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Can digital service trade promote the high-quality development of global manufacturing? Existence and mechanism

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Can digital service trade promote the high-quality development of global manufacturing? – existence and mechanism

Development
of global
manufacturing

191

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Abstract

Purpose – This thesis deeply studies the impact mechanism of digital service trade on the high-quality development of the manufacturing industry from the aspects of technological innovation and industrial structure.

Design/methodology/approach – In this thesis, 40 countries from 2010 to 2020 were selected as samples, and the panel fixed-effect model and intermediary effect model were used to empirically analyze the impact path of digital service trade on the high-quality development of global manufacturing.

Findings – Overall, digital service trade has a positive impact on the high-quality development of the global manufacturing industry. Through the analysis of the intermediary effect mechanism, it is found that digital service trade can further positively affect the high-quality development of the global manufacturing industry by promoting technological innovation and industrial structure upgrading.

Research limitations/implications – Based on the empirical results, targeted countermeasures and suggestions are given in this paper.

Practical implications – Through the test of national heterogeneity, it is found that in developing countries, digital service trade mainly acts on the high-quality development of the manufacturing industry by promoting industrial structure upgrading.

Social implications – In developed countries, digital service trade mainly promotes the high-quality development of manufacturing through technological innovation; from the perspective of industry heterogeneity, the three service industries of information and communication technology (ICT), other business services and property have the intermediary effect of technological innovation and industrial structure.

Originality/value – This manuscript suggests that trade in digital services should be promoted as a national trade priority.

Keywords Trade in digital services, High-quality development of the manufacturing industry, Entropy method, Mediating effect

Paper type Research paper

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1. Introduction

At present, the development of a new generation of information technology is changing with each passing day, triggering a new round of scientific and technological revolution, which is profoundly reshaping the global business form and trade model, giving birth to new formats and new models of development in the field of service trade, which has produced a huge impetus for the expansion of global digital trade scale and promoted the vigorous development of digital service trade worldwide. Especially in the post-epidemic era, digital service trade is a “new engine” of global economic growth, playing an increasingly important role in the restructuring of global factor resources and the reshaping of international production networks.

According to the “Digital Trade Development and Cooperation Report 2022” released by the Ministry of Commerce, the scale of global cross-border digital service trade reached US\$3.86 trillion in 2021, which was a year-on-year increase of 14.3%, and its position in service trade has become increasingly important. The top five countries in terms of digital service trade in 2020 are the United States, Ireland, the United Kingdom, Germany and China, which shows that European and American countries occupy a dominant position in the development of digital service trade. China is the only developing country in the top five, but as an industrial economic power, China has a strong digital consumer market and a complete industrial system, which provides strong support for the development of new models such as industrial internet, intelligent manufacturing and digital technology. Therefore, trade in digital services is likely to be a huge new opportunity for the economic growth of countries at different levels of development.

In addition, the emergence of global countercurrents and the impact of the new crown pneumonia epidemic will further change the competition format of global manufacturing and the distribution mode of global industrial chains. According to data released by the China Federation of Logistics and Purchasing, the average global manufacturing Purchasing Managers Index (PMI) in 2022 was 51.8%, down 4.3% points from the average in 2021. In this context, developed countries are actively formulating relevant policies to accelerate the return and transformation and upgrading of their manufacturing industries to maintain the commanding heights of manufacturing competitiveness. Developing countries are taking advantage of their latecomer advantages by seizing various opportunities, strengthening cooperation with the global manufacturing industry, expanding the international market, improving the development level of the manufacturing industry and enhancing the international competitiveness of their manufacturing industry.

Therefore, in the context of the explosive growth in digital service trade, the question of how to grasp the development opportunities of the digital service trade and reshape the global competitiveness of domestic manufacturing by achieving high-quality development of manufacturing has increasingly become the focus of manufacturing competition in all countries around world. Therefore, this thesis discusses whether digital service trade can have a positive impact on the high-quality development of global manufacturing and also what is the extent of this impact and whether there are differences. It also discusses the path of these influences in depth, which has important theoretical and practical significance for promoting the use of digital service trade to strengthen cooperation, create new competitive advantages in the manufacturing industry of various countries and achieve the high-quality development of global manufacturing.

2. Literature review

The relevant research on the impact of digital service trade on the high-quality development of the manufacturing industry mainly focuses on the definition of the concept of digital

service trade, the measurement of high-quality development of the manufacturing industry and the impact of digital service trade on the development of the manufacturing industry.

2.1 Definition study of trade in digital services

The definition of trade in digital services is still inconclusive. In 2019, the Organisation for Economic Co-operation and Development (OECD) first defined digital service trade as services provided through the mobile Internet and further expanded it from the dimensions of transaction methods, products and participation. In 2019, the Ministry of Commerce proposed in the “China Digital Service Trade Report 2018” that digital service trade is a part of digital trade, and its realization depends on the development of digital information technology, including not only the digitalization of traditional industries, but also the new economic model spawned by new technologies. [Madeleine et al. \(2016\)](#) believes that digital trade is different from traditional forms of trade and is a new trade mode that allows products to be traded through diversified carriers with the help of advanced information and communication technologies. [Wang \(2019\)](#) uses the OECD analysis framework to further define the concept of digital service trade: digital service trade is a new model derived from the combination of new digital service content on the basis of digital trade. [Zhang and Zhou \(2022\)](#) believe that digital service trade is a trade form based on communication technology and excludes digital goods trade. Ma Shuzhong has continuously improved the concept of digital service trade, believing that digital service trade refers to service trade with information networks and digital platforms as important carriers, effective use of digital technology as the driving force and digital innovation on the supply side of services and digital consumption on the demand side.

2.2 Research on the measurement of high-quality development of manufacturing industry

[Jiang et al. \(2019\)](#) used the entropy weight method to measure the high-quality development of manufacturing in 31 provinces in China and found that the development level of China’s manufacturing industry showed an upward trend and it also showed a development trend of “strong east and weak west”. [Wang and Shi \(2022\)](#) took 27 industries in China’s manufacturing industry as research objects, measured the high-quality development level of the manufacturing industry from the aspects of green development efficiency and export technology structure and found that the high-quality development level of China’s manufacturing industry showed an upward trend and accelerated after 2015. [Wang and Yu \(2022\)](#) constructed a comprehensive index of the high-quality development of China’s manufacturing industry based on the composite entropy method, and the results showed that the high-quality development level of the manufacturing industry has steadily increased, showing a pattern of “high in the east and low in the west, high in the south and low in the north”. [Zheng and Deng \(2022\)](#) constructed the evaluation index of high-quality development of China’s manufacturing industry based on the new development concept and found that the high-quality development level of China’s manufacturing industry generally showed a trend of first declining and then rising, and there was a spatial correlation, and the agglomeration effect of high-value areas and low-value areas was significant.

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

At present, there are many studies based on the relationship between the service industry, service trade and manufacturing and the impact of digital economy and digital trade on the development of manufacturing. This research has gradually increased, but there are few studies on the relationship between digital service trade and high-quality development of

manufacturing. [Ardolino et al. \(2018\)](#) in studying the role of digital technology in the service transformation of industrial enterprises found that digital technology promotes service innovation for manufacturers. Bernard Hoekman and Ben Shepherd [Hoekman and Shepherd \(2017\)](#) found from firm-level analysis that digital service trade productivity has a positive impact on manufacturing productivity and studied the restrictive measures related to digital service trade through trade gravity models to inhibit manufacturing exports. [Wei et al. \(2021\)](#) studied the relationship between digital economy and high-quality manufacturing development based on provincial panel data and concluded that digital economy can promote high-quality development of manufacturing industry and has location heterogeneity. [Lin \(2021\)](#) analyzed the ways in which digital trade can enhance the international competitiveness of China's manufacturing industry and proposed that digital trade should be deeply integrated with all aspects of the manufacturing industry to promote the transformation of the manufacturing industry. [Wang \(2022\)](#) found through the analysis of multiple regression model that digital service trade can promote the manufacturing industry to reduce production costs, improve production efficiency and promote the construction of new comparative advantages in manufacturing through economies of scale and technology spillover.

In summary, the significant research of relevant institutions and scholars provides important enlightenment for the research of this thesis. However, there is little existing literature that directly discusses the relationship between digital service trade and the high-quality development of manufacturing. In addition, most scholars are confined to a certain country. However, due to the different economic development conditions between countries, there are great differences in technical levels. In addition, the development level of digital infrastructure and service industry is also uneven and the impact of digital service trade on the high quality of manufacturing is different as well. Therefore, in order to make up for the shortcomings of relevant research, this thesis conducts research from the following aspects: first, using multiple countries as samples to build a comprehensive evaluation system for the high-quality development of the manufacturing industry and measuring the development index of each country; Then second is to analyze the direct impact of digital service trade on the high-quality development of the world's manufacturing industry and carry out corresponding heterogeneity tests; Third is to take technological innovation and industrial structure as intermediary variables to study the indirect impact of digital service trade on the high-quality development of manufacturing industry and the heterogeneity of its impact, in order to find out the mechanism and path of the former affecting the latter.

3. Hypothesis

The high-quality development of the manufacturing industry is guided by the new development concept, with the goal of improving the quality of the manufacturing supply system and better meeting the needs of consumption upgrading, taking efficiency as the fundamental requirement and innovation as the fundamental driving force and developing with high quality, efficiency, balance, coordination and sustainability. With the maturity of a new generation of information technology such as big data, the Internet of Things and artificial intelligence, digital service trade promotes the high-quality development of the manufacturing industry through data factor driven, technological innovation spillover, industrial structure upgrading and other ways.

3.1 The impact of digital service trade on the high-quality development of the manufacturing industry

First, trade in digital services can play a driving role as a data element. The digital technologies involved in the digital service trade, such as cloud computing, big data, artificial intelligence, etc.

are fully penetrating into the fields of manufacturing production management, product design, supply chain management and other fields, becoming the core factor force of manufacturing industrial transformation and promoting manufacturing production from relying on traditional factors such as labor and capital to relying on data factors. Because of the natural penetration and public goods characteristics of data elements, it has become an indispensable resource for the high-quality development of the manufacturing industry, which can help enterprises collect and analyze a large amount of data in the production process to achieve intelligent supply chain management, so as to better control the procurement, inventory and logistics of materials, realize the seamless connection of production and supply chain, promote the coordinated development of the entire industrial chain and promote the transformation of manufacturing to a more high-end and intelligent direction.

Second, digital service trade can promote the transformation of enterprises from product-oriented to customer-oriented. In the development concept of traditional manufacturing, enterprises pay more attention to the considerable profits brought by economies of scale but ignore that the experience brought by products and services to customers is an important source of value creation. With the vigorous development of digital service trade, the digital technology it relies on has broken the information barriers between consumers and producers, product design is more in line with user needs, and the bonding of data and information helps enterprises accurately locate market demand, incorporate users' differential preferences into R&D and innovation, strategic decision-making and operation management, form the traction of demand side to supply side and maximize the role of promoting the high-quality development of the manufacturing industry.

H1. Digital service trade has a positive impact on the high-quality development of the manufacturing industry.

3.2 Digital service trade promotes the high-quality development of the manufacturing industry by giving play to the effect of technological innovation

According to the smile curve theory, the added value of R&D and marketing in the industrial chain is much higher than that of manufacturing, therefore, if manufacturing enterprises want to occupy the favorable position of the “smile curve”, they must improve their technological innovation capabilities and promote the manufacturing industry to move towards the middle and high end of the value chain. Digital service trade has a certain spillover effect in the process of promoting the optimal allocation of manufacturing resources, which has a positive impact on the technological innovation of manufacturing enterprises.

First of all, according to the endogenous growth theory, technological progress and scientific and technological innovation are the source of high-quality development of the manufacturing industry. The integration of high-tech and manufacturing industry relying on digital service trade will enhance the core competitiveness of enterprises themselves, guide enterprises to catch up with cutting-edge core technologies, improve the speed of product innovation, achieve diversified product supply, shorten product life cycles and increase product added value. Second, scientific and technological innovation has a forward-forward spillover effect. With the import of digital service trade with competitive advantages such as high knowledge and high-technology content, the convenience of manufacturing industry to obtain intermediate services is greatly enhanced, and through the interaction mechanism between digital service trade and manufacturing, the technology carried by digital service trade is integrated into the manufacturing production process, thereby reducing the input cost of manufacturing, improving the existing technology of manufacturing enterprises, promoting the effective link of manufacturing research and development, production, after-sales and other links, giving play to the spillover effect of technological innovation and finally

acting on the high-quality development of the manufacturing industry. Therefore, the second hypothesis of this article is presented.

H2. Digital service trade promotes the high-quality development of the manufacturing industry by giving play to the effect of technological innovation.

3.3 Digital service trade promotes the high-quality development of the manufacturing industry by promoting the upgrading of industrial structure

Digital service trade promotes the high-quality development of the manufacturing industry by promoting the rationalization of the industrial structure and the advanced industrial structure of the manufacturing industry.

First, digital service trade can promote the rationalization of the manufacturing industry structure. In the process of integration of data and information elements brought on by the development of digital service trade and the manufacturing industry, it can strengthen the depth of exchange within the industry and technology, expand the transformation dimension of factors and products, refine the process of each production division of labor, optimize the industrial organization model and promote the adjustment of industrial structure. The efficient and interoperable network structure built by digital service trade provides convenience for the spatial exchange of manpower, technology, capital and other elements. It changes the allocation mode of resource elements and affects the regional industrial structure layout of the manufacturing industry, thereby promoting the development of the manufacturing industry. The integrated development of digital service trade and manufacturing will “soften” the factor structure of the production sector, comprehensively revitalize the stock of human capital and promotes the transformation of the traditional manufacturing industry along technology-intensive and capital-intensive pathways, thereby promoting the rationalization of industrial structure.

Second, digital service trade can promote the advanced industrial structure of the manufacturing industry. The main focus of digital service trade is to promote the advanced industrial structure of the manufacturing industry as technology-intensive industries, which have gradually developed into the main position of data monetization by virtue of their innovative advantages. Based on the industrial correlation effect and imitation effect, a large number of technology-intensive enterprises can easily gather in the network, produce huge economies of scale, drive the development of the manufacturing industry and enhance the overall competitiveness of the manufacturing industry. At the same time, trade in digital services amplifies the boundaries of manufacturing technology. In the process of exerting the penetration effect of digital service trade on the manufacturing industry, it further amplifies the extension boundary of technology and then forms a networked and intensive manufacturing model, promotes the transformation of low-end invalid supply to high-end effective supply, creates a new intelligent manufacturing production mode that integrates software and hardware, improves the production efficiency and production level of the manufacturing industry and realizes the high level of manufacturing industrial structure.

H3. Digital service trade promotes the high-quality development of manufacturing by optimizing the industrial structure.

The impact mechanism of digital service trade on the high-quality development of the manufacturing industry is shown in [Figure 1](#).

4. Econometric models, variables and data explanation

4.1 Econometric model

In this thesis, referring to the practice of [Han et al. \(2021\)](#) 40 major economies [1] from 2010 to 2020 were selected as research samples based on data availability and relevant data were

obtained from the World Bank, United Nations Conference on Trade and Development (UNCTAD) database, UNESCO Institute for Statistics (UIS) database and United Nations International Labor Organization database. Due to the difference in the evaluation index units, the logarithm of each variable is selected, and the missing data are completed by linear interpolation method, and the following econometric model is constructed:

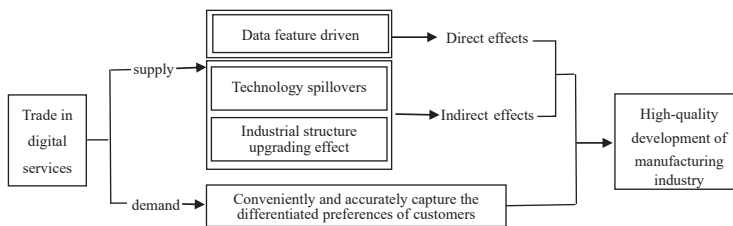
$$\ln zz_{i,t} = \alpha_0 + \alpha_1 \ln dst_{i,t} + \alpha_2 \ln cv_{i,t} + \mu_{i,t} \quad (1)$$

Among them, “*i*” and “*t*” represent the country and time, respectively, “*zz*” is the high-quality development level of the manufacturing industry of the explanatory variable, “*dst*” is the core explanatory variable Digital Service Trade Development Level, “*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*)

There are many methods for measuring the high-quality development of the manufacturing industry, considering that the high-quality development of manufacturing is affected by a variety of factors, the selection of a single index measurement is slightly one-sided, in order to measure the high-quality development of the manufacturing industry as comprehensively and as fairly as possible, it is more reasonable to choose a multi-dimensional entropy weight method. This thesis measures the high-quality development of the manufacturing industry from four aspects: economic benefits, industrial scale, competitive advantages and green development and makes the calculation results more accurate through objective



Source(s): Figure provided by author

Figure 1.
The impact mechanism
of digital service trade
on the high-quality
development of the
manufacturing
industry

Index	Calculation method	Data sources
Economic benefits	GDP per capita Manufacturing Value Added/ GDP	World Bank Database
Industry scale	Manufacturing exports/ commodity exports Investment in fixed assets	
Competitive advantage	Export Value Index Production capacity index	UNCTAD database
Green development	DEA-Malmquist Green Total Factor Productivity	World Bank Database, United Nations International Labor Organization Database

Table 1.
Index system for high-
quality development of
manufacturing
industry

empowerment. The green development data are calculated using DEAP software based on the DEA-Malmquist method and the specific index system is shown in [Table 1](#).

(2) Core explanatory variable: trade in digital services

This thesis measures digital service trade by the proportion of countries' imports of digital service trade in gross domestic product (GDP). According to the UNCTAD database, trade in digital services is divided into five categories: information and communication technology (ICT), financial services, insurance and elderly care services, intellectual property and other business services, of which other business services include research and development and technical services, information technology services, etc.

(3) control variables

In order to improve the rationality of the model and the ability of variables to explain the explanatory variables, this thesis adds the following control variables to the model.

- Servitization level (ser): expressed in terms of the number of people employed in the service sector/the total number of people. With the increase in the number of employees in the service industry, the input of after-sales consultation, market analysis and other factors of products will also increase, thereby improving the level of servitization of the manufacturing industry ([Tu and Gong, 2022](#)).
- Government size (gov): expressed as a percentage of GDP in government spending. Government spending tends to have a strong intervention in the market to make up for the lag of market spontaneous adjustment, if excessive spending will make the market's spontaneous adjustment fail, so the government's impact on the high-quality development of the manufacturing industry is uncertain.
- Openness (open): The share of foreign direct investment (FDI) stock in GDP. FDI mainly affects the capital formation, technological progress and management efficiency of the manufacturing industry through technological spillovers, thereby affecting the competitiveness of the manufacturing industry.
- Infrastructure (inf): Expressed in terms of logistics performance indicators published by the World Bank. Infrastructure construction plays an important role in the production and manufacturing of the manufacturing industry, market matching, etc. and has an impact on the high-quality development of the manufacturing industry by influencing the manufacturing production process, market matching efficiency and scope.
- Human capital (hum): expressed in terms of the number of students enrolled in colleges and universities. A high level of human capital will improve the ability of manufacturing enterprises to innovate products, increase the added value of products and generate greater profit margins ([Ni and Meng, 2017](#)).
- Mediation variables

Technological innovation is the fundamental driving force for the high-quality development of the manufacturing industry. The higher the technological innovation ability, the more it can promote the high-quality development of the manufacturing industry, the current indicators to measure technological innovation are mainly R&D, R &D investment, the number of scientific researchers, the number of patents, etc., this thesis uses the number of researchers per million of residents to measure the level of scientific and technological innovation in a country.

In order to fully reflect the ability of industrial structure upgrading, this thesis draws on the methods of [Jia et al. \(2021\)](#) to measure:

$$is = \sum_{t=1}^3 \varphi_t t, t = 1, 2, 3 \quad (2)$$

where is is the industrial structure upgrading index, φ_t represents the proportion of the “ t ” industry to GDP and “ t ” represents the “ t ” industry. The statistical descriptions of each of the above variables are detailed in [Table 2](#).

5. Demonstration results and analysis

5.1 Benchmark regression results and analysis

For panel data, you need to choose a fixed-effect or random-effects model, which was chosen based on the results of the Hausmann test. [Table 3](#) shows the benchmark return results of digital service trade to the high-quality development of the world’s manufacturing industry. Column (1) shows all country-level results without adding control variables and finds that digital service trade has a significant role in promoting the high-quality development of the manufacturing industry and every 1% increase in digital service trade will promote the high-quality development level of the manufacturing industry in various countries by an increase of 0.078%; Column (2) shows that under the significance level of 1%, digital service trade still has a significant role in promoting the high-quality development of manufacturing in various countries. In order to control the results of time effects and individual effects, digital service trade is still significantly positive for the high-quality development of the manufacturing industry. Comparing columns (1), columns (2) and (3), it is found that after adding control variables and controlling individual and time effects, the explanatory variables passed the significance test and the goodness-of-fit R^2 became significantly larger, indicating that the robustness of the model was enhanced, thus further indicating that digital service trade is a stable driving force for the high-quality development of manufacturing industries in various countries. Therefore, hypothesis one holds.

From the perspective of control variables, the servitization level of all models is promoted at a significance level of 1%, which promotes the high-quality development of the manufacturing industry. It shows that the improvement of the level of servitization has a non-negligible role in promoting the high-quality development of the manufacturing industry in various countries, and the feedback effect brought by the improvement of the level of servitization will make manufacturing enterprises more clear about the needs and preferences of customers and then determines the direction of the enterprise product research and development, so that manufacturing enterprises can form market-oriented technology research and development and product updating, so as to win diversified competitive advantages. The scale of the government has a significant inhibitory effect on the high-quality development of the manufacturing industry, which shows that the excessive intervention of the government in the market has a negative effect on the high-quality development of the manufacturing industry, and the government expenditure should be reduced and the market can play a decisive role in the allocation of resources. FDI also showed a restraining effect, possibly because manufacturing enterprises over-relied on the inflow of external technology and neglected their own technological innovation capabilities, resulting in key core technologies being subject to others and becoming obstacles to the high-quality development of the manufacturing industry. Similarly, infrastructure construction has a negative impact on the high-quality development of the manufacturing industry, which seems to be contrary to the objective understanding, but for countries that have entered the late stage of industrialization, the informatization, networking and intelligence of infrastructure construction have been relatively mature, which will promote the high-

Table 2.
Descriptive statistics
for each variable

Variable classify	The variable name and symbols	Variable description	Data sources	Mean	Standard deviation	Minimum	Maximum
The variable being explained	High-quality development of manufacturing industry	zz	UNCTAD database UN Labor Organize the database	0.1942	0.0961	0.0758	0.8123
	Trade in digital services	dst		0.6914	1.5126	0.0158	10.1162
Core explanatory variables	Technological innovation	tec	UNCTAD database	3438.591	2026.15	33.6149	7930.17
	Industrial structure	is		0.2270	0.2077	0.6223	1.476
	Human capital	hum		3,064,400	7,010,209	1.9000	50,000,000
Control variable	Degree of openness to the outside world	open	UIS database	0.4761	0.8363	0.0069	12.1512
	Level of servitization	ser	UNCTAD database	0.6952	0.0968	0.3460	0.8983
	The size of the government infrastructure	Number of employed persons in the service sector/total number of persons					
		gov	Government expenditure/GDP	0.3267	0.0986	0.1449	0.5483
		inf	Logistics performance Composite indicators	3.475	0.4402	2.2929	4.3720

				Development of global manufacturing
Variables	(1) lnzz	(2) lnzz	(3) lnzz	
Indst	0.0789*** (0.0171)	0.0519*** (0.0148)	0.0273* (0.0148)	201
Inser		1.0058*** (0.1362)	0.7173*** (0.1414)	
Ingov		−0.4515*** (0.0407)	−0.3989*** (0.0394)	
lnopen		−0.0303** (0.0138)	−0.0282** (0.0135)	
lninf		−0.1509** (0.0652)	−0.1116* (0.0630)	
lnhum		0.0038* (0.0021)	0.0035* (0.0019)	
_cons	−1.6286*** (0.0191)	0.3613** (0.1716)	−0.0550 (0.1770)	
R-sq	0.051	0.385	0.474	
N	440	440	440	
country	control	control	control	
year	Not controlled	Not controlled	control	
Note(s): The numbers in brackets are the standard error values; ***, ** and * represent the significance levels of 1, 5 and 10%, respectively, the same below Source(s): Table provided by the author				Table 3. Benchmark regression results

quality development of the manufacturing industry, while for countries in the middle of industrialization, it is relatively backward in terms of resource allocation and institutional reform, which will hinder the integration of infrastructure construction and high-quality development of manufacturing. Human capital has shown a significant positive impact, indicating that the improvement of human capital will promote the high-quality development of the manufacturing industry.

5.2 Robustness check

(1) Robustness test based on endogenous treatment

According to the analysis of benchmark regression results, the development of digital service trade can promote the high-quality development of the manufacturing industry, but 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, which in turn has also played a certain role in promoting the development of local digital service trade. Therefore, there may be a two-way causal relationship between digital service trade and manufacturing development and endogenous treatment is required. Firstly, this thesis selects the lagging first order of digital trade in services as a tool variable to include in the regression equation. Column (1) in Table 4 reports the regression results of the two-stage least squares method. It can be seen that after controlling the endogenous problem, the regression coefficient of digital service trade is still significantly positive, which further confirms that digital service trade can promote the high-quality development of manufacturing, indicating that the regression results of the model are robust. In addition, the validity of instrumental variables is also tested. The p -value of 0 for Kleibergen-Paap rk Lagrange Multiplier (LM) indicates that the instrumental variable rejects the hypothesis of underrecognition; a value of 129 for Kleibergen-Paap rk Wald-F is well above the 16.38 criterion above the 10% level, indicating that there is no weak instrumental variable problem and that the instrumental variable selected in this thesis is valid.

(2) Robustness test

Firstly, the measurement method of digital service trade is changed, and the total import volume of digital service trade (dst1) is used as the core explanatory variable for regression

Table 4.
Robustness test

Variables	(1) 2sls lnzz	(2) Replace the core explanatory variables lnzz	(3) FGLS lnzz
lndst	0.0886*** (0.0276)		0.0491*** (0.0094)
lndst1		0.1211*** (0.0125)	
lnser	0.7482*** (0.1426)	0.7840*** (0.1268)	0.8311*** (0.1067)
lngov	−0.4585*** (0.0431)	−0.3761*** (0.0380)	−0.4956*** (0.0293)
lnopen	−0.0464*** (0.0150)	−0.0364*** (0.0124)	−0.0271*** (0.0078)
lninf	−0.1679*** (0.0632)	−0.1293** (0.0594)	−0.0883** (0.0390)
lnhum	0.0036* (0.0021)	0.0047** (0.0019)	−0.0001 (0.0014)
_cons	−	−1.2537*** (0.2292)	−0.4506*** (0.1212)
R-sq	0.322	0.488	
N	400	440	440
LM	96.149 (0.000)	−	−
Wald-F	129.000 (16.38)	−	−

Source(s): Table provided by the author

and the results are shown in column (2) of Table 4, the coefficient of digital service trade is still significantly positive at the level of 1%, and the impact of the control variable on the high-quality development of the manufacturing industry has not changed significantly, and the results of this thesis are still robust. Secondly, in order to control the influence of heteroscedasticity on the regression results, this thesis uses the feasible generalized least squares method (FGLS) to perform regression analysis on the data, and the results are shown in column (3) of Table 4, the regression coefficient of digital service trade is 0.0491, which is still significant at the level of 1%, and the results are not significantly different from the benchmark regression results, which further demonstrates the robustness of the benchmark regression results.

6. Mediation effects and heterogeneity testing

6.1 Mediation effect

The benchmark test results show that digital service trade has obvious role in promoting the high-quality development of the manufacturing industry, so what dynamic mechanism does digital service trade promote in the high-quality development of the manufacturing industry? In this regard, this thesis draws on the mediation effect model of Wen and Ye (2014) to test the existence of the above mechanism and sets the following econometric model:

lnzz_{i,t} = α₀ + α₁lndst_{i,t} + α₂lncv_{i,t} + μ_{i,t} (3)

lnm_{i,t} = β₀ + β₁lndst_{i,t} + β₂lncv_{i,t} + μ_{i,t} (4)

lnzz_{i,t} = γ₀ + γ₁lndst_{i,t} + γ₂lnm_{i,t} + γ₃lncv_{i,t} + μ_{i,t} (5)

where “m” represents the mediating variables, which are technological innovation (tec) and industrial structure upgrading (is) and “cv” is the other explanatory variables, which are the same as the interpretation of model (1). Firstly, the α₁ in the model (3) is tested, if it is significant, there is a mediating effect and if it is not significant, it is treated as an obscuration effect; Continue to test the β₁ and γ₂ of model (4) and model (5), if both are significant, the indirect effects are significant, and if at least one is not significant, the bootstrap test is performed; Test the γ₁ of the model (5), if it is not significant, it means that the direct effect is not significant, it is a complete mediation effect, if it is significant, it compares the symbols of β₁γ₂ and γ₁, if it is the same sign, it belongs to a partial mediation effect, reporting the

proportion of the mediation effect in the total effect, if it is different, it belongs to the obscuring effect, reporting the absolute value of the proportion of indirect effect to direct effect.

(1) The intermediary effect of technological innovation and industrial structure

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 manufacturing industry is 0.0519, and the effect is significantly positive at the level of 1%, and the result of column (2) shows that the impact coefficient of digital service trade on technological innovation is 0.2459 and significantly positive at the level of 1%, indicating that the development of digital service trade can improve the scientific and technological research and development capabilities of manufacturing enterprises around the world. In order to add technological innovation, the empirical results show that the development level of scientific and technological innovation and digital service trade is significantly positive at the level of 1%. Comparing the coefficients of column (1) and column (3), it can be seen that the coefficient decreased from 0.0519 to 0.0342, indicating that there is a partial intermediary effect in technological innovation, that is, digital service trade can promote the high-quality development of manufacturing industry through the improvement of technological innovation level. According to the data of columns (1), (2) and (3), it can be calculated that the intermediary effect of digital service trade on manufacturing development accounts for 34.07% of the total effect, assuming that the second is true. Similarly, the regression results of column (4) show that digital service trade has a positive impact on industrial structure upgrading and further compare the coefficients in column (1) and column (5), from 0.0519 to 0.0364, indicating that industrial structure upgrading also has some intermediary effects in digital service trade on the high-quality development of manufacturing industry. Further calculated from the data in columns (1), (4) and (5), the mediating effect of industrial structure upgrading is 29.89%, assuming that the third is true. Compare the proportion of the intermediary effects of technological innovation and industrial structure, it is found that the intermediary effect of technological innovation is greater than the intermediary effect of the industrial structure, indicating that the appreciation benefit brought by digital service trade to the high-quality development of manufacturing industry through technological innovation effect is better than that of industrial structure (see [Table 5](#)).

6.2 Testing for heterogeneity

This thesis refers to the method of [Deng and Ren \(2020\)](#) to test the heterogeneity based on the intermediary effect and analyzes the role paths and mechanisms of different countries and different industries in the high-quality development of digital service trade in the manufacturing industry in more detail, so as to facilitate more targeted countermeasures and suggestions.

(1) Heterogeneous mediating effects of technological innovation

- Country heterogeneity

Considering countries at different levels of development, the extent to which digital service trade promotes the high-quality development of manufacturing may vary. Therefore, this thesis tests the heterogeneity of 40 countries according to the United Nations' classification criteria for developing and developed countries [\[2\]](#), and the results are shown in [Table 6](#). It can be seen from the return results that there are indeed differences in the role of digital service trade in promoting the high-quality development of manufacturing industry in various countries. The results from the list (1) show that the impact of digital service trade on the high-quality development of manufacturing industry in developing countries is significantly positive at the 1% level and every 1% increase in digital service trade will promote the high-

Table 5.
Mediation effect test
results

Variables	Basic model technological		Innovation industrial		Industrial structure	
	(1) lnzz	(2) lnfec	(3) lnzz	(4) lnis	(5) lnzz	
lndst	0.0519*** (0.0148)	0.2459*** (0.0385)	0.0342** (0.0153)	0.0691*** (0.0125)	0.0364** (0.0151)	
lnser	1.0058*** (0.1362)	1.3551*** (0.3541)	0.9083*** (0.1365)	0.2583** (0.1152)	0.9478*** (0.1348)	
lngov	-0.4515*** (0.0407)	-0.2135** (0.1057)	-0.4361*** (0.0402)	-0.2276*** (0.0344)	-0.4004*** (0.0421)	
lnopen	-0.0303*** (0.0138)	0.0484 (0.0360)	-0.0337** (0.0137)	0.0246** (0.0117)	-0.0358*** (0.0137)	
lninf	-0.1509** (0.0652)	-0.3126* (0.1696)	-0.1284** (0.0644)	-0.0748 (0.0552)	-0.1341** (0.0643)	
lnhum	0.0038* (0.0021)	-0.0078 (0.0054)	0.0043** (0.0020)	-0.0071*** (0.0017)	0.0054*** (0.0021)	
lnfec	—	—	0.0719*** (0.0191)	—	—	
lnis	—	—	—	—	0.2245*** (0.0585)	
_cons	0.3613** (0.1716)	9.8645*** (0.4462)	-0.3483 (0.2527)	4.1196*** (0.1452)	-0.5636* (0.2943)	
R ² sq	0.385	0.217	0.406	0.258	0.407	
N	440	440	440	440	440	
Proportion of mediation effect	—	34.07%	—	29.89%	—	
Source(s):	Table provided by the author					

Variables	Developing countries		Developed countries	
	(1) lnzz	(2) lnzz	(3) lnzz	(4) lnzz
Indst	0.0813** (0.0316)	0.0805** (0.0361)	0.0300* (0.0160)	0.0201 (0.0154)
Inser	1.2118*** (0.1965)	1.2088*** (0.2063)	0.9292*** (0.2605)	0.5992** (0.2558)
Ingov	−0.4308*** (0.0909)	−0.4297*** (0.0937)	−0.4547*** (0.0415)	−0.4518*** (0.0394)
Inopen	−0.0614*** (0.0235)	−0.0612** (0.0237)	0.0129 (0.0183)	−0.0196 (0.0185)
lninf	−0.1062 (0.1046)	−0.1060 (0.1050)	−0.0726 (0.0891)	−0.0804 (0.0846)
lnhum	−0.0016 (0.0044)	−0.0016 (0.0046)	0.0068*** (0.0021)	0.0059*** (0.0020)
Intec	—	0.0017 (0.0335)		0.1294*** (0.0253)
_cons	0.3560 (0.3458)	0.3357 (0.5348)	0.2492 (0.2066)	−0.8707*** (0.2938)
R-sq	0.344	0.344	0.472	0.526
N	176	176	264	264
Boot	[−0.0889–0.0097]		—	
verification				
Proportion of mediation effect	1.07%		33.08%	

Source(s): Table provided by authors

Table 6.
Test results of national
heterogeneity of
technological
innovation

quality development of manufacturing industry by 0.0813%. Column (2) after adding the influencing factors of technological innovation, the impact coefficient of digital service trade decreased from 0.0813 to 0.0805, indicating that there was a partial intermediary effect in technological innovation, and further calculations showed that the proportion of technical intermediary effect in the total effect was 1.07%. It can be seen from the results of column (3) that in developed countries, digital service trade can significantly promote the high-quality development of manufacturing, after adding the intermediary variable of technological innovation, the impact of digital service trade on the high-quality manufacturing industry is not significant, and technological innovation is manifested as a complete intermediary effect, which shows that digital service trade will inevitably promote the high-quality development of manufacturing through technological innovation effect.

Comparing columns (1) and (3), it is found that in developing countries, digital service trade promotes the development of manufacturing industry to a greater extent, possibly because developed countries are in the stage of high-end manufacturing, and most of them are countries with developed service industries, which are exporters of high-end services, and the import of digital service trade accounts are relatively small, so the role of improving the development of its manufacturing industry is limited. The manufacturing level of developing countries is relatively low, still in the low-end development level of the manufacturing industry, the service industry is relatively backward and a large number of high-end services will be imported, so that developing countries can play a latecomer advantage, and the direct promotion of digital service trade in the high-quality development of manufacturing is more obvious than that of developed countries. Compared with the proportion of intermediary effects of technological innovation, the intermediary effect of developed countries accounted for 33.08%, which was much larger than that of developing countries and was mainly caused by the gap in scientific and technological environment and infrastructure between countries. Developed countries regard scientific and technological innovation as the basic strategy of economic development, focused on selecting cutting-edge, scientific and technological and highly applied new digital technologies for investment and complete new infrastructure construction, thus occupying a monopoly position in technology export in the international market. However, developing countries are limited by the level of economic development, the environment for scientific and technological development is not yet mature, many core

technologies and key technologies are still subject to people, the degree of dependence on foreign technology is high and the competitiveness of core technologies lags behind. This leads to the development advantage of digital service trade in developed countries in the scientific and technological environment, which is more conducive to giving full play to the technological innovation effect of digital service trade on the high-quality development of the manufacturing industry.

- Industry heterogeneity

Considering the different impacts of digital service trade on the high-quality development of manufacturing industry in different industries, this thesis examines the high-quality development of manufacturing industry by digital service trade by industry, and due to space limitations, this thesis summarizes the regression results into [Table 7](#).

From the regression results in [Table 7](#), ICT, other business services, intellectual property rights have a significant positive impact on the high-quality development of the manufacturing industry, of which other business services have the greatest promotion effect, for every 1% increase in digital service trade, the high-quality development of the manufacturing industry increases by 0.0622%, while the insurance and pension and financial services industries do not show a significant impact on the development of the manufacturing industry. The impact coefficients of ICT, other business services and intellectual property rights on the high-quality development of manufacturing decreased from 0.0390 to 0.0205, from 0.0622 to 0.0396 and from 0.0208 to 0.0098, respectively, indicating that from the perspective of sub-industries, the intermediary effect of technological innovation also exists and the intermediary effect accounts for 47.51 and 36.29% of the total effect, respectively. Through further comparative analysis, it is found that industries with high-technology content are more likely to exert the technological innovation effect on the manufacturing industry, among which the input and application of ICT products can improve the resource allocation efficiency of the manufacturing industry, reduce production costs, enhance the diffusion effect of information technology and promote the transformation of the manufacturing industry from labor-intensive to technology-intensive. Intellectual property rights mainly transform intangible assets such as technology patents into tangible wealth, which is conducive to manufacturing to obtain higher export domestic added value and bring considerable monopoly profits; Other business services mainly provide professional technical services to the manufacturing industry according to their own knowledge reserves and improve the core technology competitiveness of the manufacturing industry by enhancing the technology diffusion effect of the digital service trade; The financial industry and the insurance and pension industry have low technology content, and there are certain difficulties in exerting the technological innovation effect on the manufacturing industry.

(2) Heterogeneous mediating effect of industrial structure

- Country heterogeneity

[Table 8](#) reports the results of the test of industrial structure heterogeneity by country. It can be seen from columns (2) and (4) that the impact coefficient of digital service trade on manufacturing in developing countries decreased from 0.0813 to 0.0425 under the condition of considering the optimization and upgrading of industrial structure, but the impact coefficient of digital service trade was not significant, indicating that there was a complete intermediary effect in the industrial structure. It is calculated that its intermediary effect accounts for 47.82% of the total effect, that is, in developing countries, digital service trade can promote the high-quality development of manufacturing industry by promoting the optimization and upgrading of industrial structure. In contrast, in developed countries, the industrial structure has not had a significant impact on the manufacturing industry, and

Test objects	Variables	Step 1	Step 2	Step 3	Test results
ICT	Trade in digital services	0.0390*** (0.0128)	0.2494*** (0.0325)	0.0205 (0.0135)	Mediation/total effect = 0.4751
Insurance and pensions finance	Technological innovation			0.0743*** (0.0195)	The mediating effect is not significant
	Trade in digital services	−0.0043 (0.0104)	0.0176 (0.0279)	−0.0058 (0.0101)	
Other business services	Technological innovation			0.0853*** (0.0183)	The mediating effect is not significant
	Trade in digital services	−0.0107 (0.0108)	0.0645** (0.0290)	−0.0163 (0.0106)	
intellectual property	Technological innovation			0.0881*** (0.0183)	Mediation/total effect = 0.3629
	Trade in digital services	0.0622*** (0.0153)	0.3451*** (0.0384)	0.0396** (0.0166)	
Source(s): Table provided by the author	Technological innovation			0.0654*** (0.0199)	Mediation/total effect = 0.5524
	Trade in digital services	0.0208* (0.0114)	0.1347*** (0.0300)	0.0098 (0.0114)	
				0.0853*** (0.0183)	

Table 7.
Heterogeneity test in
technological
innovation industry

Table 8.
Test results of
industrial structure
country heterogeneity

Variables	Developing countries		Developed countries	
	(1) lnzz	(2) lnzz	(3) lnzz	(4) lnzz
Indst	0.0813** (0.0316)	0.0425 (0.0322)	0.0300* (0.0160)	0.0244 (0.0164)
lnser	1.2118*** (0.1965)	1.0997*** (0.1916)	0.9292*** (0.2605)	0.8445*** (0.2651)
lngov	−0.4308*** (0.0909)	−0.3491*** (0.0903)	−0.4547*** (0.0415)	−0.4303*** (0.0441)
lnopen	−0.0614*** (0.0235)	−0.0677*** (0.0227)	0.0129 (0.0183)	0.0108 (0.0183)
lninf	−0.1062 (0.1046)	−0.1501 (0.1014)	−0.0726 (0.0891)	−0.0412 (0.0909)
lnhum	−0.0016 (0.0044)	0.0031 (0.0045)	0.0068*** (0.0021)	0.0073*** (0.0021)
lnis	—	0.4258*** (0.1171)	—	0.1007 (0.0635)
_cons	0.3560 (0.3458)	−1.2280** (0.5482)	0.2492 (0.2066)	−0.2257 (0.3633)
R-sq	0.344	0.396	0.472	0.478
N	176	176	264	264
Boot	—		[−0.1061 0.0204]	
verification	—		—	
Proportion of mediation effect	47.82%		—	

Source(s): Table provided by the author

its intermediary effect has not passed the bootstrap test, that is, there is no significant intermediary effect. Specific analysis may be that the industrial structure of manufacturing in developing countries is seriously imbalanced, taking China as an example, China is a veritable manufacturing country, but the upgrading of industrial structure is still in its infancy, capital-intensive industries in the output value structure, employment structure and asset structure and other aspects have shown relative stability, and the technology-intensive industries that bring the most benefits to the high-quality development of the manufacturing industry account for the lowest share in the manufacturing industry. Therefore, the transformation of the manufacturing industry from capital-intensive to technology-intensive has great development potential, and the industrial structure has greater room for development in the direction of rationalization and advancement. Comparing [Tables 6 and 8](#), it is found that for developing countries, the intermediary effect of industrial structure is much greater than that of technological innovation, which shows that in the current development stage of the manufacturing industry, digital service trade mainly plays a role in the industrial structure of the manufacturing industry and further promotes the high-quality development of the manufacturing industry. The rationalization and advanced industrial structure of developed countries have reached a high level, and it is urgent to give full play to the technological innovation effect of digital service trade on the manufacturing industry, so that the technological spillover effect of digital service trade can reach the maximum.

- Industry heterogeneity

From the regression results in [Table 9](#), it is mainly ICT, other business services and intellectual property industries that can play the intermediary effect of industrial structure, among which, in ICT and other business services, the industrial structure is manifested as a partial intermediary effect, while in the intellectual property industry, the industrial structure is a complete intermediary effect. Comparing the first and third steps, it is found that the impact coefficient of digital service trade has decreased significantly, indicating that the impact of digital service trade on the high-quality development of manufacturing industry through industrial structure upgrading cannot be underestimated, and its intermediary effect accounts for 25.7, 25 and 78.68% respectively. On the contrary, the financial industry through the upgrading of the industrial structure has a negative impact on the high-quality

Test objects	Variables	Step 1	Step 2	Step 3	Test results
ICT	Trade in digital services	0.0390*** (0.0128)	0.0422*** (0.0110)	0.0290** (0.0128)	Mediation/total effect = 0.2570
Insurance and pensions finance	Technological innovation			0.2375*** (0.0575)	The mediating effect is not significant
	Trade in digital services	-0.0043 (0.0104)	0.0201** (0.0089)	-0.0097 (0.0102)	
Other business services	Technological innovation			0.2684*** (0.0571)	Indirect effects /Direct effect = 0.5208
	Trade in digital services	-0.0107 (0.0108)	0.0403*** (0.0092)	-0.0223** (0.0108)	
intellectual property	Technological innovation			0.2882*** (0.0579)	Mediation/total effect = 0.25
	Trade in digital services	0.0622*** (0.0153)	0.0721*** (0.0130)	0.0467*** (0.0157)	
Source(s): Table provided by the author	Technological innovation			0.2157*** (0.0583)	Mediation/total effect = 0.7868
	Trade in digital services	0.0208* (0.0114)	0.0642*** (0.0094)	0.0044 (0.0118)	
	Technological innovation			0.2549*** (0.0601)	

Table 9.
Industrial structure
industry
heterogeneity test

development of the manufacturing industry, according to the model inspection process, we define the effect of its industrial structure as a cover-up effect, the reason may be that the traditional manufacturing industry is mainly labor-intensive and capital-intensive, relying on a large amount of capital investment, but with the development of new industries such as digital service trade, the financial industry large number of imports brought by the capital investment is difficult to meet the development of technology-intensive manufacturing industries. On the contrary, it has further increased the proportion of capital-intensive industries in the manufacturing industry, hindering the optimization and upgrading of the manufacturing industrial structure, resulting in a slowdown in the high-quality development of the manufacturing industry.

7. Conclusions and policy recommendations

This thesis studies the impact of digital service trade on the high-quality development of manufacturing industry in 40 countries from both theoretical and empirical aspects and the results show that.

- (1) Digital service trade has a significant role in promoting the high-quality development of manufacturing industries in various countries, and this conclusion is still true after a series of robustness tests.
- (2) In general, digital service trade is mainly to promote the high-quality development of global manufacturing through the effect of technological innovation. On the one hand, the technological innovation effect brought on by digital service trade helps manufacturing enterprises gain technological competitive advantage; On the other hand, digital service trade can also promote the high-quality development of the manufacturing industry by promoting the optimization and upgrading of industrial structure, but the intermediary effect of technological innovation is greater than the intermediary effect of the industrial structure optimization and upgrading, and the intermediary effect of both countries and industries is heterogeneous.
- (3) The heterogeneity of the intermediary effect of technological innovation is as follows: the direct promotion effect of digital service trade on the high-quality development of manufacturing industry in developing countries is higher than that of developed countries, but the intermediary effect of technological innovation in developed countries is higher than that of developing countries; The test results of the intermediary effect of technological innovation and industry heterogeneity show that ICT, other business services and intellectual property rights can promote the high-quality development of manufacturing in various countries through the effect of technological innovation, and there is no obvious intermediary effect of technological innovation in the financial and insurance industries.
- (4) The national heterogeneity of the intermediary effect of industrial structure is manifested as follows: in developing countries, digital service trade mainly promotes the high-quality development of manufacturing industry by playing a role in the industrial structure of the manufacturing industry, but there is no obvious such intermediary effect in developed countries; The industry heterogeneity of the industrial structure intermediary effect is manifested as: ICT, other business services and intellectual property rights can promote the high-quality development of the manufacturing industry through industrial structure optimization and upgrading, while the industrial structure intermediary effect of the financial industry is manifested as a concealment effect, which has a negative impact on the high-quality

development of the manufacturing industry, and there is no obvious intermediary effect in the insurance and pension industries.

Based on the previous empirical results and the conclusions drawn in this thesis, the following policy recommendations are proposed:

- (1) Countries should improve the governance system of digital service trade 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, and all countries should actively participate in the negotiation and cooperation of the future international governance system and rules of digital service trade. Propose differentiated and inclusive trade rules according to the development of various countries and jointly build an efficient and diversified trade governance system. Expand the opening of digital service trade, reduce barriers to digital service trade, build an institutional environment conducive to the development of digital service trade, expand the scale of world digital service trade and give full play to its direct role in promoting the high-quality development of global manufacturing.
- (2) Strengthen the construction of new digital infrastructure and expand the technological innovation effect of digital service trade. Priority will be given to supporting the construction of new digital infrastructure, such as 5G, cloud computing and big data centers, accelerate the digitalization process, provide an efficient platform for the development of digital service trade and improve the quality and efficiency of its development. At the same time, developed countries should take the lead in actively promoting digital technology innovation and industrial integration, encourage enterprises to increase digital transformation, optimize the quality of digital service products and services and give full play to the intermediary role of technological innovation. In addition, countries should also promote the standardization of digital service trade, strengthen the training of digital talents integrating production, education and research and provide all-round support for promoting the high-quality development of the manufacturing industry.
- (3) Cultivate a new manufacturing model empowered by digital service trade and create an intelligent manufacturing ecological industrial system. Developing countries should make full use of the new impetus empowered by digital service trade, promote the deep integration of manufacturing and digital service trade, give play to the intermediary effect of the industrial structure and promote the rationalization and advanced development of the industrial structure. At the same time, digital technology will penetrate into all aspects of manufacturing production, improve the personalized level of manufacturing with accurate digital services, create a comprehensive integrated system of interconnection within the industry and promote the coordinated development of the industry. Improve the analysis and processing capabilities of the manufacturing industry for data, realize information sharing, business collaboration and real-time interaction in the manufacturing production process, eliminate the structural barriers of high integration between digital service trade and manufacturing and build a data-based and intelligent manufacturing ecological industrial system.

Notes

1. Argentina, Ireland, Estonia, Austria, Brazil, Belgium, Iceland, Poland, Denmark, Germany, Russian Federation, France, Finland, Colombia, Costa Rica, Canada, Czech Republic, Latvia, Lithuania, Luxembourg, the United States of America, Peru, Mexico, Norway, Portugal, Japan, Sweden,

Switzerland, Slovak Republic, Turkey, Spain, Greece, New Zealand, Hungary, Israel, Italy, Indonesia, the United Kingdom, Chile and China.

2. Developing countries: Argentina, Estonia, Brazil, Iceland, Russian Federation, Colombia, Costa Rica, Latvia, Lithuania, Peru, Mexico, Turkey, Hungary, Indonesia, Chile and China. Developed countries: Ireland, Austria, Belgium, Poland, Denmark, Germany, France, Finland, Canada, Czech Republic, Luxembourg, United States of America, Norway, Portugal, Japan, Sweden, Switzerland, Slovakia, Spain, Greece, New Zealand, Israel, Italy and United Kingdom.

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