The impact of digital service imports on manufacturing upgrading

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Abstract. Based on cross-country data of major countries in the world from 2008 to 2020, this paper studies the impact mechanism of digital service imports on manufacturing upgrading. The research results show that: (1) digital service imports have a positive effect on manufacturing upgrading, and digital service imports promote manufacturing upgrading through two paths of action: improving the level of technological innovation and the level of Internet development; (2) from the results of the moderating effect, institutional quality plays a positive moderating role in the process of digital service imports acting on manufacturing upgrading; (3) from the heterogeneity test of countries, the results show that digital service imports have a more significant role in promoting manufacturing upgrading in developed countries; (4) from the analysis of the heterogeneity of segmented digital services, the promotion effect of imported ICT services, intellectual property use services, other business services and financial services on manufacturing upgrading is more significant. The findings of this paper provide important insights and policy recommendations for China and other countries in the world to promote the transformation and upgrading of manufacturing with digital trade.

Keywords. Digital service imports; manufacturing upgrading; technological innovation; level of Internet development; institutional quality

1 Introduction

Since the 21st century, digital technology and ICT are deeply integrating with international trade, and human society has entered the era of digital trade, which is developing rapidly and has become a new engine of economic development for all countries. since 2020, the new crown epidemic has spread around the world, transport, tourism, catering and other industries have been severely impacted, and the global economy is in a relatively depressed state, but digital trade has exploded with resilience. According to information released on the UNCTAD website, world trade in digital services totalled$3,167,587 million, and the share of digital services trade in services trade grew from 44.7% in 2005 to 63.55% in 2020. In 2020, the growth rate of world trade in digital services fell by 1.9% year-on-year, a small decline, but the growth rate was still higher than that of trade in goods （In 2020, world imports of digital services trade reach US$2,721.34 billion, accounting for approximately 55.4% of total world services trade, with an average growth rate of 4.8% between 2008 and 2020, with digital services trade imports contributing to countries' economic growth.

The Made in China 2025 Plan proposes that manufacturing is the pillar industry of the national economy and is the foundation of a country's economic and social development. In the era of booming digital trade, the manufacturing industry has become the main battlefield of digital trade. By importing digital services and applying digital technologies represented by the Internet of Things, cloud computing, block chain and artificial intelligence to the R&D, transportation, storage, production and management processes of enterprises, the trade and production costs of the manufacturing industry have been greatly reduced, and the operational efficiency and labour productivity of enterprises have been improved, providing a new path for developing countries to break through It provides a new path for developing countries to break through the "low-end lock" dilemma of manufacturing industry and establish a strong manufacturing country [1, 2].

This paper examines the impact of digital service imports on manufacturing upgrading, empirically testing the mediating effect of technological innovation and level of internet development and the moderating effect of institutional quality; complementing existing research from both theoretical and empirical perspectives. Secondly, this paper conducts a heterogeneity analysis based on the country's level of economic development and the classification of digital services. Finally, based on the above analysis, the paper draws more reliable conclusions and proposes corresponding recommendations and

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policies to provide new ideas for the transformation and upgrading of manufacturing industries in each country.

2 Theoretical analysis and research hypotheses and tables

2.1 The direct impact of digital service imports on manufacturing upgrading

Digital services are based on digital technology and information technology as the core elements, which have the typical characteristics of knowledge-intensive and technology-intensive. The direct impact of imported digital services on the upgrading of the manufacturing industry is manifested in the knowledge and technology spillover effect, the improvement of production efficiency and the transformation and upgrading of the management mode. Firstly, the knowledge and technology spillover effect. By importing large quantities of leading digital services, such as ICT products and patented technologies, enterprises directly use them in manufacturing procedures and links, forming knowledge and technology spillovers, thereby improving their productivity and management efficiency [3]. The second is the improvement of production efficiency. Digital services can drive the development of the Internet of Things and information technology in enterprises, and therefore can integrate information from upstream and downstream distributors more efficiently, monitor warehousing and logistics in real time, greatly reduce transaction costs, etc., improve the operational efficiency of enterprises, and promote the facilitation of production and business processes; enterprises develop artificial intelligence, improve the use of machines, promote the automation of production, reduce the complexity of work, and improve production efficiency of enterprises [4]. Third, the management model is transformed and upgraded. By importing digital services, using cloud computing, blockchain and other technologies, enterprises implement quantitative management and establish digital systems to enable management to manage, organize and coordinate efficiently and in real time within the enterprise, so that business data, workflow and tasks can be visualized and the management efficiency and effectiveness of the enterprise can be improved. Therefore, this paper puts forward hypothesis 1: Digital service imports can promote manufacturing upgrading.

2.2 Indirect impact of digital service imports on manufacturing upgrading

Technological innovation is an internal driver of economic growth [5]. On the one hand, import trade is an important channel to increase the level of technological innovation in a country (region) [6]. Enterprises import digital services represented by the Internet of Things, cloud computing and artificial intelligence, and improve their technological innovation capacity by imitating, absorbing and learning from their advanced technologies, and then increasing their investment and R&D. A large number of enterprises importing digital services will generate a clustering effect, and high spillover will cause increased competitive pressure in the industry in their home countries. In order to compete for survival space, enterprises will dig deeper into the market demand and business strategies in niche areas, thus strengthening their technological innovation capabilities. On the other hand, technological innovation is the core driver of manufacturing upgrading [7]. In an effectively competitive market, technological innovation capability becomes a strategic advantage for enterprises, and the industry undergoes superiority and elimination, promoting the transformation and upgrading of enterprises and facilitating the emergence and growth of new industries. In international competition, enterprises that use cheap labor as their competitive advantage use technological innovation to transform and upgrade their industries, enhance the added value of their products, and thus strengthen their international competitiveness, realize the leap from the low end to the high end of the value chain, and achieve advanced industrial development. Therefore, this paper puts forward hypothesis 2: digital service imports promote manufacturing upgrading through channels such as improving technological innovation capabilities.

The level of Internet development is important for the transformation and upgrading of the manufacturing industry [8]. The promotion effect of digital service imports on the level of Internet development mainly comes from the technology spillover effect and the learning effect. A country can directly introduce advanced information technology through the import of digital services, and also through trade with developed countries in the world, thus accelerating the exchange of talents, education, science and technology, and improving the efficiency of research and development in the Internet field, and therefore can directly and indirectly promote the level of Internet development in a country. At the same time, the development of the Internet allows manufacturing enterprises to reduce the restrictions of space and distance, providing a convenient means of communication between manufacturers, reducing information search costs and improving trade efficiency. Moreover, the increase in the level of Internet development creates conditions for manufacturing manufacturers to carry out real-time monitoring of production data and realize production improvements, thus promoting the upgrading of the manufacturing industry. Therefore, this paper proposes hypothesis 3: digital service imports promote the upgrading of the manufacturing industry through channels such as increasing the level of Internet development.

Institutional quality is an important driving factor for the high-quality development of foreign trade [9]. Institutional quality is a comprehensive factor that covers political and economic aspects. In terms of economic system, countries with a good economic system have a more appropriate degree of economic freedom, which provides a relaxed and fair business environment for digital service enterprises, their better property rights

protection system can protect the private property of both domestic and foreign enterprises, while their sound tax system, fiscal policy and monetary policy provide manufacturing enterprises with more adequate R&D funds and financing, thus promoting innovation in manufacturing and upgrading. In terms of political system, countries with good political system have a more convenient administrative service system, which improves the efficiency of the government and provides convenient and efficient services to enterprises. Its sounder rule of law system, government management and regulatory system can create a stable political and social environment, which becomes a security guarantee for the development of manufacturing industry. To sum up, good institutional quality can provide a relaxed and fair business environment and a stable political and social environment for digital service enterprises, thus facilitating the transformation and upgrading of manufacturing enterprises. Therefore, this paper proposes hypothesis 4: institutional quality has a positive moderating effect on the role of digital service imports in promoting the upgrading of manufacturing.

3 Empirical analyses

3.1. The Construction of the Model

To analyses the impact of digital service imports on manufacturing upgrading, the following econometric model is constructed.

$$/n\ upmf_{it} = \delta + \beta /n\ imdig_{it} + \gamma controls_{it} + \nu_i + \nu_t + \varepsilon_{it} \quad (1)$$

where $upmf_{it}$ denotes the level of manufacturing upgrades. $imdig_{it}$ denotes the level of imports. $controls_{it}$ denotes control variables; i denotes country; t denotes year. ν_i denotes individual fixed effects; ν_t denotes time fixed effects. ε_{it} denotes random disturbance terms.

3.2. Variable Description

3.2.1 Explanatory variables: Manufacturing upgrading

There are various indicators of manufacturing upgrading in the existing literature, such as labour productivity, profitability, output value, sales, etc. While manufacturing value added can reflect the position of manufacturing in the whole industrial chain, this paper therefore draws on Zhang Fan (2019), and Hou Xiaoye and Yuan Chunhui (2021) to measure the level of manufacturing upgrading by manufacturing value added[10,11].

3.2.2 Core explanatory variables: Imports of services

At present, scholars at home and abroad have made relatively preliminary discussions on the concept of digital trade and its measurement, and have not yet reached a consensus. 2020, the Handbook jointly published by OECD, WTO and IMF defines digital trade as trade ordered digitally and/or delivered digitally, and considers that digital trade consists of three main components, namely digital ordering trade, digital delivery trade and digital intermediary platforms. While scholars currently mainly use digital delivery trade to reflect the development trend of digital trade, such as the White Paper on Digital Trade Development (2020), this paper therefore draws on Han Jing et al. (2021) and Liu Jianping and Lu Hongyan (2022) to use the share of imports of digitally delivered services in the United Nations Conference on Trade and Development database (UNCTADstat) in total trade in services to measure the world level of digital service imports of major countries [12,13].

3.2.3 Control variables

(1) Level of Economic Development (*pgdp*): GDP per capita is used to measure the level of economic development of a country. (2) Foreign Direct Investment (*fdi*): Measures foreign direct investment in a country using net foreign direct investment inflows as a percentage of GDP. (3) Fixed capital intensity(*gfcf*): Measures a country's fixed capital intensity as a percentage of GDP using gross fixed capital formation. (4) R&D investment (*rd*): A measure of a country's R&D investment as a percentage of GDP using R&D expenditure. (5) Level of Level of urbanization (*urban*): Measures a country's level of Level of urbanization using the proportion of urban population.

3.2.4 Data sources and descriptions

The data for manufacturing upgrading is sourced from the World Bank database, and as the latest data is only updated to 2020, excluding countries with a large amount of missing data, the panel data for 63 major countries (regions) in the world for the period 2008-2020 is selected as the sample for the study, taking into account the completeness of the data. The data on digital service imports are sourced from the UNCTADstat database, and the data for all other control variables studied are sourced from the World Development Indicators database. In order to minimize errors caused by heteroskedasticity, the logarithmic values of the variables are taken for regression in this paper. The descriptive statistical analysis of each variable is shown in Table 1.

Table 1. Descriptive statistics of the main variables.

Var.	Obs.	Avg.	S.D.	Min.	Max.
/n upmf	819	3.463	1.924	-1.219	8.261
/n imdig	819	3.631	0.454	1.550	4.540
pgdp	819	24.501	22.992	0.871	123.679
fdi	819	6.625	21.845	-40.081	280.132
gfcf	819	22.507	5.444	10.578	48.412
rd	819	1.286	1.054	0.018	5.436
urban	819	71.576	16.328	30.246	100

3.3 Benchmark regression results

Table 2 reports the regression results of the impact of digital service imports on manufacturing upgrading. Column (1) is a two-way fixed effects model without any control variables added, and columns (2) to (6) are regression models with control variables added in turn. The sign and significance of the estimated coefficients of the regressions of remain unchanged, and the value of the adjusted R2 gradually increases, indicating that the goodness of fit also gradually becomes better, indicating that digital service imports have a significant promoting effect on manufacturing upgrading and have better robustness, and hypothesis 1 is verified.

Regarding the control variables, the *pgdp*, *gfcf* and *urban* had a significant lifting effect on manufacturing upgrading, but *fdi* and *rd* have a non-significant positive effect on manufacturing upgrading. The reason for this result could be that it may be due to the limitation of the selected sample, resulting in inconsistency with the expected results.

Table 2. Benchmark regression results.

Var.	**(1)**	**(2)**	**(3)**
ln imdig	0.0834*	0.1129***	
	(0.0432)	(0.0386)	
pgdp		0.0206***	
		(0.0015)	
fdi			
gfcf			
rd			
urban			
_cons	3.9511***	3.6078***	
	(0.1584)	(0.1433)	
Regional effects	Yes	Yes	
Time effects	Yes	Yes	
N	819	819	
adj. R2	0.9937	0.9950	
(3)	**(4)**	**(5)**	**(6)**
0.1145***	0.1203***	0.1211***	0.1395***
(0.0387)	(0.0386)	(0.0386)	(0.0386)
0.0206***	0.0203***	0.0204***	0.0210***
(0.0015)	(0.0015)	(0.0015)	(0.0015)
0.0002	0.0002	0.0002	0.0001
(0.0003)	(0.0003)	(0.0003)	(0.0003)
	0.0045***	0.0044***	0.0048***
	(0.0016)	(0.0016)	(0.0015)
		0.0407	0.0365
		(0.0270)	(0.0268)
			0.0178***
			(0.0050)
3.6013***	3.5024***	3.4809***	1.8061***
(0.1439)	(0.1473)	(0.1478)	(0.4942)
Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes
819	819	819	819
0.9950	0.9951	0.9951	0.9952

Note: Robust standard errors in brackets, *, **and *** denote significant at the 10%, 5% and 1% levels respectively, as below.

4 Analysis of impact mechanisms

4.1 Intermediary effects

In this paper, models (2) and (3) were developed using stepwise regression to test for mediating effects.

$$/n\ media_{it} = \delta + a\ /n\ imdig_{it} + \theta controls_{it} + \nu_i + \nu_t + \varepsilon_{it} \quad (2)$$

$$/n\ upmf_{it} = \delta + c'\ /n\ imdig_{it} + b\ /n\ media_{it} + \theta controls_{it} + \nu_i + \nu_t + \varepsilon_{it} \quad (3)$$

where *media* denotes mediating variables, including technological innovation (*innov*) and level of Internet development (*inter*). In this paper, the number of patent applications in a country is used to capture technological innovation. This paper draws on the idea of Huang Qunhui et al. (2019) [8], where the level of Internet development is measured by the number of mobile phone subscribers (per 100 people). The research data for both technological innovation and the level of Internet development are drawn from the World Development Indicators database.

In the mediating effect test, as shown in columns (1) and (2) of Table 3, the coefficients a and b are significantly positive and the confidence interval of Bootstrap test is [0.0131 0.0266], excluding 0, indicating that the test is passed, suggesting that upgrading technological innovation capability is one of the channels through which digital service imports promote manufacturing upgrading, supporting the previous hypothesis 2. Similarly, in columns (1) and (2) of Table 3 columns, the coefficients a and b are significantly positive with a Bootstrap test confidence interval of [0.0010 0.0614], excluding 0, indicating that the test is passed, suggesting that upgrading Internet development is one of the channels through which digital service imports promote manufacturing upgrading, supporting hypothesis 3 in the previous section.

Table 3. Regression results for mediating and moderating effects.

Var.	**(1)**	**(2)**	**(3)**
ln imdig	0.1443**	0.1110***	
	(0.0730)	(0. 0195)	
ln innov		0.1110***	
		(0.0195)	
ln inter			
ln insti			
ln imdig× *ln insti*			
Control variables	Yes	Yes	
_cons	3.6267***	1.5919***	
	(0.9115)	(0.4887)	
Regional effects	Yes	Yes	
Time effects	Yes	Yes	
N	819	819	
adj. R2	0.9896	0.9954	
(3)	**(4)**	**(5)**	**(6)**
0.0768**	0.1108***	0.1648***	0.1443**

(0.0321)	(0.0368)	(0.0396)	(0.0730)
	0.3745***		
	(0.0421)		
		-0.0097	
		(0.0291)	
		0.1472***	
		(0.0548)	
Yes	Yes	Yes	Yes
-0.4142	1.9612***	1.6759***	3.6267***
(0.4113)	(0.4703)	(0.4952)	(0.9115)
Yes	Yes	Yes	Yes
Yes	Yes	0.1648***	Yes
819	819	(0.0396)	819
0.7472	0.9956		0.9896

4.2 Moderating effects

$$ln\ upmf_{it} = \delta_2 + \beta_2\ ln\ imdig_{it} + \beta_3\ ln\ insti_{it} + \beta_4\ ln\ imdig_{it} \times ln\ insti_{it} + \gamma_2 controls_{it} + \nu_i + \nu_t + \varepsilon_{it} \quad (4)$$

This paper adds to the baseline regression model the institutional quality variable ($ln\ insti_{it}$) and an interaction term between digital service imports and institutional quality ($ln\ imdig_{it} \times ln\ insti_{it}$) to build the moderating effect model, i.e., model (4). In order to measure institutional quality variables in a comprehensive and integrated manner, this paper follows Lin, Ling and Liu, Yao (2018)[14] and analyses both political and economic systems. Political system quality is measured by the Global Governance Indicator (WGI), which consists of a composite of six governance dimensions, namely government efficiency, corruption control capacity, voice and accountability, regulatory quality, political stability, and degree of rule of law. The quality of economic institutions is measured by the Index of Economic Freedom, which includes the protection of property rights, fiscal expenditure, business freedom, labor freedom, monetary freedom, trade freedom, investment freedom, and financial freedom. In order to reduce the correlation between the data of these indicators, this paper uses principal component analysis to assess the quality of institutions and to reflect the information of the original data to the greatest extent possible. Data on institutional quality were obtained from the World Bank database and the annual reports published by the Heritage Foundation.

This paper examines institutional quality as a moderating variable and the regression results are shown in column (5) of Table 4. The regression coefficient of *insti* is negative and insignificant, but then the regression coefficient of $imdig \times ln\ insti$ is significantly positive, indicating that institutional quality has a positive moderating effect in the impact of digital service imports on manufacturing upgrading.

5 Heterogeneity analysis

5.1 Studies based on the level of economic development

Considering that for countries at different levels of economic development, the role of digital service imports on manufacturing upgrading may heterogeneous. In this paper, 63 major countries are divided into two groups, i.e. developing and developed countries, based on the United Nations' criteria for classifying developed and developing countries, and regressed separately, as shown in columns (1) and (2) of Table 4. The coefficients of *imdig* in both sets of regressions are positive, indicating that digital service imports have a positive impact on the upgrading of manufacturing in both developed and developing countries. Through further analysis, the paper finds that there are differences in the coefficients of digital service imports, which are larger and significant at the 1% level for developed countries, but smaller and insignificant in developing countries, indicating that digital service imports play a more significant role in promoting the level of manufacturing upgrading in developed countries compared to developing countries. The reason for the above results may be that, on the one hand, digital services are technology and capital intensive products, and compared with developing countries, developed countries have more advanced high technology and more adequate capital, as well as better infrastructure and talent pool, which can bring into play to a greater extent the benefits of technology absorption and technological innovation of digital services imported by manufacturing enterprises, thus promoting the upgrading of manufacturing industries more significantly.

5.2 Research based on segmented digital service types

Considering that digital services can be subdivided into different types, importing different digital service types may play a different role in upgrading the manufacturing industry. In this paper, digital services are classified into insurance and pension services (*insur*), financial services

Table 4. Results of heterogeneity analysis.

Var.	(1)	(2)	(3)	(4)	
ln imdig	0.1430***	0.0091			
	(0.0495)	(0.0483)			
ln insur					
ln finan					
ln intelpro					
ln ICT					
ln other					
ln audio					

Control variables	Yes	Yes				
_cons	4.3930***	2.5410***				
	(0.6383)	(0.6554)				
Regional effects	Yes	Yes				
Time effects	Yes	Yes				
N	403	416				
adj. R2	0.9984	0.9942				

(3)	(4)	(5)	(6)	(7)	(8)
0.0500***					
(0.0135)					
	0.0837***				
	(0.0114)				
		0.1021***			
		(0.0134)			
			0.0897***		
			(0.0166)		
				0.1349***	
				(0.0167)	
					0.0141*
					(0.0083)
Yes	Yes	Yes	Yes	Yes	Yes
2.4734***	3.1865***	2.6661***	2.3994***	2.2451***	2.3788***
(0.4510)	(0.4376)	(0.4403)	(0.4324)	(0.4389)	(0.4338)
Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes
817	817	818	818	819	817
0.9952	0.9957	0.9954	0.9956	0.9955	0.9956

(*finan*), intellectual property royalties (*intelpro*), telecommunications, computer and information services (*ICT*), other business services (*other*) and audiovisual and related services (*audio*). Columns (3) to (8) of Table 4 report the results of the heterogeneity regressions for each of these six products. The coefficients of digital service imports are positive in all six sets of regressions, indicating that importing any of the digital services would enhance manufacturing upgrading. Further comparative analysis reveals larger coefficients for other business services, intellectual property royalties, telecommunications, computer and information services and financial services, suggesting a greater contribution to manufacturing upgrading, and smaller coefficients for audiovisual and related services for insurance and pension services, suggesting a weaker contribution to manufacturing upgrading. The reasons for these results may be that intellectual property use services can enable manufacturing enterprises to use industry-leading patented technologies; telecommunications, computer and information services can use the development of digital technology and Internet technology to reduce the costs of manufacturing enterprises and improve production efficiency; services such as research and development, professional and management consulting and technology in other business services can promote the technological progress of manufacturing enterprises; financial services can meet the financing needs of enterprises for industrial transformation and upgrading; while audiovisual and related services, insurance and pension services are not closely linked to the upgrading of manufacturing industries.

6 Research conclusions and policy recommendations

In the era of digital trade, how digital service imports drive manufacturing upgrading has become a topic of great interest in the world. Based on data from 63 major world countries from 2008 to 2020, this paper explores the impact of digital service imports on manufacturing upgrading from both theoretical and empirical perspectives, and empirically examines the mechanism of the effect of digital service imports on manufacturing upgrading. The findings show that: (1) digital service imports have a significant contribution to manufacturing upgrading, and the findings pass a series of robustness tests. (2) The impact of digital service imports on manufacturing upgrading is divided into direct and indirect effects, where the indirect effects include two channels of action, namely, technological innovation and the level of Internet development, and among the regulation mechanisms, institutional quality can regulate the upgrading effect of digital service imports on manufacturing upgrading. (3) Heterogeneity analysis shows that, compared with developing countries, in developed countries the digital service imports on manufacturing upgrading Among the different segments of digital services, other business services, intellectual property use services, ICT services and financial services other business services have a stronger positive impact on manufacturing upgrading, while insurance and pension services and audiovisual and related services have a weaker positive impact on manufacturing upgrading.

The research in this paper provides important practical value and reference experience for China and other countries to implement the strategy of a strong manufacturing industry and achieve high-quality economic development. Taking into account China's current situation and actual circumstances, this paper puts forward the following policies and recommendations: (1) Strengthen the development of digital trade, improve digital trade infrastructure, further promote the import of digital services, realize the deep integration of digital technology and manufacturing, accelerate the process of digital technology enabled industrial upgrading, and give full play to the stimulating effect of digital services on the

climbing of China's manufacturing industry from the low end to the high end of the value chain. (2) Enhance technological innovation capabilities, better utilize the knowledge spillover and technology spillover benefits of the Internet and ICT, increase investment in R&D, pinpoint demand markets, dig deeper into niche markets, improve the added value of products, and promote the transformation and upgrading of manufacturing industries. (3) Strengthen investment and construction in the field of information infrastructure, enhance the penetration rate of the Internet, improve the efficiency of resource allocation in the market, and help manufacturing enterprises transform and upgrade. (4) Improve the quality of China's system, improve the economic system, build a fair and just judicial system, protect intellectual property rights and private property, and provide a stable social security environment for the development of the manufacturing industry, while strengthening international cooperation and exchanges, learning from the advanced management experience and governance concepts of developed countries, and improving the enterprises'. (5) For the analysis of segmented digital service heterogeneity, China needs to pay more attention to the upgrading effect of intellectual property use services, ICT services and other business services on the upgrading of the manufacturing industry; for the analysis of national heterogeneity, China should improve its infrastructure, bring into play the effect of economies of scale, improve the absorption capacity of technology, and provide important support for the high-quality development of the manufacturing industry.

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