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Digital Service Trade and High Quality Development of China's Manufacturing Industry: Mechanism and Path—From the perspective of chain multiple mesomeric effect

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Abstract

This the article analyzes in-depth the mechanism of how digital service trade impacts the high-quality development of the manufacturing industry. Also, by selecting 30 provinces in China from 2003 to 2020 as samples, the paper empirically analyzes the impact and path of digital service trade on the high-quality development of the manufacturing industry by using the chain multiple intermediary effects model and spatial Durbin model. The empirical results show that: (1) digital service trade has a positive impact on the high-quality development of China's manufacturing industry; (2) digital service trade can positively impact the high-quality development of the manufacturing industry by promoting human capital, green technology innovation, and chain intermediary effects between the two; (3) compared with the eastern region and the central-western region, digital service trade has a greater promotion effect on the high-quality development of the manufacturing industry in the central-western region.

Keywords: Digital service trade; High-quality development of manufacturing industry; Chain multiple intermediary effects; Spatial measurement.

JEL classification: O31, O32, O33, O38.

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1. Introduction

The report of the 20th National Congress of the Communist Party of China pointed out that high-quality development is the primary task of building a modern country in an all-round way. Considering the main role of the manufacturing industry in economic development, China also needs to take advantage of the development of the digital economy to achieve new breakthroughs in the quality of manufacturing development. With the increasingly fierce competition among countries in the manufacturing field, the competition among countries has gradually transitioned from primary competition models such as accelerating scale expansion and minimizing the cost of production factors to advanced competition models such as pursuing high quality and famous brands. High-quality development has gradually become the core issue of the development of the manufacturing industry, and it is also the internal driving force for the sustainable development and rapid growth of China’s economy. On the one hand, with the in-depth development of the technological revolution and industrial transformation, the demographic dividend of China’s manufacturing industry has gradually disappeared, and the phenomenon of diminishing marginal returns to capital has become prominent. The transfer of labor-intensive manufacturing industries from the mid to low end to countries such as Southeast Asia and India has hindered the development speed of China’s manufacturing industry. On the other hand, international trade protectionism has resurged, and developed countries have introduced “re industrialization” policies and taken measures to promote the return of manufacturing industries, causing the loss of production and trade opportunities in some of China's manufacturing industries, resulting in double pressure on their development. In addition, the COVID-19 epidemic has greatly impacted the integrity of the global and Chinese manufacturing industry chains and supply chains and has brought great resistance to the sustainable development of China’s manufacturing industry. Therefore, the current core issue of China’s manufacturing industry is how to reshape the global competitiveness of the manufacturing industry by achieving high-quality development under this situation.

At the same time, driven by the rapid development of the new generation of information and communication technology, digital service trade has gradually become the core of the development of service trade. Relying on Internet technology, it breaks the constraints of time and space, enables producers to collect and process various information more quickly, expand new international markets more easily, and define and segment target customers and consumer groups more accurately. The digitization of service trade results in shorter transaction time, lower transaction costs, and higher transaction efficiency. At the same time, the services provided by digital service trade to the manufacturing industry are digital. As a new element, digital is a more important intermediate input for the manufacturing industry. The advanced technology it relies on can cause a disruptive change in the production and operation mode of the manufacturing industry, which will undoubtedly promote the transformation of the manufacturing industry from low-end to high-end.

In this context, the article discusses the impact of digital service trade on the high-quality development of China’s manufacturing industry and its path, and how China can use digital service trade to create new competitive advantages in the manufacturing industry and promote manufacturing production and competition to break through the “low-end lock-in”. It has important theoretical and practical significance to realize the development to a “high-level leap forward”.

2. LITERATURE REVIEW

This thesis mainly summarizes the literature on the relationship between digital service trade and the high-quality development of the manufacturing industry, so as to explore the existence and mechanism of the role of digital service trade in promoting the high-quality development of the manufacturing industry. However, there is no direct research on the relationship between the two, and academic related research mainly focuses on the following two aspects:

2.1 Research on the relationship between digital service trade and the high-quality development of manufacturing industry

Digital service trade is leading the iterative upgrading of global trade, but there are still few studies on digital service trade and high-quality development of manufacturing industry in academia, mostly starting from the digital economy and digital service trade and studying the relationship between it and the high-quality development of manufacturing.

(1) Research on the relationship between the digital economy and the high-quality development of manufacturing

Scholars believe that the digital economy has broken the constraints of time and space, realized the cross-border free allocation of production resources and other factors, and the supply capacity and level of the industry have improved accordingly. The service innovation of business operators has promoted the effective connection between the production chain and the industrial chain, accelerated the rise of new industries and the transformation of traditional industries, and promoted the quality change, efficiency change and powering change of the manufacturing industry (Ardolino *et al*., 2018[1]; Li Yingjie *et al*., 2021[2]; Liu Xinxin *et al*., 2021[3]). From the perspective of spatial spillover effects, some scholars have found that the digital economy has broken through geographical space constraints to a certain extent, facilitated the dissemination and exchange of information and knowledge between regions, and enhanced the density of manufacturing innovation activities in adjacent areas will have a positive impact on the improvement of total factor productivity in adjacent areas (Bai Junhong *et al*., 2017[4]; Xu Xing *et al*., 2023[5]).

(2) Research on the relationship between digital service trade and high-quality development of manufacturing industry

The rapid development of digital technology and digital service trade, as well as their deep integration with various industries, are triggering major changes in the economic field. (Du Chuanzhong *et al*., 2017[6]; Ma Shuzhong *et al*., 2018[7]). Digital service trade is different from traditional service trade, which can conduct online transactions through "digital transmission", promote the increase of enterprise R&D investment, enrich the types of imported products, improve the level of manufacturing services, and ultimately improve the technical complexity of manufacturing exports (Ren Tonglian, 2021[8]).

2.2 Relevant research on the mechanism of digital service trade promoting the high-quality development of manufacturing industry

At present, there is a lack of relevant academic research on the mechanism of digital service trade promoting the high-quality development of manufacturing industry. Therefore, this thesis reviews the literature on its impact path from the perspective of input and output. On the one hand, human capital is the most "dynamic" factor of production in the high-quality development of the manufacturing industry. The increase in its input level can significantly improve the green total factor productivity of the manufacturing industry and promote the high-quality development of the manufacturing industry (Yang Renfa *et al*., 2023[9]). Human capital and entrepreneurial activities are the most important intermediary paths (Hui Ning *et al*., 2022[10]), and digital service trade can optimize the human capital structure and thus have an impact on the high-quality development of the manufacturing industry. Digital service trade is based on the integrated development of digital technology and manufacturing industry. In the process of promoting the intelligent transformation of manufacturing industry, it has stimulated the increase of enterprises' demand for knowledge-intensive labor (Mao Bing *et al*., 2021[11]). At the same time, the development of digital service trade has deepened the application of digital technology, resulting in the replacement of low-end labor by advanced machinery and equipment, promoting the upgrading of skilled labor, and stimulating new demands for high-quality human capital (Zhu Zhaoyi *et al*., 2022 [12]). On the other hand, green transformation has become an inevitable requirement for the high-quality development of the manufacturing industry. Improving the level of green technology innovation is crucial to the green transformation of the manufacturing industry. Green technology innovation plays an intermediary role between regional digitalization and green total factor productivity of the manufacturing industry (Xiao Jing *et al*., 2023[13]). At the same time, as an important part of regional digitalization, the development of digital inclusive finance has significantly reduced the cost of green technology innovation for enterprises and improved their green technology innovation capabilities (Zhong Tingyong *et al*., 2022[14]; Yu Jintao *et al*., 2022[15]), Reduce corporate pollution emissions from the source, greatly reduce the cost of emission reduction for enterprises, increase support for green technology innovation activities, promote the transformation and upgrading of pollution-intensive manufacturing industries to clean manufacturing industries, and ultimately achieve sustainable economic development (Yuan Yijun *et al*., 2019[16]; Cheng Guangbin *et al*., 2022[17]).

In summary, the previous achievements of relevant institutions and scholars have provided important inspiration for the research of this thesis. However, the existing literature seldom explores the path through which digital service trade has an impact on the high-quality development of manufacturing industry and whether there is a spatial spillover effect of digital service trade. Therefore, the possible marginal contribution of this thesis is firstly to construct chained multiple intermediary effects based on human capital and green technology innovation to explore the different paths that digital service trade has on the high-quality development of manufacturing; secondly, to construct a spatial Durbin model to explore the spatial spillover effect of digital service trade on the high-quality development of manufacturing industry.

3. HYPOTHESIS

The high-quality development of the manufacturing industry is guided by the new development concept, with the ultimate goal of improving the quality of the supply system, with the improvement of efficiency and benefits as the fundamental requirement, and with innovation as the source of power to achieve high-quality, efficient, balanced, coordinated and sustainable green development. Therefore, the important task of the high-quality development of the manufacturing industry is to increase the productivity of green total factors. The key is to seize new opportunities to achieve “changing lanes and overtaking”, breaking through the low-end lock of the value chain, and realize the climb to the middle and high end of the value chain.

3.1 Digital service trade and high-quality development of manufacturing industry

Firstly, digital service trade integrates resource elements through digital network platforms to improve the efficiency of manufacturing resource allocation. Relying on the digital service trade of the digital platform, it can promote the new generation of information technology to gradually penetrate into the production process of the manufacturing industry, efficiently and transparently screen a large amount of data in the manufacturing production process, accurately distribute various production factors to all stages of the manufacturing production process, break the limitations of asset specificity, and produce incremental benefits without boundary restrictions (Zhang Keer, 2021[18]). Secondly, digital service trade is forcing the transformation and upgrading of the manufacturing industry by restructuring the industry competition model. Under the action of the market competition mechanism, relying on the penetration effect of digital service trade, there will be a Matthew effect in which the strong will always be strong, and the competitive advantages of capital-intensive and labor-intensive low-end manufacturing industries will gradually disappear. The space is shrinking day by day, and the competition mode of the manufacturing industry has gradually evolved from price competition to value competition, forcing the transformation and upgrading of low-end manufacturing enterprises (Zhang Yunping *et al*., 2021[19]), and the ecological environment for manufacturing development is gradually improving, thereby promoting green global Improvement of factor productivity (Zhu Guangyin *et al*., 2020[20]). Thirdly, digital service trade creates the core competitive advantage of the manufacturing industry chain by reshaping the way supply and demand are matched. The advanced data analysis technology supported by digital service trade can reduce the information asymmetry between consumers and producers, help manufacturing enterprises improve the efficiency of information matching, conduct multi-dimensional analysis of consumer behavior data, integrate consumers' personalized needs into the R&D, design, production and manufacturing of the manufacturing industry chain, and form a pulling effect on the demand side to the supply side, so that consumers' heterogeneous needs can be better satisfied (Liu Xiaojun *et al*., 2022[21]; Han Minchun *et al*., 2023[22]). At the same time, digital service trade enables manufacturing companies to capture changes in consumer demand in real time, launch new products that are updated in real time, and enhance the competitiveness of companies in the market, thereby boosting the high-quality development of the manufacturing industry. Therefore, the first hypothesis of this thesis is proposed:

H1: Digital service trade can promote the high-quality development of manufacturing industry

3.2 The mediating effect of human capital

The spillover effect of human capital accumulation and the effect of increasing marginal returns are the core driving forces for the transformation and upgrading of the manufacturing industry (Dou Zhengyan *et al*., 2016[23]). Compared with traditional growth theory, endogenous growth theory also pays more attention to the role of human capital as the main source of economic growth. Zhou Mao *et al*. (2019)[24] proposed that the expansion of human capital has improved the skill level of the labor force through the dual functions of "factor agglomeration" and "skill carrier" and has had a positive impact on the complexity of the manufacturing export technology structure. From the perspective of demand, in the process of the integration and development of digital service trade and manufacturing industry, the existing industrial correlation effect and the spillover effect of digital technology have prompted manufacturing enterprises to invest in advanced equipment with cutting-edge technology on a large scale, and the acceleration of intelligent production As a result,

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the low-end labor force has been eliminated, the demand for high-end information technology talents has increased, and the human capital structure has been optimized. From the perspective of the supply side, digital service trade relies on an efficient and interoperable network structure to broaden the channels for the dissemination of educational resources. Communication provides more convenient and effective conditions, promotes the further optimization of the knowledge structure and skill structure of the labor force, promotes the transformation of simple labor to complex labor, provides a source of power for the high-quality development of manufacturing, and promotes the transformation of manufacturing enterprises to high-end and intelligent. In the process of intelligent manufacturing enterprises, the professionalism of labor factor input continues to improve, high-quality labor force and professional production technology help the integration of all links of the manufacturing industry chain and the climbing of the value chain, optimize the production and trading process of enterprises, and improve the production efficiency and product added value of the manufacturing industry (Sun Xiangxiang *et al*., 2018[25]). Therefore, the second hypothesis of this thesis is proposed:

H2: Human capital plays an intermediary role between trade in digital services and high-quality manufacturing development

3.3 The Mediating Effect of Green Technology Innovation

Green innovation development is the ability to improve the core competitiveness of enterprises and provide new technologies or new products that meet the needs of consumers under the premise of coordinating the relationship between development and the environment. Under the dual pressure of the complex and ever-changing international situation and the increasingly scarce natural resources, it is an inevitable requirement for manufacturing enterprises to improve their green technology innovation capabilities to achieve high-quality development (Liu Kaiyue *et al*., 2022[26]).

First of all, the "green" and "high-tech" characteristics of digital service trade can help the manufacturing industry create a differentiated and professional innovation environment, carry out subversive green reforms to the production system, improve green technology innovation capabilities, and promote the green elements of the manufacturing industry productivity development. Second, green technology innovation has forward and backward spillover effects. With the development of high-knowledge, high-tech digital service trade, the convenience for the manufacturing industry to obtain high-quality intermediate services has been greatly enhanced. Through the interaction between digital service trade and manufacturing industry, the technology carried by digital service trade is integrated into the production chain of the manufacturing industry, making up for the existing technical shortcomings of the manufacturing enterprises, and generating green technology spillover effects (Lun Xiaobo *et al*., 2022[27]), and then promote the high-quality development of the manufacturing industry. Finally, the development of digital service trade has formed a series of new economic forms such as the platform economy and the sharing economy, enabling green technology innovation activities to break through geographical restrictions. Different entities can simultaneously participate in green technology innovation in different spaces and share digital the green technological innovations brought about by trade in services will accelerate the pace of high-quality development of the manufacturing industry. Therefore, the third hypothesis of this thesis is proposed:

H3: Green technology innovation plays an intermediary role between trade in digital services and high-quality manufacturing development

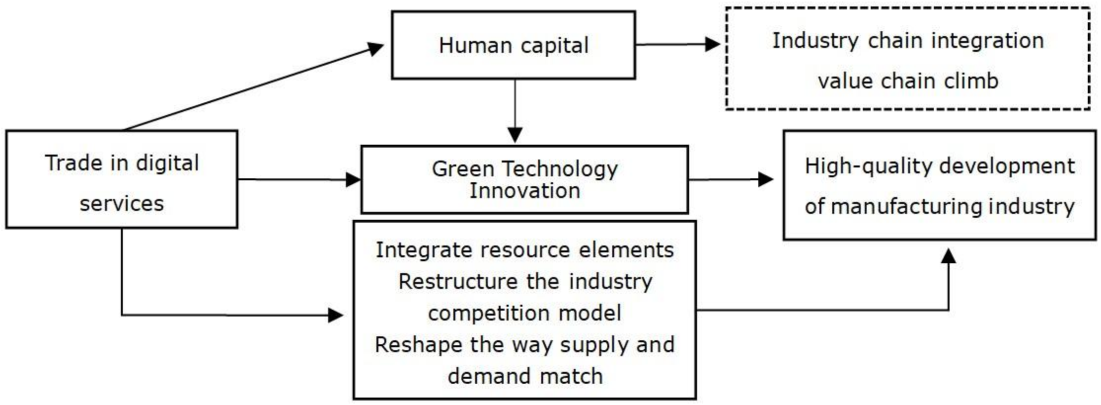
3.4 The chain intermediary role of human capital and green technology innovation

Human capital creates new value for the social economy by changing the traditional knowledge structure, which is the key for enterprises to obtain high returns through green R&D activities. In addition, the role of green R&D investment in promoting the high-quality development of the manufacturing industry largely depends on the degree of specialization of human capital and input efficiency (Yang Minghai *et al*., 2021[28]). First of all, human capital is the core element of technological updating and knowledge accumulation, through the accumulation of human capital to encourage high-quality talents to engage in scientific research and innovation activities, improve the ability of enterprises to digest and absorb technology, increase the benefits obtained by enterprises in green research and development activities, thereby having a positive impact on the independent innovation of enterprises. Secondly, the new knowledge and new technologies about green technology innovation brought by human capital can change the traditional knowledge base of enterprises, enable enterprises to develop and research green products (Zhao Xi *et al*., 2018[29]), and improve the quality of enterprise products. Added value, breaking through the dilemma of "low-end lock-in" in the manufacturing value chain. At the same time, with the help of the platform effect of digital service trade, the flow efficiency of human capital and other elements can be improved, and the scope of knowledge dissemination of green technology innovation can be expanded, thereby promoting the sharing of spillover effects of green technology innovation among regions, and accelerating the "innovation chain", "The in-depth integration of the "talent chain" will build a new pattern of regional linkage development, continue to consolidate and enhance the competitive advantage of the manufacturing industry, and promote the high-quality development of the manufacturing industry. Therefore, the fourth hypothesis of this thesis is proposed:

H4: Human capital and green technology innovation play a chain intermediary role between trade in digital services and high-quality manufacturing

To sum up, the theoretical mechanism of the effect of digital service trade on the high-quality development of the manufacturing industry summarized in this thesis is shown in Figure 1:

Figure 1
The mechanism by which digital service trade affects the high-quality development of the manufacturing industry



4. Econometric Models, Variables and Data Explanation

4.1 Econometric Model

From the availability of data, this thesis selects 30 provinces in China from 2003 to 2020 (Tibet data are deleted due to too much missing data) as research samples. All the data are completed by linear interpolation, and the following econometric model is constructed:

$$lnzz_{i,t} = \alpha_0 + \alpha_1 lnser_{i,t} + \alpha_2 lncv_{i,t} + \mu_{i,t} \quad (1)$$

Among them, "I" and "t" represent the province and time, respectively, "zz" is the high-quality development level of the explained variable manufacturing industry, "ser" is the core explanatory variable digital service trade, "cv" represents the control variable, and "$\mu_{i,t}$" is the random error term.

4.2 Variable setting and description

(1) Explained variable: high-quality development level of manufacturing industry (zz)

The main feature of the high-quality development of the manufacturing industry is to achieve economic benefits but also take into account environmental benefits and social benefits, mainly reflected in low pollution, low energy consumption and high efficiency. Although the production capacity of China's manufacturing industry has been greatly improved, but also facing the challenges of energy and environmental constraints, which has become the main obstacle restricting high-quality development, so this thesis selects green total factor productivity as one of the indicators to measure the high-quality development of the manufacturing industry, not only considering economic benefits but also taking into account the impact on the environment. Secondly, the high-quality development of the manufacturing industry is constrained by the low-end locking of the value chain in the industry, and the high-quality development is no longer the pursuit of scale and speed expansion, but through the improvement of product added value and industrial value chain upgrading, therefore, this thesis selects the export technology complexity to measure the competitive advantage of the product, and finally uses the entropy method to objectively assign the weight of the two to measure the high-quality development level of the manufacturing industry.

1) Manufacturing Green Total Factor Productivity (Gtfp)

The traditional directional distance function cannot solve the problem of non-proportional adjustment of input and output, and there will be the problem of exaggerated estimation of input-output efficiency. Therefore, this thesis draws on Fukuyam *et al*. (2009)[30] and Liu Zuankuo *et al*. (2018) [31]construct the GML index of the SBM directional distance function including the undesired output to measure the green total factor productivity of the manufacturing industry. SBM Directional Distance Function Including Undesired Outputs:

$$\overrightarrow{S_V^t}\left(x^{t,k'}, y^{t,k'}, b^{t,k'}, g^x, g^y, g^b\right) = \max_{s^x, s^y, s^b} \frac{\frac{1}{N}\sum_{n=1}^{N}\frac{S_n^x}{g_n^x} + \frac{1}{M+I}\left(\sum_{m=1}^{M}\frac{S_m^y}{g_m^y} + \sum_{i=1}^{I}\frac{S_i^b}{g_i^b}\right)}{2}$$

$$s.t. \quad \sum_{k=1}^{K} z_k^t x_{kn}^t + s_n^x = x_{k'n}^t, \forall n; \sum_{k=1}^{K} z_k^t y_{km}^t - s_m^y = y_{k'm}^t, \forall m;$$

$$\sum_{k=1}^{K} z_k^t b_{ki}^t + s_i^b + b_{k'i}^t, \forall i; \sum_{k=1}^{K} z_k^t = 1, z_k^t \geq 0, \forall k; s_m^y \geq 0, \forall m; s_i^b \geq 0, \forall i \qquad (2)$$

Among them, (g^x, g^y, g^b) are direction vectors, respectively representing the decrease of input, the increase of expected output, and the decrease of non-expected output, (s_n^x, s_m^y, s_i^b) is the slack vector of input and output reaching the frontier of efficiency, respectively representing the slack variables of redundant input, insufficient expected output, and excessive undesired output. If the obtained result is greater than 0, the actual input and undesired output It is greater than the boundary value of input and output, while the expected output is smaller than the boundary value. Similarly, the global SBM directional distance function can be deduced.

$$\overrightarrow{S_V^G}\left(x^{t,k'}, y^{t,k'}, b^{t,k'}, g^x, g^y, g^b\right) = \max_{s^x, s^y, s^b} \frac{\frac{1}{N}\sum_{n=1}^{N}\frac{S_n^x}{g_n^x} + \frac{1}{M+I}\left(\sum_{m=1}^{M}\frac{S_m^y}{g_m^y} + \sum_{i=1}^{I}\frac{S_i^b}{g_i^b}\right)}{2}$$

$$s.t. \quad \sum_{t=1}^{T}\sum_{k=1}^{K} z_k^t x_{kn}^t + s_n^x = x_{k'n}^t, \forall n; \sum_{t=1}^{T}\sum_{k=1}^{K} z_k^t y_{km}^t - s_m^y = y_{k'm}^t, \forall m;$$

$$\sum_{t=1}^{T}\sum_{k=1}^{K} z_k^t b_{ki}^t + s_i^b + b_{k'i}^t, \forall i; \sum_{k=1}^{K} z_k^t = 1, z_k^t \geq 0, \forall k; s_m^y \geq 0, \forall m; s_i^b \geq 0, \forall i \quad (3)$$

Refer to oh (2010)[32] and Yang Xiang *et al*. (2015) [33]to construct the GML index based on the SBM direction distance function:

$$GML_t^{t+1} = \frac{1+\overrightarrow{S_V^G}(x^t, y^t, b^t; g^x, g^y, g^b)}{1+\overrightarrow{S_V^G}(x^{t+1}, y^{t+1}, b^{t+1}; g^x, g^y, g^b)} \quad (4)$$

The selection of relevant variables for the measurement of green total factor productivity: Due to the lack of relevant data in the manufacturing industry, this thesis uses the indicators shown in Table 1 to measure the GML index using MATLAB software. Since this index represents the rate of change of green development efficiency. As such, this thesis refers to the processing method of Qiu Bin *et al*. (2008) [34], assuming that the GTFP in 2003 is 1, then the GTFP in 2004 is the product of the GTFP in 2003 and the GML index in 2004, and so on to get the 2004 - Green overall productivity of the manufacturing industry in each province in 2020.

Table 1
Index selection of GTFP

index		Indicator description
put in	labor input	Annual average number of employees in manufacturing
	capital investment	Select the fixed capital investment of the whole society in the manufacturing industry, take 2003 as the base period, select 9.6%[35] as the depreciation rate, and use the perpetual inventory method to estimate the capital stock
	energy input	(Gross manufacturing output value/Gross industrial outputvalue)*Total industrial energy consumption (10,000 tons of standard coal)
expected output		Gross output value of manufacturing (using producer price index deflation)
undesired output		(Gross manufacturing output value/Gross industrial output value)*Industrial wastewater discharge
		(Gross manufacturing output value/Gross industrial output value)*Industrial sulfur dioxide emissions
		(Gross manufacturing output value/Gross industrial output value)*Industrial dust emissions

2) Manufacturing Export Technical Sophistication (TSI)

This thesis refers to the calculation methods of Hausmann *et al*. (2007) [36]and Du Chuanzhong *et al*. (2021)[37] to measure the technical complexity of manufacturing exports. The formula is as follows:

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$$prody_{kt} = \sum_i \left[\frac{(e_{ikt}/E_{it})}{\sum_i (e_{ikt}/E_{it})} \times pgdp_{it}\right]$$
$$TSI_{it} = \sum_k \left[\frac{e_{ikt}}{E_{it}} \times prody_{kt}\right] \quad (5)$$

Among them,e_{ikt} is the export value of manufacturing industry "*k*" in region "*i*" in period "*t*", E_{it} is the total export value of the manufacturing industry in region "i" in period "*t*", $pgdp_{it}$it is the per capita gdp in region "*i*" in period "*t*", and $prody_{kt}$kt is industry "*k*" in period "*t*",TSI_{it}it is the technical complexity of manufacturing export in region "*i*" in period "*t*".

(2) Core explanatory variable: trade in digital services (ser)

In view of the aforementioned relationship between digital service trade and the high-quality development of the manufacturing industry is essentially based on the inherent close input-output relationship between the service industry and the manufacturing industry. Therefore, this thesis selects 16 manufacturing industries based on the input-output tables of various provinces in China. With reference to Yue Yunsong *et al*. (2020)[38], Han Jing *et al*. (2021)[39] and UNCTAD's classification of digital service trade, six digital service trade industries were selected. The intermediate input of digital service trade in the manufacturing industry is measured by the product of the complete consumption coefficient of the input-output table of each province and the output value of the manufacturing industry. The calculation method is as follows:

$$service_{ijm} = \alpha_{ijm} + \sum_{k=1}^{n} \alpha_{ijk}\alpha_{kjm} + \sum_{s=1}^{n}\sum_{k=1}^{n} \alpha_{ijs}\,\alpha_{sjk}\alpha_{kjm} + \cdots \quad (6)$$

Among them, $service_{ijm}$ represents the complete consumption coefficient of digital service trade in the manufacturing industry, "*i*" represents each sub-sector of the manufacturing industry, "*m*" represents the six digital service trade industries, "*j*" represents the province, and the first item on the right represents the first round Consumption, the second item represents the second round of consumption, and so on to get the coefficient after n rounds of consumption. Since the input-output table of each province is not continuous, this thesis adopts the "equalization" assumption of most scholars to obtain the data of other provinces. The specific method is to replace the data of 2003-2006 with the data of 2007, replace the data of 2008-2011 with the data of 2012, replace the data of 2013-2016 with the data of 2015, and replace the data of 2017-2020 with the data of 2017. The above data is further processed according to the following formula:

$$service_{jm} = \sum_{i=1}^{16} gdp_{ij} \times service_{ijm} \quad (7)$$

After calculation, we obtained the complete consumption coefficient of digital service trade in each sub-industry of the manufacturing industry, and then multiplied the output value of each sub-industry of the manufacturing industry with the obtained

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$service_{ijm}$ value, and obtained the impact of digital service trade in each province on the manufacturing industry the total input of the sub-industry, and finally the data of the 16 manufacturing sectors are summed up to obtain the panel data of the investment of digital service trade in the overall manufacturing industry in each province.

(3) Control variables

In order to improve the rationality of the model and the ability of variables to explain the explained variables, this thesis adds the following control variables to the model: (1) Government size (gov). It is measured by the ratio of local fiscal general budget expenditure to GDP; (2) Urbanization level (urb). The ratio of the urban population to the total population of each province is used; (3) fixed assets (inv). It is measured by the ratio of fixed asset investment to GDP in each region; (4) Industrialization level (il). It is measured by the ratio of industrial added value to GDP.

(4) Mediator variables

Human capital (hum). Human capital is generally measured by the number of years of education received per capita. It is generally believed that the number of years of education received by a worker is directly proportional to the level of human capital. The calculation formula is as follows, where "ST" represents the number of people who have not attended school, the number of people with a primary school education, the number of people with a junior high school education, and the number of people with a junior high school education. The number of people with high school and technical secondary education, the number of people with college degree or above. "N" means the total population over 6 years old.

$$hum = \frac{ST_1 + ST_2 * 6 + ST_2 * 9 + ST_3 * 12 + ST_4 * 16}{N} \quad (8)$$

Green Technology Innovation (GTP). Existing research measures green technology innovation mainly by the number of green patent applications and authorizations. However, the number of green patents mainly reflects the degree of importance that enterprises attach to green technology innovation, which is not enough to reflect their technological innovation transformation capabilities. Therefore, this thesis chooses the number of green technology patent authorizations is used to measure the level of green technology innovation in each province. The descriptive statistics of the above variables are shown in the table below:

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Table 2

Descriptive statistics of each variable

Variable Classification	variable name and symbols		mean	standard deviation	minimum	maximum
Explained variable	High-quality development of manufacturing industry	zz	0.3551	0.1613	0.0793	0.6577
core explanatory variable	trade in digital services	ser	7.1937	1.5169	2.7479	10.3189
intermediary variable	human capital	hum	2.1668	0.1175	1.7985	2.5480
	Green Technology Innovation	gtp	6.6747	1.7906	0.6931	10.8744
control variables	government size	gov	0.2027	0.0822	0.0808	0.5643
	Urbanization level	urb	0.4244	0.9197	0.2257	0.6654
	fixed assets	inv	0.5295	0.1674	0.1946	0.9725
	Industrialization level	il	0.3336	0.0843	0.0920	0.5601

5. Demonstration Results and Analysis

5.1 Benchmark regression results and analysis

Table 3 is the benchmark regression results of digital service trade on the high-quality development of manufacturing industry. Column (1) is a mixed regression model, and it is found that digital service trade has a significant role in promoting the high-quality development of the manufacturing industry. Every 1 percent increase in digital service trade will promote the growth of manufacturing industry by 0.0776 percent; column (2) is a random effect Model, it is found that at the significance level of 1 percent, digital service trade still has a significant role in promoting the high-quality development of manufacturing industry, and the random effect model is selected after LM test; Column (3) is a fixed-effect model, digital service trade is still significantly positive for the high-quality development of the manufacturing industry, every 1 percent increase in digital service trade will promote the growth of manufacturing development by 0.0568 percent, and after the Hausmann test, the fixed-effect model is selected. Comparing models (1), models (2) and models (3), it is found that the explanatory variables have passed the significance test, and the goodness-of-fit R2 has significantly increased, indicating that the robustness of the model is enhanced, and further indicating that digital service trade is a stable driving force for the high-quality development of the manufacturing industry. Therefore, hypothesis one holds.

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Table 3

Benchmark regression results

variables	model (1)	model (2)	model (3)
	lnzz	lnzz	lnzz
lnser	0.0776***(0.0021)	0.0786***(0.0022)	0.0568***(0.0036)
lngov	0.7426***(0.0503)	0.7772***(0.0527)	0.5676***(0.0714)
lninv	0.2292***(0.0240)	0.2071***(0.0246)	0.0977***(0.0214)
lnurb	0.2052***(0.0339)	0.2497***(0.0374)	1.4667***(0.0739)
lnil	-0.6426***(0.0379)	-0.6727***(0.0393)	-0.6802***(0.0379)
_cons	-0.3476***(0.0247)	-0.3593***(0.0253)	-0.6159***(0.0268)
R-sq	0.837	0.899	0.943
N	540	540	540
LM	-	384.06	-
Hausman	-	-	1501.3

Note: The numbers in brackets are the standard error values; ***, **, * represent the significance levels of 1percent, 5percent, and 10percent, respectively, the same below.

5.2 Robustness check

According to the analysis of benchmark regression results, the development of digital service trade can promote the high-quality development of the manufacturing industry. However, regions with a high level of manufacturing development also tend to optimize local production efficiency, improve infrastructure construction, and attract leading enterprises to settle in. The development of digital service trade in China has also played a certain role in promoting it. Therefore, there may be a two-way causal relationship between trade in digital services and manufacturing development, and endogeneity needs to be dealt with.

First of all, this thesis selects the first-order lag of digital service trade as an instrumental variable to be included in the regression equation. Column (1) in Table 4 reports the regression results of the two-stage least squares method, from which it can be seen that after controlling for endogenous issues, the regression coefficient of trade in digital services is still significantly positive, further confirming that trade in digital services can promote manufacturing high-quality development indicates that the regression results of the model are robust. In addition, this thesis also tests the validity of instrumental variables. The Kleibergen-Paaprk LM has a value of 316.891, indicating that the instrumental variable rejects the hypothesis of underidentification; the Kleibergen-Paaprk Wald-F has a value of 922.836, well above the criterion of 16.38 at the 10percent level, indicating the absence of weak instruments the variable problem, that is, the instrumental variables selected in this thesis are valid. This thesis further uses the dynamic system GMM model for parameter estimation, and the results are shown in Table 4. The results of AR(2) show that the autocorrelation problem of the model does not exist, and the endogeneity problem has also been controlled to a certain extent, and the research conclusions obtained are basically consistent with the benchmark regression results, which further shows that the regression results are robust.

Table 4
Robustness check

variables	(1) 2sls	(2) Dynamic System GMM
	lnzz	lnzz
L.lnzz		0.9039***(0.0380)
lnser	0.0732***(0.0047)	0.0154***(0.0023)
lngov	0.4763***(0.0772)	0.1531*(0.0875)
lninv	0.0685***(0.0229)	-0.0681**(0.0294)
lnurb	1.3112***(0.0856)	0.1027(0.1556)
lnil	-0.6960***(0.0417)	0.0431(0.0338)
R-sq	0.935	-
N	510	480
LM	316.891	-
Wald-F	922.836	-
AR(1)	-	0.000
AR(2)	-	0.806
Hansen	-	29.63

6. Mediating effect and heterogeneity test

6.1 Mediating Effect Model Construction

The benchmark test results show that digital service trade has a significant role in promoting the high-quality development of the manufacturing industry. Then, through what dynamic mechanism does the digital service trade promote the high-quality development of the manufacturing industry? Basic mediation models can only test the effect of a single mediator variable. In this regard, this thesis constructs a chain-type multiple mediation effect model to test the multiple multi-step effects of digital service trade on the high-quality development of the manufacturing industry through two intermediary variables. The following chain-type multiple mediation effect measurement model is set:

$$lnhum_{i,t} = \beta_0 + \beta_1 lnser_{i,t} + \beta_2 lncv_{i,t} + \mu_{i,t} \quad (9)$$

$$lngtp_{i,t} = \gamma_0 + \gamma_1 lnser_{i,t} + \gamma_2 lnhum_{it} + \gamma_3 lncv_{i,t} + \mu_{i,t} \quad (10)$$

$$lnzz_{i,t} = \theta_0 + \theta_1 lnser_{i,t} + \theta_2 lnhum_{i,t} + \theta_3 lngtp_{i,t} + \theta_4 lncv_{i,t} + \mu_{i,t} \quad (11)$$

Among them, "hum" and "gtp" are intermediary variables human capital and green technology innovation respectively, and "cv" is a control variable. If α_1 in formula (1) is significant, it means that the overall mediation effect of the model exists. In theory, the overall mediation effect is equal to the sum of the direct effect and each mediation effect; if θ_1 in formula (4) is significant, it means that the direct effect exists; If $\beta_1\theta_2$ is significant, it means that human capital has a mediating effect in digital service trade promoting high-quality manufacturing; if $\gamma_1\theta_3$ is significant, it indicates that green technology innovation has a mediating effect in digital service trade and manufacturing high-quality development; if $\beta_1\gamma_2\theta_3$ is significantly positive, indicating that human capital and green technology innovation play a chain intermediary role in the high-quality development of manufacturing.

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6.2 Mediating Effect Results Analysis

Column (1) is the benchmark regression result. It can be seen that the total utility of digital service trade on the high-quality development of the manufacturing industry is 0.0568, and the effect is significantly positive at the 1 percent level. The result of column (4) shows that digital services the impact coefficient of trade on the high-quality development of the manufacturing industry is 0.0223 and is significantly positive at the 1 percent level, indicating that the direct effect of the digital service trade on the high-quality development of the manufacturing industry is 0.0223. The intermediary effect of digital service trade on the high-quality development of the manufacturing industry by improving the level of human capital is the product of the coefficient of digital service trade in column (2) and the human capital coefficient in column (4) in Table 5. The result is 0.0053 and significantly positive at the level of 1percent, hypothesis (2) is confirmed. The intermediary effect of digital service trade on the high-quality development of the manufacturing industry by improving the level of green technology innovation is the product of the coefficient of digital service trade in column (3) in Table 5 and the coefficient of green technology innovation in column (4), and the result is 0.0207 and it is significantly positive at the 1 percent level. Therefore, hypothesis (3) is confirmed. The chain intermediary effect of digital service trade via human capital and green technology innovation is the product of the coefficient of digital service trade in column (2) of 0.0210, the coefficient of human capital in column (3) and the coefficient of green technology innovation in column (4), The result is 0.0085 and the three coefficients are all significantly positive at the 1 percent level, indicating that there is a chain intermediary mechanism in which digital service trade promotes green technology innovation through human capital and has a positive impact on the high-quality development of manufacturing. As a result hypothesis (4) is obtained and verified.

Table 5
Mediating effect test results

variables	(1)	（2）	（3）	（4）
	lnzz	lnhum	lngtp	lnzz
lnser	0.0568*** (0.0036)	0.0210*** (0.0031)	0.3502*** (0.0328)	0.0223*** (0.0027)
lnhum			6.8649*** (0.4564)	0.2501*** (0.0413)
lngtp				0.0592***（0.0033）
lngov	0.0938***（0.0227）	0.1663*** (0.0606)	1.7064*** (0.6258)	0.3574**（0.0474）
lninv	0.0090（0.0065）	0.0438** (0.0182)	0.8456*** (0.1876)	0.0188（0.0144）
lnurb	-0.0261（0.0288）	0.6505*** (0.0627)	7.1322*** (0.7082)	0.6174***（0.0583）
lnil	-0.0385**（0.0160）	-0.2219*** (0.0321)	-3.2758*** (0.3448)	-0.3406***（0.0281）
_cons	0.0903***（0.0126）	1.7577*** (0.0227)	-13.4473*** (0.8349)	-0.97303***（0.0772）
R-sq	0.943	0.777	0.934	0.976
N	540	540	540	540

6.3 Mediating effect test

At present, there are AHP and Bootstrap methods for testing the panel mediation effect model. The Bootstrap method has no specific requirements for the distribution of the mediation effect. Through repeated sampling with replacement to ensure the robustness of the results, multiple mediation effects can be reasonably tested. The test results are shown in Table 6. The mediation effect of human capital and green technology innovation and the Bootstrap 95 percent confidence interval of the chain mediation effect of the two do not contain 0, indicating that all mediation effects exist, and the mediation effects are the same as the mediation effects calculated in Table 5. The results are consistent, indicating that the results of the mediation effect are robust. Furthermore, it is found from Table 6 that the direct effect of digital service trade on the high-quality development of the manufacturing industry accounts for the largest proportion of 39.3 percent of the total effect, followed by the intermediary effect of green technology innovation accounting for 36.44 percent, and the third is the human capital. The chain intermediary effect of capital and green technology innovation accounts for 15 percent of the total effect, and the last is the intermediary effect of human capital, which accounts for 9.3 percent of the total effect. The above test results show that digital service trade between the high-quality development of the manufacturing industry, human capital and green technology innovation have a significant intermediary effect, and the intermediary effect is generated through three intermediary chains: Path 1, digital service trade→humancapital→high-quality manufacturing development; path 2, digital service trade→Green technology innovation→high-quality development of manufacturing industry; path 3, digital service trade→humancapital→green technology innovation→high-quality development of manufacturing industry; draw the action path shown in Figure 2 according to the results of the intermediary effect.

Table 6

Bootstrap test

path	Mediation effect	percent of total effect	95percent confidence interval	
			Boot CL upper limit	Boot CI lower limit
direct effect	0.0223	39.3%	0.0136	0.0310
Path 1	0.0053	9.3%	0.0034	0.0071
Path 2	0.0207	36.44%	0.0157	0.0257
Path 3	0.0085	15.0%	0.0062	0.0109
total effect	0.0568	-	0.0450	0.0686

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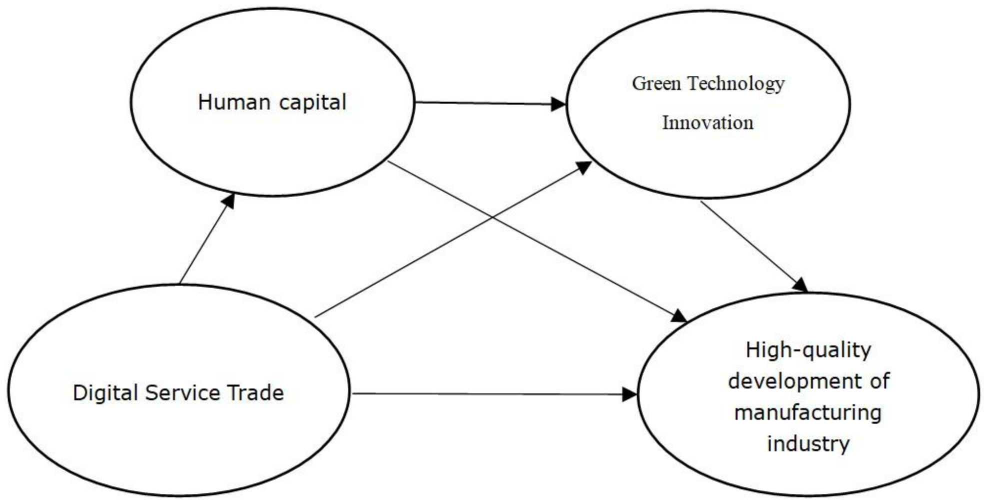
Figure 2

Chain intermediary path diagram of human capital and green technology innovation



6.4 heterogeneity test

(1) Regional heterogeneity test

The development levels of different regions are different, and the development level of digital service trade is also different. Therefore, the role and effect of digital service trade on the high-quality development of manufacturing industry are also different. In this thesis, 30 provinces are divided into the eastern region and the central and western regions, and the chain multiple intermediary effect models are respectively constructed to specifically examine the regional differences in the high-quality development of the digital service trade in the manufacturing industry, the results are shown in Table 7. First, the total effect of digital service trade in the eastern region on the high-quality development of the manufacturing industry is calculated to be 0.0375. From the regression results, it can be found that the coefficient of human capital in Path 1 is not significant, indicating that the mediating effect of human capital in the eastern region does not exist. The green technology innovation coefficient of path 2 is 0.0897, which is significantly positive at the 1percent level. After calculation, its mediation effect is 0.0218, accounting for 58.1 percent of the total effect. The coefficients of each variable in path 3 have passed the significance test. After calculation, the chain intermediary effect of human capital and green technology innovation is 0.0104, accounting for 27.7 percent of the total effect. Secondly, by analyzing the regression results of the central and western regions, it is found that the coefficients of the three paths all pass the significance test. Calculated according to the method described above, the direct effect is 0.0296, the mediation effect of path 1 is 0.0073, the mediation effect of path 2 is 0.0215, the chain mediation effect of path 3 is 0.0073, and the total effect is 0.0657. By comparing the eastern and midwestern regions, this thesis finds that digital service trade has a greater role in promoting the high-quality development of the manufacturing industry in the central and western regions, and the three mediation paths all exist significantly. Due to long-term geographical advantages and policy advantages, the eastern coastal areas have accumulated relatively strong development capital and technological advantages, making the intermediary effect of green technology innovation higher than that of the central and western regions, making the high-quality development of the manufacturing industry ahead of the central and western regions for a long time. However, based on the law of diminishing marginal effects, the impact of digital service trade on the high-quality development of the manufacturing industry may be small, and may not even produce a significant optimization effect. In contrast, the transformation of the manufacturing industry in the central and western regions has not been successful, and the integration of digital service trade and manufacturing is still in the growth stage. Therefore, digital service trade has shown a stronger role in promoting the development of the manufacturing industry in the central and western regions.

Table 7

Regional heterogeneity test

variables	Eastern China			Central and Western China		
	lnhum	lngtp	lnzz	lnhum	lngtp	lnzz
lnser	0.0167*** (0.0046)	0.2431*** (0.0444)	0.0042 (0.0048)	0.0241*** (0.0040)	0.4406*** (0.0404)	0.0296*** (0.0034)
lnhum		6.9891*** (0.7185)	0.0587 (0.0904)		6.1740*** (0.5179)	0.3037*** (0.0450)
lngtp			0.0897***（0.0078）			0.0487***（0.0040）
lngov	0.1680 (0.1291)	3.6437*** (1.1979)	0.5765***（0.1234）	0.1659** (0.0711)	1.3891** (0.6798)	0.2994***（0.0498）
lninv	0.0724* (0.0374)	1.8970*** (0.3494)	-0.0487（0.0380）	0.0420* (0.0216)	0.7503*** (0.2056)	0.0229（0.0152）
lnurb	0.7776*** (0.0798)	10.075*** (0.9246)	0.1854（0.1287）	0.5406*** (0.0902)	4.9598*** (0.9001)	0.7045***（0.0684）
lnil	-0.2550*** (0.0603)	-3.7243*** (0.5858)	-0.3115**（0.0656）	-0.2162*** (0.0398)	-3.1342*** (0.3934)	-0.3521***（0.0312）
_cons	1.776*** (0.0453)	-14.6478*** (1.3430)	-0.5183***（0.1768）	1.7589*** (0.0285)	-11.6655*** (0.9503)	-1.0597***（0.0833）
R-sq	0.835	0.967	0.977	0.758	0.934	0.978
N	180	180	180	360	360	360

(2) Industry Heterogeneity Test

Considering that the impact of digital service trade in different industries on the high-quality development of the manufacturing industry is different, this thesis examines the mechanism of digital service trade on the high-quality development of the manufacturing industry by industry. Due to limited space, this thesis uses the mediation effect coefficient and bootstrap test results Summarized in Table 8. It can be seen from the table that the mediating effect of each digital service trade industry on the high-quality development of the manufacturing industry has passed the bootstrap test, indicating that each industry can pass the innovation effect of human capital and green technology and the chain between the two. The intermediary effect promotes the high-quality development of the manufacturing industry. Specifically, information and communication services mainly promote the high-quality development of the manufacturing industry through green technology innovation, and the intermediary effect of human capital accounts for only 9.5 percent. The financial industry is the main source of financing for the manufacturing industry. By broadening financing channels and providing diversified financing methods, it can solve the problem of financing constraints in corporate green technology innovation activities. Therefore, the intermediary effect of its green technology innovation is also higher than that of human capital. The mediating effect of green technology innovation in research and development services and other business services accounted for as high as 49.4 percent and 46.2 percent of the total effect respectively. The reason is that these two industries mainly include technology research and development, professional and management consulting, etc. Provide professional technical services to the manufacturing industry based on its own knowledge reserves and improve the core technology competitiveness of the manufacturing industry by enhancing the technology diffusion efficiency of digital service trade. In the two industries of education and training and personal entertainment, the proportion of human capital in the total effect is higher than that of other industries. Comparing the total effects of different industries on the high-quality development of the manufacturing industry, it is found that the financial service industry has a higher role in promoting the high-quality development of the manufacturing industry than other industries. This is because the financial industry, as the core of the modern economy, is responsible for providing funds for the real economy, risk management, investment guidance and other responsibilities. In the rapid development of the modern manufacturing industry, the role of the financial service industry is more prominent. The financial service industry can help the manufacturing industry to improve production efficiency, improve product quality, reduce costs, and expand market share through various means, thereby promoting the manufacturing industry to achieve high-quality development.

Table 8
Industry heterogeneity test

industry	path	Mediation effect	percent of total effect	95percent confidence interval	
				Boot CL upper limit	Boot CL lower limit
Information and Communication Services	direct effect	0.0150	40.9%	0.0072	0.0227
	path 1	0.0035	9.5%	0.0021	0.0049
	path 2	0.0103	28.1%	0.0058	0.0149
	path 3	0.0079	21.5%	0.0057	0.0102
	total effect	0.0367	-	0.0271	0.0464
Financial Services	direct effect	0.0176	38.1%	0.0104	0.0248
	path 1	0.0042	9.1%	0.0026	0.0057
	path 2	0.0172	37.2%	0.0122	0.0222
	path 3	0.0073	15.8%	0.0047	0.0098
	total effect	0.0462	-	0.0358	0.0565
Research and Development Services	direct effect	0.0074	23.6%	0.0028	0.0119
	path 1	0.0028	8.9%	0.0013	0.0044
	path 2	0.0155	49.4%	0.0115	0.0195
	path 3	0.0058	18.5%	0.0028	0.0087
	total effect	0.0314	-	0.0241	0.0387
Other business services	direct effect	0.0119	29.1%	0.0063	0.0175
	path 1	0.0037	9.0%	0.0023	0.0051
	path 2	0.0189	46.2%	0.0142	0.0237
	path 3	0.0064	15.6%	0.0041	0.0087
	total effect	0.0409	-	0.0324	0.0494
Education and Training Services	direct effect	0.0145	35.5%	0.0094	0.0196
	path 1	0.0034	8.3%	0.0021	0.0047
	path 2	0.0113	27.6%	0.0075	0.0151
	path 3	0.0074	18.1%	0.0048	0.0101
	total effect	0.0367	-	0.0294	0.0440
Personal cultural and recreational services	direct effect	0.0090	36.4%	0.0042	0.0138
	path 1	0.0028	11.3%	0.0018	0.0037
	path 2	0.0064	25.9%	0.0021	0.0108
	path 3	0.0066	26.7%	0.0044	0.0089
	total effect	0.0247	-	0.0175	0.0320

7. Further Discussion: Spatial Spillover Effects

With the continuous improvement of China's infrastructure construction, the interaction between various economic systems continues to increase, and the linkage effect of various industries is stronger. At the same time, digital service trade takes information networks and digital platforms as important carriers and is driven by the effective use of digital technologies. The digital space network constructed by it can provide the flow channel of element resources to guide the inter-regional flow of resources to realize the efficient allocation of resources, further expanding the spillover effect of traditional space, and show a stronger role in promoting the high-quality development of regional manufacturing industries. That is to say, digital service trade in the region will not only improve the high-quality development of the manufacturing industry in the region, but also drive the high-quality development of the manufacturing industry in other regions. At this time, only using the general panel data regression model cannot reasonably explain this effect, so this thesis uses the spatial econometric model to further explore the relationship between the two.

7.1 Spatial correlation test

Before using a spatial econometric model for analysis, it is necessary to examine the spatial correlation of trade in digital services and the high-quality development of manufacturing. A positive Moran I index indicates that the observed variables are positively correlated in space, and a value less than zero indicates that the observed variables are negatively correlated in space. The closer the Moran I index is to 1, the stronger the spatial agglomeration effect, and the closer it is to 0, the random distribution of observed variables in space. This thesis calculates the Moran index based on the spatial adjacency matrix. The results are shown in Table 9. The Moran I index of China's digital service trade has passed the significance test, indicating that there is a significant spatial positive correlation in the digital service trade, and the high-quality development of the manufacturing industry is except for a few years, the Moran I index from 2003 to 2020 has passed the significance test, indicating that there is a significant spatial positive correlation in the high-quality development of the manufacturing industry. Therefore, this model can be used for further analysis.

Table 9

Moran I index

year	High-quality development of manufacturing industry		trade in digital services	
	Moran I	Z value	Moran I	Z value
2003	0.251**	2.292	0.265***	2.426
2004	0.287***	2.604	0.175**	1.698
2005	0.232**	2.189	0.256***	2.358
2006	0.239**	2.216	0.268***	2.452
2007	0.183**	1.758	0.290***	2.626
2008	0.259***	2.382	0.359***	3.182
2009	0.253***	2.326	0.340***	3.026
2010	0.237**	2.195	0.349***	3.099
2011	0.272***	2.48	0.346***	3.078
2012	0.176**	1.707	0.369***	3.256
2013	0.108	0.124	0.225**	2.109
2014	0.159*	1.564	0.241**	2.239
2015	0.172**	1.673	0.257***	2.371
2016	0.159*	1.565	0.261***	2.404
2017	0.058	0.794	0.302***	2.723
2018	0.315***	2.93	0.341***	3.047
2019	0.057	0.842	0.303***	2.741
2020	0.038	0.637	0.287***	2.611

7.2 Spatial econometric model construction and result analysis

Based on the investigation of spatial correlation, this thesis constructs the following spatial durbin model:

$$lnzz_{it} = \alpha + \rho wlnzz_{it} + \beta lnser_{it} + \eta wlnser_{it} + \gamma lncv_{it} + \delta_t + \theta_p + \varepsilon_{it} (11)$$

Among them, "i" represents 30 provinces in China, "t" represents time, and "w" represents the constructed spatial weight matrix, which represents the spatial autoregressive coefficient and reflects the spatial autocorrelation of high-quality manufacturing development in different regions. In order to objectively measure the spatial effect of digital service trade on the high-quality development of the manufacturing industry, this thesis uses the spatial autoregressive model (SAR), spatial error model (SEM) and spatial Durbin model (SDM) for analysis. In Table 10, comparing the results of these three models, it is found that digital service trade can significantly promote the high-quality development of local manufacturing. By comparing the R^2 and Log-L values of these three models, it is found that the R^2 and Log-L values of the SDM model are the highest, and the null hypothesis that the SDM model can degenerate into the SAR model and the SEM model is rejected by the LR test. Therefore, this thesis believes that the constructed spatial SDM model is the most suitable to describe the spatial effect of digital service trade on the high-quality development of manufacturing.

By analyzing the SDM regression results, it can be obtained that the impact coefficient of digital service trade on the high-quality development of manufacturing industry is significantly positive at the level of 1percent, that is, every 1 percent increase in digital service trade will promote the high-quality development of local manufacturing industry by 0.0038 percent. On the spatial spillover effect, the coefficient of the spatial lag item is significant at -0.1326, indicating that the high-quality development of the manufacturing industry in neighboring provinces will have an inhibitory effect on the high-quality development of the local manufacturing industry. The reason for this is that if a region wants to promote the local manufacturing industry High-quality development requires the development of high-end manufacturing and the formulation of policies to attract and support related enterprises. However, such development may lead to a shortage of development factors in the manufacturing sector in neighboring provinces, resulting in relatively backward development of the manufacturing industry. In addition, as the manufacturing industry in a region continues to become high-end and smart, local low-value-added and high-polluting manufacturing companies will migrate to neighboring regions, further hindering the development of manufacturing industries in neighboring regions, resulting in extremely uneven development of manufacturing industries in various regions.

Table 10
Spatial econometric model regression results

variable	(1) SAR	(2) SEM	(3) SDM
	lnzz	lnzz	lnzz
lnser	0.0041***(0.0013)	0.0043***(0.0013)	0.0038*** (0.0013)
lngov	0.0962*** (0.0216)	0.0950***(0.0209)	0.0932*** (0.0247)
lninv	0.0085 (0.0062)	0.0087(0.0061)	0.0078 (0.0063)
lnurb	-0.0251 (0.0274)	-0.0238(0.0275)	-0.0177 (0.0280)
lnil	-0.0407***(0.0153)	-0.0437(0.0154)	-0.0413**(0.0152)
W*lnser			0.0067**(0.0027)
W*lngov			-0.0030(0.0383)
W*lninv			0.01610.0130)
W*lnurb			0.0605(0.0539)
W*lnil			-0.0825***(0.0279)
ρ	-0.0683（0.0542）	-0.0962*（0.0579）	-0.1326*（0.0579）
R-sq	0.817	0.841	0.949
N	540	540	540
Log-L	1694.5517	1695.1443	1701.7024
LR test	14.3	13.12	-
province	control	control	control
years	control	control	control

7.3 Spatial Effect Decomposition

Since there are a large number of interaction terms between adjacent regions, it is not comprehensive enough to explain the spatial effect of digital service trade on the high-quality development of manufacturing industry with the regression coefficients in Table 10. Therefore, this thesis decomposes the impact of digital service trade on the high-quality development of manufacturing into direct effects and indirect effects. Specifically, the direct effect represents the impact of digital service trade on the high-quality development of local manufacturing, and the indirect effect, namely the spatial spillover effect, represents the impact of digital service trade on the high-quality development of manufacturing in adjacent regions. The results are shown in Table 11: the total effect of digital service trade on the high-quality development of the manufacturing industry is 0.0094. From the perspective of direct effects, digital service trade has a significant positive impact on the high-quality development of the province's manufacturing industry. Every increase in digital service trade by 1 percent will promote the high-quality development of the province's manufacturing industry by 0.0037 percent; from the perspective of indirect effects, digital service trade will promote the high-quality development of the manufacturing industry in neighboring provinces, and every 1 percent increase in the province's digital service trade will promote the high-quality manufacturing of neighboring provinces. Quality development increased by 0.0057 percent. To sum up, digital service trade can not only promote the high-quality development of the manufacturing industry in the region, but also promote the high-quality development of the manufacturing industry in neighboring regions through the spatial spillover effect.

Table 11
Spatial effect decomposition

variables	direct effect	indirect effect	total effect
	lnzz	lnzz	lnzz
lnser	0.0037*** (0.0013)	0.0057** (0.0024)	0.0094*** (0.0025)
lngov	0.0962*** (0.0244)	-0.0133 (0.0359)	0.0793** (0.0332)
lninv	0.0080 (0.0062)	0.0130 (0.0115)	0.0210** (0.0119)
lnurb	-0.0196 (0.0274)	0.0597 (0.0479)	0.0402 (0.0545)
lnil	-0.0395*** (0.0142)	-0.0698*** (0.0242)	-0.1092*** (0.0271)

8. Conclusions and Policy Recommendations

8.1 Conclusions and Policy

On the basis of theoretical analysis, this thesis uses the panel data of 30 provinces in China from 2003 to 2020 to study the impact and path of digital service trade on the high-quality development of China's manufacturing industry, and draws the following conclusions:

First, digital service trade has a significant role in promoting the high-quality development of China's manufacturing industry. This conclusion is still robust after testing with instrumental variables.

Second, through the chain multiple mediation effect test, it is found that digital service trade can promote the high-quality development of manufacturing industry through human capital, green technology innovation and the chain mediation effect of the two.

Third, compare the eastern and central western regions, it is found that digital service trade has a greater role in promoting the high-quality development of the manufacturing industry in the central and western regions; the intermediary role of green technology innovation and the chain of human capital and green technology innovation. The intermediary effect still exists, but the intermediary effect of human capital in the eastern region is not significant.

Fourth, through empirical research using the constructed spatial durbin model, it is found that digital service trade has a spatial spillover effect on the high-quality development of China's manufacturing industry, which means that the role of digital service trade in promoting the high-quality development of manufacturing industry is not limited to local regions but will radiate to other regions.

8.2 Policy Recommendations

Based on the above conclusions, this thesis puts forward the following policy recommendations:

(1) Improve the digital service trade governance system and expand the scale of digital service trade imports. The healthy development of digital service trade is closely related to the international trade governance system. China should actively participate in the current and future negotiations on the international governance system of digital service trade, propose corresponding trade rules according to its own development, and jointly build an efficient and diversified trade governance system. Construct an institutional environment conducive to the development of digital service trade. China can also reduce barriers to digital service trade, expand the opening up of digital service trade, vigorously introduce high-tech digital service trade, and give full play to the technological spillover effect of digital service trade on the high-quality development of the manufacturing industry. At the same time, manufacturing enterprises are encouraged to introduce a variety of digital service trade through service outsourcing and give play to the role of different industries in promoting the high-quality development of the manufacturing industry.

(2) Strengthen the construction of new digital infrastructure and expand the effect of green technology innovation in digital service trade. The construction of digital infrastructure is the basis for the development of digital service trade. China must pay attention to the construction of new infrastructure such as big data, 5G, and artificial intelligence. The flexible manufacturing production system and digital service trade platform based on the intelligent application platform create an intelligent technical environment for the development of digital service trade, create a convenient and efficient online service transmission channel, give full play to its green technology innovation effect, and promote high-quality development of the manufacturing industry.

(3) Formulate regional development strategies and create a favorable institutional environment. According to the impact of digital service trade in different regions on the high-quality development of the manufacturing industry and the differences in paths, implement differentiated development strategies. The digital service trade has a stronger driving effect on the high-quality development of the manufacturing industry in the central and western regions, bringing it the opportunity to “overtake on a bend”. Therefore, China should increase support for the central and western regions, promote the cultivation of digital service trade industry, create new industrial development models and new formats with local characteristics, fully release the driving role of digital service trade in regional manufacturing development, accelerate the layout of new manufacturing industry chains in the eastern region, and strengthen the leading role of digital service trade in driving the development of the manufacturing industry.

(4) Build a regional coordinated development network and deepen the coordinated development of the two industries. Make full use of the new impetus empowered by digital service trade, promote the deep integration of manufacturing and digital service trade, penetrate digital technology into all aspects of manufacturing production, improve the personalized level of manufacturing with accurate digital services, create a comprehensive integrated system of cross-regional interconnection, improve the analysis and processing capabilities of data in the manufacturing industry, realize information sharing, business collaboration and real-time interaction in the manufacturing production process, and build a data-based and intelligent manufacturing ecosystem for regional coordinated development.

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