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Measurement of Servitization Level of Manufacturing Industry based on Input-Output

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Abstract: To measure the servitization level of the manufacturing industry in Shaanxi Province and reveal the current situation of the servitization input and output. Based on the input-output tables of the whole country, Shaanxi provinces from 2002 to 2017, the direct consumption coefficient and the complete consumption coefficient are calculated to measure the input servitization level of Shaanxi's manufacturing industry and its subsectors. 56 listed manufacturing companies in Shaanxi Province were selected to measure the servitization level of manufacturing output in Shaanxi Province. The results show that from 2002 to 2017, the manufacturing industry in Shaanxi Province presents a development trend of seeking improvement in stability, but the development of servitization is slow, and the overall input servitization level is not high. The development among manufacturing industry and its subsectors is not balanced, and the gap of the input servitization level is large. The service import rate of manufacturing enterprises is not high, and the servitization level of manufacturing output is in the primary and intermediate stage. Based on those above, from the four points of policy support, optimizing the industrial structure, accelerating the integration and application of internet technology in the manufacturing industry and changing the traditional manufacturing concept, the corresponding suggestions to improve the servitization level of manufacturing in Shaanxi Province is put forward.

Keywords: Servitization in Manufacturing; Servitization of Manufacturing Input; Servitization of Manufacturing Output; Direct Consumption Coefficients; Complete Consumption Coefficients.

1. Introduction

Serviceization has become an important trend for the future development of the manufacturing industry. Given that China's manufacturing sector occupies a mid to low-end position in the international value chain, a thorough investigation into the factors influencing the serviceization of manufacturing and the pursuit of value chain extension and value addition has become an urgent issue. The strategy of serviceization in manufacturing has been elevated to the level of a national strategy, as evident in 'Made in China 2025,' which explicitly calls for the vigorous development of service-oriented manufacturing, with the goal of fundamentally achieving the transformation of manufacturing into a service-oriented industry by 2025. As one of the advanced manufacturing bases in the country, Shaanxi, with its strong industrial foundation and defense industry advantages, is leading the economic development of the province. This has led to the emergence of typical service-oriented manufacturing enterprises like Shaanxi Coal and Chemical Industry Group. However, the degree of serviceization in the manufacturing industry in Shaanxi remains undocumented. Measuring the level of serviceization in the manufacturing industry in Shaanxi will contribute to a deeper understanding of the current status of serviceization in the province. This, in turn, holds significant theoretical and practical value for promoting the transformation and upgrading of manufacturing, as well as driving high-quality development in the manufacturing sector.

2. Literature Review

Vandermerwe and Rada were the first to introduce the concept of serviceization in manufacturing [1]. They posited that serviceization is a trend in which manufacturing companies are inclined to provide services, specialized technical knowledge, and establish dedicated service departments in addition to their products to gain new competitive advantages. In Luca Mastrogiacomo's research [2], manufacturing serviceization is defined as the capability and processes of innovative companies to support the shift from offering products to providing product-service systems. With the rise and development of productivity services, the interconnection between manufacturing and the service sector has become even closer, prompting scholars to define manufacturing serviceization from an input-output perspective [3].

From the perspective of measuring manufacturing serviceization, existing literature primarily focuses on two levels of measurement: industry-level input serviceization in manufacturing and enterprise-level output serviceization in manufacturing. At the meso-level, the study of input serviceization in manufacturing is mostly conducted from an input-output perspective, with many scholars calculating direct consumption coefficients and total consumption coefficients. Chen Hua and Cao Yan [4] argue that both coefficients can more comprehensively reflect the use of service sector elements by the manufacturing industry, demonstrating the interdependence between the manufacturing and service sectors. The larger the coefficients, the higher the level of input serviceization.

Based on the existing research, it is feasible to measure the level of serviceization in manufacturing using the input-output method. However, most studies tend to focus on either input or output aspects individually. There are relatively fewer studies that combine both aspects to evaluate the level of serviceization in a particular region. Additionally, the analysis of serviceization levels in specific manufacturing subsectors is somewhat lacking. There is a significant scarcity of systematic studies on the level of serviceization in the

manufacturing industry in Shaanxi province. In this paper, the authors approach the measurement of the overall level of input serviceization in the manufacturing industry of Shaanxi province from both input and output perspectives. They use input-output tables from 2002 to 2017 and analyze the development of serviceization in specific manufacturing subsectors. The data is sourced from listed companies in the province to assess their output serviceization levels. The aim is to provide valuable insights and references for the development of serviceization in the manufacturing industry in Shaanxi.

3. Evaluation Methods and Data Sources

3.1. Direct Consumption Coefficient

This article employs the input-output analysis method to measure the level of input serviceization in manufacturing. It does so by calculating the direct consumption coefficients and total consumption coefficients of manufacturing on the service sector. Input serviceization represents the extent to which services contribute to manufacturing output, i.e., the amount of service inputs in each unit of manufacturing output. A higher consumption coefficient indicates a higher level of serviceization in manufacturing.

The direct consumption coefficients include direct production costs, expenses related to management, costs for labor protection, and costs for minor repairs incurred during the production and operation processes. These coefficients are used to measure the relationships between production structures among various sectors within an economic operational system, facilitating a deeper exploration of mathematical relationships in various aspects. The expression for direct consumption coefficients is as follows:

$$a_{ij} = x_{ij} / x_j \tag{1}$$

In equation (1), a_{ij} represents the direct consumption coefficient of industry j on industry i. x_{ij} represents the quantity of services from industry i directly consumed in the production and operation of industry j's products. x_j A represents the total input of industry j, a_{ij} 's values range between 0 and 1, with a higher direct consumption coefficient indicating a greater level of direct dependence of industry j on industry i.

This coefficient matrix is denoted as A.

3.2. Total Consumption Coefficients

On the basis of direct consumption coefficients, we can calculate the total consumption coefficients, which represent the sum of the direct and indirect consumption of a particular final product or intermediate product by a production unit. This reflects the intrinsic logical relationship between the two more accurately and directly. The total consumption coefficient (denoted as b_{ij}) represents the sum of the direct consumption of industry j's products on industry i's products and all indirect consumption. The expression is as follows:

$$b_{ij} = a_{ij} + \sum b_{ik} a_{kj} \tag{2}$$

This coefficient matrix is denoted as B.

3.3. Data Sources

The data for input serviceization measurement primarily comes from the currently published input-output tables, with the latest domestic data available up to 2017. Therefore, the calculation of consumption coefficients extends up to 2017, including the '*Input-Output Tables of Shaanxi Province (2002-2017)*'.

The data for output serviceization measurement is sourced from the Wind database. A total of 56 A-share listed companies in the manufacturing sector in Shaanxi province, as of December 31, 2019, were selected for the sample (excluding ST stocks). The Wind database includes specific descriptions of the business scope of these listed companies under the name 'Business Scope.' In this study, each of the 56 sample companies' 'Business Scope' descriptions were manually inspected to determine whether the company falls under the category of serviceization enterprises.

4. Measurement of Service-oriented Level of Shaanxi Manufacturing Industry Input

4.1. Calculation of Direct Consumption Coefficient

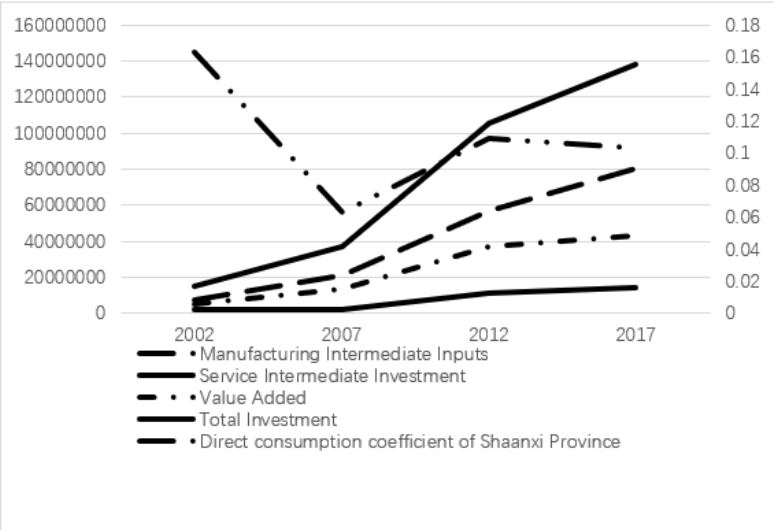

Figure 1. Input Situation in the Manufacturing Industry of Shaanxi Province from 2002 to 2017 and Direct Consumption Coefficients on the Service Sector

The application of formula (1) resulted in the calculation of the input situation in the manufacturing industry of Shaanxi province from 2002 to 2017, as well as the direct consumption coefficients on the service sector, as depicted in Figure 1.

Figure 1 depicts the characteristics of manufacturing and serviceization in Shaanxi province. In general, intermediate inputs in manufacturing, intermediate inputs in services, value-added, and total input show an increasing trend. In 2017, the total input in manufacturing was 9.21 times that of 2002, indicating a positive trend in the development of the manufacturing sector in Shaanxi. However, the growth rate of intermediate input in services has been relatively slow, with a 2017 value of only 5.83 times that of 2002.In terms of input proportions, from 2002 to 2017, the share of intermediate input in manufacturing as a percentage of total input increased from 50.17% to 58.21%, while the share of intermediate input in services decreased from 16.32% to 10.32%. Regarding the direct consumption coefficients of manufacturing on the service sector, there was a declining trend from 2002 to 2007, an increasing trend from 2007 to 2012, and a gradual decline from 2012 to 2017. This suggests that the serviceization of the manufacturing sector in Shaanxi has not kept pace with the overall development of manufacturing. During the process of manufacturing sector growth, there may have been an emphasis on expanding the quantity at the expense of optimizing the overall structure, particularly in services. Thus, there is a pressing need for the transformation of manufacturing into services.

4.2. Calculation of Complete Consumption Coefficients

Using formula (2), we calculated the complete consumption coefficients of the manufacturing industry in Shaanxi province on the service sector from 2002 to 2017, as illustrated in Figure 2.

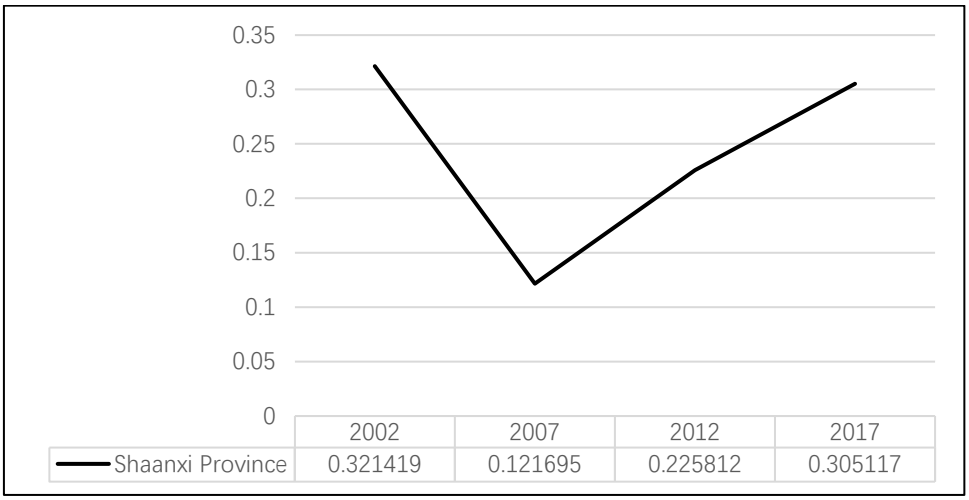

Figure 2. Complete Consumption Coefficients in Shaanxi Province from 2002 to 2017

The complete consumption coefficients of the manufacturing industry in Shaanxi province on the service sector show a 'V'-shaped trend with a decrease followed by an increase. In 2007, there was a sharp decline in Shaanxi's complete consumption coefficient (0.121695). From a developmental perspective, Shaanxi province's manufacturing industry has a complete consumption coefficient ranging from 0.12 to 0.32, suggesting variations in its engagement with the service sector. Overall, the level of serviceization in the manufacturing industry in Shaanxi province is relatively low compared to other provinces and cities, which aligns with the results from the direct consumption coefficients comparison.

5. Measurement of Output Serviceization Level in Shaanxi's Manufacturing Industry

5.1. Main Types of Service Businesses in Listed Manufacturing Companies in Shaanxi Province

According to the Wind database, a statistical analysis was conducted on the serviceization status of 56 sample manufacturing companies in Shaanxi province. Neel categorized service business into 12 types, such as consulting services, design and development services, financial services, etc. For the purpose of comparison, this study, based on research by Neely [5], Wang Dan [6], Guo Meina, and considering the actual situation of listed manufacturing companies in Shaanxi, introduced an additional 5 categories: technical services, project management, import and export business, after-sales services, advertising, and publishing services. This led to the categorization of service businesses of Shaanxi province's manufacturing companies into 17 types, as shown in Table1.Through the survey, it was found that among the 56 listed manufacturing companies in Shaanxi, 49 provided service businesses, resulting in a service business adoption rate of 87.5%. This indicates that service businesses have been widely introduced into companies in the manufacturing sector of Shaanxi. However, when compared to the overall serviceization level in Shanghai's listed manufacturing companies, which reached 97.73% in 2014, there is still a significant gap.

Table 1. Main Types of Service Businesses in Shaanxi Province's Listed Manufacturing Companies and Their Proportions.

Number	Service Type	Number of Companies Providing the Service	Percentage of Companies Providing This Service (%)
1	Consulting Services	31	55.36
2	Design and Development Services	35	62.5
3	Financial Services	2	3.57
4	Installation and Execution Services	18	32.14
5	Leasing Services	27	48.21
6	Maintenance and Repair Services"	15	26.79
7	Outsourcing and Operations Services	4	7.14
8	Purchasing Services	4	7.14
9	Property and Real Estate	2	3.57
10	Sales and Trade"	48	85.71
11	Solutions Services	5	8.93
12	Transportation Services	5	8.93
13	Technical Services	45	80.36
14	After-Sales Services	4	7.14
15	Advertising/Publishing	8	14.29
16	Import/Export Business	38	67.86
17	Engineering Project Services	2	3.57

Looking at the specific content of service businesses provided by manufacturing companies, 'Import/Export Business,' 'Technical Services,' 'Sales and Trade,' 'Design and Development Services,' and 'Consulting Services' have the highest proportions in service businesses. Among these, manufacturing companies providing 'Sales and Trade' services have the highest proportion at 85.71%, indicating that Shaanxi's manufacturing companies have a clear advantage in the sales phase of the value chain. Manufacturing companies providing 'Technical Services' account for 80.36%, suggesting that they are relatively advanced in technical service delivery. Those offering 'Import/Export Business' services make up 67.86%, reflecting Shaanxi's recent emphasis on 'outward-oriented' economic development. However, it's worth noting that 'Engineering Project Services' (3.57%) and 'Solutions Services' (8.93%) have relatively low proportions. These types of services are typically more comprehensive and high-end, requiring a high degree of integration capability from the companies. This indicates that there is room for improvement in the overall service capability of Shaanxi's manufacturing industry."

5.2. Main Types of Serviceization in Listed Manufacturing Companies in Shaanxi Province

In this study, drawing on the classification method employed by Wang Dan and Guo Meina [6], serviceization in manufacturing companies in Shaanxi province is categorized into three types: integration-oriented, function-oriented, and integration-oriented. The services and classification statistics for each serviceization type are shown in Table 2.

Table 2. Classification of Serviceization in Listed Manufacturing Companies in Shaanxi Province

Primary Serviceization Types	The included service categories are	The percentages (%)
Integration-Oriented	Consulting Services, Technical Services; Design and Development Services; Sales (Wholesale, Retail, Agency, and Domestic and International Trade) Services; Installation and Execution Services; Maintenance and Repair, After-Sales, and Inspection Services; Logistics (Warehousing, Transportation) Services; Import/Export Business	37.5
Function-Oriented	Financial Services; Leasing Services; Exhibition, Marketing Planning, and Advertising Services; Property and Real Estate; Supply Chain Management Services; Outsourcing and Operations Services; Scrap Material Recycling and Reuse Services	51.79
Integration-Oriented	Engineering Project Services; Comprehensive Solutions Services	10.71

The classification statistics reveal that the predominant serviceization types among manufacturing companies in Shaanxi are 'Integration-Oriented' and 'Function-Oriented.' Specifically, 'Integration-Oriented' serviceization companies account for 37.5%, and these companies primarily enhance added value by extending services upstream and downstream in the industry chain. 'Function-Oriented' companies constitute 51.79%, and they mainly rely on specialized functions to provide market-oriented development services. Only 10.71% of serviceization companies are 'Integration-Oriented,' indicating that there are relatively fewer manufacturing companies offering personalized and integrated comprehensive solution services to customers.

In conclusion, through the measurement of output serviceization in the manufacturing sector, it is evident that both the provision of service businesses and the current serviceization types of manufacturing companies in Shaanxi province are in the early to intermediate stages. These companies are progressing towards comprehensive serviceization both upstream and downstream in the value chain. Therefore, it is clear that there is a long road ahead in terms of strengthening manufacturing companies' investments in serviceization and achieving high-quality development in the manufacturing sector.

6. Conclusion and Suggestions

This research, through the analysis of input and output serviceization in the manufacturing sector of Shaanxi province, has drawn the following conclusions: The first, The manufacturing sector in Shaanxi province is maintaining an overall stable development trend with gradual progress. However, there is a tendency to focus on expanding quantity

without sufficient consideration for structural optimization. The proportion of intermediate service input in total input has continuously decreased, indicating that serviceization has not closely followed the development momentum of the manufacturing sector. The second, there is an uneven development across various industries in the manufacturing sector of Shaanxi province. There are significant differences in the level of input serviceization, with traditional manufacturing industries having a relatively higher level, while high-tech manufacturing industries are progressing slowly and have a lower level of serviceization. The last, the introduction of service businesses in manufacturing companies is not highly prevalent, and the level of output serviceization remains at the early and intermediate stages.

Based on this, to further enhance the serviceization level in Shaanxi province's manufacturing sector and achieve high-quality development in manufacturing, the following recommendations are suggested:

First, the introduction of relevant policies to create a conducive environment for the development of the manufacturing sector. By comparing the progress, it is evident that the development of Shaanxi province's manufacturing sector in recent years has been relatively good. However, the serviceization process has consistently lagged behind the national development level. Therefore, at the government level, it is necessary to consider providing a series of stable and proactive policy support. First, in terms of financial support, measures such as increasing investment in research and development, as outlined by Premier Li Keqiang in the Government Work Report, should be taken to achieve upgrading during development and development during upgrading. Second, it is important to reduce the market access thresholds for various service enterprises associated with the manufacturing sector and enhance the quality of service enterprises. Finally, in terms of innovation and research and development, the government can construct innovation platforms to attract various experts and talents and establish special funds to support the research and development of critical technologies.

Second, optimize the industrial structure of the manufacturing sector and vigorously develop high-tech manufacturing. While the traditional manufacturing industries in Shaanxi province have a relatively high level of development, high-tech manufacturing has been progressing slowly and remains at a lower level. This development pattern of the industrial structure is not conducive to the progress of manufacturing serviceization. Therefore, it is imperative to optimize the industrial structure and accelerate the development of high-tech industries. Utilizing low-energy consumption and long-industry-chain sectors like high-tech manufacturing to drive economic growth is essential. Additionally, capitalizing on existing advantages in industries and continuing to develop the province's economy can promote the transformation and development of manufacturing serviceization. The focus should be on key industries such as energy and chemical, equipment manufacturing, new materials, biopharmaceuticals, and others. By leveraging educational and scientific resources, promoting innovation along the industry chain, conquering key technologies, and advancing manufacturing towards the middle and high-end sectors.

Third, accelerate the application of Internet technology in the manufacturing sector to promote the development of smart manufacturing. To facilitate the serviceization transformation of the manufacturing sector in Shaanxi, it is crucial to optimize the infrastructure level of the Internet and enhance its application in manufacturing. The development of the Internet industry should align with the needs of serviceization in manufacturing, leveraging its positive impact on the manufacturing sector. Simultaneously, the investment of manufacturing companies in Internet infrastructure should be in line with the overall development of manufacturing, ensuring that the Internet maximally facilitates the serviceization transformation of manufacturing in Shaanxi. Furthermore, the development of the communication equipment, computer, and other electronic device manufacturing industry should be expedited, increasing intermediate service input and enhancing serviceization levels. The convergence and application of next-generation information technology with manufacturing, centered around the Internet and smart manufacturing, should be accelerated to promote the digital transformation of the manufacturing industry.

Fourth, manufacturing companies should shift their traditional mindset towards service-oriented manufacturing. Research indicates that due to the relatively immature serviceization transformation in Shaanxi's manufacturing sector, many companies do not possess a strong service-oriented mindset. They may only offer basic service businesses, and the level of serviceization remains in the early and intermediate stages. There is a shortage of comprehensive and high-end service types, which results in a slower serviceization progress, impacting business development. Currently, manufacturing in Shaanxi should alter traditional mindsets, enhancing service awareness in areas such as research and development, product marketing, and brand operation. This should involve further extending the industrial chain and elevating product added value. Simultaneously, leading companies can continue to play a demonstrative and leading role in the industry, accelerating the serviceization transformation process, particularly in areas like solution design, software development, equipment modification, inspection services, and technical support.

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