Have the construction of China's software industry bases improved the level of manufacturing servitization?

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Abstract. This paper takes the software industry base of national torch plan as the research object, describes its construction process and distribution characteristics for more than 20 years, and uses the cross-sectional data of 2007, 2012 and 2017, Empirically test the impact of software industry base on the service level of manufacturing industry in the region, and further analyze the regulatory effect of regional intellectual property protection intensity. It is found that the overall scale of the national software industry base has expanded steadily in recent 20 years, but the spatial distribution is extremely unbalanced. The software industry base in the eastern region is significantly stronger than that in the central and western regions in terms of base number and base income. The construction and development of software industry base can significantly improve the service level of manufacturing industry in the region. After the robustness test, the conclusion is still valid. The results of regional heterogeneity test show that with the deepening of industrialization, the construction of software industry base plays a more obvious role in improving the service-oriented manufacturing industry in the eastern region. The results of industry heterogeneity test show that the construction of software industry base can more effectively improve the service-oriented level of technology intensive manufacturing industry. The results of regulation effect test show that the strength of local intellectual property protection and strengthening the construction of software industry base have a positive regulation effect on the service level of manufacturing industry.

Keywords: Software industry, Manufacturing servitization, Strength of intellectual property protection.

1 Introduction and literature review

The high-quality development of the manufacturing industry is the central task to comprehensively improve the quality and efficiency of the supply system. In recent years,

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new technologies, new industries, new formats, and new models spawned by a new round of technological revolution and industrial transformation have driven significant changes in the global industrial pattern of the manufacturing industry. In the early stage of China's manufacturing industry, the comparative advantage of parts processing, production and equipment has been continuously weakened [1]. More and more manufacturing enterprises are promoting service-oriented strategies, shifting from providing products to providing service solutions, and manufacturing servitization. It has become an important breakthrough in the transformation and upgrading of China's manufacturing industry. However, at this stage, the complexity of manufacturing products is increasing day by day, and the servitization of manufacturing through business transformation and service model innovation in the traditional sense has been difficult to meet the current needs of high-quality transformation of the manufacturing industry [2]. Therefore, relying on a new generation of information technology-based service upgrades to integrate manufacturing enterprises in an all-round, wide-ranging, and deep-level manner has important practical significance for improving the quality and efficiency of the manufacturing industry [3].

Software is the soul of the new generation of information technology. The emergence of leading industries such as artificial intelligence, big data, and 5G continues to optimize the development ecology of industrial integration, and has become an important foundation and core support for the transformation and upgrading of manufacturing services in the new development pattern. As a new factor-driven emerging industry, the development of the software industry depends on the agglomeration and efficient use of new production factors such as knowledge, information, and data. The National Torch Program Software Industry Base (hereinafter referred to as the Software Base), built by the Ministry of Science and Technology on the basis of local governments, is an important policy carrier for the agglomeration of innovation elements, software business incubation, and software technology export and transformation, and provides an important tool for the cluster development of the software industry in various regions.

Regarding software industry bases, the existing ones mainly focus on the summary of base construction and development experience [4], the characterization of distribution characteristics [5], the measurement of operational efficiency[6], the analysis of innovation models and efficiency[7]and so on. These studies are explained from the perspective of the development of the software industry base itself, affirming the significance of the construction of the software industry base, and demonstrating through theoretical and empirical research that China's software industry base has been realized under various supportive policies, the scale and efficiency have steadily improved. However, the goal of building a software industry base is not only to achieve technological breakthroughs and integrated innovation within the base, but more importantly to create distinct industrial characteristics for the region, and give full play to its leading role and spillover effect to deepen the industrial structure adjustment. With the new round of scientific and technological revolution and the continuous transformation of industrial development to digitization, the in-depth development of my country's manufacturing industry is increasingly dependent on the in-depth application of the new generation of information technology[8]. Then, can the software industry base as the source of the new generation of information technology promote the service level of the regional manufacturing industry?

Based on this, this paper attempts to analyze the impact of software industry base construction on the transformation of regional manufacturing services on the basis of existing literature, and uses the data of national software industry bases and regional input-output tables to conduct empirical tests. Compared with the existing literature, the possible contributions of this paper are: (1) Jumping out of the research perspective of "talking about bases in terms of bases", discussing the mechanism of software industry bases on the service level of manufacturing in the region, and contributing to the economic

development of software industry bases. Effect research provides a new perspective and makes up for the insufficiency of existing research; (2) this paper draws on existing literature to measure the level of manufacturing servitization at the regional level, which can describe the evolution characteristics and influence relationship between the construction of the software industry base and the servitization of the manufacturing industry from a more in-depth scale; (3) This paper comprehensively uses data such as "China Torch Statistical Yearbook" and "China Regional Input-Output Table" to empirically test the impact and heterogeneity of software industry bases on regional manufacturing servitization, which provides more objective empirical evidence than previous studies.

2 The construction process and development characteristics of China's software industry base

In 1995, in order to actively participate in the division of labor and competition in the global software industry, the Ministry of Science and Technology, relying on local governments, science and technology management departments at all levels, and national high-tech zones, began to select and identify some excellent software industry parks as the software industry bases of the National Torch Program, giving priority to support, officially open the prelude to the cluster development of China's software industry. After more than 20 years of development, 44 national-level software industry bases have been built across the country, becoming the main force leading China's software technology innovation and industrialization.

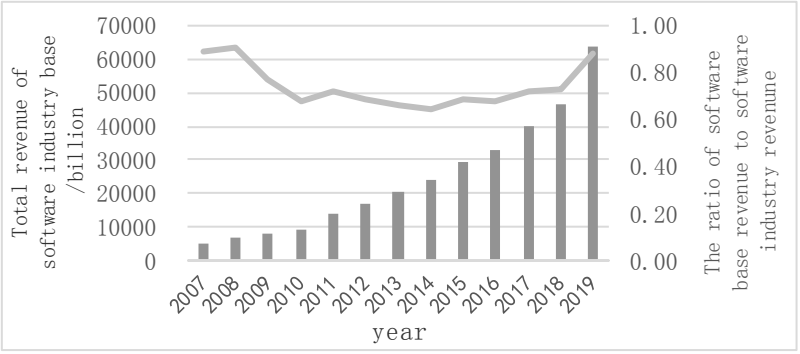

Fig. 1. The total revenue of software industry bases and the ratio of software base revenue to software industry revenue.

Figure 1 shows the total revenue of software bases and the ratio of base revenue to software industry revenue from 2007 to 2019. From 2007 to 2019, the scale of the software base continued to expand, and it has been supporting the development of the software industry. From 2007 to 2019, the total revenue has increased every year. Although the base's software industry revenue accounted for a decrease in the proportion of the national software business revenue, it has always been above 60%.

As shown in Figure 2, the software base has a great imbalance in the spatial distribution. Although my country's software bases are developing rapidly, the large-scale software bases are still concentrated in the eastern region. Although software bases in some provinces and cities in the central and western regions have expanded rapidly in recent years and their strength has increased, the overall scale of the central and western regions is far less than that of the eastern regions. Moreover, the software revenue of software bases in the eastern region also grew rapidly, much higher than central and western city. In

addition, the software bases were mostly located in provincial capital cities in the initial stage, and with the development, more and more non-provincial capital cities have built software bases.

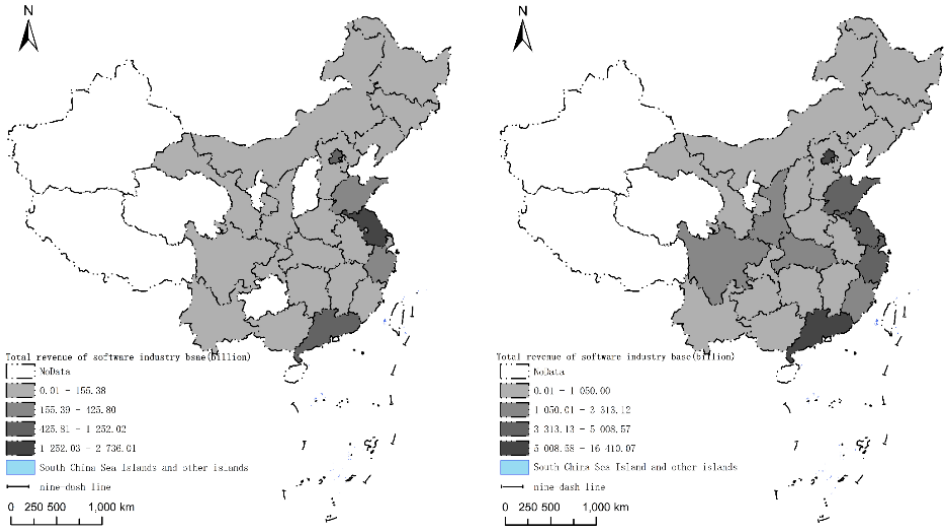

Fig. 2. Distribution map of total revenue of software bases in China in 2007 and 2019.

3 Theoretical analysis and research assumptions

The concept of manufacturing servitization was first put forward by Vandermerwe et al [9], which refers to the transformation of manufacturing enterprises from providing goods and their accessories to providing goods-service packages. The establishment of the software base can improve the service-oriented manufacturing industry in the following aspects:First, the construction of software bases promotes the improvement of the service level of the manufacturing industry through knowledge spillovers. The software industry is a knowledge-intensive industry, which contains a wealth of tacit knowledge, and the software base, as the carrier of the cluster development of the software industry, promotes the transmission of tacit knowledge. On the one hand, the rapid development and wide application of software can promote the generation and spillover of knowledge through technologies such as big data analysis and deep learning, thereby promoting the advancement of enterprise technology[10]. The establishment of software base facilitates the exchange of information within and among software enterprises, and promotes knowledge spillover and sharing of tacit knowledge; on the other hand, the application of software can transform tacit knowledge into explicit knowledge. The externalization of tacit knowledge can allow enterprises to maximize the added value of products in all aspects of the value chain, thereby improving the level of service-oriented manufacturing. Secondly, the construction of software bases promotes the improvement of the service level of the manufacturing industry through the cost effect. On the one hand, the development of software enterprise clustering reduces the information barriers between enterprises and improves the internal operation efficiency of enterprises. At the same time, local enterprises can more easily use software products, use big data to track and classify consumption behaviors, and reduce communication costs, search costs and transaction costs between enterprises and consumers; on the other hand, enterprises use new technologies to optimize. At the same time, enterprises integrate software products or other information technology

products into all aspects of R&D design and marketing services to improve the service level of manufacturing.

H1: The construction and development of China's software base can improve the level of service-oriented manufacturing in the region.

There are differences in the economic level and the development level of software bases in the three regions in the eastern, central and western regions. The software base in the eastern region is developing rapidly, and the software base may play a greater role in improving the service level of the manufacturing industry. In addition, compared with labor-intensive manufacturing and capital-intensive manufacturing, technology-intensive manufacturing has high technical content, and the software industry may play a greater role in improving its service level.

H2: China's software bases have regional heterogeneity and industry heterogeneity in the improvement of the service level of the manufacturing industry.

The monopoly profits generated by intellectual property rights can safeguard the interests of enterprises[11], and greatly promote enterprise innovation and the transformation of technological achievements into industries. Thereby promoting the upgrading of the industrial structure. The software industry base is mainly based on technology research and development to produce a new generation of high-level information technology, which requires a large number of innovative elements in the research and development process. In areas with high intellectual property protection intensity, exclusive protection can prevent intangible assets such as enterprise innovation from being imitated by others, and the technology of enterprises can be better applied to the transformation of manufacturing industry, thereby improving the level of service-oriented manufacturing.

H3: The strength of regional intellectual property protection has a positive moderating effect on the impact of software base on the service level of manufacturing industry.

4 Model setting and data description

4.1 Variable select

1. Explained variable. The explained variable in this paper is the service level of the manufacturing industry, which is measured by the complete consumption coefficient and expressed in ms.

$$X=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix}+\begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \end{bmatrix}=AX+Y \tag{1}$$

Among them, A is the matrix of direct consumption coefficient. The economic meaning of direct consumption coefficient is the quantity of product i directly consumed by the production unit j, and its calculation formula is as shown in formula 2.

$$a_{ij}=x_{ij}\Big/X_{ij} \tag{2}$$

The complete consumption coefficient refers to the production of a unit product in an industrial sector, the sum of the direct consumption and indirect consumption of the products of each sector, and its calculation formula is 3.

$$b_{ij} = a_{ij} + \sum_{k=1}^{n} a_{ik} a_{kj} + \sum_{s=1}^{n} \sum_{k=1}^{n} a_{is} a_{sk} a_{ky} + \ldots \quad (3)$$

The first item of the formula refers to the direct consumption coefficient of manufacturing j to service industry i, and the latter refers to the sum of indirect consumption of manufacturing j to service industry i from the first round to the s-th round. Represented by a matrix as in Equation 4.

$$B=(I-A)^{-1}-I \quad (4)$$

A is the direct consumption coefficient matrix, and B is the indirect consumption coefficient matrix, which is used to measure the service level of the manufacturing industry.

2. core explanatory variables. The core explanatory variables of this paper are represented by the software industry income (soft) of each software industry base.

3. Moderator. The moderating variable in this paper is the strength of intellectual property protection. Referring to the practice of Jin[12], this paper uses the proportion of technology market turnover to local GDP to represent the local intellectual property protection strength (GP).

4. control variable. The control variables select the amount of foreign direct investment in each province (fdi), per capita GDP as the level of development (pgdp), the total profit of industrial enterprises above designated size represents the profitability of the manufacturing industry (ps), and the number of employees in the manufacturing industry as the labor force level (labor).

4.2 Model settings and Data sources

This paper mainly studies the impact of the software industry on the service level of the manufacturing industry. In view of the fact that the "China Regional Input-Output Table" is published every five years, the cross-sectional data measurement model is set as shown in formula 5:

$$ms = \beta_0 + \beta_1 soft + \beta X_i + \xi_i \quad (5)$$

Among them, ms is the explained variable, soft is the explanatory variable, X_i is the control variable, and ξi is the random disturbance term.

The samples studied in this paper are the 26 provinces, municipalities and autonomous regions in China since the establishment of the software industrial bases, namely in 2007, 2012 and 2017 (Five provinces without software industry bases were excluded. In 2007, Guizhou and Shanxi without software industry bases were also excluded.) The data come from "China Torch Statistical Yearbook", "China Regional Input-Output Table", "China Statistical Yearbook" and statistical yearbooks of various provinces and cities.

5 Metrological inspection results

5.1 Basic estimation results

This paper performs OLS regression on the cross-sectional data in 2007, 2012 and 2017 respectively. The basic estimation results are shown in Table 1. The test results show that the estimated coefficient in 2007 is not significant, while the estimated coefficient of software industry bases on the servitization of manufacturing in 2012 and 2017 is significantly positive, that is, the construction of software industry bases has an effect on

the level of servitization in the manufacturing industry. The estimated coefficient in 2007 is not significant. The reason may be that in 2007, the overall servitization level of the manufacturing industry in China was only about 20%. The manufacturing enterprises were still in the early stage of servitization transformation, and the software base did not play a significant role in improving the servitization level of the manufacturing industry. In 2012 and 2017, the service level of the manufacturing industry has been greatly improved, and the role of the software base in improving the service level of the manufacturing industry has also begun to appear. In this paper, the hypothesis H1 was confirmed.

Table1. Regression estimation results table.

	2007	2012	2017
	ms	ms	ms
soft	-0.010	0.008***	0.004**
	(0.013)	(0.003)	(0.002)
fdi	0.006	0.018**	0.007
	(0.021)	(0.008)	(0.006)
pgdp	27.350***	2.237	4.569
	(8.719)	(6.527)	(8.791)
ps	0.000	-0.003*	0.000
	(0.006)	(0.001)	(0.002)
labor	-0.061	0.004	-0.031
	(0.054)	(0.023)	(0.025)
_cons	-226.684**	13.444	-2.742
	(83.253)	(66.936)	(93.303)
N	24	26	26
r2	0.610	0.630	0.484

Note: 1) ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively; 2) The values in parentheses are standard errors. The same below.

5.2 Robustness check

5.2.1 Replace explained variable

Referring to the practice of Tang [1], the direct consumption coefficient is used to represent the service level of the manufacturing industry. After replacing the explanatory variable with the direct consumption coefficient, the sign and robustness of the coefficient of the core explanatory variable are basically unchanged, indicating that the result is robust. It is not shown here due to space.

5.2.2 Heterogeneity test

Regional heterogeneity. There are large differences in the economic level between regions in China, and there are also large differences in the development of software bases and the level of service-oriented manufacturing industries. The economic level and software base

development of the eastern coastal cities are far ahead of the central and western cities. This paper divides the 26 cities into three regions: east, middle and west according to their location. Table 2 regresses the 2012 and 2017 data, respectively.

Table 2. Heterogeneity test by region.

	2012			2017		
	eastern	central	western	eastern	central	western
soft	0.005	-0.083	0.030*	0.005*	-0.104	-0.013
	(0.003)	(0.050)	(0.012)	(0.002)	(0.094)	(0.007)
controls	yes	yes	yes	yes	yes	yes
_cons	-88.775	-365.479	247.719**	91.920	-1 973.439	3.152
	(126.413)	(398.694)	(58.690)	(162.961)	(1 877.145)	(137.010)
N	9	8	9	9	8	9
r2	0.930	0.828	0.912	0.865	0.382	0.722

As shown in Table2, in 2012, the regression coefficients of the eastern and central regions were not significant, while the regression coefficients of the western cities were significantly positive; in 2017, the regression coefficients of the eastern regions were significantly positive, while the regression coefficients of the central and western regions were not significant. The possible reason is that in the early stage of the manufacturing transformation, the western region can quickly use software products to improve labor productivity and promote the service-oriented transformation of the manufacturing industry; while in 2017, the eastern region has a high level of economic development, and the software base is developing rapidly, and more technology can be invested in manufacturing.

Industry heterogeneity. The impact of the software base on the service level of manufacturing in different industries will be different. This paper divides manufacturing into labor-intensive manufacturing, capital-intensive manufacturing and technology-intensive manufacturing. The data for 2012 and 2017 are regressed separately.

Table 3. Heterogeneity test by industry.

	2012			2017		
	labor	capital	technology	labor	capital	technology
soft	0.009***	0.006*	0.008**	0.003*	0.005***	0.007***
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
controls	yes	yes	yes	yes	yes	yes
_cons	-18.408	61.901	70.643	-68.593	90.295	71.590
	(61.150)	(83.341)	(81.553)	(101.778)	(100.613)	(118.674)
N	26	26	26	26	26	26
r2	0.692	0.333	0.481	0.459	0.422	0.584

It can be seen from Table 3 that in 2012 and 2017, the software industry played a significant role in improving the service level of labor-intensive manufacturing, capital-intensive manufacturing and technology-intensive manufacturing. In 2012, the software base played the most significant role in the labor-intensive manufacturing industry, which may be the early stage of the service-oriented transformation of manufacturing enterprises. The labor quality of my country's labor-intensive manufacturing industry was originally low, and the application of high-tech software such as software can replace ordinary the labor force can quickly improve production efficiency. In 2017, the software base played the most significant role in promoting technology-intensive manufacturing. The possible reason for this is that by 2017, the software bases has been established for 20 years, the technology-intensive manufacturing industry has the highest technical content, and business activities have the greatest demand for various software products, and can also adapt to the software industry and the rapid development of other high-tech industries.

5.3 Further analysis

As a platform for the agglomeration of my country's software industry, software bases have a large number of innovative elements. Intellectual property protection can reduce the risk of R&D innovation of enterprises in the bases, reduce externalities and R&D spillover loss mechanism, and give enterprises exclusive rights to innovative products. Therefore, the innovation input of regional software bases with high level of intellectual property protection can bring more output, and the new technologies and new products in the park can be more applied to the transformation of manufacturing services, thereby improving the service level of local manufacturing. In this paper, on the basis of basic regression, the multiplication term of software base software revenue and intellectual property protection strength (GP) is added to the model, and the set measurement model is such as 6.

$$ms = \beta_0 + \beta_1 soft + \beta_2 GP + \beta_3 soft * GP + \beta X_i + \xi_i \quad (6)$$

The regression results are shown in Table 4. The coefficients of the interaction term soft*GP in the two columns are both significantly positive at the level of 10%, indicating that the intensity of intellectual property protection has a positive moderating effect in the software base's promotion of manufacturing services. The regional software industry with high intellectual property protection intensity has a more obvious role in improving the service level of the manufacturing industry, which is confirmed by H3 in this paper.

Table 4. Regression estimation result table.

	2012	2017
	ms	ms
soft	-0.009	-0.005
	(0.007)	(0.004)
soft*GP	0.139*	0.059*
	(0.079)	(0.030)
GP	-1.108	-29.255
	(346.075)	(235.291)
controls	yes	yes
_cons	54.420	-39.840
	(65.928)	(88.212)
N	26	26
r2	0.749	0.599

6 Conclusion and suggestion

This paper uses 26 provincial cross-sectional data in 2007, 2012 and 2017 to study the relationship between software bases and manufacturing servitization. The conclusions of this study are as follows: (1) In 2007, the software base did not improve the level of servitization of the manufacturing industry. In 2012 and 2017, the software base significantly promoted the improvement of the level of servitization of the manufacturing industry; (2) The influence of the software base on the level of servitization of the manufacturing industry varies from region to region. Software bases in western cities can significantly improve the service level of manufacturing in 2012, and the service level of labor-intensive manufacturing in 2012 was improved more significantly; in 2017, software

bases in eastern cities improved significantly the servitization level of the manufacturing industry, and the servitization level of the technology-intensive manufacturing industry in 2017 increased most significantly; (3) The intensity of intellectual property protection plays a positive regulating role in the software base to promote the level of the manufacturing industry. Based on the conclusions, the following policy recommendations are put forward:

It is necessary to strengthen the integrated development of the software industry and the manufacturing industry. It is necessary to use software technology to improve the performance and intelligence of machines, shift the profit focus of manufacturing enterprises from processing and assembly to R&D, design and marketing services, and increase the added value of products.;(2) It is necessary to speed up the construction of software bases in central and western cities, improve the operating efficiency of software bases, and encourage enterprises to use information technology to realize the transformation of manufacturing into service; support the development of capital-intensive manufacturing and technology-intensive manufacturing, and encourage labor-intensive manufacturing to optimize their own factor input structure, make full use of software base development, and improve the service level of manufacturing industry;(3) Improve China's intellectual property system and strengthen regional intellectual property protection. Local governments should strengthen the guidance and support for intellectual property protection, crack down on various infringements, increase the enthusiasm of enterprises for innovation and research and development, and improve manufacturing servitization level.

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