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Can Digital Services Trade Liberalization Improve the Quality of Green Innovation of Enterprises? Evidence from China

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Abstract: Green innovation is a critical driver in achieving the goals of "carbon peaking" and "carbon neutrality", as well as an important aid in accelerating green transformation. Does the opening-up of digital services trade, as a major component of the high-level opening-up strategy, serve to improve the quality of green innovation of Chinese enterprises at this critical juncture in China's promotion of ecological civilization? To answer this question, this paper measures the degree of openness of digital services trade in each industry in China, and it empirically examines the impact of digital services trade liberalization on enterprises' green innovation quality using data from A-share listed companies from 2014 to 2021. This research finds that, first, digital services trade liberalization can significantly improve the quality of green innovation of Chinese enterprises, which still holds after a series of robustness tests. Second, mechanism analysis indicates that digital services trade liberalization promotes enterprises' green innovation quality by improving human capital level, increasing green R&D expenditure, and strengthening information resource sharing. Third, a heterogeneity test shows that the effect of digital services trade liberalization on the quality of green innovation is more prominent for state-owned enterprises, enterprises with stronger technology absorption capacity, highly competitive industries, and regions with a high intensity of environmental regulations. The study's findings not only provide new perspectives and ideas for enterprises' green innovation practices in the midst of the digital services trade wave but also theoretical and empirical support for the inherent self-consistency between high-level opening-up and green development.

Keywords: digital services trade liberalization; enterprise green innovation; green innovation quality; green high-quality development

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1. Introduction

Since the reform and opening-up, China's economic development has been remarkable, but the extensive growth style of high energy consumption, high pollution, and low efficiency has exacerbated the ecological load, making environmental issues highly urgent and difficult [1,2]. According to the report of the 20th Party Congress, "promoting the greening and decarbonization of economic and social development" is a critical component of achieving high-quality development. China's ecological civilization and environmental protection have been constructed with unprecedented zeal and determination. Green innovation is the first driving force in promoting ecological civilization construction [3], which can reduce pollution, improve ecology, and promote high-quality and sustainable development that is compatible with the economy and environment [4]. In 2021, the State Council issued the "Carbon Summit Action Plan by 2030", which emphasizes that green innovation is the key task of "carbon peaking", and proposes to strengthen the primary position of enterprise innovation and support enterprises in undertaking major national green low-carbon science and technology projects. However, due to limitations of the level of domestic technology and green knowledge base, Chinese enterprises face many challenges in green low-carbon technology research and development. Owing to the distortion of some industrial policy incentives and the high difficulty and long-term characteristics of green innovation activities, the creativity, influence, and practical value of Chinese enterprises' green innovation results remain low, and the thrust of enterprises toward high-quality development through green innovation is severely constrained. Given this, how to effectively improve the quality of enterprises' green innovation is a critical issue that must be addressed if China is to consistently promote "carbon peaking" and "carbon neutrality", as well as achieve green transformation and high-quality development.

It is worth noting that the new generation of digital technology and the real economy are currently deeply integrated; telemedicine, sharing platforms, cross-border e-commerce, and other "Internet+" new business models continue to emerge, and digital services trade has emerged as one of the most promising emerging forms of trade in the field of international trade. Digital services trade encompasses knowledge-intensive service trade fields such as telecommunications, computer and information services, and intellectual property services, which broadens the channels for the exchange and integration of global knowledge, technology, and information resources, and is an important way for countries to integrate deeply into the new economic globalization [5]. The existing literature indicates that digital services trade can increase the variety of imported products, increase R&D investment, and thus improve the technological complexity of manufacturing exports [6]. Simultaneously, digital services trade drives the cross-border flow of high-end knowledge, talent, and technology, providing a strong impetus to further activate innovation factors and unleash innovation potential [7]. Beyond that, the digital services trade opens up many new opportunities for enterprises to engage in high-quality green innovation practices in the context of the new era. On the one hand, digital services trade promotes the diffusion and spillover of knowledge and technology across countries and industries, constantly broadens the space for enterprises to tackle green and low-carbon technologies, and improves the quality of their green innovation. On the other hand, digital services trade can promote the exchange and sharing of global green energy-saving technologies and environmental protection solutions, which helps to consolidate the knowledge reserve for high-quality green innovation activities of enterprises. Thus, it is of great theoretical and practical significance to explore the realization path of improving the quality of enterprises' green innovation from the perspective of digital services trade.

In recent years, the digital services trade has become an important opportunity for China to open up to the rest of the world. The Fourteenth Five-Year Plan for the Development of Trade in Services clearly states: "further promoting the innovative development of digital services trade and orderly promoting the opening-up of telecommunications, Internet, and other related businesses". At the BRICS Business Forum on 22 June 2022, President Xi Jinping emphasized that "we should seize the opportunity of the new round of technological revolution and industrial transformation, promote the global flow of innovation factors, and help developing countries accelerate the development of digital economy and green transformation". In accordance with the new trend of the global digital economy and digital services trade, and in response to the national strategic decision of green development, this study focuses on the core theme of "the impact of digital services trade liberalization on the quality of green innovation of Chinese enterprises", and attempts to answer the following three questions: (1) Can digital services trade liberalization improve the quality of green innovation of enterprises? (2) What is the mechanism behind it? (3) Does the impact of digital services trade liberalization on the quality of green innovation in enterprises differ depending on their micro characteristics, industry nature, and regional endowment? This paper conducts a comprehensive and systematic test of the micro-paths of digital services trade liberalization that affect the quality of green innovation of enterprises using data from the OECD-DSTRI database, the OECD-STRI database, and the A-share listed companies from 2014 to 2021. This offers policy references for China to attain high-quality development focused on ecological priorities and green development, in addition to valuable thinking for the coupling and compatibility between high-level foreign opening and green development strategies.

2. Literature Review

2.1. Influencing Factors of Enterprise Green Innovation

Green innovation is a crucial strategy to achieve a "win-win" situation for both economic efficiency and environmental conservation [8]. In recent years, academics have given enterprise green innovation the attention it deserves. There have been significant discussions about the factors that affect enterprise green innovation, with a focus on two categories of studies. The first type of research focuses on the "legitimacy" of transmission effects of external regulations such as environmental regulations and policies on firms' green innovation orientation, which includes environmental protection laws [9], environmental protection taxes [10], the environmental protection target responsibility system [11], and environmental rights and the interests trading market [12,13], among other factors. The theoretical foundation is based on institutional economics theory, which contends that incentive and disciplinary policies in environmental regulation can "push" firms to engage in green innovation [14]. The second type of research examines the impact of a firm's internal factors on enterprise green innovation, with a focus on firm ownership [15], corporate culture [16], strategic orientation [17], executive characteristics [18], board membership [19], and inter-firm cooperation [20].

With the accelerated process of economic globalization and trade liberalization, a few studies have examined the relationship between the open economy and enterprise green innovation. Yang et al., for example, contended that FDI, OFDI, and import/export trade all have a catalytic effect on the technological driving force, market pull force, and environmental control driving force of green innovation in industrial enterprises [21]. According to Meng et al., participation in global value chains can introduce advanced green production technologies and improve enterprise absorption capacity, which has a positive impact on enterprise green innovation [22]. Wang et al. demonstrated that multinational enterprises can reap innovation dividends from international expansion, which effectively increases their green innovation [23].

2.2. Economic Effects of Digital Trade and Digital Services Trade

Digital trade has emerged as a new trend and form of international trade, with digital services trade serving as an important component [24]. The existing literature focuses on the economic effects of digital trade and digital services trade, which primarily includes a few aspects. First, scholars agree that digital trade and digital services trade have the best effect on technological innovation, economic development, and value chain climbing [5,6,24,25]. It has been stated that digital trade has altered the nature of trade [26] and is a critical factor in promoting technological progress and global economic growth [25]. Digital services trade is an important way for countries to deepen their integration into the new economic globalization and strengthen the global value chain [5]. Second, most quantitative research on digital trade and digital services trade is based on national, industry, or provincial-level data. Yao, for example, used data from 30 Chinese provinces to show how digital trade encourages industrial structural upgrading by increasing human capital and R&D intensity [27]. Ren examined the contribution of digital services trade to the technological sophistication of manufacturing exports using cross-country panel data [6]. Using Chinese province-level data, Zhang investigated the relationship between digital trade openness and green total factor productivity [28].

2.3. The Impact of Digital Economy on Enterprise Green Innovation

The digital services trade is a result of the deep intersection of the digital economy and service trade, and it is an important component of the digital economy. The impact of the digital economy on enterprise green innovation has become a hot topic for domestic and international scholars as a result of the global digital transformation. Zhang et al., for example, argued that the digital economy promotes energy conservation and emission reduction by improving green technology innovation capabilities [29]. El-Kassar and Singh used microscopic research data from 215 companies to empirically demonstrate that big data applications can boost green innovation and help enterprises cultivate new competitive advantages [30]. Mubarak et al. demonstrated that Industry 4.0 technologies promote open innovation practices in businesses, which leads to increased productivity [31]. According to Song et al., enterprise digitalization promotes enterprise green innovation by increasing the level of information sharing and the ability of enterprises to integrate knowledge [32].

After combing the relevant literature, we can see that first, studies on the factors influencing enterprise green innovation are still primarily focused on external environmental regulation policies and internal enterprise factors, with little research on foreign trade and the open economy. Meanwhile, the majority of relevant research is focused on the number of green patents, and insufficient attention is paid to the quality of enterprise green innovation. Second, due to data availability, most studies on the economic effects of digital services trade focus on theoretical qualitative research and macro-level quantitative analysis, while empirical research in the micro-area is scarce. Third, while studies have focused on the impact of digital economy development on enterprise green innovation, the connection between digital services trade and enterprise green innovation has largely been ignored, and the existing literature has yet to explore the inner mechanism of digital services trade liberalization affecting enterprise green innovation.

The marginal contributions of this paper constitute three aspects. First, this paper enriches the research on the determinants of enterprise green innovation quality. This paper explores the realization path of improving the quality of enterprise green innovation under the perspective of digital services trade liberalization, which not only compensates for a lack of research in the established literature on whether and how digital services trade liberalization affects enterprise green innovation but also provides a new idea and direction for research related to the improvement of Chinese enterprises' green innovation quality.

Second, this paper extends the study of the microeconomic effects of the digital services trade. This paper measures the degree of openness of digital services trade in each industry in China and empirically examines the impact of digital services trade liberalization on the quality of green innovation of Chinese enterprises. In addition, this paper also discusses heterogeneity from the multidimensional perspectives of the nature of firm ownership, firm technology absorption capacity, industry competition level, and regional environmental regulation intensity. It broadens the scope of digital services trade research to the micro-domain, expands the boundaries of the existing digital services trade research literature, and fills a gap in related studies.

Third, this paper reveals the inherent link between digital services trade liberalization and enterprise green innovation quality. Unlike the established literature on the effect of enterprise green innovation from the perspective of the digital economy, this paper incorporates digital services trade into the enterprise green innovation research framework, focuses on the intermediary effect, and provides an in-depth analysis of the intrinsic mechanism of digital services trade liberalization affecting the quality of enterprise green innovation from the perspectives of human capital, green R&D expenditure, and information resource sharing, thus providing a new theoretical analysis framework for subsequent research. Meanwhile, this paper meticulously tests and identifies transmission paths using a mediating effects model, providing a more comprehensive exploration of the mechanism for understanding the relationship between digital services trade liberalization and enterprise green innovation quality.

3. Theoretical Analysis and Research Hypothesis

Green innovation is a type of technological innovation in which companies introduce new green processes, materials, and products to the market with the primary goal of improving the environment [33,34]. To create breakthroughs in new renewable energy technologies, businesses must apply more complicated and diverse knowledge and skills that are necessary to increase the quality of green innovation [8,35]. The digital services trade is a new trade form that employs information and communication technologies, big data, and other digital technologies as carriers to facilitate the exchange of digital products and services, digital knowledge, and information [24]. In theory, digital services trade liberalization strengthens the flow and sharing of high-end knowledge, technology, and talents among countries. This results in a digital-driven disruptive innovation environment for enterprises, the continuous expansion of space for enterprises to achieve green and low-carbon technology research, and the improvement of the quality of green innovation for enterprises. In combination with the extensive discussions on the influencing factors of enterprise green innovation and the economic effects of the digital services trade, this paper explores the impact mechanism of digital services trade liberalization on the quality of green innovation of enterprises from the perspectives of "improving human capital", "increasing green R&D expenditure", and "strengthening information resource sharing". Following the mechanism analysis, this paper proposes research hypotheses to serve as the theoretical foundation for the following empirical analysis.

3.1. Improving the Level of Human Capital

Digital services trade liberalization can impact enterprises' human capital in two ways by increasing the pool of highly skilled personnel and improving the skill level of existing employees. To begin with, digital services trade liberalization relaxes market access for digital services, resulting in increased domestic enterprise investment in intermediate goods of digital service elements. Realizing the full potential of digital services necessitates the use of highly skilled labor, which creates new job opportunities for IT service practitioners, high-end software technicians, and general technical personnel. Enterprises will be more inclined to hire high-skilled labor and eliminate low-skilled labor, which accelerates human capital accumulation. On the other hand, the liberalization of digital services trade has given rise to new modes of "Internet+" trade such as distance education, online entertainment, and cross-border e-commerce, which necessitates practitioners having stronger knowledge reserves. Companies will invest more in their on-the-job employees, improving their skills and quality through on-the-job education and technical training, which increases the supply of high-end labor on a continuous basis.

The importance of human capital stock in corporate new product creation is highlighted by innovation theory [36]. Human capital, as the primary carrier of knowledge and skills, is the first resource of enterprise innovation [37], and the core subject for green innovation is a high-level workforce, particularly top-ranking scientific and technological talents with strong knowledge reserves. Green R&D activities, as well as the transformation and application of green innovation results, are inextricably linked to high-level human capital [38]. As a result, as human capital levels rise, companies become more likely to allocate funds to the research and development of green technologies as well as the implementation of green processes, continuously raising the standard of green innovation in enterprises.

3.2. Increasing Green R&D Expenditure

Green R&D expenditures are closely related to enterprise green innovation. Green innovation has higher technological risk and more uncertain market development prospects than traditional innovation [39], so enterprises will face greater financing constraints during the green innovation process, and R&D spending becomes a stumbling block to improving the quality of green innovation in business owners. Digital services trade liberalization will address this issue by increasing corporate profits and lowering unit R&D costs.

First, digital services trade liberalization provides domestic enterprises with more high-quality and low-cost foreign high-end digital services, as well as lowers the price of intermediate digital services used by enterprises for production and R&D. As a result, digital services trade liberalization can reduce production costs and increase enterprises' profit, thereby providing sufficient R&D funds for green innovation and allowing enterprises to increase green R&D expenditures and improve the quality of green innovation. Second, digital services trade liberalization can drive the cross-border flow of knowledge and technology, accelerating knowledge transfer, diffusion, and spillover [27]. Knowledge spillover promotes enterprise knowledge accumulation while lowering unit R&D costs [40], encouraging enterprises to increase R&D investment in green innovation and form high-quality green innovation achievements.

3.3. Strengthening Information Resource Sharing

Green innovation is fundamentally an interdisciplinary and cross-disciplinary innovation activity that entails the generation, integration, and dissemination of knowledge in various areas of pollution reduction and energy control [41]. To effectively carry out green innovation, it is difficult to rely solely on a firm's knowledge in a single technology area [31,42]. Sharing information between departments and enterprises can promote the effective integration of innovation resources [43], which is especially important for firms engaged in green innovation [44].

The inter-temporal and nearly zero-cost dissemination of information on the Internet under the opening of digital services trade has broken through time and space constraints, promoting information sharing, breaking down information silos, and realizing interconnection. The sharing and rapid dissemination of global information resources can increase the possibility of knowledge spillover, promoting the continuous improvement of the quality of corporate green innovation. Furthermore, the digital services trade is a technology transfer process involving digital technology, information, and data, that contains more know-how and innovative knowledge about resource utilization and pollution treatment [45,46]. Under the opening of the digital services trade, the exchange and sharing of information on global environmental protection solutions and pollution treatment technologies are conducive to the knowledge coupling of enterprises in various green technology fields, which increases the knowledge reserve of green innovation [47,48], prompting enterprises to continuously and steadily carry out green innovation practices of high technological complexity.

Based on the analysis above, this paper puts forward the following hypothesis:

Hypothesis 1 (H1). *Digital services trade liberalization can improve the quality of green innovation of enterprises.*

Hypothesis 2a (H2a). *Digital services trade liberalization promotes the quality of green innovation of enterprises by improving the level of human capital.*

Hypothesis 2b (H2b). *Digital services trade liberalization promotes the quality of green innovation of enterprises by increasing green R&D expenditure.*

Hypothesis 2c (H2c). *Digital services trade liberalization promotes the quality of green innovation of enterprises by strengthening information resource sharing.*

The theoretical model of this study is shown in Figure 1:

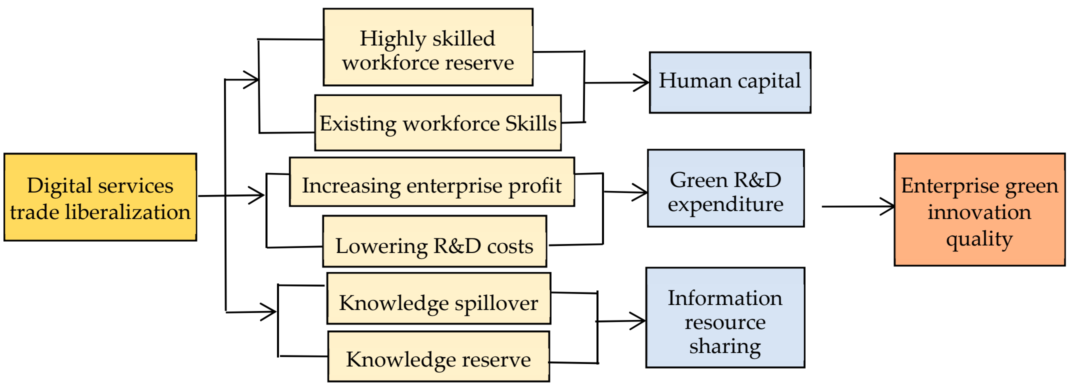

Figure 1. Theoretical model.

4. Empirical Models and Data Processing

4.1. Empirical Model

To articulate the impact of digital services trade liberalization on the quality of green innovation of enterprises and verify the hypothesis above, the benchmark regression model is constructed as follows:

$$GreInva_{ijt} = \beta_0 + \beta_1 CDSTRI_{jt} + \beta_2 Controls_{it} + ui + uj + ut + \varepsilon ijt \quad (1)$$

In Equation (1), the subscripts i, j, and t represent the firm, industry, and year respectively; $GreInva_{ijt}$ denotes the green innovation quality of firm i; $CDSTRI_{jt}$ represents the degree of digital services trade openness of j in which the firm is located; and *Controls* means control variables. Drawing on Amore and Bennedsen [49] and Qi et al. [13], *Controls* include: (1) firm size (Size), which is the natural logarithm of total firm assets; (2) firm age (Age), which is the logarithm of the year in which the enterprise is located minus the year in which the enterprise was started; (3) firm performance (ROA), which is the ratio of net income to total assets; (4) financial leverage (Lev), which is the ratio of total liabilities to total assets; (5) Tobin's Q value (TobinQ); (6) R&D investment intensity (RD), which is the logarithm of the ratio of R&D expenditures to total assets measured; (7) market power (Market), which is the logarithm of the ratio of sales revenue to operating costs; (8) technical employees (Tech), logarithm of the number of technical employees; (9) dummy variables for state-owned enterprises (SOE); (10) industry capital intensity (CI), which is the logarithm of the median of the ratio of total fixed assets to the number of employees of enterprises in the industry; and (11) Industry concentration (HHI), which is the industry-level Herfindahl index. The symbols ui, uj, and ut represent firm, industry, and time-fixed effects. The term εcit is a random error term.

4.2. Variable Definition

4.2.1. Core Explanatory Variable—Digital Services Trade Liberalization Index

Unlike inter-border trade barriers that affect the goods trade, the majority of barriers to digital services trade are "within border", such as data localization measures, discriminatory licensing conditions for e-commerce activities, and unnecessary administrative procedures, among other things. The OECD-STRI database contains the Services Trade Restriction Index (STRI) for 22 service sectors in 48 countries, and the OECD bases the Digital Services Trade Restriction Index on the STRI (DSTRI). The DSTRI is a quantitative index with a value ranging from zero to one that measures any "within-border" policy impediments to digital services trade. The higher the index, the greater the degree of restriction and the less openness of the digital services trade, which provides a possible condition for measuring the degree of digital services trade liberalization of each industry.

The United Nations Conference on Trade and Development (UNCTAD) defines digital services trade as "all trade in services delivered across borders via information and communication networks", which includes telecommunications, computer information services, intellectual property, audiovisual media, and other business services. Jia et al. [24] proposed a "binary and three-ring" conceptual framework for measuring digital trade, with core digital services including communication services, computer services, information services, digital media, and digital content, as well as potential digital technology-enabled services. Based on UNCTAD [50] classification criteria for digital services trade and Jia et al.'s [24] accounting framework for digital service businesses, this paper uses the National Economic Classification of Industries as the basis to screen digital services trade industries with a high degree of digitization, with the completion of data one by one, and these are then matched with OCED-STRI and OCED-DSTRI databases, as shown in Table 1.

Table 1. Division of digital services trade industry.

Core Elements	Content	Industries (under GB/T 4754—2017 Classification Standard)	Corresponds to OECD-STRI and OECD-DSTRI
Digital Empowerment Infrastructure	Telecommunications Equipment and Services	I Information transmission, software, and information technology services I-63 Telecommunications, radio, and television and satellite transmission services I-64 Internet and related services * I-65 Software and information technology services *	Infrastructure and connectivity
	Computer Software		
Digital Media	Internet Radio	R-87 Radio, television, film, and sound recording production industry R-8710 Broadcast R-8720 TV R-8740 Radio and television integrated broadcast control R-8750 Film and radio and television program distribution	Broadcasting service Motion pictures service Sound recording service
	Traffic and Downloads	R-87 Radio, television, film, and sound recording production industry R-8730 Film and television program production activities R-8760 Film projection R-8770 Recording production activities	
	Related Support Services	I-64 Internet and related services * I-6421 Internet search service * I-6422 Internet gaming services * I-6429 Other information services on the internet * I-6490 Other internet services *	Computer service
		I-65 Software and information technology services * I-6531 Information systems integration services * I-6550 Information processing and storage support services *	Telecom service
Digital Trading	B2B Wholesale	F-51 Wholesale industry * F-5193 Wholesale Internet F-5181 Trade Agent *	Electronic transactions
	B2C Retail	F-52 Retail * F-5292 Internet Retailing	

Note: "*" indicates that only part of the industry belongs to the digital activities category, they can not be directly classified as a digital services trade industry, and there is a need to carry out an industry split.

Given that only some of the activities in individual sectors in Table 1 are digital activities, and in reference to Xu and Zhang's [51] method for constructing "digital economy adjustment coefficients", this paper introduces digital splitting coefficients to separate the digital component from the F-51 and F-52 sectors. Among these, the F-51 and F-52 sector splitting coefficients are measured by the ratio of the sum of the main business revenues of "Internet wholesale", "Internet retail", and "online trade agency", to the main business revenues of "wholesale and retail" in the China Economic Census Yearbook, and the ratio is assumed to be constant in the short term. For the six subcategories of "Internet search services", "Internet game services", "Other Internet information services", "Other Internet services", "Information systems integration services", and "Information processing and storage support services" in Sector I, 90% of these six subcategories belong to "Digital Empowerment Infrastructure" and 10% belong to "Related Support Services" in "Digital Media" with reference to BEA.

In this paper, we refer to Arnold et al. [52] to construct a digital services trade liberalization index using the proportion of digital service inputs in each industry as weights. The calculation method is as follows:

$$CDSTRIjt = \sum_s (1 - DSTRI_{sr}) \times \omega_{jst} \quad (2)$$

In Equation (2), j represents the industry and s represents the digital services trade industry. The term $DSTRI_s$ is the Digital Services Trade Restrictiveness Index of the OECD-DSTRI assessment framework; $1 - DSTRI_s$ measures the degree of openness of the digital services trade industry; and ω_{js} is the complete consumption coefficient of each industry for the digital services trade industry based on the 2017 China Input-Output Table. In addition, $CDSTRI_j$ can reflect the degree that each industry is affected by the openness of the digital services trade, and the greater the value, the greater the degree of digital services trade liberalization in each industry. Table 2 shows the average value of the digital services trade liberalization index for each industry. Among them, the cultural, sports, and entertainment industry, as well as the information transmission, software, and information technology service industry have the lowest rating in the digital services trade liberalization index. This is followed by the electricity, heat, gas, and water production and supply industry, the transportation, storage and postal industry, the education and social work industries, and the scientific research and technical service industry, whose digital services trade openness is lower than the sample average. Further subdivisions of the manufacturing industry found that the technology-intensive instrument and apparatus manufacturing industry along with the electrical machinery and equipment manufacturing industry are less open to digital services trade; resource-intensive industries such as petroleum and nuclear fuel processing, metal smelting and processing, and labor-intensive industries such as food manufacturing, textile, clothing, and apparel industries (including the leather, fur, feathers, and their products and footwear industries) are open to a higher degree of digital services trade.

Table 2. Average value of the digital services trade liberalization index for each industry.

Industry	Index Average	Industry	Index Average
Agricultural and food processing industry	0.0250	Special equipment manufacturing	0.0134
Food manufacturing	0.1021	Automobile manufacturing industry	0.0371
Wine, beverage, and refined tea manufacturing	0.0140	Transportation equipment manufacturing	0.0082
Textile industry	0.0517	Electrical machinery and equipment manufacturing	0.0040
Textile clothing, apparel industry	0.0943	Computer, communication, and other electronic equipment manufacturing	0.0076
Leather, fur, feathers, and their products and footwear industry	0.0895	Instrument and apparatus manufacturing	0.0046
Wood processing and wood, bamboo, rattan, palm, and grass products industry	0.0195	Other manufacturing industries	0.0073
Furniture manufacturing	0.0405	Electricity, heat, gas, and water production and supply industry	0.0035
Paper and paper products industry	0.0153	Construction	0.0189
Printing and recording media reproduction industry	0.0097	Wholesale and retail trade	0.0117
Education, sports, and entertainment goods manufacturing	0.0176	Transportation, storage and postal services	0.0041
Petroleum, coal, and other fuel processing industries	0.0685	Accommodation and catering	0.0104
Chemical raw materials and chemical products manufacturing	0.0142	Information transmission, software and information technology services	0.0015
Pharmaceutical manufacturing	0.0154	Leasing and Business Services	0.0122
Chemical fiber manufacturing	0.0133	Scientific Research and Technology Services	0.0043
Rubber and plastic products industry	0.0239	Water, Environment, and Public Facilities Management	0.0079
Non-metallic mineral products industry	0.0154	Residential Services, Repairs, and Other Services	0.0104
Ferrous metal smelting and rolling processing industry	0.0795	Education	0.0051
Non-ferrous metal smelting and rolling processing industry	0.0736	Social Work	0.0047
General equipment manufacturing	0.0074	Culture, Sports, and Entertainment	0.0017

4.2.2. Explained Variable—The Quality of Green Innovation of Enterprises

The majority of the literature has used the number of green patent applications or green patent authorizations to characterize the level of green innovation [11,19,49,53]. However, this only reflects the number of enterprises' green technology R&D and innovation achievements and cannot reflect the value and quality of green innovation. Currently, the mainstream literature regards the number of patents cited as the most reliable way to assess an enterprise's innovation quality [37,54]. According to the concept of "peer evaluation", a patent will be cited when it is more valuable and cutting-edge than other similar patents. In comparison to the number of green patent applications or authorizations, the cited status of corporate green patents can better reflect the extent to which green technologies are recognized and accepted, and it can aid in measuring the quality of green innovation outputs. As a result, the total number of citations of different types of green patents of listed companies (excluding self-citation) is used in this paper to indicate the quality of corporate green innovation. Due to how the patent data has a right-skewed distribution, the logarithmic value of the number of green patents cited plus one is used to assess enterprise green innovation quality.

4.3. Data Source Description

In this paper, the data of Chinese A-share listed enterprises from 2014–2021 are used as the sample, and the cited data of listed companies' green patents are obtained from CNRDS. The data for measuring the digital services trade liberalization index are mainly obtained from the OECD-STRI database, OECD-DSTRI database, and China Input-Output database. The control variables are obtained from the CSMAR database and the Wind database. On the basis of collecting the original data, this paper carried out the following treatments: excluding the samples of financial listed companies and ST, *ST, or PT listed companies; excluding the samples with missing main indicators; and winsorizing all continuous variables at the 1% and 99% levels in order to eliminate outliers. After the above processing, the final sample of 22,147 observations was obtained.

The results of descriptive statistics of the main variables are shown in Table 3. The average value of enterprise green innovation quality is 0.4836, the maximum value is 2.8044, the minimum value is 0, and the standard deviation is 0.5225, which shows that the overall deviation of the sample is not significant. The average value of the digital services trade liberalization index is 0.0242, the maximum value is 0.1021, the minimum value is 0.0015, and the standard deviation is 0.0284, indicating that there are significant differences in the level of openness of digital services trade in different industries. In addition, the maximum value of the variance expansion factor (VIF) of variables is 4.45 and the minimum value is 0.97, both of which are less than six, indicating that there is no multicollinearity problem.

Table 3. Description of variables and descriptive statistics.

Variables	Variable Description	Sample Size	Average Value	Standard Deviation	Minimum Value	Maximum Value
InGreen	The quality of green innovation of enterprises	22,147	0.4836	0.5225	0	2.8044
CDSTRI	Digital services trade liberalization index	22,147	0.0242	0.0284	0.0015	0.1021
Size	Firm size	22,147	23.0252	1.2893	19.5245	27.3526
Age	Firm age	22,147	2.9638	0.2705	1.9459	3.6045
ROA	Firm performance	22,147	0.0308	0.0681	−0.2267	0.2137
Lev	Financial leverage	22,147	0.4427	0.2056	0.0512	0.9981
TobinQ	Tobin's Q	22,147	1.9139	2.2009	0.5987	19.4728
RD	R&D investment intensity	22,147	0.0651	0.0887	0	0.3934
Market	Market power	22,147	0.9299	0.3821	0.0920	5.7597
Tech	Technical employees	22,147	5.8457	1.2735	0	11.2261
SOE	Dummy variables for state-owned enterprises	22,147	0.3118	0.4641	0	1
DS	Industry capital intensity	22,147	12.9708	0.7858	4.8423	16.5358
HHI	Industry concentration	22,147	0.0299	0.0194	0.0106	0.1679

The correlation coefficients between the variables are shown in Table 4. First, the correlation coefficients between digital services trade liberalization and enterprise green innovation quality are positive (=0.187) and significantly positive at the 1% level ($p < 0.01$), which initially supports H1. Second, all of the control variables have significant correlation coefficients with the explained variables, indicating that the control variables used in this paper are convincing. Third, the correlation coefficients for each variable are less than one, showing that multicollinearity is not a significant issue in this study, which is consistent with the findings of VIF in the preceding analysis.

Theoretical analysis shows that digital services trade liberalization can improve the quality of green innovation of enterprises. After the preliminary processing of the data, Figure 2 depicts the scatter fit graph of digital services trade liberalization and the logarithm of the average green patent citations by industry. It can be seen that there is a positive correlation between digital services trade liberalization and the quality of green innovation in China. Based on this, this paper investigates this relationship further using more detailed empirical analysis.

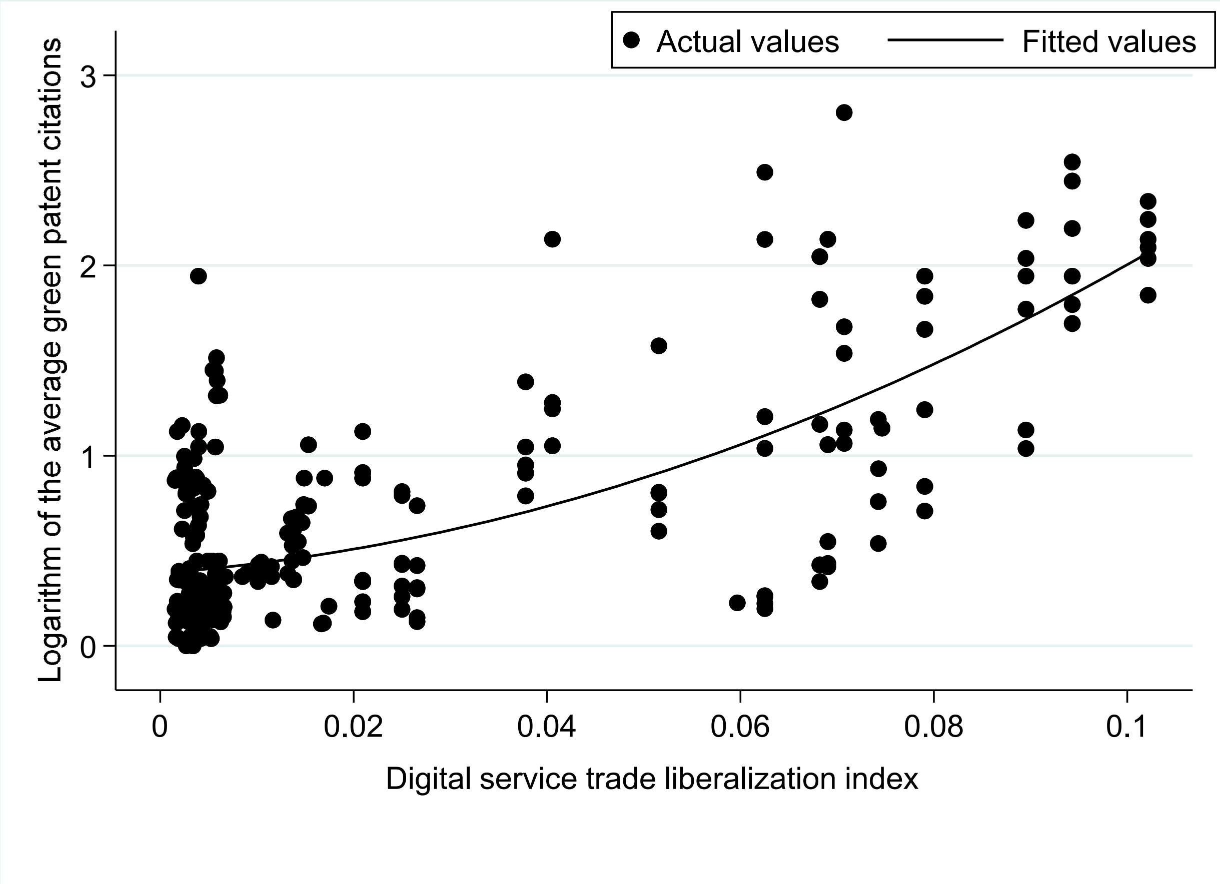

Figure 2. Scatter fit graph.

Table 4. Pearson correlation analysis.

	InGreen	**CDSTRI**	**Size**	**Age**	**ROA**	**Lev**	**TobinQ**	**RD**	**Market**	**Tech**	**SOE**	**DS**	**HHI**
InGreen	1												
CDSTRI	0.187 ***	1											
Size	0.313 ***	0.235 ***	1										
Age	−0.089 **	0.178	0.169 ***	1									
ROA	0.020 ***	−0.069 **	−0.007	−0.107 ***	1								
Lev	−0.116 ***	0.281 ***	0.502 ***	0.172	−0.374 ***	1							
TobinQ	0.056 ***	−0.067	−0.410	−0.060 ***	0.086 ***	−0.226 ***	1						
RD	0.214 ***	−0.177 **	−0.223 ***	−0.163	0.139	−0.231	0.169 ***	1					
Market	0.185 ***	−0.028	0.334 ***	0.049 ***	0.045 ***	0.120 ***	−0.070 ***	−0.003	1				
Tech	0.298 ***	0.031 ***	0.465 ***	−0.026	0.011	0.206	−0.126	−0.016 **	0.540 **	1			
SOE	−0.115 ***	0.135	0.369 ***	0.232 ***	−0.076	0.259 *	−0.134	−0.215 ***	0.082	0.155 *	1		
DS	−0.055 ***	0.034 ***	0.212 ***	0.090 ***	−0.024 ***	0.125 ***	−0.124 ***	−0.199 ***	−0.029 ***	0.013 *	0.243 ***	1	
HHI	−0.111 ***	0.050	0.037 ***	0.009	−0.012 *	0.009	0.005	−0.225 ***	0.001	0.050 ***	0.081 ***	0.083	1

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Empirical Results

5.1. Benchmark Regression Results

Table 5 presents the findings of the benchmark regression of the impact of digital services trade liberalization on enterprise green innovation quality. Column (1) is estimated using least squares. The coefficient size of CDSTRI is 0.0372 and significantly positive at the 1% level, indicating that digital services trade liberalization has a significant contribution to the quality of green innovation of Chinese firms. Column (2) controls for firm-, industry- and year-level fixed effects, and the regression results show that the coefficient of CDSTRI is significantly positive at the 5% level, indicating that there is a positive relationship between digital services trade liberalization and the quality of green innovation of enterprises. Column (3) includes firm-level control variables, and column (4) further includes industry-level control variables, and the FE estimation results of both show that the sign of the coefficient of CDSTRI is still significantly positive, which means that digital services trade liberalization has significantly promoted the improvement of firms' green innovation quality after considering the effects of other factors. The results for the control variables are consistent with established studies and intuitive logic. The benchmark regression results provide preliminary evidence of the direction of the aggregate effect in the theoretical analysis, and H1 of this paper is supported by empirical evidence.

Table 5. Benchmark regression results.

Variables	**(1)**	**(2)**	**(3)**	**(4)**
CDSTRI	0.0372 *** (3.82)	0.0421 ** (2.12)	0.0365 *** (3.62)	0.0331 *** (3.72)
Size	0.3235 *** (4.93)		0.4036 *** (5.01)	0.3763 *** (5.02)
Age	0.1343 (0.34)		−0.3395 (−1.46)	−0.4053 * (−1.79)
ROA	1.0344 (1.08)		1.0269 ** (2.10)	0.9743 ** (2.11)
Lev	−0.0238 (−0.87)		−0.0829 (−1.23)	−0.0739 * (−1.82)
TobinQ	0.0432 ** (2.01)		0.0593 ** (2.09)	0.0571 ** (2.08)
RD	0.1235 ** (2.02)		0.1782 *** (3.21)	0.1593 *** (3.22)
Market	1.3232 *** (2.67)		1.0523 * (1.79)	1.0232 ** (2.25)
Tech	0.7382 **		0.6533 **	0.7123 **
	(2.17)		(2.15)	(2.07)
SOE	−0.0212		−0.0523	−0.0576
	(−1.32)		(−0.53)	(−0.63)
DS	−0.0822 * (−1.80)			−0.0697 ** (−2.17)
HHI	−0.5023 * (−1.78)			−0.2562 (−1.30)
Constant	−4.2523 * (−1.85)		−5.0252 *** (−2.72)	−5.4363 *** (−3.08)
Firm fixed effect	No	Yes	Yes	Yes
Industry fixed effect	No	Yes	Yes	Yes
Year fixed effect	No	Yes	Yes	Yes
Observations	22,147	22,147	22,147	22,147
R^2	0.088	0.099	0.134	0.145

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5.2. Robustness Test

5.2.1. Core Explanatory Variable Substitution

This section uses the direct consumption coefficient to measure the digital services trade liberalization index (CDSTRI_D) instead of the complete consumption coefficient, and the higher value of this index likewise indicates the higher degree of openness of the digital services trade of each industry. The estimation results of replacing the core explanatory variable are shown in column (1) of Table 6, and it can be found that the coefficient of CDSTRI_D is positive at the 5% significance level, which is consistent with the results of the benchmark regression, indicating that the findings of this paper are robust.

Table 6. Endogenous treatment and robustness test.

Variables	Core Explanatory Variable Substitution	Explained Variable Substitution	Estimation Model Substitution	Multi-Dimensional Combined Fixation Method	Instrumental Variables I		Instrumental Variables II	
					Phase I	Phase II	Phase I	Phase II
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CDSTRI		0.0701 ** (2.19)	0.0879 *** (3.40)	0.0398 *** (3.24)	5.2412 *** (63.12)	0.0410 *** (3.11)	0.5535 *** (2.88)	0.0350 *** (2.62)
CDSTRI_D	0.0290 ** (2.13)							
Constant	−2.2352 ** (−2.07)	−1.2382 * (−1.77)	−2.3252 *** (−5.36)	−3.4235 ** (−2.09)	−0.3323 (−1.25)	−2.2428 ** (−2.03)	−0.6322 (−0.80)	−2.6246 ** (−2.13)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Unidentifiable test					6322.252 ***	6322.252 ***	3322.253 ***	3322.253 ***
Weak instrumental variable test					1.1×10^4 ***	1.1×10^4 ***	7802.334 ***	7802.334 ***
Observations	22,147	22,147	22,147	20,891	21,257	21,257	21,490	21,490
R^2	0.126	0.063	0.257	0.612	0.708	0.312	0.304	0.230

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5.2.2. Explained Variable Substitution

In reference to Li and Zheng [55], compared with utility model patents and design patents, invention patents are "high quality" substantive innovations of enterprises. Therefore, the ratio of green invention patents granted to all green patents granted by enterprises (GreIN_ratio) is used as a proxy variable for the quality of green innovation of enterprises. The results in column (2) of Table 6 show that the coefficient of the effect of CDSTRI on the GreIN_ratio is positive and significant at the 5% level, which is consistent with the benchmark regression results.

5.2.3. Estimation Model Substitution

The number of enterprise green patents cited is a non-negative integer, and even after adding one to the original data and taking the logarithm, it still represents typical shortened data. As a result, the Tobit model, which fits the truncated data better, is used to re-estimate. Table 6 column (4) displays the test results. The sign and significance of the coefficients of CDSTRI are consistent with the benchmark regression, confirming the robustness of the empirical findings.

5.2.4. Multi-Dimensional Combined Fixation Method

We incorporate city-fixed effects, city-time fixed effects, industry fixed effects, and city-industry fixed effects into the regression model to reduce the endogeneity problem caused by city and industry characteristics. As seen in column (4) of Table 6, the coefficients of the effects of CDSTRI on firms' green innovation quality are all positive at the 1% significance level, indicating that the empirical findings of this paper are still robust.

5.2.5. Endogenetic Treatment

To address the possibility of endogeneity, this paper employs an instrumental variables approach. To begin, the lagged one-period digital services trade liberalization index (*L.CDSTRI*) is used as the instrumental variable in 2SLS regression, as is common practice in the existing literature. Second, in accordance with Beverelli et al. [56] and Shao et al. [57], the Digital Services Trade Restrictiveness Index of India is used to build the instrumental variable, namely, $CDSTRI_{jt}^{IV} = \sum_s \left(1 - DSTRI_{st}^{IV}\right) \times \omega_{jst}$, where $DSTRI_{st}^{IV}$ is the Digital Services Trade Restrictiveness Index of India in the OCED-STRI and OCED-DSTRI databases; ω_{jst} is consistent with the benchmark regression. This instrumental variable construction is based on the following two considerations: First, China and India have similar economic development processes, trade policies, and service sector protection characteristics, and thus the two countries' digital services trade opening policies have a strong correlation. Second, the degree of digital services trade liberalization of a country is primarily determined by national policies, and the direct impact of India's digital services trade restriction measures on the green innovation quality of Chinese enterprises is minimal. As a result, the instrumental variables are nearly exogenous and satisfy the "exclusivity constraint".

The results of the 2SLS regressions with *L.CDSTRI* and $CDSTRI_{jt}^{IV}$ as instrumental variables are reported in columns (5)–(6) and (7)–(8) of Table 6. First, in the first stage IV estimation, the regression coefficients of the instrumental variable on the digital services trade liberalization index are 5.2412 ($p < 0.01$) and 0.5535 ($p < 0.01$), respectively, indicating a significant positive relationship between IV and the explanatory variables. The regression results passed the unidentifiable and weak instrumental variable tests, indicating that the instrumental variables are valid. The estimated coefficients of CDSTRI in columns (6) and (8) of Table 6 are both significantly positive at the 1% level, which means that the effect of digital services trade liberalization on enterprise green innovation quality remains after dealing with the endogeneity problem in this paper.

5.3. Mechanism Test

As stated in H2a, H2b, and H2c, digital services trade liberalization can improve the green innovation quality of enterprises through improving human capital level, increasing green R&D expenditure, and strengthening information resource sharing. To demonstrate this, this section sets the mediating effect model to further test the impact channels of digital services trade liberalization on the quality of enterprise green innovation, and the complete mediating effect model consists of the following three equations:

$$GreInva_{ijt} = a_0 + b_0 CDSTRI_{jt} + c_0 Controls_{it} + ui + uj + ut + \varepsilon ijt \quad (3)$$

$$M_{ijt} = a_1 + b_1 CDSTRI_{jt} + c_1 Controls_{it} + ui + uj + ut + \varepsilon ijt \quad (4)$$

$$GreInva_{ijt} = a_2 + b_2 CDSTRI_{jt} + c_2 M_{ijt} + d_2 Controls_{it} + ui + uj + ut + \varepsilon ijt \quad (5)$$

where M_{ijt} is the mediating variable, including corporate human capital level (HC), corporate green R&D expenditure (GRS), and corporate information sharing level (IS), and the other variables which have the same meaning as in Equation (1). Model (3) is the benchmark regression model (1), model (4) tests the effect of digital services trade liberalization on the mediating variables, and model (5) tests the effect of the mediating variables on the quality of green innovation of enterprises. Table 7 displays the results of the mechanism test. Column (1) of Table 7 displays the results of estimating model (3), columns (2), (4), and (6) of Table 7 display the results of estimating model (4), and columns (3), (5) and (7) of Table 7 displays the results of the estimating model (5).

Table 7. Mechanism test.

Variables	GreInva (1)	HC (2)	GreInva (3)	GRS (4)	GreInva (5)	IS (6)	GreInva (7)
CDSTRI	0.0331 *** (3.72)	0.3012 *** (3.10)	0.0301 *** (3.30)	0.0891 *** (2.96)	0.0307 *** (3.02)	0.0612 ** (2.11)	0.0313 *** (3.22)
HC			0.2312 ** (2.19)				
GRS					0.1325 ** (2.09)		
IS							0.0456 *** (8.04)
Constant	−5.4363 *** (−3.08)	−0.2352 (−0.54)	−3.2325 *** (−2.90)	−2.3456 *** (−3.04)	−5.3733 *** (−3.22)	2.4751 (0.90)	−5.2352 *** (−3.91)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22,147	22,147	22,147	22,147	22,147	22,147	22,147
R^2	0.145	0.119	0.207	0.109	0.170	0.077	0.166

Note: t statistics in parentheses; ** $p < 0.05$, *** $p < 0.01$.

5.3.1. Mechanism I: Improving Human Capital Level

Using a common research scholar practice, the proportion of employees with a bachelor's degree or higher in listed enterprises is used as a proxy variable for the level of corporate human capital (HC). The estimated coefficient of CDSTRI is significantly positive, as shown in column (2), indicating that digital services trade liberalization can improve firms' human capital. Column (3) incorporates the mediating variable HC on the basis of the benchmark model. The regression coefficient of HC is 0.2312 ($p < 0.05$), confirming that human capital enhancement is conducive to improving the quality of enterprises' green innovation, and after controlling for the mediating variable HC, the estimated coefficient of the core explanatory variable CDSTRI is 0.0301 ($p < 0.01$), which is lower than the coefficient of 0.0331 of the benchmark regression result in column (1), showing that improving human capital levels is an important channel through which digital services trade liberalization improves enterprise green innovation quality.

5.3.2. Mechanism II: Increasing Green R&D Expenditure

The amount of R&D expenditure of listed enterprises is used to measure R&D expenditures in this paper, and the proportion of green patent applications to total patent applications is used as a weight to estimate enterprises' green R&D expenditures (GRS). According to Column (4) of Table 7, the estimated coefficient of CDSTRI is positive at the 1% significance level, indicating that digital services trade liberalization has a positive impact on enterprises' green R&D expenditures. Column (5) demonstrates that the estimated coefficient of GRS is significantly positive, whereas CDSTRI is still significantly positive but has a lower value when compared to the benchmark regression result. This empirical result supports the previous mechanism analysis, indicating that digital services trade liberalization can improve firm green innovation quality by encouraging enterprises to increase green R&D spending.

5.3.3. Mechanism III: Strengthening Information Resource Sharing

Drawing on the approach of Song et al. [32], this paper uses Python to analyze the text of annual reports of listed companies, extracting keywords such as "information sharing", "information interaction", "information exchange", and "information integration", and organizing and summarizing them by manual recognition to analyze their meanings. IS is a dummy variable that has a value of one if the company discloses information about information sharing in its annual report, and zero otherwise. The coefficient of CDSTRI in column (6) of Table 7 is 0.0612 ($p < 0.05$), showing that digital services trade liberalization can improve the information-sharing level of enterprises. As shown in column (7), the estimated coefficient of CDSTRI is significantly positive and has a lower value when compared to the benchmark regression result, whereas the estimated coefficient of IS is significantly positive, demonstrating that the information resource sharing effect is the influence channel through which digital services trade liberalization improves enterprise green innovation quality. It can be predicted that enterprises with higher levels of information sharing will promote the effective integration and optimal allocation of internal and external innovation resources, motivating companies to continuously and steadily develop green innovation practices of greater technological complexity.

For rigorous considerations, the Sobel test results demonstrated the significance of the product term (b_1c_2) of the coefficients of each mediating variable, confirming the existence of mediating effects. In conclusion, the mechanism test validates H2a, H2b, and H2c.

5.4. Heterogeneity Analysis

5.4.1. Enterprise-Level Heterogeneity Analysis

First, considering that the type of enterprise ownership is a significant factor affecting the innovation pattern and green innovation capabilities of enterprises, this paper separates the sample into two subsamples of state-owned firms and non-state-owned enterprises for group regression. The regression coefficient of CDSTRI is statistically positive in the sample of SOEs, but not in the non-SOEs, as seen in columns (1) to (2) of Table 8. The explanation for this may be that national policies, such as the liberalization of the digital services market and the shift to a clean, low-carbon economy, frequently have better enforcement and execution methods in SOEs. Additionally, SOEs outperform non-SOEs in terms of resources, expertise, and policy backing. Non-SOEs cannot fully benefit from the impact of the deregulation of the digital services market on fostering high-quality green innovation among firms because the green innovation return cycle is protracted and resource-intensive.

Table 8. Heterogeneity test.

Variables	SOEs	Non-SOEs	Firms with Strong Technology Absorption Capability	Firms with Weak Technology Absorption Capability	Monopolistic Industries	Highly Competitive Industries	Region with High Environmental Regulation Intensity	Region with Low Environmental Regulation Intensity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CDSTRI	0.0343 *** (3.62)	0.0090 (1.26)	0.0351 *** (3.65)	0.0193 * (1.75)	0.0202 (1.12)	0.0341 *** (3.24)	0.0346 ** (2.17)	0.0160 * (1.80)
Constant	−3.2352 *** (−2.90)	−3.2352 ** (−2.08)	−3.2353 *** (−3.14)	−2.2463 *** (−3.91)	−4.3711 ** (−2.18)	−1.3257 * (−1.71)	−5.4636 *** (−3.09)	−4.3237 *** (−3.03)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7561	14,586	11,070	11,077	10,650	11,497	11,140	11,007
R^2	0.122	0.175	0.159	0.142	0.110	0.158	0.163	0.140

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Second, technology absorption capacity can profoundly affect the process of "digesting, absorbing, and reinventing" new technologies and knowledge [58], which is critical for improving the quality of green innovation of enterprises following the opening of the digital services trade. Based on the median of firms' technology absorption capability, the sample in this paper is divided into firms with strong technology absorption capability and firms with weak technology absorption capability. Referring to Liu et al. [59], we compute the fitted value of corporate profits, i.e., potential profits, and use the ratio of actual to potential profits to assess the technological absorptive capacity of the firm. The subgroup regression results are shown in columns (3) to (4) of Table 8, and the comparison shows that the promotion effect and significance of digital services trade liberalization on the quality of green innovation is greater for firms with strong technology absorption capacity than for firms with weaker technology absorption capacity. The reason for this is that the technology absorption ability is a prerequisite for converting external knowledge into high-quality green innovation output, and firms with a stronger technology absorption ability are better able to identify and apply high-end digital elements, integrate various heterogeneous green innovation resources and bring them into greater value, thereby promoting the improvement of enterprise green innovation quality.

5.4.2. Industry-Level Heterogeneity Analysis

Due to varying degrees of competition, different industries have different characteristics of innovation activities, which may cause the impact of digital services trade liberalization on the quality of green innovation of enterprises to differ. In light of this, this paper divides the sample based on the median HHI of each industry, with monopolistic industries having a higher HHI and highly competitive industries having a lower HHI. The CDSTRI has a significant contribution effect on the quality of green innovation of enterprises in high market competition industries, but not in monopolistic industries, as shown in Columns (5) to (6) of Table 8. One possible explanation is that enterprises in monopolistic industries have more market power, which leads to "product inertia" and a lack of motivation for green innovation. However, the competitive environment will force enterprises in competitive industries to compete in innovation, and these enterprises will accelerate the cultivation of green competitive advantages and continuously improve the quality of green innovation in order to cope with the competitive pressure from domestic and international markets.

5.4.3. Regional-Level Heterogeneity Analysis

There may be differences in the effect of digital services trade liberalization on the quality of firms' green innovation for firms with varying degrees of environmental regulation. According to Zhang and Chen [60], the word frequency of environmental clauses in local government work reports is used in this paper to calculate the environmental regulatory intensity (ER) of each prefecture-level city. Columns (7) to (8) of Table 8 show that digital services trade liberalization has a greater impact on the quality of corporate green innovation in regions with strict environmental regulations. The reason for this is that firms in regions with stricter environmental regulations face more environmental pressure and have more incentives to engage in high-quality green innovation activities, so digital services trade liberalization can have a greater impact on green innovation quality promotion.

6. Conclusions and Further Discussions

6.1. Conclusions

This paper measures the degree of within-border openness of digital services trade by each industry in China and conducts a comprehensive and systematic examination of the micro paths through which digital services trade liberalization affects the green innovation quality of enterprises based on the data of A-share listed companies in China from 2014–2021. This paper discovered that first, digital services trade liberalization promotes the quality of green innovation of Chinese enterprises. Second, improving human capital level, increasing green R&D expenditure, and strengthening information resource sharing are important channels through which digital services trade liberalization improves enterprises' green innovation quality. Third, the promotion effect of digital services trade liberalization on enterprises' green innovation quality is more prominent in state-owned firms, firms with stronger technology absorption capacity, highly competitive industries, and regions with a higher degree of environmental regulation.

6.2. Suggestions

Based on the conclusions above, this paper puts forward the following suggestions:

1. First, the high level of digital services trade opening up should be expanded, and high-quality digital services trade development should be continuously promoted. According to the findings of this study, digital services trade liberalization is an effective way to improve the quality of green innovation in Chinese enterprises. As a result, it is critical to seize the new opportunities in the digital services trade and encourage firms to participate in high-quality green innovation activities. Furthermore, market access for digital services should be liberalized further to accelerate the formation of a positive interaction mechanism between high-level opening-up and green innovation development, as well as to provide strong support for overall green transformation and green high-quality development.
2. Second, in line with the trend of digital services trade development, enterprises should strengthen employees' vocational skill training and optimize the human capital structure. Local governments should act as financial fund advisors to encourage firms to increase R&D investments in green innovation. Regulatory authorities must improve the enterprise information disclosure mechanism and smooth the information transmission mechanism of digital services trade to create a good green innovation environment for enterprises.
3. Third, the principle of differentiation should be prioritized and targeted digital services trade liberalization policies should be developed based on the actual situation of enterprises. Reform measures to ease market access in the digital economy should be explored and the development of new modes of digital services trade should be encouraged in high-competition industries. Local governments can implement differentiated digital services trade opening policies based on the degree of regional environmental regulations, providing more effective green innovation incentives for local businesses and promoting rapid green technology upgrading and iteration. Relevant departments should clarify key areas and significantly relax or eliminate relevant restrictive measures for state-owned enterprises and enterprises with a higher capacity for technology absorption. Such enterprises should be encouraged to take the lead in better integrating and allocating globally diverse and heterogeneous innovation resources through digital services trade, to continuously broaden their green innovation quality improvement space, and to provide demonstration paths for the society's overall green transformation development.

6.3. Limitations and Further Research

Firstly, there are no consistent standards or requirements for measuring indicators related to the digital services trade. Although we applied the findings of existing literature and used the input-output approach to measure the degree of openness of digital services trade in each industry in China, this measurement method is subjective, which may bias our results. We will continue to monitor the latest research progress on the digital services trade and continuously improve the indicators in order to provide more robust findings for future studies. Secondly, this study only discussed the relationship between digital services trade liberalization and enterprises' green innovation quality, whereas future research can explore how digital services trade liberalization affects enterprises' environmental performance, green governance, environmental responsibility, and green total factor productivity. These factors also play an important role in the green and sustainable development of firms. Finally, in practice, this study can include some other significant contextual factors that affect digital services trade liberalization and enterprise green innovation quality, such as firm knowledge stock, firm digitization, organizational learning, business environment, and government regulation, to further explore the boundary conditions for firms to improve their green innovation quality.

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