Cross-country Comparative Research on the Impact of Service Industry on Manufacturing Efficiency - Based on Digital Background

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Abstract. With the acceleration of digital industrialization and industrial digitization, new technologies is driving the transformation of service industry models, which improves the efficiency of service efficiency and ultimately improves the efficiency of other industries especially manufacturing industry. It is conducive to create a modernized industrial chain. This paper first measures service input rate. Then, with the Non-Competitive I-O, this paper decomposes service efficiency into domestic value-added efficiency and import efficiency. Based on the domestic value-added efficiency of service industry, this paper analyzes the impact of service industry on manufacturing efficiency in China, UK, Germany and Mexico. The result shows that most of the domestic value-added of low-end services in China and Mexico has a positive effect on the efficiency of other industries, while most of the domestic value-added of high-end services does not have the same impact. However, in the developed countries such as the UK and Germany, both low-end and high-end contribute significantly to the efficiency of other industries. On this basis, this paper makes a dynamic expansion analysis. Finally, this paper puts forward the relevant countermeasures and suggestions.

Keywords: Domestic Value-added; Manufacturing Efficiency; Industrial Correlation; Digital Economy.

1 Introduction

In recent years, the new forms and modes of service industry driven by digital technology have been emerging. The input and allocation of data factors promotes service development and formed new productivity. The proportion of service elements in manufacturing production has increased, which promotes the factor flow and allocation among manufacturing enterprises and smooth the economy of all links. In addition, the integration of digital technology and service industry leads to the industrialization of digital technology and focus on research and development innovation. These have continuously empowered industry, i mproves industry efficiency and promoted

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industry development. Therefore, it should accelerate the application of new digital technologies and promote the transformation of the service economy towards digitalization and intelligence, which is of great significance to increase manufacturing efficiency and promote manufacturing transformation development, build a modern industrial chain.

2 Literature Review

In recent years, the new technology promotes the increasingly status of service industry in national economy, empowers industrial development and improves industrial efficiency.

2.1 The Impact of Digitalization on Industry Development

In recent years, the scholars conducte research on industry development under the background of digitalization, and most of them believe that digitalization promotes industry development. Pan, Yaru et al.[1](2023) analyzes the Impact of Digital Infrastructure on the Allocation Efficiency of Green Resources in the Service Industry. Some scholars conducte research on the impact of digitalization on service efficiency,industrial transformation and upgrading(Li Shuaina[2], 2021;Dai Kuizao et al.[3], 2023).Some scholars conducte research on the impact of digitization on service division status in GVC and the high-quality development of service(Zhou Shengqi et al.[4],2022).Some scholars studies the relationship among digitalization and manufacturing and service industries (Guo Kesha et al.[5], 2023). Liu, Changet al.[6](2023) analyzes the impact of digital transformation on innovation efficiency of manufacturing enterprise in China. As for the above research on industry development under the Background of digitalization, most of the scholars conclude that digitalization improves industry efficiency, accelerates service development and manufacturing development, promotes the industrial upgradation .

2.2 The Impact of Services on Manufacturing Efficiency

As for the impact of service industry on manufacturing efficiency, European and American scholars have studied earlier. For example, Grubel&Walker[7](1989) believed producer services improve operational efficiency and business scale, thus increase factor productivity. Karaomerlioglu and Carlsson[8](1999) argue that service industry, especially productive service industry, is the premise and foundation for manufacturing productivity improvement. Raff[9](2001) believes that producer service diversification reduces manufacturing costs and increases productivity in host countries. Arnold, J. M. et al.[10](2016) take India as an example to analyze the relationship between service reform and manufacturing performance. In general, the scholars believe that service industry promotes manufacturing efficiency.

In recent years, Chinese scholars have gradually carried out research on the relationship between service industry and manufacturing efficiency (Liu Zhibiao, 2006;

Gu Naihua et al.[11], 2006).Some scholars analyze the mechanism that service industry effect on manufacturing efficiency, and most of them think that service industry can reduce production cost and improve manufacturing efficiency (Jiang Jing et al., 2007) .Some scholars use panel model and dynamic panel model to analyze the impact of service industry on manufacturing efficiency (Ling Yonghui et al.[12], 2017; Peng Jizong et al.,2022).Some scholars have used total factor productivity to analyze the impact of service industry on manufacturing efficiency (Deng, Jiangshan et al.[13],2014;Lv Yue et al.[14],2017;Li Zhan, 2022).Most of the above scholars believe that service industry has positive effect on manufacturing efficiency, while a few scholars believe that service industry has a relatively low effect on manufacturing efficiency(Du Yuwei et al.[15],2016).

In summary, Most of scholars believe that service industry has a positive effect on manufacturing efficiency. These studies has often been used panel models and total factor productivity models, which are usually conducted at the provincial or national level. However, there is limited research that distinguishes between domestic intermediate inputs and imported intermediate inputs, thus, it is not possible to analyze the impact of domestic service and imported service on manufacturing efficiency respectively. Recently, some scholars have decomposed the Non-Competitive Input-Output table from different perspectives, distinguish domestic intermediate inputs and imported intermediate inputs, and eliminating "double-counting items"(Richard Baldwin[16], 2014; Koopman et al.[17], 2014; Wang Fei et al.[18],2013;Cheng Dazhong[19], 2017; Hua Guangmin[20], 2020;Lin Weibin et al.[21],2022;Ni Hongfuet al.[22],2023).Referring to the methods of Wang Fei et al.[18](2013) and Lin Weibin et al.[21],(2022),this article adopts the non-competitive input-output analysis method. Based on distinguishing between domestic and imported service industry intermediate inputs, this article analyzes the impact of the service industry on manufacturing efficiency under the digital background.

3 Industry correlation analysis

This paper measures the input rate of service industry, which analyzes the input and consumption of service industry in China, the UK, Germany, and Mexico.

3.1 Services input rate (F_j)

The services input rate is the ratio of service inputs in industry i to the ratio of the total inputs in industry i . The formula is:

$$F_j = \frac{\sum_{i=1}^{n} x_{ij}^{d}}{\sum_{i=1}^{n} x_{ij}^{m} + N_j} (j = 1, 2, 3 ....., n)$$

Where $\sum_{i=1}^{n} x_{ij}^{d}$ is the service input of industry j, $\sum_{i=1}^{n} x_{ij}^{m}$ is the total input of industry j, and N_j is the value added of industry j.In general, the higher service input rate, the higher service participation degree.

The data is from Non-Competitive I-O in OECD STAN Industrial Analysis database.

3.2 Analysis on the industrial correlation

From service inputs rate in manufacturing industry, in 2015, China's service inputs rate in Food products, beverages and tobacco, Textiles, wearing apparel, leather and related products, Wood and of products of wood and cork, Paper products and printing, Chemicals and pharmaceutical products, Rubber and plastics products, Other non-metallic mineral products, Manufacture of basic metals, Fabricated metal products, Computer, electronic and optical products, Electrical equipment, Machinery and equipment n.e.c., Motor vehicles, trailers and semi-trailers, is 8.691%, 11.087%, 8.983%, 11.716%, 9.703%, 9.327%, 10.62%, 6.357%, 8.098%, 10.452%, 10.131%, 9.605%, 9.224% respectively. The UK's service input in the above manufacturing industry is 23.358%, 20.859%, 13.05%, 19.507%, 19.828%, 16.291%, 20.134%, 17.788%, 14.126%, 16.887%, 16.501%, 16.354% and 19.065% respectively. Germany service input in the above manufacturing industry is 19.504%, 23.377%, 18.752%, 18.605%, 15.784%, 14.749%, 18.364%, 13.627%, 12.042%, 14.919%, 11.716%, 11.906%, 9.561% respectively. Mexico' service input in the above manufacturing industry is 19.500%, 14.264%, 16.779%, 20.549%, 21.180%, 18.915%, 20.000%, 13.696%, 17.170%, 14.183%, 15.051%, 14.9176%, and 14.429%, respectively(as shown in Table 1).The rate of service input in manufacturing industry in China is the lowest. The lower service input rate in China's manufacturing industry, the lower Service-oriented manufacturing industry in China.

Table 1. Service input rate in Manufacturing industry

Unit: %

	Food products, beverages and tobacco	Textiles, wearing apparel, leather and related products	Wood and of products of wood and cork	Paper products and printing	Chemicals and pharmaceutical products	Rubber and plastics products	Other non-metallic mineral products	Manufacture of basic metals	Fabricated metal products,	Computer, electronic and optical products	Electrical equipment	Machinery and equipment n.e.c.	Motor vehicles, trailers and semi-trailers
China	8.691	11.087	8.983	11.716	9.703	9.327	10.620	6.357	8.098	10.452	10.131	9.605	9.224
United Kingdom	23.358	20.859	13.050	19.507	19.828	16.291	20.134	17.788	14.126	16.887	16.501	16.354	19.065
Germany	19.504	23.377	18.752	18.605	15.784	14.749	18.364	13.627	12.042	14.919	11.716	11.906	9.561
Mexico	19.500	14.264	16.779	20.549	21.180	18.915	20.000	13.696	17.170	14.183	15.051	14.917	14.429

Data source: OECD database STAN Input Output

4 Empirical analysis on the impact of service industry on manufacturing efficiency

With the Non-Competitive I-O from OECD database, this paper distinguishes between domestic services intermediate inputs and imported services intermediate inputs, then analyzes the impact of services on manufacturing efficiency in China, the UK, Germany, and Mexico.

4.1 Non-Competitive Input-Output model

In the Non-Competitive I-O, whether it is used for a single sector or the whole national economy, the input and output in a certain period indicate as "Total Output=Total Input", that is:

Intermediate Product + Final Product + Import = Domestic Intermediate Input + Import Intermediate Input + Value Added

Assuming C is the vector for total domestic output, U^w is intermediate consumption matrix for domestic products, A^w , A^f is the vector for domestic final products and the vector for imported products respectively. U^f is the intermediate consumption matrix for imported products, H is the import vector. Then the constant equation for domestic demand and the constant equation for import demand can be respectively represented as:

$$C = U^w C + A^w \tag{1}$$

$$H = U^f C + A^f \tag{2}$$

Equation (1) is the constant equation on the domestic demand; Equation (2) is the constant equation on the imports demand. Where $\left(I - U^w\right)^{-1}$ is Leontif inverse matrix.

Equation (1) can be deformed into:

$$C = \left(I - U^w\right)^{-1} A^w \tag{3}$$

Extending the basic model further, the relationship for intermediate input coefficient in a Non-Competitive I-O can be represented as:

$$\theta = Z_e + \theta U^w + \theta U^{\mathrm{f}} \tag{4}$$

Where θ is the unit row vector for N elements, Z_e is the added value vector.

Formula (4) can be deformed into:

$$\theta = Z_e (I - U^w)^{-1} + \theta U^{\mathrm{f}} (I - U^w)^{-1} \tag{5}$$

Given $K=\left(I-U^{w}\right)^{-1}$, formula (5) can be deformed into:

$$\theta=Z_{e}K+\theta U^{\mathrm{f}}K \tag{6}$$

Given $\hat{G}$ is diagonalized matrix for efficiency column vector G, multiplied $\hat{G}$ on the right-hand side of each term of the above equation, obtain

$$\theta\hat{G}=Z_{e}K\hat{G}+\theta U^{\mathrm{f}}K\hat{G} \tag{7}$$

Substituting $Z_{e}=\theta\hat{Z}_{e}$ (the relationship between a row vector and its diagonal matrix) into equation (7) ,obtain

$$\theta\hat{G}=\theta\hat{Z}_{e}K\hat{G}+\theta U^{\mathrm{f}}K\hat{G} \tag{8}$$

Deleting the left-multiplying unit row vector of each item on both sides of formula (8), obtain:

$$\hat{G}=\hat{Z}_{e}K\hat{G}+U^{\mathrm{f}}K\hat{G} \tag{9}$$

Formula (9) shows that the industry efficiency $\hat{G}(G=\theta\hat{G})$ can be decomposed into domestic value added efficiency $(\hat{Z}_{e}K\hat{G})$ and imported efficiency $(U^{\mathrm{f}}K\hat{G})$. $\hat{Z}_{e}K\hat{G}$ is the core formula for domestic value-added efficiency. The paper focuses on the formula $\hat{Z}_{e}K\hat{G}$, which is a matrix indicating the specific sources and specific directions of domestic value added efficiency.

(1)The domestic value added efficiency $\hat{Z}_{e}K\hat{G}$ is summed in the direction of the column, that is, the value added created by the industry is counted as long as it is included in the efficiency of this industry. The paper sum in the direction of the columns, that is, it accounts for the efficiency generated by domestic value added from a driving perspective:

$$VBdrive=\theta\hat{Z}_{e}K\hat{G}=Z_{e}K\hat{G}=Z_{e}\hat{G}+Z_{e}(K-I)\hat{G} \tag{10}$$

In formula (10), the added value of domestic efficiency is decomposed into two parts: the added value directly driven by the efficiency of the industry and the added value indirectly driven by the efficiency of other industries.

(2)The domestic value added efficiency is summed in the direction of the row, that is, the domestic value-added that generates efficiency is calculated in the industries

that create value added.The paper sum in the direction of the rows, that is, it measures the ability of an industry's value added that generates efficiency from the perspective of participation:

$$VBparticipate = \hat{Z}_e K \hat{G} \theta^T = \hat{Z}_e KG = \hat{Z}_e G + \hat{Z}_e (K - I)G \tag{11}$$

In equation (11), the efficiency generated by the domestic value added is decomposed into two parts: the efficiency $\hat{Z}_e G$ generated by the value-added directly involved in the industry and the efficiency $\hat{Z}_e (K - I)G$ generated by the value-added indirectly involved in the industry.

According to the research purpose, this paper focuses on the efficiency generated by the value-added indirectly involved in the service industry.

4.2 Data Sources

With Non-Competitive I-O, this paper analyzes the impact of service industry on manufacturing efficiency. The Non-Competitive I-O data is from OECD STAN Industrial Analysis database. In the UK, Germany, and Mexico, the industry efficiency is measured by industry value added/employment number. The value added and employment numbers for these countries are from the OECD's "STAN Industrial Analysis" database and are adjusted to correspond with the I-O industry classifications. In China, industry efficiency is measured by industry value added/employment number. China's industry value added is from the OECD database. The employment number in China's primary industry and tertiary industry is from the National Bureau of Statistics (NBS).The employment number in China's secondary industry is from the China Industrial Statistics Yearbook. According to"The Classification of Industries in the National Economy", the employment number for each industry is categorized to correspond with the I-O industry classifications in OECD database.

4.3 Empirical analysis on the impact of service domestic value added on Manufacturing Efficiency

With Non-Competitive I-O, this paper decomposes service efficiency into Domestic Value-added efficiency and import efficiency. Then, based on the domestic value added efficiency, from the perspective of participation, this paper focuses on the efficiency generated by the service industry’s value-added indirectly.

4.3.1 Cross-Country Comparison of the impact of Service domestic value added on Manufacturing Efficiency.

From the industry efficiency rate and the value-added efficiency rate(Participation Indirect),in 2015,the industry efficiency rate for China's Wholesale and retail trade and repair of motor vehicles, Transportation and storage, Accomodation and food

services, Publishing, audiovisual and broadcasting activities, Telecommunications, IT and other information services, Finance and insurance industry is 5.08%, 2.41%, 3.29%,—, 4.06%, 1.27%, 5.54% respectively. The value added efficiency rate(Participation Indirect) for China's above service industry is 12.27%, 5.33%, 1.67%,—, 2.54%, 0.41% and 13.04% respectively. The industry efficiency rate for the UK' above service is 0.91%, 1.48%, 0.58%, 2.19%, 3.12%, 1.45% and 2.57% respectively. The value added efficiency rate (Participation Indirect) for the UK' above service is 11.01%, 5.10%, 1.58%, 1.24%, 2.46%, 3.33%, and 9.05% respectively. The industry efficiency rate for Germany above service is 1.25%, 1.63%, 0.72%, 2.49%, 5.55%, 2.58%, 2.60% respectively. The value added efficiency rate(Participation Indirect) for Germany above service is 13.97%, 5.71%, 0.88%, 1.62%, 2.32%, 3.51%, and 6.45% respectively. The industry efficiency rate for Mexico' above service is 1.79%, 1.34%, 0.79%, 2.37%, 7.10%, 1.00% 5.31% respectively. The value added efficiency rate(Participation Indirect) for Mexico' above service is 25.06%, 5.14%, 0.17%, 0.48%, 2.20%, 0.03%, 3.37% respectively(as shown in Table 2).

In China and Mexico, the value-added efficiency rate(Participation Indirect) in the Wholesale and retail trade and repair of motor vehicles, Transportation and storage is higher than the industry efficiency rate. It indicates that the rising traditional service value-added promotes the development of other industries, especially the manufacturing industry in China and Mexico. In addition, the Value-added efficiency rate(Participation Indirect) is higher than the industry efficiency rate in China's finance and insurance industry. The rising Value-added in China's Finance and insurance industry promotes the development of other industries, which is related to the rapid development of China's Finance and insurance industry in recent years. In the UK and Germany, the Value-added efficiency rate(Participation Indirect) is higher than the industry efficiency rate in Wholesale and retail trade and repair of motor vehicles, Transportation and storage, Accomodation and food services, IT and other information services, Finance and insurance industry. It indicates that the rising value-added in these industries in the UK and Germany, promotes the development of other industries, especially the manufacturing industry.

The reason is mainly that the UK's service industry is very developed, the UK's animation industry and creative industry have been at the forefront of the world. The UK's investment is huge in digital infrastructure and the UK' new technologies promotes the digital transformation of the industry, effectively drives the development of other industries and improves industrial efficiency, especially manufacturing efficiency. Although Germany's service industry is relatively weak in international comparison, the inheritance of "innovative spirit" and Germany's "Industry 4.0" make Germany's manufacturing industry more intelligent and Service-oriented, which effectively improves the efficiency of other industries, especially manufacturing industry. The advantages of China's service industry are mainly concentrated on the traditional service industry, while the effective supply of China's high-end service industry is insufficient. Digital technology and industry have not been effectively integrated. The digital economy cannot effectively empower industrial development. China's high-end service industry cannot effectively improve the efficiency of other industries. Mexico, as a developing country, has a significant advantage in labor cost. Sim-

ilar to China, Mexico's supply of high-end services is insufficient to improve the efficiency of other industries, especially manufacturing industry.

Table 2. The impact of Service domestic value added on Manufacturing Efficiency

Unit: %

	Industry Efficiency				Domestic Value-added Efficiency Rate(Participation Indirect)			
	China	United Kingdom	Germany	Mexico	China	United Kingdom	Germany	Mexico
Wholesale and retail trade; repair of motor vehicles	5.08	0.91	1.25	1.79	12.27	11.01	13.97	25.06
Transportation and storage	2.41	1.48	1.63	1.34	5.33	5.10	5.71	5.14
Accomodation and food services	3.29	0.58	0.72	0.79	1.67	1.58	0.88	0.17
Publishing, audiovisual and broadcasting activities	—	2.19	2.49	2.37	—	1.24	1.62	0.48
Telecommunications	4.06	3.12	5.55	4.10	2.54	2.46	2.32	2.20
IT and other information services	1.27	1.45	2.58	1.00	0.41	3.33	3.51	0.03
Finance and insurance industry	5.54	2.57	2.60	5.31	13.04	9.05	6.45	3.37

Note: "—" indicates default data.

4.3.2 Dynamic Analysis on the Impact of Service Domestic Value Added on Manufacturing Efficiency.

From the industry efficiency rate and the value-added efficiency rate(Participation Indirect), China's value-added efficiency rate(Participation Indirect)in the Wholesale and retail trade and repair of motor vehicles, Transportation and storage,Finance and insurance industry in 2015, is higher than the industry efficiency rate in 2010.The UK's and Germany's value-added efficiency rate(Participation Indirect) in Wholesale and retail trade and repair of motor vehicles, Transportation and storage, Accomodation and food services, IT and other information services, Finance and insurance industry, is higher than industry efficiency rate in both 2015 and 2010.Mexico's value-added efficiency rate(Participation Indirect) in Wholesale and retail trade and repair of motor vehicles, Transportation and storage, is higher than the industry efficiency rate in both 2015 and 2010. In China and Mexico, most of the domestic value-added of low-end services improves industry efficiency of other industries, while most of high-end services does not have the same impact. In the UK and Germany, the rising Value-added in both low-end and high-end service, promotes industry efficiency improvement of other industries.

The reason is mainly that in China and Mexico, the development of traditional service industry has always had significant advantages, which promotes the development of relevant upstream industries and improves the efficiency of other industries, while

the high-end service industry does not have a competitive advantage, thus cannot provide effective service support and improve industry efficiency of other industries, especially manufacturing. The UK's service industry has been developed, whose financial and insurance, business services and other services are pillar industries. In addition, the UK's new digital services have become a trade "hot spot", providing high-quality services for local industries, promoting the development of other industries, and improving the efficiency of other industries. In Germany, "Industry 4.0" make manufacturing industry more intelligent and Service-oriented, effectively improving the efficiency of other industries, especially manufacturing industry.

5 Conclusion

This paper measures the input rate of service industry, which analyzes the input and consumption of service industry in China, the UK, Germany, and Mexico. The results show that China's service input rate to manufacturing industry is mostly lower. Then, with the Non-Competitive I-O, this paper analyzes the impact of service industry on manufacturing efficiency in China, UK, Germany and Mexico. The results show that most of the Domestic Value-added of low-end services in China and Mexico can improve the efficiency of other industries, while most of the Domestic Value-added of high-end services in China and Mexico cannot improve the efficiency of other industries. However, both Domestic Value-added of low-end and high-end service in developed countries such as the UK and Germany, can mostly promote the efficiency of other industries. This is mainly due to the fact that the United Kingdom and Germany, as developed countries, their industries are highly intelligent and service-oriented. The service industry provides strong support for local industries and improves the efficiency of other industries, especially manufacturing. Mexico and China, as developing countries, have strong competitiveness in their traditional service industries, which improves the efficiency of other industries, especially the manufacturing industry; while their high-end service industries cannot provide strong support for other industries and cannot effectively improve the efficiency of other industries, especially the manufacturing industry.

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