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Kajian ini mengkaji kesan pembangunan kewangan dan inovasi teknologi terhadap pertumbuhan hijau dari tiga dimensi teknologi dan mengambil sampel data daripada 30 provinsi China antara 2011 dan 2018. Akhirnya, artikel ini mengkaji dan menganalisis kesan perkembangan kewangan yang digabungkan dengan inovasi teknologi pada hujung depan dan belakang laluan pertumbuhan hijau berdasarkan kemajuan teknologi dan populasi yang bergerak. Hasil penyelidikan untuk tujuan pertama menunjukkan bahawa kelemahan institusi kewangan menyebabkan "struktur kewangan" yang dibentuk oleh tahap kewangan dan tahap yang bersepadu, yang membawa kepada pengedaran secara langsung di antara dua sistem itu. Orang seperti ini akan melemahkan perkembangan yang selaras dan akhirnya melambatkan evolusi atau mengecilkan perkembangan sistem kawalan diri. Apabila pembangunan kewangan melebihi bahagian tertentu inovasi teknologi, "kesan hilang" kewangan akan diburukkan lagi. Walau bagaimanapun, inovasi sistem kewangan tidak dapat mengimbangi sepenuhnya kesan buruk pembangunan berlebihan kewangan terhadap pertumbuhan hijau. Keputusan empirikal matlamat kedua menunjukkan bahawa pengembangan institusi kewangan tempatan mempunyai kesan menghalang pertumbuhan hijau tempatan yang ketara, di samping mempromosikan kawasan sekitarnya. Saiz pasaran saham tempatan memainkan peranan yang besar dalam pertumbuhan hijau di kawasan tempatan dan bersebelahan. Inovasi teknologi tempatan telah banyak menyumbang kepada pertumbuhan hijau tempatan, tetapi tidak banyak memberi kesan kepada kawasan sekitarnya. Interaksi antara pembangunan kewangan dan inovasi teknologi meningkatkan kesan negatif kepada pertumbuhan hijau. Hasil daripada Matlamat Ketiga menunjukkan bahawa pertumbuhan dalam skala institusi kewangan akan menggalakkan volatiliti pertumbuhan hijau. Pengembangan saiz pasaran saham juga akan meningkatkan turun naik pertumbuhan hijau dengan ketara. Di samping itu, sinergi (interaksi) antara pembangunan kewangan dan inovasi teknologi dapat mengurangkan turun naik pertumbuhan hijau dengan ketara. Selain itu, perkembangan kewangan yang dicerminkan dalam petunjuk pasaran ekuiti adalah lebih cekap dalam membendung ketidaktentuan pertumbuhan hijau daripada yang dilindungi oleh petunjuk institusi kewangan. Untuk meningkatkan pertumbuhan hijau secara

signifikan, kemajuan teknologi yang berorientasi kepada output lebih memerlukan bantuan industri kewangan digital daripada inovasi teknologi yang berorientasi. Dari perspektif "Digital + Financial Scale + Industrialization", kewangan digital tidak hanya meningkatkan peranan positif inovasi teknologi terhadap pertumbuhan hijau, tetapi juga membantu mengurangkan kesan negatif pertumbuhan hijau kepada penduduk yang bergerak. Kajian ini mempunyai makna yang penting untuk memetik transformasi dinamik baru dan lama dalam pembinaan ekonomi pada peringkat ini, peningkatan struktur industri, perubahan cara pembangunan, dan pengoptimuman pembangunan ekonomi, dan menyediakan asas teori baru untuk mempromosikan kelestarian, keseimbangan dan kestabilan pertumbuhan hijau China.

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LIST OF ABBREVIATIONS

UPM	Universiti Putra Malaysia
GG	Green Growth
GDP	Gross National Product (Nominal)
VGG	Volatility of Green Growth
FP	Floating Population
FDS	Scale of Financial Institutions
STO	Scale of Stock Markets
TI	Technology Innovation
FDCI	Financial Development Composite Index
TICI	Technological Innovation Composite Index
RFT	Ratio of financial development and technological innovation
VST	The Scale of Stock Market
NPA	Technological Innovation
IBTP	Input Biased Technological Progress
OBTP	Output Biased Technological Progress
DFII	Digital financial Inclusion Indicator
INVE	Investment
HC	Human Capital
INC	Income
POP	Population Growth
MAR	Marketization
URB	Urbanization
OPEN	Trade Openness

ER	Environmental Regulation
ERI	Environmental Regulation Index
IND	Industrialization
FDI	Foreign Direct Investment
IFL	Inflation

CHAPTER 1

INTRODUCTION

1.1 Chapter Description

This chapter firstly describes the historical background, presents the status and the significance of green growth in China. Secondly, this chapter illustrates the mechanism of financial development and technological innovation on green growth. This chapter also gives the relationship between digital financial inclusion and the green growth path. Thirdly, this chapter also expounds the denotations of green growth, financial development and technological innovation, as well as their current development trend in China. In addition, this chapter presents the problems statement, research objectives and research significance. Finally, this chapter provides the overall organizational structure of the thesis. In conclusion, this chapter briefly outlines the framework of this study.

1.2 Background

1.2.1 Development Background of Green Growth

In the face of the obstacles posed by resource depletion, contamination of the environment, and ecological disasters to economic development, whether "green growth" development strategy can stimulate weak economic growth and solve the problems brought by environmental and ecological deterioration to peoples living environment has become an important topic recently (Ploeg and Withagen, 2013; Melnyk et al., 2020; Jakob and Edenhofer, 2014; Borel - Saladin and Turok, 2013). Through the industrial revolution, human beings have made great improvement in productivity, so the material living standards of human beings have also improved rapidly (Ćwiklicki et al., 2020; Rotatori et al., 2021; Nuha and Afandi, 2022). However, people focus on enjoying the huge material civilization they created but ignore the cost of serious damage to the ecological environment, and the natural environment is quietly causing anti-macrophage to human beings. The deterioration of ecological environment is undoubtedly a warning to the extensive development mode of human behaviour (Nettle, 2009; Sullivan et al., 2017; Bieg et al., 2017).

At present, the global ecology has been severely damaged (Legge et al., 2022; Wang et al., 2022). Soil erosion and desertification are expanding, and the forest area is decreasing sharply, the supply of fresh water is insufficient. The global surface soil loss is estimated about 25 billion tons per year. Referring to the "Food and Agriculture Organization of the United Nations" in 2019, 202 km of the world’s forests are destroyed every minute for various reasons (Brassard et al., 2022). According to the World Bank’s study in 2019, freshwater resources available to humans are scarce, with less than 2000 m^3 of renewable water resources per capita in 22 countries worldwide. At the same time, environmental contamination is also growing more severe (Boyce, 2007; Jackson, 2001). It is estimated that more than 2 trillion tons of pollutants are produced worldwide every year. According to the World Resources Institutes' study "Let Choice Continue" in 2019, the current rate of extinction of mammals and birds on earth is 1,000 times that of nature. At this rate, 1% of global species will be lost annually over the next 20 years, and nearly 150 species will become extinct every day on Earth. The increasingly serious problems of ecological environment trigger human reflection on industrial civilization and the relationship between humans and nature.

Since the 1960s, with the rapid progress of industrialization, environmental pollution has become more severe by the industrialized countries, and human beings have gradually realized the seriousness of environmental protection (Sharma et al., 2021; Usman and Balsalobre-Lorente, 2022). Therefore, some western scholars began to study the causes and solutions of environmental pollution. The "Silent Spring" published by Carson (1962) is the first to put forward about the impact of the development of science and technology on human progress, but also brought unexpected negative impact. In 1972, Meadows (1972) published "The Limits to Growth", which proposed the limits of the earth and the limits of human society progress and questioned growing development model of human society pursuit. Pearce et al. (1989) first proposed green economy in "Blueprint for a green economy".

In the China Human Development Report (2003), the view of "green development" was explicitly put forward. The report explains that China's environmental problems are the main factors affecting future development, and the solution is to practice green development and realize the simultaneous development of economy and environment. In 2005, the Fifth Asia-Pacific Conference on Environment and Development provided "green growth", which is to prevent environmental degradation and ensure the sustainable utilization of natural resources. After the 2008 world financial crisis, the United Nations Environment Programme (UNEP, 2012) proposed to develop "green economy" and achieve "green recovery". At the "Rio +20" Summit Held in 2012, the new direction of global economy growth is confirmed as "developing green economy" (Barbier, 2012; Loiseau et al., 2016), and the global economy should be transformed into a green economy development model.

The Second United Nations Environment Assembly, held in Nairobi in May 2016, highlighted sustainable development agenda with a focus on global environmental governance and green development, inclusively through carbon emission reduction, resource efficiently use, lifestyle changes and preservation of the Earth's ecosystems. The OECD (2017c) also notes that the current path of economic development holds some threat to the foundations of long-term economic development. Therefore, world leaders as a whole should adopt a resilient and inclusive green growth approach as the economic development policies (OECD, 2017b).

Green growth emphasizes a comprehensive manner of economic growth that combines economic growth with environmental protection (Hettige et al., 2000; Zhou et al., 2021). When developing the economy, it emphasizes the improvements based on production and consumption patterns that increase social welfare, increase employment, improve physical health and achieve efficient resource allocation (Glavič and Lukman, 2007). Current theories of green growth extend the model by adding natural resources and social capital to Ramsey (1928) models (Song et al., 2019; Quaas and Smulders, 2017; Dinda, 2014). In the 21st century, many scholars have studied green growth. According to classical growth theory, any production need to invest material and human capital (Solow, 1956). According to this theory, natural resources and environment are regarded as material capital (Hallegatte et al., 2011), but the negative externality of environmental resources is neglected. Pearce et al (1989) explicitly proposed the concept of a "green economy " for the first time in his "Blue Book" on the Green Economy, and he argues that economic growth should not exceed the limit of natural resources reserves, otherwise the growth of economic volume will cause permanent stagnation of economic growth due to the depletion of resources. The main points in the book lay the foundation for the study of green development theory. In the same year, the term "green growth" was firstly proposed by Colby (1989), followed by Barnes (1998) and Goodstein (1996).

In general, the connotation of green growth is relatively narrow, because it only refers to the increase of social wealth, which is a quantitative concept (Weng et al., 2020; Barbier et al., 1987). However, green development covers a wider range, including the coordinated development of many levels of society, such as green travel, green production, green finance, green building, green consumption and so on, which is a dual concept of quantity and quality. In this study, green growth is studied from three perspectives: economic growth, resource conservation and environmental protection. Green economy aims to realize economic transformation, promote the improvement of social welfare, and significantly reduce environmental and ecological threats. However, green growth seeks to achieve sustainable economic growth with the incorporation of natural capital into national accounts (Endl and Sedlacko, 2012). Reilly (2012) gives an explanation of the three objectives of green growth: "economic growth, job creation, and reduced environmental impact".

1.2.2 Status of Green Growth

Considering China's national conditions, green growth has different characteristics in China. China is a country with a wide area and abundant natural resources, but the main per capita resources are far lower than the world per capita resources, and the distribution is uneven. Rapid economic growth has resulted a "Chinese miracle", but the growth pattern of high investment, high consumption and high pollution is difficult to sustain (Zheng et al., 2019; Fan et al., 2017). According to the data of Bureau of National Statistics, China's overall GDP surpassed 99 trillion yuan in December 2019, with a per capita GDP of 70,892 yuan, surpassing the $10,000 threshold for the first time. China's engineering institute experts estimate that by year 2040, China's annual energy consumption will increase to 3.0-3.8 billion tons of standard coal, and by year 2050, the annual domestic energy supply will increase to 3.2 billion tons of standard coal. The Chinese government proposes to take green development as the main development mode of ecological civilization construction, which reflects the great importance China attaches towards ecological civilization.

China urgently needs to realize the green transformation of growth, that is, to achieve resource saving and environmental improvement as far as possible while considering economic growth (Vazquez-Brust et al., 2014), to get out of a development path of innovation, coordination, green, openness and sharing, and then promote green development and build a clean environment of China. The core of the "beautiful China" is to achieve resource conservation and environmental friendliness, and the essence is sustainable development, but the embodiment is green economy. The green growth is the inherent requirement of realizing "Beautiful Chinese Dream" and "Healthy Ecological Environment". Green economy is a new type of economy under the influence of sustainable development theory, and capital accumulation, technological progress, human capital, knowledge innovation, and environmental pollution are its important components. Based on the 2019 China Environmental Statistics Yearbook, carbon emissions per 10,000 yuan of GDP decreased by 4.1 %; clean energy consumption increased by 1.3 %; the number of days of good air quality was 82 %. From these figures, China is actively promoting green development and has achieved certain results, but it will still take some time to accelerate the green revolution of economic development.

However, due to the significant regional differences in China’s geographical and natural conditions, human customs, social and economic conditions, and the level of scientific and technological development, the degree of dependence on natural resources, environmental awareness, financing channels of enterprises, pollution control technological level, industrialization level and urbanization process in various regions also have heterogeneity, which eventually leads to great differences in the development of green economy. The present situation itself is an important realistic background for China to practice the green development mode and build ecological civilization. The National Bureau of Statistics issued "the 2016 ecological civilization construction annual evaluation results bulletin" for the first time and published the 2016 provincial green development comprehensive index with a total of 56 evaluation indicators.

Figure.1.1 shows the 2016 green development index. Future quantitative study on China's green development will be greatly aided by the publication of this index. It not only provides a reference for scholars to build a green development index system, but also provides a data basis for investigating the variables affecting green development. The data in the figure shows that there is significant provincial heterogeneity in China's green development index. On the whole, the green development index decreases from the southeast coast to the northwest inland, which is closely related to the differences in natural resource endowment, economic development level, technological innovation level and industrial structure between regions in China.

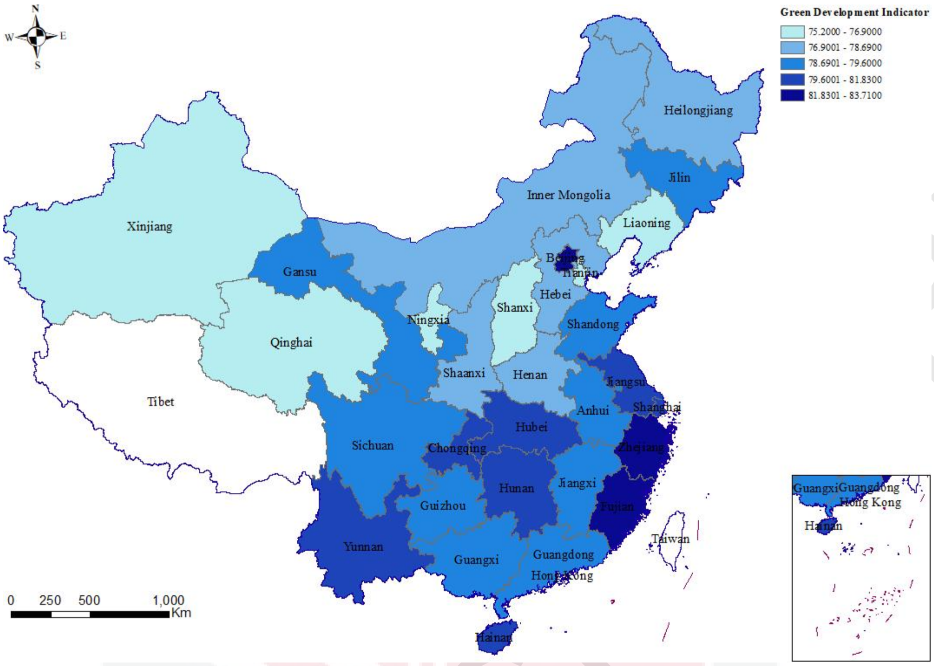

Figure 1.1 : Green Development Index in China (2016)
(Source: Author's computation using ArcGIS using the data from National Bureau of Statistics)

The southeast coast has gathered the most abundant human capital, material capital, political and cultural centers, financial centers and scientific research institutions. Most of the high-tech industries in the country are located here, enterprises have unique regional advantages, have a good financing environment, and introduce the most advanced technology at home and abroad to carry out enterprise reform. In addition, the state's environmental performance evaluation and supervision of local governments and enterprises in the southeast coast is stronger than that in the remote areas of the northwest, thus reducing the environmental and external uneconomic behaviors of local governments and enterprises.

Green Road — China's Economic Green Development Report (2018) evaluated the green development path of 31 provinces and 100 cities in China by collecting data from 2015 and 2016 and calculating the green development index of provincial and urban scales. Compared with the Green Development Index released, the report highlights the coordinated balance between green and the economy (Shi and Xu, 2018). The evaluation results of the report show that the green development of China is unbalanced. The comprehensive score of green development is gradually decreasing from southeast coast to northwest inland, and the advantage of green development in eastern coastal area is obvious, so the high value provinces and cities are mainly distributed in coastal areas, while the low value provinces and cities are mostly distributed in the northern inland areas. In the provincial level, Zhejiang, Guangdong and Jiangsu are ranked the top three, and in the urban level, Shenzhen, Hangzhou, Beijing, Guangzhou and

Shanghai are ranked top five. In addition, the development of green economy shows the characteristics of obvious short-board constraints, the disharmony between economic development and sustainability, and the conflict between negative externalities of spatial agglomeration and sustainability. Figure 1.2 presents the green growth composite index measured applying the Entropy Weight Method (EWM) according to annual panel data comes from China's 30 provinces in 2018. The figure shows that China's green growth does have the characteristics of spatial imbalance and presents a decreasing trend in the northwest inland compared to the southeast cost.

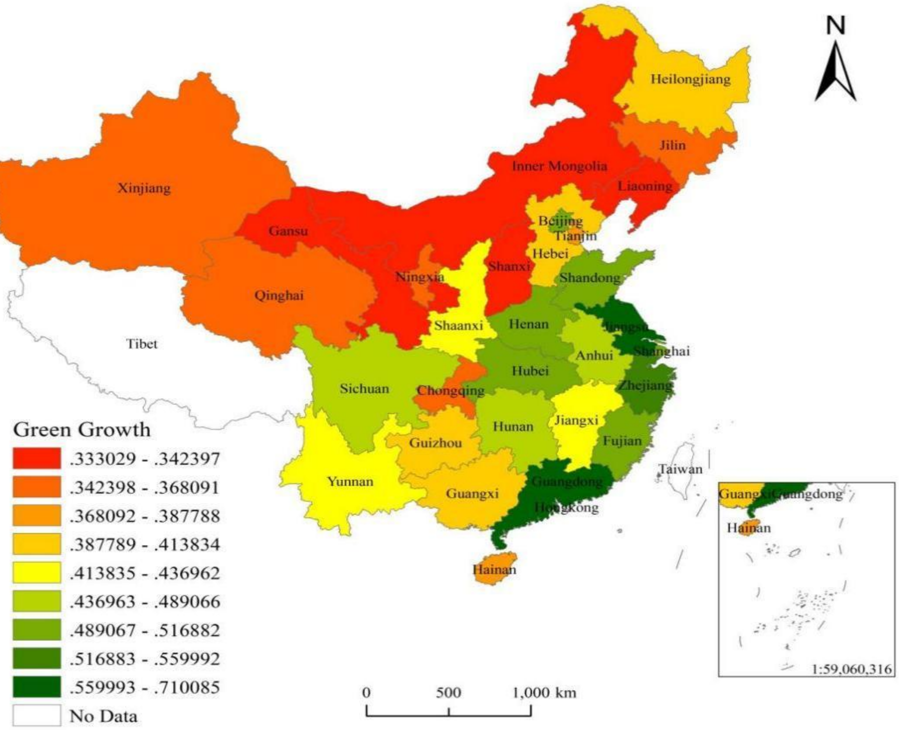

Figure 1.2 : China's Green Growth in 2018
(Source: Author's measurement using ArcGIS based on the index of Green growth measured using EWM. The color reflects the intensity of the change in the green growth index)

In addition, the stability of green growth is tested from a dynamic perspective. Because of the complexity of performance evaluation in green economic development and the lack of an effective monitoring mechanism, the interests of various subjects are affected in the concrete implementation process, which leads some local governments to purely compete for GDP growth rate (Lin and Zhu, 2019), and fiscal decentralization cannot make full use in promoting the growth of green economy. In addition, there are some small and medium-sized enterprises (SMEs) because lack of funds then cannot improve the production technology, thus these kind of enterprises have to conduct high energy consumption, high pollution mode of production. As a result, resulting in unsupervised external environmental uneconomic behavior. The stability of China's energy conservation and emission reduction efforts has an influence on stability of green growth. Xie and Liu (2019) found that the first lag term of green growth has the promotion function to the green growth in this period. However, the second lag term have inhibitory effect on green growth. This indicates that China's green growth is growing in a volatile state. Figure 1.3 reveals that green growth volatility presents an fluctuating upward trend.

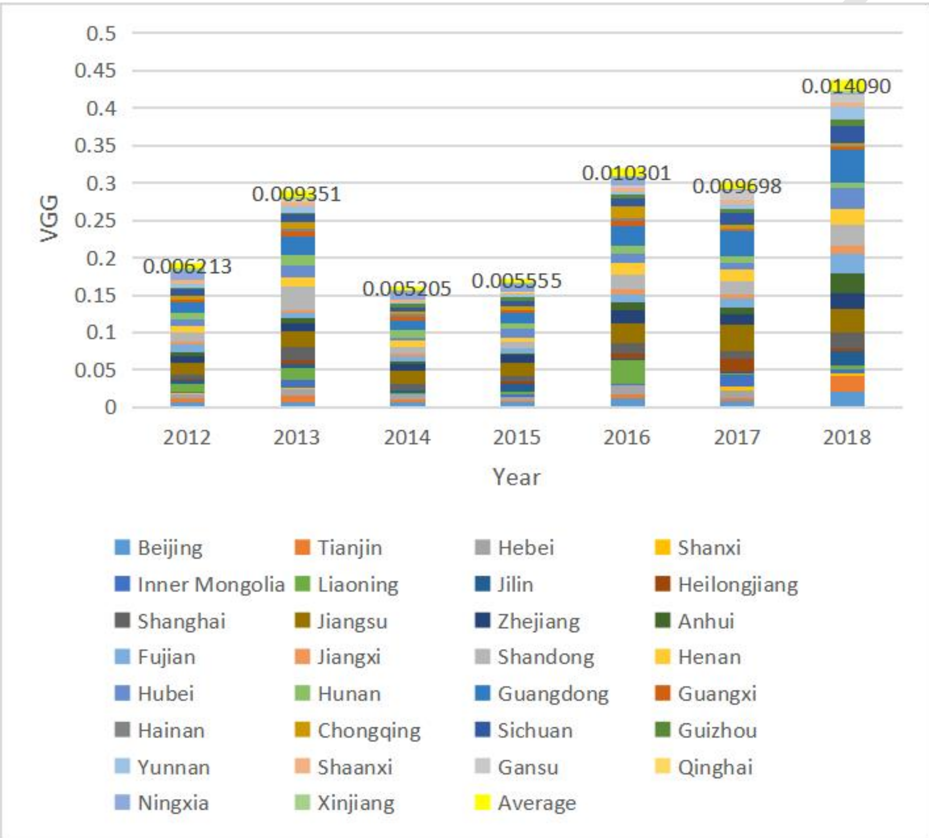

Figure 1.3 : Volatility of green growth (VGG) during 2011-2018
(Source: Author's measurement based on the data of the the volatility of green growth that calculated using two-year moving standard deviation of green growth)

According to Pan et al. (2019), the contribution of financial development and technological innovation to energy intensity will grow in the short run but will decrease in the long run. This trend is expected to occur in both the developed and developing worlds. Farhani and Solarin (2017) demonstrated that financial development lessen the need for energy, but real GDP and capital can reduce energy consumption in the long run, and FDI can boost energy demand in a short period of time. Therefore, to carry the concept of green development through the whole process of economic development and promote the construction of ecological civilization, we should emphasize the growth of green economy from the perspective of space and time. In the scientific formulation of regional green development policy measures, we must first understand the spatial and temporal pattern of green development in China in recent years, and investigate in great detail the impact that economic growth and innovation might have on the progress of green development in a variety of places. At present, green competitiveness has become an important bargaining chip for introducing financial capital and upgrading industrial structure. It has become an important research topic to explore the temporal and spatial characteristics of green development.

Figure 1.4 shows that in the period 2011–2017, the total amount invested in the successful treatment of industrial pollution in each of in 30 areas. From the perspective of time series, there has been an increasing tendency in the total amount of investment in the finished treatment of industrial pollution. There is significant heterogeneity in the data of each province.

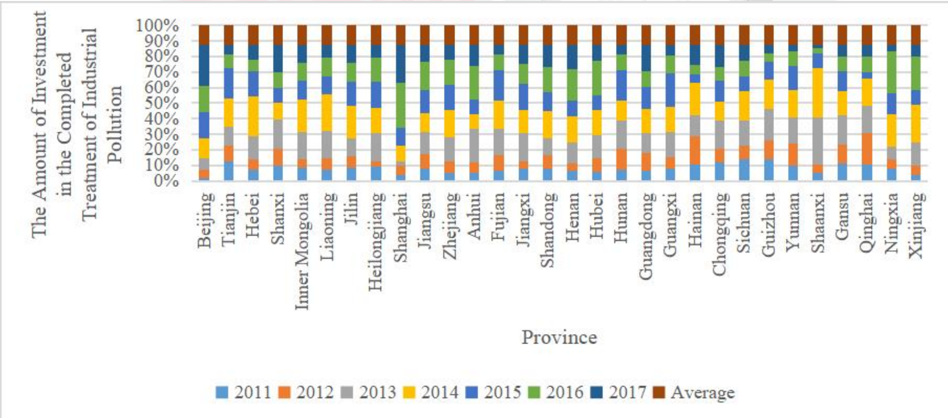

Figure 1.4 : The amount of investment in the completed treatment of industrial pollution (Yuan)
(Source: Author's computation from National Environment Statistics Yearbook in 2019)

1.2.3 Green Growth Path Based on Technological Progress and Floating Population

To encourage the high-quality economic growth and speed its green transformation, the government must eliminate the hurdles on the path to green growth (Herbig et al., 1994). However, the green growth path may face both front-end and back-end obstacles. Firstly, China may need to solve the front-end obstacles from technological progress, which is considered to be an important endogenous variable to promote economic development (Romer, 1990), and it is also an indispensable factor to optimize the environmental quality. However, the rapid economic development benefits from sufficient labor and natural resources. Under the mode of labor and resource driven economic development, the production sector has a low rate of technical innovation and a high rate of energy usage, high pollution emissions, low productivity, and needs to pay high human costs. Therefore, China's green economic transformation process is also the transformation process of the driving force of economic development. However, China still faces many problems in the process of transforming old and new driving force. For example, producers' awareness of environmental protection is weak and lack of funds, national supervision is weak, and there is a lack of effective monitoring technology for energy consumption and emissions indicators. One of the biggest problems is the problem of funds.

Secondly, green growth not only has a short board of front-end thrust, but also may have friction at the back-end, such as the reduction of floating population. The reduction of floating population may lead to the loss of potential demographic dividends, thereby inhibiting economic growth. Therefore, in terms of scale, it may eventually inhibit green growth. However, this side effect of green growth is rarely concerned by scholars. The main reason for this phenomenon is that in the process of green development, the state's environmental supervision of enterprises may make enterprises face environmental pressure, resulting in enterprises following the cost principle to reduce employment, or even close down. The number of the accompanying floating population will also decrease accordingly. Therefore, the fundamental reason is that the current resource allocation efficiency of China's finance is not high, which can not cover the traditional backward firms in the "long tail" market, resulting in financing pressure for such enterprises in the face of environmental compliance issues. As a side effect of green growth, it will in turn affect green growth itself, so this study is also worthy of attention.

1.2.4 Status of Financial Development

The universal definition of financial development in the world is that the dynamic process of the expansion of financial assets is accompanied by the improvement of financial institutions and financial market efficiency enhancemnet, meanwhile, the financial system is constantly optimized (Stolaric and Florida, 2006). As the representative of financial structure theory, Goldsmith (1969) noted that financial development is a shift in financial structure. Alterations to the structure of the financial system, which may include alterations to financial instruments and institutions. The changes of financial instruments and financial institutions refers to any kind of change in their type, nature, quantity and proportion in the market. Generally, financial structure changes are measured by financial correlation (FIR). Financial correlation rate is the proportion of the growth of the financial superstructure and the total amount of national economic activities. The commonly used calculation formula is financial assets / GDP, indicating the degree of economic monetization.

In terms of financial development, China's economic size continues to increase. Based on the information published by Financial Market Development Report (2019) in China, there was a 4.36 times rise in the percentage of domestic deposits and loans made by financial institutions to the total GDP from 2011 to 2018. Total financial institution financing at the end of 2018 was 313,819.24 billion yuan, which is 6.43 times of GDP. The loan balance was 136.3 trillion yuan, increased about 13.5% compared to the same period last year. During the period of 2011-2018, the gap between deposits and loans increased to a total of 8,366.34 billion yuan, from a previous level of 3,928.84 billion yuan. The increase of deposits in financial institutions shows the increasing level of residents' income, and the increase of loans from financial institutions shows the vitality of China's economy. However, China's deposits are growing faster than lending based on the data released. The increasing difference between deposit and loan indicates that the efficiency of the financial system is low, and the conversion rate of savings and investment is not high. As a result, the primary objective of China's effort to revamp its financial system is to raise the rate at which savings are converted into investments. Through looking at the China Financial Yearbook, this study found that the balance of broad money supply (M2) at the end of 2018 already 182.67 trillion yuan, increased 8.1% from the same period last year. The rise in loans to the actual economy was 19.6 percent, or 15.67 trillion yuan, compared to the same time previous year. This means that the reform of the financial system from virtual economy to real economy has achieved some results. In addition, by the August 2019, the total amount of social financing was 216 trillion yuan, year on year growth of 10.7%, still larger than the economic increment of 6%, but compared with the social financing history of the highest increase of 35% year-on-year, it is still at a slower growth stage.

Second, the contradiction between supply and demand of funds in China's market is prominent. In recent years, SMEs and small and micro enterprises have developed rapidly, but they are facing with the problem of financing difficulty, especially for SMEs. Referring to the information disclosed by the Central Bank of China, at the end of 2018, there are 9,200 individual industrial and commercial houses, including small and microbusinesses in China, and their number accounted for 90% of the total, the contribution rate to the GDP was more than 60%. Moreover, these enterprises are responsible for more than seventy percent of the technical advancements that have been made. However, because of the low valuation, high uncertainty and high risk of investment return, many enterprises are excluded by the high credit threshold of bank financial institutions. By year's end in 2018, the loans of small and micro enterprise were about 26 trillion-yuan, only 19% of the total loans. SMEs with registered capital less than 10 million only have the loans about 3.34 trillion-yuan, accounting for 4.5% of all industry loans, but the corporate loans granted to small and micro enterprises is gradually increasing, with an increase of 35.2% compared with the end of 2017. The data of the Central Bank in China for 2018 show that the small and micro loan enterprise in the southeast coastal area is more developed. However, at the end of 2018, the total amount of loans from financial institutions in China accounted for 1.5 times of GDP and continued to rise. This suggests that a lot of capital is not going into the real economy, but it is circulating within the financial system, which is not only intensifies the contradiction between the supply and demand of funds, but also accumulates financial risks.

Moreover, financial capital has long been skewed towards the state sector. Most Chinese financial institutions are state controlled. Since 1990, according to the WIND database, the non-performing loan percentage of banks has remained constant at 22 percent, threatening the integrity and security of the whole financial system. For one thing, because state-owned financial institutions and SOEs belong to the same ownership structure, they will unavoidably support the development of state-owned enterprises in response to national policies. For the another thing, due to the low valuation, high risk and strong concealment of information of SMEs, financial institutions have increased the sentiment to cherish loans, leading to the problem of high financing threshold for these enterprises. However, on a more positive view, In recent years, China's financial system has been improved, leading to the fast growth of direct funding techniques. At the end of 2018, the net financing of corporate bonds was 2.48 trillion yuan, increased 2.03 trillion yuan over the same period last year. China's bond market stock in 2018 ranked third in the world, green bond market ranked first. China's multi-level capital market has developed rapidly, and the overall leverage ratio of society has a downward trend, but in recent years, the stock market of China fluctuates violently, practical progress has not been achieved in reforming the stock issuance system. Therefore, stock market reform will be a pressing issue in the financial system reform.

At present, finance-technology is continuously integrated (Yang et al., 2013). New financial products, financial instruments and financial technology are constantly emerging. The rapid development of financial innovation in China has provided an important driving force for deepening financial reform (Merton, 1996). The innovative application of financial technology in business has provided an vital role in advancing the emergence of inclusive finance and addressing SME financing issues, and made up for the shortcomings of traditional finance. Based on the data released by the Peking University Digital Inclusive Financial Development Index report (2019), the average Digital Inclusive Financial Development Index in 31 provinces increased from 40.0 to 300.2 from 2011 to 2018. However, during 2012-2017, while the financial innovation is booming, the bank's non-bank creditor's rights (bank finance companies) increased from 5 trillion yuan to 28.5 trillion yuan (Cao et al., 2020; Ye et al, 2021). This issue prompts this study to consider whether there is financial innovation or inefficient innovation in China, thus exacerbating the financial bubble. In addition, there is a lag in the supervision of Internet finance, resulting in some confusion, but under the special regulation, the number of online lending institutions has declined. At the end of 2018, the balance of personal loans in the Internet industry fell 22.7 % from a year earlier, decreased about 63.3% compared to 2017.

In addition, the financial leverage ratio of Chinese enterprises is high (Guo et al, 2021). On the one hand, the enterprise development in China focuses much on scale development, expanding the scale of assets through various financing channels, and focusing on exogenous financing. In addition, the phenomenon of "Shadow Banking" intensified leverage. At present, in China, where banks are leaders in the financial sector, and banking development scale has been maintaining a growth trend. However, some of the bank's assets skipped financial regulation into the bottom, and banks increased the leverage of the financial sector by turning deposits into financial products and working with non-bank financial institutions to make financial products turn into the bottom assets through layers of nesting. The total assets of the banking sector in August 2019 were 272 trillion yuan, of which only about 1/2 of the assets entered the entity industry, so it is still very difficult to deleverage. Since 2018, China's macro leverage ratio has further declined, structural deleveraging has achieved initial results. According to the China Financial Stability Report (2019), the level of total leverage in China fell to 249.4% by the end of 2018, continuing the trend of fluctuation and decline since the end of 2017. Among them, the leverage ratio of the non-financial enterprise sector fell significantly, from a peak of 157.8% in the first quarter of 2018 to 152% at the end of 2018. At the end of 2018, the government's legal debt risk was 37.1%, although it has declined, the leverage ratio of various sectors in China still has structural problems.

In addition, there is a regional imbalance financial development, but the coordinated development between regions has achieved some results in China. The Operation of regional banks (2020) in China stated that, the overall economic operation of various regions in China is stable, and China's various regions have achieved certain results in insisting on the complementarity of resources between regions to achieve coordinated development. What's more, China's inter-city financial co-development trend is good in 2019. The structural supply-side reforms of the financial industry have achieved some results and continues to promote the financial industry to serve the real industry. The datasets show that in 2019, the growth rate of loans in the eastern, central and western regions decreased 0.6%, 0.3% and 1.2%, respectively from the end of last year, while northeast China rose 1.4% compared to the end of last year. The capital adequacy ratio of corporate banks in the eastern, central and western regions increased by 0.3%, 0.1% and 0.7%, respectively from the end of last year. Also, the non-performing ratio of financial assets in the eastern, central and northeast regions decreased 0.15%, 0.26% and 0.05%, respectively compared with the beginning of 2019, while the western region increased 0.39% compared with the beginning of the year. Bond financing environment industry has improved significantly.

Figure 1.5 shows the added value of the financial industry in 30 provinces from 2011 to 2018. The figure shows that from 2011 to 2017, the added value of the financial industry increased significantly. However, there are great differences in the added value of the financial industry between provinces. Among them, Beijing, Shanghai, Guangdong and other southeast coastal areas have the most added value of the financial industry, while the northwest inland areas have the least.

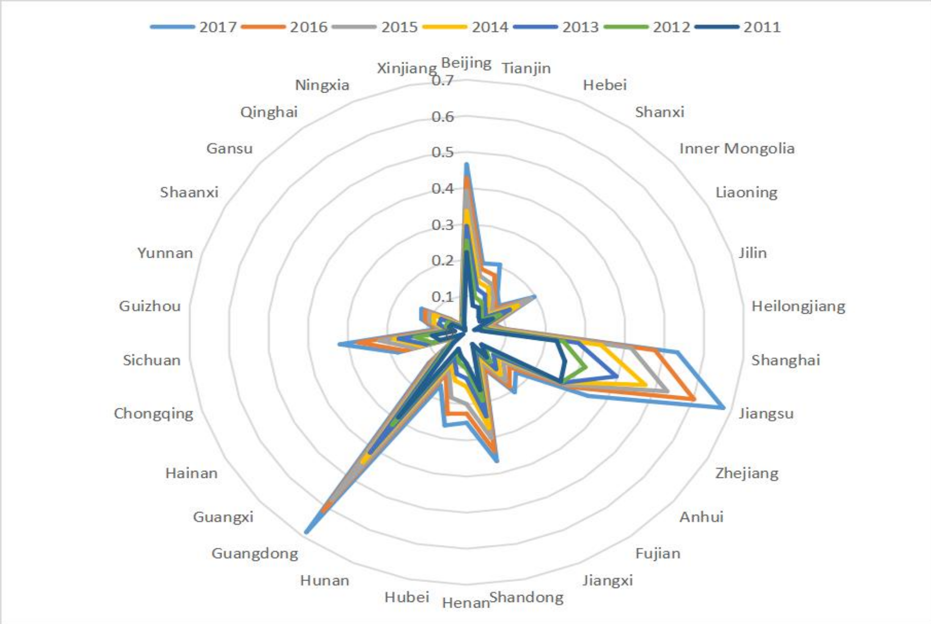

Figure 1.5 : Financial added value (Ten thousand yuan)
(Source: Author's computation from China National Bureau of Statistics in 2019)

1.2.5 Status of Technological Innovation

Schumpeter (1912) first gave the definition of innovation. According to him, innovation is the introduction of a "new combination" of factors and conditions into the production function. Technological innovation involves an innovation in production technology, both by developing new technologies or by applying existing technologies. And technological innovation is different from scientific discovery or technological invention, cause its purpose is to transform scientific discovery and technological invention into new products and services and create new values. Chinese government document "decision on strengthening technological innovation and developing high-tech industrialization" defines technological innovation as: Technological innovation means that enterprises use the latest technology and related knowledge, use the latest mode of production technology and management mode, improve service quality and product quality, to produce new products, provide new services, and finally obtain market recognition and realize market value.

Mansfield (1968) segmented the process of technological innovation into steps such as design, production, finance, management and market, and he argues that technological innovation is a new process introduced into innovative products or the production of innovative products. Lynn (1998) defined technological innovation since the process of technical advancement requires an accumulation of time and noted that technological innovation is "the whole behavior process that begins with the understanding of the commercialization perspective of technological innovation and finally transforms it completely into commercial products". This study argues that it is not the accumulation of scientific research innovation results, but the application of scientific research results to the processing of new products and new services aimed at creating social and economic value. And the characteristic of technological innovation is different from the accumulation of innovation, because it is oriented by market demand and value output, which is the key process of scientific research achievements from laboratory to market. Any innovation that cannot create market value can only be regarded as the accumulation of innovation.

Overall, China's investment in technological innovation is rising steadily, and its technological output is also increasing. China's total social R&D investment in 2011 was 868.7 billion yuan, compared with 1,967.79 billion yuan in 2018 have increased about 227 times. The number of patent applications processed increased from 1,083,997 to 4,121,475 items covers the period 2011-2018, raised almost 3.8 times. The Chinese level of scientific and technological innovation is also rising in the ranking of countries in the world, but there are still some problems that need to pay more attention. According to the China National Innovation Index Report (2010), China's innovation index is 57.9, ranking 21 out of 40 countries around the world. Among them, R&D investment is in the fourth place in the world, and patent application acceptance is the third place in the world. China National Innovation Index Report (2018) based on 2016 statistical survey data shows that China's comprehensive innovation ability is ranked the 17th in the international ranking, and it is the only developing country to enter the top 20. The overall level of innovation in China is rising. However, according to the 2016-2017 Global Competitiveness Report, technological innovation ability of China ranks 30th in the world. This shows that the transmission rate of innovation achievements in China still needs to be enhanced, and how to accelerate the transformation from theoretical achievements to promote productivity and economic growth is a topic that needs further investigation.

According to statistics issued by the China National Bureau of Statistics in 2019, China's R&D expenditure is still not adequate, financial support for technological innovation is not robust. In 2011, China's R&D expenditures were just 1.84 % of the GDP. By 2018, this proportion will rise to 2.10 %. Although R&D investment has increased, there is still a certain gap relative to R&D investment in other countries. This is partly because the majority of China's financial institutions tend to supply funds to state-owned enterprises, but they are more exclusive to SMEs, so most of this kind of enterprises facing the problem of financing difficulty. Nevertheless, these enterprises contribute the most to China's scientific and technological innovation, reaching more than 70%. Although state-owned enterprises are easier to obtain more funds with the support of state policy, they have only the strength of innovation but lack the enthusiasm of innovation (Lin and Xiong, 2013). Therefore, these enterprises are not able to give full play to its contribution to China's technological innovation. The National Science and Technological Innovation Top 100 Index Report (2020) shows that enterprises with registered capital of more than 10 billion take 8.8% of the enterprises that science and technological innovation take top 500 place; Enterprises with registered capital between 10 million and 10 billion RMB account for 85.8%, which is the main innovation subject; Enterprises with registered capital of less than 10 million account for 5.4%. It can be seen that the importance of financial support for enterprises' technological innovation, but only to expand the scale of funds is not the leading factor for enterprises to improve technological innovation, and the registered capital controlled between 10 million and 10 billion for enterprises to support technological innovation is the optimum.

Technological innovation in China is in the green transformation stage. It is true that technological innovation can increase the productivity of enterprises and thus help enterprises to accumulate more capital to expand the scale of production. As a result, the total social output will be improved. However, technological innovation has two sides for economic growth, which not only improves the productivity of enterprises, but also accelerates the speed of human grabbing for non-renewable natural resources, which may lead to the resource and environmental issues. With the gradual deterioration of the environment, China have put forward the idea of developing green technology, which means in the process of production and use of products, people can make maximum use of natural resources and reduce the damage to the environment. However, the enterprises in the market are profit-driven, combined with the externality of environmental pollution, many enterprises will not practice the concept of green development. The most important constraint is that many SMEs do not have sufficient funds to upgrade green technologies. At present, many enterprises still adopt the production technology of 1960s, while the disadvantages of high energy consumption and high pollution accelerate the environmental deterioration. Although China has recognized the importance of technological innovation for environmental protection earlier but pays more attention to the improvement of pollution terminal treatment technology, and it is mostly government-supported projects.

In addition, the development of technological innovation is also characterized by spatial imbalance. According to the China Regional Innovation Index Report (2018), the regional innovation shows decline trend from the east to the west. The innovation composite index of the eastern, central and western regions is 69.7, 66.77 and 65.87, respectively, and only the eastern region is above the average level in the nationwide. In addition, the National Science and Technological Innovation top 100 Index Report (2020) published by Ba Yue Gua Innovation Institute shows that the national science and technology top 500 enterprises represented by Huawei, State Grid and JingDong are mainly gathered in the eastern region, and mainly gathered in four regions: Beijing, Shanghai, Guangzhou and Shenzhen. Specifically, in 2018, Guangdong Province's comprehensive innovation ability ranked first, and enterprises contributed the most to its R&D funds. Beijing's unique historical and cultural foundation has accumulated many excellent scientific and technological resources. In 2018, its knowledge creativity ranked first in the country, and its comprehensive innovation ability ranked second in the country. The Yangtze River Delta region relies on investment, import and export to stimulate economic growth. Traditional industries rely on technological innovation to transform into high-tech industries. In 2018, Jiangsu, Shanghai, Zhejiang and Anhui were ranked third, fourth, fifth and tenth in the country, respectively. Because of its geographical disadvantage, the central and western regions have long relied on natural resources to develop traditional industries, which has a certain degree of exclusion from technological innovation and industrial transformation, so the comprehensive innovation ability is still not high. However, the innovation level of the central and western regions shows a catch-up trend, and Qinghai's comprehensive innovation ranking rose by 6 places in 2018.

Figure 1.6 shows the number of patent applications in China from 2011 to 2018. The figure shows that China's technological innovation level has significant regional heterogeneity, but the total amount exhibits an upward tendency year after year. The degree of technical advancement in southeast coastal provinces is relatively higher. The main reason is that there are many high-tech industries in the southeast coast, while there are mainly resource dependent traditional heavy industries in the northwest inland. However, with the accelerated process of marketization, SMEs with a high level of technological innovation in China have entered the market, thereby promoting the improvement of technological innovation.

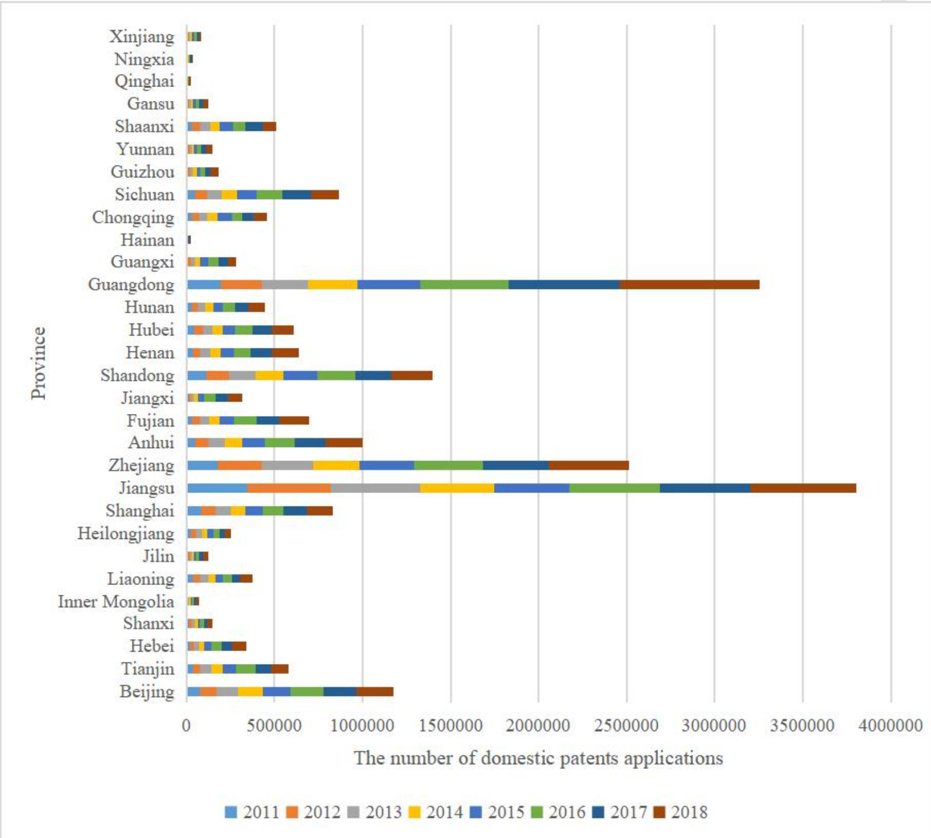

Figure: 1.6 : The number of domestic patent applications (Unit)
(Source: Author's computation from China National Bureau of Statistics in 2019)

1.2.6 Digital Financial Inclusion and Green Growth Path

Because the green growth path may face the obstacles of technological progress at the front end and the obstacles of floating population at the back end at the same time, it is necessary to explore tools that can effectively dredge the green growth path. Digital financial inclusion symbolizes the digital technology innovation of conventional finance and the deepening reform of financial system, thus it may represent the combination of financial development and technological innovation. Digital financial inclusion can be defined as the development and implementation of many technologies, such as digital technology, in the financial sector via Internet technology (Naumenkova et al., 2019). These technologies encourage information sharing, significantly lower the transaction cost and threshold for financial services, and broaden the range and availability of financial services. Build a data-based risk control system using digital financial sharing, convenience, safety, low cost, low threshold, big data, cloud computing, and AI, so as to increase financial risk control. Digital financial inclusion is a suitable interpretation of scientific and technology innovation in conventional finance, and it is a digital approach for long-excluded people to access formal financial services (Fernandes et al., 2021). Therefore, it is vital to investigate the influence that dredging effect has on digital financial inclusion on the road toward green growth in order to verify the impact that financial development and technical innovation have had on green growth.

On the one hand, front-end dredging effect. Digital financial inclusion may disturb the nexus of technological progress-green growth from three levels: digitalization, financial scale and inclusion. First, digital financial inclusion may increase the efficiency of financial sector information filtering (Ali et al., 2020). By means of digital technology, traditional finance can obtain more business and financial information of financing enterprises, which is conducive to avoiding the problem of high non-performing loan rate. Due to the characteristics of high investment, and a lengthy and risky investing cycle of enterprises' investment in green technology R&D, the investment preference of the financial sector is low (Li et al., 2021). However, with the improvement of ICT, the financial sector can provide more financial support for technology R&D of enterprises, to push technological advancement and ultimately promote green growth. Secondly, more digital and inclusive finance may lead to greener technological progress, thereby promoting green growth. Under the macro policy of green development, the screening criteria of digital finance inclusion for financing objects include not only the operation and financial status of enterprises, but also the cleaner production status of enterprises, so as to avoid environmental compliance risks. Finally, the digital and inclusive innovation of finance may reduce financing constraints and promote green growth. Inclusion in the digital financial sector makes it easier for SMEs in the "long tail" of the financial market to get finance for their innovative activities., and then to increase the green growth guided by technology change (Maslennikov et al., 2017).

On the other hand, back end dredging effect. Similarly, digital financial inclusion has an impact on the relationship between green growth and floating population from three levels: digitalization, financial scale and inclusiveness. First, digital financial inclusion may increase the liquidity of the population by improving the spatial availability of finance (Su et al., 2021). This type of financial formats can extend the tentacles of finance to remote areas, so that the labor force in remote areas can obtain mobility costs. Therefore, it can inhibit the binding of labor in central and western regions and local polluting industries, and promote the flow of labor to higher productivity and greener sectors (Li et al., 2021). Secondly, digital financial inclusion increases the financial capital available to the labor force through the inclusive nature of finance, which is conducive to the labor force to invest in education and avoid the impact of green transformation on the labor force (Xue et al., 2022). In the stage of green transformation, some labor forces face the risk of elimination Owing to the fact that professional expertise concerned is lacking, and the potential outflow population will also be affected. However, digital financial inclusion has promoted the green transformation of labor force, thus inhibiting the reduction of floating population. Finally, this financial innovation may also curb the side effects of green growth on the population migration by expanding financing channels. Compared with enterprises, it gives additional financial avenues for enterprises, especially small and medium-sized enterprises, so as to avoid enterprises from reducing employment when under the pressure of environmental policies, and ultimately curb the reduction of floating population (Lin et al., 2022).

1.3 Problem Statement

During the time of fast economic expansion in China, a great deal of natural resources was consumed. China's daily oil consumption is 680,000 barrels, accounting for 48.6 % of total global consumption, followed by the US about 500,000 barrels per day. With the deterioration of global ecological and environment quality, the increasing contradiction between economic growth and environment load in China has attracted much attention. Although China have realized the importance of developing green economics and taking the road of green growth, how to realize the green growth of economy efficiently is the problem that China is exploring at present.

First, after the global financial crisis in 2007-2008, numerous academics have tested the nonlinear relationship between financial development and economic growth and claimed that too much finance is detrimental to economic progress (Cecchetti and Kharroubi, 2012; Zhu et al., 2020; Law and Singh, 2014). However, few of literature is relative to the nonlinear nexus of financial development-green growth. Despite the fact that much research have shown the nonlinearity of the link between financial development and either economic expansion or environmental damage, because of the diversity of intermediary factors, the inflection point of this nonlinear relationship has no unified conclusion (Ibrahim and Alagidede, 2018). Additionally, a number of studies have shown a coupling effect between the subsystems of financial development and technical innovation, indicating that these two subsystems interact (Zheng et al., 2019; Zhang et al., 2016). Numerous studies, however, have proved that the coupling degree between financial development and technological innovation in China is weak, and the gap between them is gradually increasing. The formation mechanism of this gap may be the intrinsic determinant that accounts for the linear link between financial development and green growth. Although the coupling effect between financial development and technological innovation has been extensively researched and given the accounting process of coupling degree and coordination ratio of subsystems, coupling degree as a threshold variable cannot reflect the coordination ratio within its subsystem. However, the coordination ratio of financial development and technological innovation can be regarded as a mediating variable to study the threshold effect of the coordination state of the two subsystems on financial-green growth nexus, so that we can grasp the optimal scale of financial development more accurately and timely prompt the internal upgrading of the financial sector. However, few researchers have done the research.

Second, China has a population of more than 1.4 billion people and a land area of 9.6 million km^3. From East to West, its social, economic, topographical, and human aspects drastically different. In China, the levels of green growth, financial development, and technical innovation vary significantly by region. It is uncertain about the impact of the imbalance of these elements on China's green growth. Meanwhlie, the first law of geography is that there is always some kind of geographical link between things. Therefore exploring the effects of these factors on the dependent variables, excluding the spatial interaction of these factors in order to do so would lead to major inaccuracies in the results (Wang et al., 2013; Hao et al., 2016a; Wang and He, 2019). Therefore, in order to achieve the green growth synergistically, we must consider the regional characteristics of the key factors affecting green growth and its spatial interaction. However, a few of scholars studied spatial spillover characteristics of these two subsystems on green growth. According to the characteristics of significant spatial imbalance in green growth in China, this study is essential for fulfilling the coordinated development of green growth among regions.

Third, according to the relevant literature, green growth presents a fluctuating situation in China (Xie and Liu, 2019; Lin and Zhu, 2019), while the existence of such volatility affects the efficiency and sustainability of green growth. How to eliminate the negative impact of this volatility on green growth is the key to promote China's economic transformation. At present, economic development in China is undergoing transition, in the process of changing from the traditional industrial development model with low technology level and high energy consumption to the high-tech industrial model, it will unavoidably touch the interests of the relevant stakeholders, and then hinder the smooth implementation of the green development strategy. Because of the difficulty of environmental performance appraisal, and the environmental disclosure mechanism of local government and various enterprises is still not perfect, so it is difficult to effectively and continuously supervise the uneconomical behavior in the external environment of the enterprise. At the same time, local governments' regulation of environmental pollution lacks continuity, which can further impact green growth volatility (Cao et al., 2012). In order to achieve the sustained and stable green growth, the key factors that affect this volatility must be identified to reduce the risk factors in green development. From the literature this study revealed that financial development (Schumpeter, 1912; Yuan et al., 2019) and technological innovation (Sepehri and Sarrafzadeh, 2019) are vital factors affecting economic growth and environmental quality. However, there is a paucity of research that examines the impacts of financial development, technological innovation, and their association on green growth volatility within the context of a coherent framework.

Fourth, the impact of financial development and technological innovation on green growth can be embodied not only in the three dimensions of nonlinear relationship, spatial effect and volatility, but also in the dredging shock on the path of green growth. The green growth path may be hindered by both the thrust of technological progress at the front end and the friction of floating population at the back end. With the continuous progress of digital technology, some advanced technologies have been gradually applied to the financial field, but there are still some special problems in the initial integration phase. Digital financial inclusion can not only give full play to the resource allocation function of traditional finance, but also enhance the financial accessibility of the financial "long tail" market through digitalization and inclusion, and improve the efficiency of financial services across time and space. However, at present, the digital technology reform in the financial sector is still dominated by large financial institutions, and most SMEs exclude digital technology innovation due to cost problems. Therefore, the level of digital technology in China's financial sector is not high. In addition, the inclusive reform of finance is still not deep enough to cover the entire financial tail market. It is yet undetermined what the effects of this dredging impact will be due to the limited development of digital financial inclusion in China. In principle, digital financial inclusion has a dredging effect on the green growth path; however, the actual effects of this dredging effect are still unknown. However, few scholars have studied the dredging effect of digital financial inclusion as a threshold variable on green growth path.

1.4 Research Questions

Main question: what are the effects of financial development and technological innovation on green growth in China?

The specific research questions are as follows:

i What are the threshold effects of financial development and technological innovation on the finance-green growth nexus?

ii How can the spatial effect of financial development and technological innovation on green growth?

iii How do financial development and technological innovation influence the volatility of green growth?

iv What is the effect of digital finance inclusion on the green growth path based on technological progress and floating population?

1.5 Research Objectives

Main research objective: To analyze the effects of financial development and technological innovation on green growth from a linear, spatial and dynamic perspectives, based on annual panel data from 30 provinces in China during 2011-2018.

Specific research objectives are shown below：

i To evaluate the threshold effects of financial development and technological innovation on the finance-green growth nexus.

ii To analyze the spatial effects of financial development and technological innovation on green growth.

iii To examine the impacts of financial development and technological innovation on green growth volatility.

iv To investigate the dredging effect of digital financial inclusion on the green growth path on basis of technological progress and the floating population.

1.6 Significance of the Study

1.6.1 Theoretical Significance

First, this study gives a novel viewpoint to the contemporary research direction, which attracts scholars' attention to green growth. What's more, this study comprehensively evaluates the effects of financial development and technological innovation on green growth from linear, spatial and dynamic dimensions, respectively. Thus, this study makes up the gap of current literature that lacks the comprehensive perspective to do this research, which provides a theoretical reference value for studying the driving factors of green growth. Furthermore, this study provides a comprehensive review and summary of the basic theory and empirical research related to financial development, technological innovation and green growth, and systematically combs and summarizes the interaction relationship and internal transmission mechanism among the three by studying relevant literature.

Second, this study has calculated the comprehensive index of green growth, financial development and technological innovation, which provides more theoretical reference for future research. In addition, this study employs concrete financial institution and stock market indicators, as well as an aggregate financial development index to measure financial development levels, which can clarify the effect of financial development on green growth from the specific and comprehensive dimensions, and compare the effect of credit market and capital market on green growth. Moreover, this study also analyzes the linear link between financial development and green growth by taking the ratio of financial development composite index and technological innovation composite index as the threshold variable to provide more evidence for the existing effect of "financial vanishing". Finally, this study also calculated the indicator of green growth volatility and empirically investigates its internal influencing factors.

Third, this study also researched the dredging effect of digital financial inclusion on the green growth path on the basis of technological progress and floating population from the perspective of front-end and back-end for the first time. Current studies pay more attention to how to promote green growth rapidly, but few scholars focus on the side impacts of green growth on the floating population. In addition, few scholars have studied the dredging effect of digital financial inclusion on the road of green growth. As a result, this study broadens the scope of research on green growth, and puts forward new research ideas. In addition, this study provides more theoretical basis for China's high-quality economic development and green transformation, so as to to avoid many phased problems in this special period.

1.6.2 Practical Significance

Chinese government is actively promoting the green development strategy and have reached a consensus that realizing the green growth of the economy is the key (Song et al., 2020; Zhao et al., 2022). The National Bureau of Statistics of China reports that China's GDP has increased from 367.9 billion yuan in 1978 to 99.1 trillion yuan in 2019, representing an increase of over 269 times over the course of 40 years. It is worth mentioning that China's GDP reached 41.2 trillion yuan in 2010, overtaking Japan for the first time according to Statistical Yearbook of China, 2019. However, China's economy has historically been dominated by secondary sector, relying heavily on natural resources and low-cost labor to gain a competitive advantage (Cheng et al., 2020; Dai et al., 2016). The unsustainable problem of resources and the aging trend of China's population make the advantage in traditional industry gradually disappear, and China is in the critical period of dual transformation, so the traditional extensive and consumable industries need to be transformed to achieve sustainable development. During the time of fast economic expansion in China, a great deal of natural resources was consumed (Qian et al., 2021; Guo et al., 2021). For example, resources such as coal, oil and gas are being exploited in large quantities. The consumption of coal, oil and natural gas was 2,737.60, 876.96, 361.92 million tons of standard coal, which is about 2.7, 2.7 and 11.2 times higher than that in 2000, respectively. This study is valuable to fostering the green transformation of China's economy and preventing the loss in environmental quality while encouraging economic growth. It is also beneficial to fostering the green transformation of the economy.

First, this study replaces the threshold variable with an endogenous intermediate variable with more general nature, which can help the financial sector to judge the critical point of financial failure more accurately, thus improving the sensitivity of the financial sector's early-warning mechanism of financial overdevelopment. In addition, using the ratio of financial development and technological innovation subsystems as the threshold variable, this study analyzes the influence of the coordination state of financial development and technological innovation on the nonlinear nexus of finance-green growth in order to investigate the internal influence mechanism of the financial vanishing effect and provide a reference for national macro-control policies.

Second, because of China's enormous geography, there are uneven economic progress, environmental pollution degree, resource endowment condition, industrial structure foundation, production technological condition and government management policy. However, there is a strong geographical and spatial association between economic growth, technical innovation, and green expansion, and studying its spatial effect on green growth is not only helpful to make up for the missing variable deviation, but also crucial to realize the coordinated development of green growth among regions. This study supplies the central government with a theoretical foundation to formulate macro policies and for local governments to formulate joint development policies, and then to promote balanced and efficient green growth.

Third, examining the impact of financial development and technical innovation on green growth volatility is crucial for reducing green green growth risks and contributing to the sustainability and consistency of green growth. In addition, the volatility of green growth can better reflect the true level of economic growth than the volatility of economic growth. The GMM method is used to achieve study objectives. This is because green growth volatility is a dynamic process. Identifying the impact of the previous volatility on the present period might indirectly reflect the execution of the green development plan by local governments, therefore preventing the destruction of the natural environment caused by "political competition".

Fourth, this research uses digital financial inclusion as an example for further discussion and analysis, which serves as a theoretical guide for the modernization and restructuring of the financial industry, traditional finance and digital technology innovation. On this basis, this study emphasizes the importance and shortcomings of digital financial inclusion for green growth, which is beneficial to promoting the improvement and development of digital financial inclusion in China. Furthermore, this study compared the impact of input-output biased technological progress on green growth, and examines the threshold effect of digital financial inclusion, denoting to guiding the direction of technological research and development and enhancing the beneficial impact of technology advancement on green growth. Furthermore, this study chooses the floating population for analysis and research, which is critical in addressing the issue of growing unemployment rates during the green transition era.

1.7 Scope of Study

Based on yearly panel data from 30 Chinese provinces from 2011 to 2018, this study adopts a quantitative method to evaluate the effects of financial development and technological innovation on green growth. Limited by data accessibility, the sample of this study only includes the data of Chinese Mainland excluding Tibet. In addition, for the missing data, the interpolation method is used in this study.

1.8 Organization of the Research

There are five chapters in the thesis. The main contents are as follows:

Chapter 1 introduces the research background, expounds the existing research problems, and then puts forward the research questions, research objectives and research significance.

Chapter 2 reviews the relevant literature according to the three research problems and summarizes the gaps in the literature.

Chapter 3 presents the research methodology. Firstly, this chapter constructs the index system and explains the variables used in the study. Next, this chapter introduces the theoretical framework of the research and proposes the research hypothesis. Finally, this part specifies the models used in this study.

Chapter 4 reports the empirical results for the previous hypothesis, and conducts the result analysis compared with the relative literature.

Chapter 5 summarizes and discusses the results of previous chapters, and the policy recommendations are put forward according to the current state situation. Finally, the limitations and prospects of the research are provided.

1.9 Chapter Summary

This chapter gives the solid theoretical basis and organizational structure for the current research. Green growth is an important strategy to guarantee the economy and environment grow sustainably, and the level of green growth has gradually become a reference index reflecting the actual economic level of countries and regions. Financial development, technological innovation and the interaction between them are important factors affecting green growth. Consequently, utilizing dynamic threshold, spatial panel and dynamic panel models to diagnose the impact of financial development and technological innovation on green growth is valuable in terms of theory and practice. And the discussion and analysis based on digital financial inclusion is also the finishing touch of this section, in order to specifically examine the dredging effect of the integration of financial development and technological innovation on the green growth path. The next chapter provides the literature review for these three research perspectives.

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