

# Servitization, Market Power and Export of Firms

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## Abstract

Following the growing penetration of service industry into manufacturing industry, this paper verifies the effect of manufacturing firm servitization on exports and reviews the regulating effect mechanism of corporate market power. Firstly, this paper constructs a theoretical model including the selection of service business strategy and the selection of corporation export, and elaborates on the effect mechanism among servitization, market power and export of firms. Secondly, this paper precisely describes the servitization indicators of listed manufacturing firms in China at the microscopic level from 2004 to 2016 based on the corporate business activities released in the annual reports of listed firms, the innovative research perspective of service business strategy selection and two levels, including the breadth and depth of servitization. Finally, the paper applies PPLM (Poisson Pseudo Maximum Likelihood) regression method to the research based on theoretical analysis and indicator formulation. The research findings are as follows: First, servitization significantly improves the export tendency of firms, and servitization depth has a greater effect on the export of firms than servitization breadth; second, market power enhances the solvency of fixed costs and variable costs faced by the export of firms and promotes the marginal effect of servitization on the export of firms by influencing the corporate service business strategy; third, servitization significantly improves the export tendency of the products characterized by a higher level of product support servitization and digitization but a lower international market threshold; fourth, the technology spillover effect and scope economy effect caused by servitization promote the export of firms while the crowding-out effect and sunk cost effect inhibit the export of firms. The above findings provide both theoretical support and empirical basis for rooting out the dilemma of export from the research perspective of manufacturing firm servitization.

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## Keywords

Servitization, Market Power, Manufacturing Firms, Export of Firms

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### 1. Introduction

Since the reform and opening up, China has evolved as the “World Factory” and has seen the booming foreign trade with the help of its demographic bonus and complete industrial infrastructure. Now, China is suffering from the aging tendency of population and developed countries are speeding up the comeback of manufacturing sector. On May 11, 2021, the results of China’s seventh national population census showed that the proportion of people aged 60 and above in China exceeded 18%, and the degree of population aging further deepened. The “de-globalization” power is rising again. Consequently, the export of manufacturing firms faces double pressure (Mao, 2020). In order to cope with the increasingly severe domestic and international situations, manufacturing firms have gradually adjusted their business strategies. In other words, they are evolving from the previous model of single product manufacturing to the business strategy of focusing on both product manufacturing and service offering (Vandermerwe & Rada, 1988; Blanchard et al., 2017). The process of adjustment is called servitization. Traditional international manufacturing firms, such as GE, Philips and IBM, have achieved business transformation and service model innovation based on the continuous optimization of business strategies in recent years. As an objective fact in the new international trade environment, servitization during the transformation and upgrading of traditional manufacturing industry to advanced manufacturing industry is not only an important measure to “promote the integrated development of advanced manufacturing industry and modern service industry and accelerate the process of building China into a manufacturing power” but also a decisive step in promoting the global market competitiveness of firms and eliminating China’s export dilemma. However, most of the literature cited by the current relevant research is based on the input-output perspective and uses the input of service factors (Liu et al., 2016; Xu et al., 2017). From the perspective of corporate business strategy selection, this paper intends to observe more microscopic and particular business activities of listed firms, identify whether manufacturing firms provide service businesses and what types of service businesses they provide and then formulate the servitization indicators of corporate business strategy selection accordingly.

Different from the single product manufacturing of traditional manufacturing industry, the adjustment of service business strategies requires a large amount of cost input. High risks brought by the yield of service business have aggravated the uncertainty of the effect caused by servitization to the export of firms (Breinlich et al., 2018). Therefore, it is particularly necessary to make clear the effect mechanism of servitization on the export of firms. First, servitiza-

tion involves not only the fusion of production sectors and service sectors within a firm, but also the interaction between the firm and its consumers (Lightfoot et al., 2013). The fusion of different sectors is known as a favorable factor for the sharing of knowledge and information and for the joint development and utilization of scarce resources. The technology spillover effect therefrom improves firm's productivity and reduces unit production cost (Visnjic et al., 2018; Shah et al., 2020). Lower production cost will help boost the international market competitiveness of firms and promote exports. Moreover, after-sales services provided by firms strengthen the tie with consumers. The "market feedback" from consumers facilitates firms to develop a stronger ability in capturing the information relating to differentiated market demand (White et al., 1999; Miroudot & Cadestin, 2017). As a result, these firms have increased unit added value of products while diversifying their product dimensions, thus leading to the scope economy effect. The scope economy effect not only enhances the product differentiation but also alleviates the fierce competition in the homogeneous product market for manufacturing firms (Kohtamaki, 2013; Ariu, 2016; Xu et al., 2017). It also reduces the unit cost of firms on producing differentiated products and providing diversified services, constituting a favorable factor for the export of firms. Besides, resource constraints tend to be severe. The selection of corporate service business strategy means that manufacturing firms allocate higher costs to service businesses, cutting down the investment in product manufacturing. Consequently the "crowding-out effect" occurs (Berlingieri, 2014; Li et al., 2020), which is not conducive to the export of firms. Furthermore, the service business strategy represents a startup for manufacturing firms in a totally new service field. With insufficient experience, the traditional manufacturing industry will face a greater uncertainty of yields than the existing service firms while developing the service industry. As a result, servitization increases the corporate profitability risks and sunk costs (Kowalkowski et al., 2015; Partanen et al., 2017). In summary, crowding-out effect and sunk cost effect make the effect of servitization on the export of firm uncertain.

As demonstrated by the above analysis, the adjustment of service business strategy indicates a large amount of cost input and a higher uncertainty in profitability for firms. With the growing global trend of servitization, not all traditional manufacturing firms will choose servitization. In contrast, the firms with a stronger market power will have stronger competitiveness, market profitability and market pricing power (Li et al., 2019; Loecker et al., 2020). Therefore, they also have abundant service capital and strong service risk tolerance. The firms with a higher market power can effectively overcome the crowding-out effect and sunk cost effect caused by servitization (Partanen et al., 2017; Greenstein, 2020), thereby promoting the marginal effect of servitization on the export of firms. Different from non-export firms, export firms are faced with tariff barriers and international trade costs to export their products to the international market. Market power enhances the solvency for variable costs and fixed costs in-

curred by exports (Bernard et al., 2003; Melitz & Ottaviano, 2008; Ju et al., 2020) and improves the corporate bargaining ability and pricing ability in the international market. After that, these firms have developed the comparative advantage in exports (Loecker & Warzynski, 2012; Shah et al., 2020). Market power will not only enhance the export competitiveness of firms directly but also improve the marginal effect of servitization on the export of firms. In consideration of the uncertain effect of servitization on the export of firms and the reciprocal effect mechanism of market power and servitization on the export of firms, it is of great theoretical significance and practical value to clarify the relationship among servitization, market power and export of firms by formulating a theoretical framework and conducting empirical analysis.

## 2. Literature Review

As a significant trend of global economic development in recent years, servitization has attracted the attention of many scholars at home and abroad. In terms of the definition and indicator formulation for servitization, Reiskin et al. (2000) defined servitization as an input of service factors in the manufacturing industry. Liu et al. (2016) further divided servitization into the servitization of transportation, telecommunication, finance and distribution based on the above outcomes. By determining whether the services provided by firms are related to products, Kindstrom and Kowalkowski (2009) and Mathieu (2011) divided servitization into two categories, including product support service and non-product support service. Gebauer et al. (2010) and Kohtamaki et al. (2013) conducted a comprehensive measurement on corporate service strategies according to the quantity and dimension of services provided by firms. By investigating whether the relationship between consumers and suppliers is a pure buyer-seller relationship, Partanen et al. (2017) measured whether firms have servitization behaviors. Coreynen et al. (2018) formulated the relevant indicators in three dimensions, including service development, service scheduling and service orientation, to measure the corporate servitization strategies. Breinlich et al. (2018) measured the participation of firms in servitization using the ratio of the business income from services provided by a manufacturing firm to its total income. In the relevant domestic research, servitization indicators are formulated by referring to the input-output relationship and the proportion of service factors to the total input at the level of industry to describe the servitization of manufacturing (Xu et al., 2017; Shah et al., 2020). Few references are available to review the corporate service business strategy at the microscopic level.

In light of the relationship between servitization and corporate behavior, some research has demonstrated the linear correlation between servitization and firm's productivity. In other words, improved corporate servitization will facilitate the rise of corporate innovation level and productivity in such ways as technology spillover effect and scope economy effect (Pelli, 2018; Humbeck et al., 2019). However, Blanchard et al. (2017) discovered the nonlinear correlation

between servitization and firm's productivity due to the crowding-out effect. Some literature has also analyzed the relationship between servitization and corporate behavior from the perspective of firms' export performance and value chain. For example, according to some literature, the offering of product-related services by manufacturing firms will bring the added value effect and improve product quality (Manova & Yu, 2017; Jang et al., 2021). From the perspective of service input heterogeneity, some literature has verified that vertical effect and level effect could improve product quality and promote the progress of corporate value chain (Liu et al., 2016; Miroudot & Cadestin, 2017; Heuser & Mattoo, 2017). From the perspective of domestic value added, Xu et al. (2017) proved that servitization could increase the domestic value added in the export of firms through technology spillover effect and cost reduction effect and such promotive effect varied greatly due to different marketing degrees and servitization openness.

From the above literature, we can learn that: 1) Most of the literature studies the relationship between servitization and corporate behavior from the perspective of firm's productivity, innovation level and value chain and some of the literature discusses the behaviors of servitization and the export of firms. However, most of these studies only describe servitization from the perspective of service factor input. Almost no literature quantifies servitization indicators in light of corporate service business strategy selection. In the literature more relevant to the descriptive indicators of servitization in this paper, Song Can (2021) ignored the breadth of servitization, also the scope of service business activities involved in manufacturing firms, while using the 0-1 variable and the proportion of service income to total income as indicators to measure servitization. 2) Some literature has theoretically described the effect mechanism of servitization on the export of firms or verified a certain effect mechanism of servitization. However, we can hardly discover the literature analyzing the effect mechanism of "technology spillover effect", "scope economy effect", "crowding-out effect" and "sunk cost effect" at the empirical level, or analyzing the comprehensive effect of these four mechanisms on the export of firms. 3) Market power is a factor significantly affecting servitization. However, few references are available to discuss to analyze the marginal effect of servitization affecting the export of firms.

As reflected by the literature review above, this paper is innovative in the following aspects:

Firstly, by including market power into the model of corporate servitization strategy selection and firms' export model, this paper clarifies the effect mechanism of servitization and market power on the export of firms: On one hand, servitization can promote the export of firms through the technology spillover effect and scope economy effect; on the other hand, the crowding-out effect and sunk cost effect caused by servitization inhibit the export of firms; market power not only enhances the solvency of fixed costs and variable costs faced by the export of firms but also improves the marginal effect of servitization on the export

of firms.

Secondly, this paper tries to describe the dynamic adjustment of corporate service business strategies more comprehensively and precisely from two levels, including the breadth and depth of servitization. In detail, it probes into more microscopic and particular business activities of listed firms, identify whether manufacturing firms provide service businesses and what types of service businesses they provide and then formulate the servitization indicators accordingly. It also measures the breadth of servitization using the scope of service business activities in manufacturing firms and measures the depth of servitization using the proportion of the income from service business activities to the total income of manufacturing firms. In addition, this paper formulates the market power indicators based on the practice of [Loecker et al. \(2020\)](#) to fully reflect the market competitiveness, market profitability and market pricing ability of firms.

### 3. Theoretical Model

With the theoretical basis of imperfect competition market assumption and service-to-goods one-way necessary complementarity assumption proposed by [Ariu et al. \(2016\)](#), this paper incorporates the market power indicators and analyzes the effect of servitization on the export of firms and the marginal promotive effect of market power for the effect of servitization on the export of firms.

#### 3.1. Consumer Behaviors

It is assumed that labor is the only input factor in an imperfect competition market and labor is fully mobile across industries. Consumers in country  $d$  have the same utility function, which is determined by the Cobb-Douglas function and consists of different kinds of goods  $k$  and services  $k$ . The utility function ( $U(\cdot)$ ) of consumers is shown in Equation (1).

$$U(g_{kd}, s_{kd}) = \int_{kd} \alpha_k^g \ln(g_{kd}) dk + \int_{kd} \alpha_k^s \ln(s_{kd}) dk \quad (1)$$

where,  $\alpha_k^g$  indicates the consumption share for the  $k$ -th goods by consumers,  $\alpha_k^s$  indicates the consumption share for the  $k$ -th service by consumers,  $\alpha_k$  indicates the consumption share ( $\alpha_k = \alpha_k^g + \alpha_k^s$ ,  $\int \alpha_k dk = 1$ ) for the  $k$ -th consumable by consumers.  $g_{kd}$  and  $s_{kd}$  refer to the consumption index of consumers from the country  $d$  for the goods  $k$  and the service  $k$  respectively.  $g_{fkd}$  and  $s_{fkd}$  refer to the portion of goods and service provided by the firm  $f$  in the consumable  $k$ . The consumption indexes are shown in Equation (2) and (3).

$$g_{kd} = \left( \int_{f \in \Omega_{kd}} g_{fkd}^{\sigma_k - 1/\sigma_k} df \right)^{\sigma_k - 1/\sigma_k} \quad (2)$$

$$s_{kd} = \left( \int_{f \in \Omega_{kd}} s_{fkd}^{\sigma_k - 1/\sigma_k} df \right)^{\sigma_k - 1/\sigma_k} \quad (3)$$

Unlike the previous consumer assumptions, the service-to-goods one-way necessary complementarity in this model indicates that consumers can buy

goods alone and buy goods along with services. In other words, goods  $k$  and service  $k$  can be provided together, thus constituting  $q_{kd}$ . Here, use  $q_{fkd}$  to represent the quantity of the  $k$ -th goods provided by the firm  $f$  (without providing the corresponding service),  $q_{fkd}^s$  to represent the quantity of the  $k$ -th service provided by the firm  $f$  and  $q_{fkd}^s \leq q_{fkd}$ , and use  $s_{fkd}$  to represent the service consumption corresponding to the goods. No utility will be caused if a consumer only consumes service  $s_{fkd}$  unless the consumer consumes the goods corresponding to the service at the same time, also  $q_{fkd}^s \geq s_{fkd}$ . It means that goods are essential but services optional for consumers.

It is assumed that the consumer  $L_d$  is continuous and has the same share of firm in the country  $d$ , thus constituting labor income  $I_d$ . Then its budget constraint can be expressed as  $\int P_{kd} q_{kd} dk \leq I_d$ . Use  $P_{kd}$  to represent the price index of the  $k$ -th goods,  $p_{fkd}$  to represent the price index of the  $k$ -th goods provided by the firm  $f$  without the corresponding service and  $p_{fkd} + p_{fkd}^s$  to represent the price index of the  $k$ -th goods provided by the firm  $f$  with the corresponding service. Then the price index of the  $k$ -th goods in the country  $d$  is given as follows:

$$P_{kd} = \left( \int_{\Omega_{kd}} P_{fkd}^{1-\sigma_k} \right)^{1/1-\sigma_k} \tag{4}$$

$$P_{fkd} = \left[ p_{fkd}^{1-\sigma_k} + (p_{fkd} + p_{fkd}^s)^{1-\sigma_k} \right]^{1/1-\sigma_k} \tag{5}$$

When the consumer utility is maximum,  $q_{kd}^s = s_{kd}$ , deducing the demand functions of goods and service (expressed with  $d$  and  $d^s$  respectively).

$$d \left[ p_{fkd}, p_{fkd}^s; P_{kd} \right] = \alpha_k I_d P_{kd}^{\sigma_k - 1} \left( p_{fkd}^{-\sigma_k} + (p_{fkd} + p_{fkd}^s)^{-\sigma_k} \right) \tag{6}$$

$$d^s \left[ p_{fkd}, p_{fkd}^s; P_{kd} \right] = \alpha_k I_d P_{kd}^{\sigma_k - 1} (p_{fkd} + p_{fkd}^s)^{-\sigma_k} \tag{7}$$

Thus, the total expenditure on the  $k$ -th consumable consumed by consumers and provided by the firm  $f$  is given in the following equation:

$$E_{fkd} = \alpha_k I_d \left( P_{fkd} / P_{kd} \right)^{1-\sigma_k} \tag{8}$$

### 3.2. Firms' Production Behavior

Assume that the domestic firm  $f$  decides whether to servitize its goods while deciding whether to export goods to the country  $d$ , each laborer in the country provides 1 unit of labor and the labor wage is standardized to 1.  $c_{fk}$  and  $c_{fk}^s$  refer to the marginal cost of firms on producing a single product and the marginal cost of firms on producing products and providing services respectively. The trade cost of goods and service is  $\tau_{kd}$  and  $\tau_{kd}^s$  respectively. Thus, the cost increment of the goods  $k$  containing trade cost can be expressed as

$$\omega_k = 1 + \left( \tau_{kd}^s c_{kd}^s / \tau_{kd} c_{kd} \right).$$

It is also assumed that firm export should face two types of fixed costs: On one hand, firms must pay an additional fixed cost  $F$  to export goods to overseas markets; on the other hand, firms should pay an additional cost  $F^b$  to provide



the services matching the export of goods. Here, set  $\Omega_{kd}^b$  as the consumption bundle of the goods exported by firms and the corresponding services provided by firms. The profit function of the firm's export of goods and corresponding services to the country  $d$  is:

$$\pi_{fkd} = (p_{fkd} - \tau_{kd}c_{fk})L_d d \left[ p_{fkd}, p_{fkd}^s; P_{kd} \right] + (p_{fkd}^s - \tau_{kd}^s c_{fk}^s)L_d d^s \left[ p_{fkd}, p_{fkd}^s; P_{kd} \right] 1_{\Omega_{kd}^b} [f] \tag{9}$$

According to the assumption of the CES utility function, the market power of a firm can be expressed as the ratio of price to cost,

$M_{kd} = p_{fkd} / (\tau_{kd}c_{fk}) = p_{fkd}^s / (\tau_{kd}^s c_{fk}^s)$ . Under the assumption of monopoly competition for the maximum profit of firms, the output function relating to the production of products and the offering of services is given as follows:

$$g_{fkd} = \alpha_k I_d P_{kd}^{\sigma_k - 1} M_k^{-\sigma_k} \tau_{kd} c_{fk}^{-\sigma_k} \left( 1 + \omega_{fk}^{-\sigma_k} 1_{\Omega_{kd}^b} [f] \right) \tag{10}$$

$$s_{fkd} = \alpha_k I_d P_{kd}^{\sigma_k - 1} M_k^{-\sigma_k} \tau_{kd} c_{fk}^{-\sigma_k} \omega_{fk}^{-\sigma_k} 1_{\Omega_{kd}^b} [f] \tag{11}$$

Under such circumstance, the firm's net profit (after deducting fixed costs) is:

$$\pi_{fkd} = \frac{\alpha_k I_d P_{kd}^{\sigma_k - 1} M_k^{1 - \sigma_k}}{\sigma_k} (\tau_{kd} c_{fk})^{1 - \sigma_k} \left( 1 + \omega_{fk}^{1 - \sigma_k} 1_{\Omega_{kd}^b} [f] - F \right) 1_{\Omega_k} [f] - F^b 1_{\Omega_{kd}^b} [f] \tag{12}$$

### 3.3. Selection of Servitization Strategy and Firms' Export

According to the result of derivation using the profit maximization function, the marginal cost threshold for firms to choose export rather than service is:

$$\bar{c}_{kd} = \left( \frac{\alpha_k I_d}{\sigma_k F} \right)^{\frac{1}{\sigma_k - 1}} \frac{P_{kd}}{\tau_{kdf} M_{kd}} \tag{13}$$

The marginal cost threshold for a firm when choosing both export and service is:

$$\bar{c}_{kd}^b = \frac{1}{\omega_k} \left( \frac{\alpha_k I_d}{\sigma_k F^b} \right)^{\frac{1}{\sigma_k - 1}} \frac{P_{kd}}{\omega_k \tau_{kdf} M_{kd}} \tag{14}$$

According to the marginal cost threshold under different business strategies, the firm's market power can be obtained as follows:

$$\frac{\partial \bar{c}_{kd}^b}{\partial M_{kd}} = - \left( \frac{\alpha_k I_d}{\sigma_k F} \right)^{\frac{1}{\sigma_k - 1}} \frac{P_{kd}}{\omega_k \tau_{kdf} (M_{kd})^2} < 0 \tag{15}$$

$$\frac{\partial \bar{c}_{kd}^b}{\partial M_{kd}} = - \frac{1}{\omega_k} \left( \frac{\alpha_k I_d}{\sigma_k F^b} \right)^{\frac{1}{\sigma_k - 1}} \frac{P_{kd}}{\omega_k \tau_{kdf} (M_{kd})^2} < 0 \tag{16}$$

According to Equations (15) and (16), a stronger market power for the firm will correspond to a lower marginal threshold cost for export no matter whether the firm has chosen the service business strategy. Therefore, we can obtain the first theoretical assumption: Enhanced market power has a positive effect on the



export of firms. In other words, the firms with a stronger market power tend to export when other conditions remain unchanged.

We deduce the difference between the marginal threshold cost when firms choose the servitization strategy and the marginal threshold cost when firms do not choose the servitization strategy during export based on Equations (13) and (14). See Equation (17) for details.

$$\Delta(\bar{c}) = \bar{c}_{kd}^b - \bar{c}_{kd} = \left( \frac{1}{\omega_k} - \left( \frac{F^b}{F} \right)^{\frac{1}{\sigma_k - 1}} \right) \left( F^b \right)^{\frac{-1}{\sigma_k - 1}} \left( \frac{\alpha_k I_d}{\sigma_k} \right)^{\frac{1}{\sigma_k - 1}} \frac{P_{kd}}{\omega_k \tau_{kdf} M_{kd}} \quad (17)$$

If a firm does not have the efficiency to export a single type of goods, it will not have the efficiency to export multiple types of goods and services according to the assumption of Ariu et al. (2016). In case of technology spillover effect and scope economy effect in actual economic activities, a firm, which does not have the efficiency to export a certain type of goods, may enjoy a comparative advantage in exporting multiple types of goods or services at the same time. Therefore, this paper broadens the assumption of Ariu et al. (2016) relating to the self-selection effect of bilateral export firms. According to Equation (17),  $\bar{c}_{kd}^b < \bar{c}_{kd}$  if  $\omega_k < (F/F_b)^{1/\sigma_k - 1}$ . In detail, the marginal cost threshold for firms to choose service business strategy is lower when the ratio of the fixed cost to be paid for exports with servitization chosen to the fixed cost to be paid for exports without choosing servitization is higher if the cost increment to be paid by firms for servitization is smaller. In this sense, servitization will promote the export of firms. Similarly, if  $\omega_k > (F/F_b)^{1/\sigma_k - 1}$ ,  $\bar{c}_{kd}^b > \bar{c}_{kd}$ . In detail, the marginal cost threshold for firms to choose service business strategy is higher when the ratio of the fixed cost to be paid for exports without choosing servitization to the fixed cost to be paid for exports with servitization chosen is lower if the cost increment to be paid by firms for servitization is larger. In this sense, servitization will inhibit the export of firms.

If the relative ratio of the fixed cost to be paid by firms for exports is constant, the cost increment of corporate servitization will decide whether the service business strategy chosen by firms has competitive advantages in export. If the positive effect (technology spillover effect and scope economy effect) is greater than the negative effect (crowding-out effect and sunk cost effect) in the process of servitization, servitization will promote the export of firms. If the positive effect (technology spillover effect and scope economy effect) is weaker than the negative effect (crowding-out effect and sunk cost effect) in the process of servitization, servitization will inhibit the export of firms.

Therefore, we can obtain the second assumption: the impact of servitization on the export of firms is uncertain. When other conditions remain unchanged, a lower corporate servitization cost (a weaker negative effect caused by servitization) corresponds to a more significant marginal promotive effect on the export of firms.

If servitization has a significant positive effect on the export of firms ( $\Delta\bar{c} < 0$ ),

the absolute value can be obtained using Equation (17) and the market power of firms is derived from the equation below:

$$\frac{\partial |\Delta(\bar{c})|}{\partial M_{kd}} = \left| \frac{1}{\omega_k} - \left( \frac{F^b}{F} \right)^{\frac{1}{\sigma_k - 1}} \right| \left( F^b \right)^{\frac{-1}{\sigma_k - 1}} \left( \frac{\alpha_k I_d}{\sigma_k} \right)^{\frac{1}{\sigma_k - 1}} \frac{P_{kd}}{\omega_k \tau_{kdf} M_{kd}^2} > 0 \quad (18)$$

In light of Equation (18), the absolute difference between the marginal cost thresholds when firms choose service business strategy and do not choose service business strategy during export will be greater if firms have a stronger market power when other conditions remain unchanged. As proven by the above analysis, both the technology spillover effect and scope economy effect of servitization are positive effects for the export of firms. However, crowding-out effect and sunk cost effect are negative effects for the export of firms. A stronger market power is a symbol of stronger market competitiveness, market profitability and market pricing ability for firms. It also indicates that the firms have more abundant service capital and stronger service risk tolerance. Consequently, the crowding-out effect and sunk cost effect caused by servitization can be overcome effectively, thus promoting the marginal effect of servitization on the export of firms.

Therefore, we can obtain the third theoretical assumption: for the firms with a higher level of market power, servitization will cause a stronger marginal effect on the export of firms when other conditions remain unchanged.

## 4. Setting of Variables and Models

### 4.1. Variables and Data Sources

#### 1) Explained variable

*Export*: If a firm has export business, the value of *Export* is 1. If the firm does not have an export business, the value is 0. All data relating the export of firms are derived from the customs database for the period of 2004 to 2016.

#### 2) Core explanatory variable

##### a) Servitization

This paper formulates the servitization indicators of manufacturing firms at two levels according to the servitization definition of Breinlich et al. (2018) and Kohtamaki et al. (2013), the innovative perspective of specific business activity information released by listed firms in their annual reports and the application of text recognition technology. In light of the quantity of service activities involving manufacturing firms (also the quantity of service businesses involving corporate servitization), this paper formulates the indicator of servitization breadth (*Servnum*). A higher indicator of servitization breadth indicates that manufacturing firms are involved in more service businesses in the process of servitization and the service scope is larger. When defining the breadth of servitization, this paper refers to the detailed description of industries at the second level in *Classification of National Economy Industries GBT4754-2002*. For example, the value of *Servnum* is 2 if a manufacturing firm is simultaneously

involved in both investment service and transportation service. The research period in this paper is 2004-2016. *Classification of National Economy Industries* was amended in 2011. However, any substantial change has not occurred to the classification standard for industries at the second level. Therefore, it will not influence the formulation of indicators.

This paper uses the ratio of the income earned by providing services to the total business income to measure the servitization depth (expressed with *Servreve*). A higher indicator of servitization depth represents a higher level of participation of manufacturing firms in servitization. Specific calculation formula:  $Servreve_{it} = R_{is} / R_{it}$ . Where,  $R_{is}$  represents the income earned by the firm  $i$  from providing services in the period  $t$ , and  $R_{it}$  represents the total income earned by the firm  $i$  in the period  $t$ . The data of servitization indicators are mainly derived from the annual reports of listed firms from 2004 to 2016. These annual reports disclose the business scope information of each listed firm in detail and provide the income, profit and cost of each business. Servitization indicators are formulated by identifying whether each business is a manufacturing or service business, or which service industry under industry codes of the second level each business belongs to.

#### b) Market power

Different from the traditional definition of monopoly power from the industry level (such as Herfindahl Index), Loecker et al. (2020) in the derivation of the theoretical model, market power is defined as a comprehensive indicator of market competitiveness, market profitability and enterprise pricing ability, and micro-level enterprise market power indicators are formulated to reflect the differences of market powers for different firms. In the theoretical model, this paper measures market power using the ratio of price to marginal cost, and the core concept of market power defined by Loecker et al. (2020) is similar to the market power in the theoretical model derivation, but the measurement is more comprehensive and accurate. The specific calculation formula is as follows:

$$Mp_{it} = \theta_{it}^v / (P_{it}^v V_{it} / P_{it} Q_{it}) \quad (19)$$

where,  $i$  represents a firm and  $t$  represents a period.  $\theta_{it}^v$  Represent the factor input-output elasticity, estimated by the Cobb-Douglas production function, and  $P_{it}^v V_{it} / P_{it} Q_{it}$  represents the factor input ratio.  $P_{it}^v$  represents the unit cost of labor input,  $V_{it}$  represents the total amount of labor input,  $P_{it}$  represents the price of the unit product,  $Q_{it}$  represents the total output of products, and  $P_{it} Q_{it}$  represents the total income. Unfortunately, some data on labor wage income are missing in the database of listed firms. For the above reason, this paper uses two methods to estimate labor input, and compares the results of the two estimates: In the first estimation, it takes the number of employees as the proxy variable of labor input; in the second estimation, it estimates some of the missing labor wage income based on the average labor wages at the industry level each year and the number of employees<sup>1</sup>. According to the result of comparison, we

<sup>1</sup>In order to remove the effect of inflation on the indicators, we deflate all variables for price.

can discover a difference between the market power values obtained using the two above estimation methods. However, the difference is quite slight regardless of the market power of different firms based on lateral correlations and the market power trend of the same firm in different years based on longitudinal correlation. It also proves the validity of estimation methods in this paper<sup>2</sup>.

### 3) Other control variables

There are diverse and complex factors affecting the export of firms. In order to reduce the econometric bias caused by the wrong setting of the model to obtain more accurate econometric results, this paper adds other control variables that may affect the export of manufacturing firms in the econometric model based on the existing research.

a) *Age*: Calculate the duration of firms from the year of founding to the period of sample and then take the logarithm plus 1. b) *Size*: Measure the firm size using the total assets possessed by the firm, and perform logarithmic processing. In general, the larger the firm size is, the stronger its tendency to export will be. c) *Lev*: It refers to the ratio of a firm's liabilities to its assets. d) *Roa*: It refers to the ratio of the total profit of a firm to its total assets to express the return on assets; the higher the return on assets is, the greater its profitability will be. In general, the tendency of firms to export is increasing with the growing profitability. e) *Current*: It is expressed as the ratio of current assets to total assets. f) *Revrt*: It refers to the growth ability of firms expressed with the business income growth rate. g) *Soe*: For a state-owned firm, the value is 1, otherwise the value is 0. h) *Foe*: For a foreign-funded firm, the value is 1, otherwise the value is 0. See **Table 1** for the descriptive statistics of each variable.

### 4) Match between the database of listed firms and the database of customs

When matching the database of listed firms and the database of customs, this paper first uses the accurate matching method according to full firm names, eliminates the words "limited liability company" and "joint stock limited partnership" in the name of firms, and adopts the abbreviation of firm names for fuzzy matching. In order to avoid any mismatch due to fuzzy matching, this paper conducts a secondary inspection to the data with matched postcodes, cities and other information of firms.

## 4.2. Model Setting and Econometric Method Selection

In view of a large number of 0 characteristics in the export indicator of manufacturing firms, this paper refers to the processing method of Santos Silva and Tenreyro (2006) and uses PPML (Poisson Pseudo Maximum Likelihood) model to regress the correlation between servitization, market power and export of firms in order to avoid any regression deviation caused by wrong setting of econometric model.

<sup>2</sup>In addition, this paper merges the database of listed firms with the database of industrial enterprises, and uses the data of labor wage income in the database of industrial enterprises to measure the market power, and the index is still robust. Due to the missing data samples after merge, this paper still uses the estimation results of the market power in the database of listed firms to ensure the validity of regression results.

**Table 1.** Descriptive statistics.

Variable	Name	Sample size	Mean value	Standard deviation	Minimum value	Maximum value
<i>Export</i>	Export of firms	20,866	0.266	0.442	0	1
<i>Servnum</i>	Breadth of servitization	20,866	0.267	0.823	0	4
<i>Servreve</i>	Depth of servitization	20,866	0.121	0.365	0	2.258
<i>Mp</i>	Market power	20,866	0.359	0.258	0.001	1.112
<i>Age</i>	Age (log)	20,866	2.648	0.379	0	4.094
<i>Size</i>	Size (log)	20,866	21.702	1.441	10.842	30.657
<i>Lev</i>	Lev	20,866	0.480	0.229	0.046	1.677
<i>Roa</i>	Roa	20,866	0.054	0.060	-0.289	0.263
<i>Current</i>	Current	20,866	0.545	0.225	0	0.971
<i>Revrt</i>	Revrt	20,866	15.317	27.550	-54.885	136.832
<i>Soe</i>	Soe	20,866	0.507	0.500	0	1
<i>Foe</i>	Foe	20,866	0.045	0.206	0	1

Data source: The author collated according to the database of listed companies in China.

The specific econometric model is set as follows:

$$Export_{it} = \exp(\alpha + \beta serv_{it} + \lambda X_{it} + \varepsilon_i + \varepsilon_t + \mu_{it}) \quad (20)$$

$$Export_{it} = \exp(\alpha + \beta serv_{it} + \theta Mp_{it} + \zeta serv_{it} \times Mp_{it} + \lambda X_{jit} + \varepsilon_i + \varepsilon_t + \mu_{it}) \quad (21)$$

where,  $i$  represents a firm and  $t$  represents a period. The explained variable is the firm's tendency to export (*Export*), and the core explanatory variable is servitization (*Serv*), including servitization breadth (*Servnum*) and service depth (*Servreve*). Besides, Equation (21) contains the market power indicator (*Mp*) and the interaction between servitization and market power of firms.  $X$  represents other control variables that may affect the servitization of manufacturing firms, including *Age*, *Size*, *Lev*, *Roa*, *Current*, *Revrt*, *Soe*, *Foe*, etc. Furthermore, this paper adds the fixed effect of year and firm level in the regression, and performs the standard error clustering at the city level.

## 5. Empirical Analysis

Firstly, this paper tests the effect of servitization on the export of firms and the effect of market power on the marginal effect of servitization in the part of empirical analysis based on the above theoretical analysis and research assumption. Secondly, this paper conducts a series of robustness tests on solving endogeneity issue, considering the impact of financial crisis, remeasuring servitization and export of firms and excluding special service firms. Thirdly, this paper further considers the differences caused by the types of service, the degree of digitization and the threshold of international market access and other factors that affect the export of firms. Finally, this paper identifies the mechanism of servitization af-

fecting the export of firms.

## 5.1. Benchmark Regression Analysis

### 1) Effect of servitization on the export of firms

Before the benchmark regression, this paper first analyzes the validity of PPML econometric method. Among the test results shown in **Table 1**, the Park\_type and HPC\_test statistics verify the PPML validity, and the GNR test shows that there is no heteroskedasticity in the explained variables, so the PPML regression method used in this paper is reasonable. After confirming the validity of the PPML regression results, this paper first uses the PPML regression method to test the theoretical assumption “what kind of causal relationship exists between the servitization of manufacturing firms and the export of firms” according to the econometric model (Equation (20)), and the regression results are shown in **Table 2**. After the fixed effect of firm and year is added, the effect of servitization on the export tendency of firms is significantly positive at the level of 1%, which initially verifies that servitization is an important factor affecting the export of firms. The result of verification is consistent with the theoretical expectation.

In the benchmark analysis, this paper conducts comprehensive measurement of servitization from servitization breadth and depth. Servitization breadth refers to the scope of service activities involved in manufacturing firms. The larger the servitization breadth indicator is, the more service industries are involved in the firm. The regression results in **Table 2** (1)-(3) show that the effect of servitization breadth on the export of firms is significantly positive, indicating that the export tendency continues to increase with the expanding scope of service activities involved in the firms. Servitization depth refers to the relative degree of firms' participation in service activities compared with the production of a single product. The regression results in **Table 2** (4)-(6) show that the effect of servitization depth on the export of firms is significantly positive at the level of 1%, indicating that the higher participation of firms in service activities, the stronger the export tendency of firms will be when other conditions remain unchanged. According to the result of comparative analysis, the effect of servitization depth on the export of firms is significantly greater than that caused by servitization breadth. This situation mainly arises from that firms are faced high crowding-out cost and sunk cost at the beginning of servitization. With the increasing servitization depth and the growing production scale of products relating to services, both the crowding-out effect and sunk cost caused by servitization see a gradual decline. If a firm blindly pursues servitization breadth (by widely involving itself in various service activities), its businesses will face a strong crowding-out effect and sunk cost effect at the beginning of servitization, making it unable to bring the marginal effect of servitization on the export of firms into play.

### 2) Effect of market power on the marginal effect of servitization

In order to verify the first theoretical assumption and the third theoretical

**Table 2.** Regression results of the effect of servitization on the export of firms.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Breadth of servitization			Depth of servitization		
<i>Servnum</i>	0.058*** (0.013)	0.065*** (0.012)	0.062*** (0.013)			
<i>Servreve</i>				0.110*** (0.028)	0.130*** (0.028)	0.123*** (0.029)
<i>Age</i>		-0.246*** (0.031)	-0.152*** (0.035)		-0.247*** (0.031)	-0.152*** (0.035)
<i>Size</i>		0.084*** (0.010)	0.104*** (0.011)		0.083*** (0.010)	0.103*** (0.011)
<i>Lev</i>		-0.634*** (0.063)	-0.695*** (0.069)		-0.634*** (0.063)	-0.696*** (0.069)
<i>Roa</i>		0.053 (0.219)	-0.034 (0.234)		0.053 (0.219)	-0.034 (0.234)
<i>Current</i>		0.816*** (0.054)	0.782*** (0.059)		0.817*** (0.054)	0.783*** (0.059)
<i>Revrt</i>		0.001 (0.000)	0.000 (0.000)		0.001 (0.000)	0.000 (0.000)
<i>Soe</i>		-0.026 (0.025)	0.045 (0.028)		-0.026 (0.025)	0.047* (0.028)
<i>Foe</i>		-0.100* (0.056)	-0.031 (0.057)		-0.101* (0.056)	-0.031 (0.057)
<i>Year</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	No	Yes	Yes	No	Yes
<i>N</i>	20866	19360	19360	20866	19360	19360
<i>PseudoR<sup>2</sup></i>	0.310	0.222	0.317	0.310	0.222	0.317
<i>Park_type</i>	0.000	0.000	0.000	0.000	0.000	0.000
<i>NLR_test</i>	0.000	0.000	0.000	0.000	0.000	0.000
<i>HPC_test</i>	0.487	0.762	0.657	0.486	0.765	0.661

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Data source: The author calculated based on the database of listed companies in China.

assumption, this paper adds the interaction (Equation (21)) between market power and servitization and performs empirical analysis. The regression results are shown in Table 3. In Table 3, column (1) and column (2) show the regression



**Table 3.** Regression results of the effect of market power on the marginal effect of servitization.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.049*** (0.014)	0.055*** (0.015)		
<i>Servnum* Mp</i>	0.260* (0.223)	0.334* (0.230)		
<i>Servreve</i>			0.068** (0.033)	0.079** (0.033)
<i>Servreve* Mp</i>			0.239** (0.097)	0.275*** (0.101)
<i>Mp</i>	0.372*** (0.047)	1.485*** (0.077)	0.378*** (0.047)	1.491*** (0.077)
<i>Age</i>		-0.091** (0.036)		-0.090** (0.036)
<i>Size</i>		0.136*** (0.011)		0.135*** (0.011)
<i>Lev</i>		-0.759*** (0.069)		-0.757*** (0.069)
<i>Roa</i>		-0.112 (0.235)		-0.110 (0.235)
<i>Current</i>		2.008*** (0.094)		2.010*** (0.093)
<i>Revrt</i>		0.001 (0.000)		0.001 (0.000)
<i>Soe</i>		0.014 (0.029)		0.015 (0.029)
<i>Foe</i>		-0.003 (0.057)		-0.003 (0.057)
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	20,866	19,360	20,866	19,360
<i>PseudoR<sup>2</sup></i>	0.312	0.329	0.312	0.329

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Data source: The author calculated based on the database of listed companies in China.

results with servitization breadth as the core explanatory variable, and column (3) and column (4) show the regression results with servitization depth as the core explanatory variable. According to the regression results in **Table 3**, market power has a significant effect on the export of firms at the level of 1% no matter whether control variables are added. The higher the level of market power is, the stronger the profitability, market competitiveness and market pricing ability of the firm, and the higher the solvency of the fixed and variable costs caused by the firm's export to the international market will be. Meanwhile, the tendency of the firm to export will increase with the growing market power. The first theoretical assumption is thus verified. As reflected by the regression results in **Table 3**, the effect caused by the interaction between market power and servitization on the export of firms is significantly positive at the level of 10% at least no matter whether servitization breadth or servitization depth is referenced to describe the service business strategies of manufacturing firms. This fact implies that the marginal effect caused by servitization to the export of firms will keep rising along with the growing market power when other conditions remain unchanged. The following two aspects lead to the above situation. First, the rising market power of firms lays a capital foundation for the input of service factors and facilitates the implementation of corporate servitization strategies. Second, market power promotes the risk tolerance of firms, reduces the crowding-out effect and sunk cost effect possibly caused by servitization and verifies the third theoretical assumption.

## 5.2. Endogeneity and Robustness Test

### 1) Endogeneity test

In most cases, there are two reasons for endogeneity in empirical analysis, including the endogeneity issue caused by omitted variable and the endogeneity issue caused by reverse causality. Therefore, this paper conducts endogeneity tests by adding possible omitted variables and formulating instrumental variables.

#### a) Control omitted variables

In the benchmark analysis, this paper controls a series of factors that may affect exports at the level of firms. However, variables at the level of industry may also affect firms' expectations and judgments on the overall industry prospects, thus affecting firms' decisions on export. Therefore, this paper further selects some industry-level control variables, such as industry market expansion (*Indsales*) expressed by the growth rate of industry sales, the proportion of state-owned assets in the industry (*Indsoe*) expressed by the proportion of assets to the total assets in the industry and the industry capital density (*Indkl*) expressed by the ratio of industry paid-in capital to the total number of employees in the industry. After adding the above industry-level control levels, this paper performs another empirical analysis to the relationship among servitization, market power and export of firms. The regression results are shown in **Table 4**.

**Table 4.** Regression results after adding industry-level variables.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.050*** (0.013)	0.060*** (0.015)		
<i>Servnum</i> * <i>Mp</i>		0.255*** (0.009)		
<i>Servreve</i>			0.114*** (0.030)	0.130*** (0.034)
<i>Servreve</i> * <i>Mp</i>				0.095* (0.105)
<i>Mp</i>		0.956*** (0.082)		0.953*** (0.082)
<i>Indsales</i>	0.027*** (0.009)	0.015 (0.010)	0.027*** (0.009)	0.016*** (0.001)
<i>Indsoe</i>	-0.533*** (0.017)	-0.542*** (0.017)	-0.532*** (0.017)	-0.541*** (0.017)
<i>Indkl</i>	0.538*** (0.006)	0.540*** (0.006)	0.538*** (0.006)	0.540*** (0.006)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	19360	19360	19360	19360
<i>Pseudo R<sup>2</sup></i>	0.415	0.419	0.415	0.419

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Data source: The author calculated based on the database of listed companies in China.

In this table, column (1) and column (2) show the regression results with servitization breadth as the core explanatory variable, and column (3) and column (4) show the regression results with servitization depth as the core explanatory variable. In light of the regression results in **Table 4**, the effect of servitization on the propensity of firms to export is significantly positive after industry-level control variables are added. Moreover, servitization breadth causes a significantly greater effect on the export of firms than servitization depth and the effect caused by the interaction between servitization and market power on the export of firms is significantly positive at the level of 10% at least. The above fact implies that the regression results are still valid after taking into account possible

omitted control variables.

## 2) Formulate instrumental variables

According to the results of the above benchmark regression, servitization significantly improves the tendency of firms to export. However, as demonstrated by the existing research, export firms always have higher production efficiency and therefore have the conditions and abilities of servitization, thus leading to the endogeneity issue. In order to avoid the endogeneity issue caused by reverse causality, this paper uses the World Input-Output Tables (WIOT) in the WIOD (the World Input-Output Database) to calculate the ratio of service factor input at the level of manufacturing industry in other countries except China. In detail, the paper first calculates the servitization indicator ( $Indserv_{jt}$ ) of industry  $j$  in another country  $i$ , weights the industry-level servitization indicator according to the similarity ( $SI_{it}$ ) between this country and China and then obtains the instrumental variable of China's industry-level servitization indicator. The specific calculation formula is as follows:

$$IVIndserv_{jt} = \sum Indserv_{ijt} \times SI_{it} \quad (22)$$

$$SI_{it} = 1 - \left\{ \frac{pcGDP_t}{pcGDP_t + pcGDP_{it}} \right\}^2 - \left\{ \frac{pcGDP_{it}}{pcGDP_t + pcGDP_{it}} \right\} \quad (23)$$

$SI_{it}$  represents the similarity index between the country  $i$  and China,  $pcGDP_t$  represents the per capita GDP of China in the period  $t$  and  $pcGDP_{it}$  represents the per capita GDP of the country  $i$  in the period  $t$ . The research period is very long and some countries are developing at a high speed. Therefore, the similarity index calculated in this paper is changing along with time. Based on the instrumental variable, this paper conducts empirical analysis on the relationship among servitization, market power and export of firms using the two-stage least squares method. The regression results are shown in **Table 5**. In **Table 5**, column (1) and column (2) show the regression results with servitization breadth as the core explanatory variable, and column (3) and column (4) show the regression results with servitization depth as the core explanatory variable. In light of the regression results in **Table 5**, the effect of servitization on the tendency of firms to export is significantly positive. Moreover, servitization breadth causes a significantly greater effect on the export of firms than servitization depth and the effect caused by the interaction between servitization and market power on the export of firms is significantly positive at the level of 5%, which is consistent with the benchmark regression result. In the instrumental variable validity test, the p-value of the Kleibergen-Paap rk LM statistic is 0, while the Cragg-Donald Wald F statistic is significantly greater than the given threshold of 10%. This fact implies that this instrumental variable passes the underidentification test and weak instrumental variable test.

## 2) Robustness test

### a) Consider the impact of financial crisis on regression results

In order to verify the robustness of the benchmark regression results, this

**Table 5.** Endogeneity analysis of instrumental variables.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.102*** (0.015)	0.111*** (0.020)		
<i>Servnum* Mp</i>		0.534*** (0.186)		
<i>Servreve</i>			0.230*** (0.034)	0.241*** (0.045)
<i>Servreve* Mp</i>				0.184** (0.083)
<i>Mp</i>		0.522*** (0.023)		0.519*** (0.023)
<i>First Stage</i>	0.250*** (0.007)	0.193*** (0.007)	0.111*** (0.003)	0.086*** (0.003)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>K-P rk LM</i>	120.542	71.860	125.110	75.151
<i>P-val</i>	0	0	0	0
<i>C-DW F</i>	44.403	30.837	44.345	30.967
<i>10 % maximal IV</i>	30.986	25.453	29.889	24.093
<i>N</i>	19360	19360	19360	19360
<i>R<sup>2</sup></i>	0.321	0.342	0.320	0.340

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. "First Stage" is the regression results of the first stage, K-P rk LM represents the Kleibergen-Paap rk LM statistic, P-val represents the P value of the Kleibergen-Paap rk LM statistic, C-DW F represents the Cragg-Donald Wald F statistic, and 10% maximal IV represents the given threshold of 10%. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.

paper analyzes the relationship among servitization, market power and export of firms again by building a difference-in-differences (DID) model and considering the exogenous impact caused by financial crisis. If it is earlier than the financial crisis, *T* is 0; if it is later than the financial crisis, *T* is 1. If the firm is affected by financial crisis, *Post* is 1; otherwise *Post* is 0. In order to determine whether firms suffer from financial crisis, this paper divides samples according to the ra-

tio of the total amount of import from a country affected by financial crisis or export to a country affected by financial crisis to a firm's total import and export. After establishing the DID model, this paper performs another empirical analysis to the relationship among servitization, market power and export of firms. The regression results are shown in **Table 6**. In this table, column (1) and column (2) show the regression results with servitization breadth as the core explanatory variable, and column (3) and column (4) show the regression results with servitization depth as the core explanatory variable. In light of the regression results in **Table 6**, the effect of financial crisis on the export of firms is significantly negative. After taking into account the exogenous impact caused by financial crisis, servitization causes a significantly positive effect on the tendency of firms to export, and servitization breadth causes a significantly greater effect on the export of firms than servitization depth. In addition, the effect caused by the interaction between servitization and market power on the export of firms is

**Table 6.** Analysis of robustness after considering financial crisis.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.073*** (0.012)	0.063*** (0.015)		
<i>Servnum* Mp</i>		0.309*** (0.001)		
<i>Servreve</i>			0.155*** (0.028)	0.108*** (0.033)
<i>Servreve* Mp</i>				0.242** (0.101)
<i>Mp</i>		1.396*** (0.078)		1.400*** (0.078)
<i>T*Post</i>	-0.195*** (0.012)	-0.136*** (0.014)	-0.196*** (0.012)	-0.136*** (0.014)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	19360	19360	19360	19360
<i>Pseudo R<sup>2</sup></i>	0.329	0.432	0.429	0.432

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.

significantly positive at the level of 10% at least. The above fact implies that the regression results are still valid after taking into account the impact of financial crisis.

b) Re-measure servitization

While firms are engaged in servitization, the increase of income from service-related business activities is accompanied by the increase of service profit and service cost. This paper re-measures the servitization indicator based on the proportion of service-related costs to total costs and the proportion of service-related profits to total profits disclosed in the annual reports of listed manufacturing firms. The annual reports of listed firms disclose the business scope information of each listed firm in detail and provide the income, profit and cost of each business. The related indicators can be formulated by identifying each business. By re-measuring servitization, this paper conducts another empirical analysis on the relationship among servitization, market power and export of firms. The regression results are shown in **Table 7**. In light of the regression results in **Table 7**, the effect of servitization on the tendency of firms to export is significantly positive after re-measuring servitization. Moreover, the effect caused

**Table 7.** Regression results of re-measuring servitization.

Variable	(1)	(2)	(3)	(4)
	Servitization cost/Total cost		Servitization profit/Total profit	
<i>Servcost</i>	0.126*** (0.028)	0.095*** (0.033)		
<i>Servcost*Mp</i>		0.485** (0.229)		
<i>Servpro</i>			0.184*** (0.031)	0.131*** (0.037)
<i>Servpro*Mp</i>				0.646** (0.257)
<i>Mp</i>		1.487*** (0.077)		1.494*** (0.077)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	19360	19360	19360	19360
<i>Pseudo R<sup>2</sup></i>	0.222	0.329	0.222	0.329

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.



by the interaction between servitization and market power on the export of firms is significantly positive at the level of 5% at least. The above fact implies that the regression results are still valid after re-measuring servitization.

c) Re-measure the export of firms

In the benchmark regression, this paper takes whether a firm chooses to export or not as the explained variable. The probability of export of firms has been taken account. However, it cannot reflect the export volume. Therefore, this paper further measures the export intensity of firms using the ratio of firm exports to operating income, and further analyzes the relationship among servitization, market power and export of firms. The regression results are shown in **Table 8**. In **Table 8**, column (1) and column (2) show the regression results with servitization breadth as the core explanatory variable, and column (3) and column (4) show the regression results with servitization depth as the core explanatory variable. In light of the regression results in **Table 8**, the effect of servitization on the tendency of firms to export is significantly positive after the export of firms is re-measured. Moreover, servitization breadth causes a significantly greater effect on the export of firms than servitization depth and the effect caused by the

**Table 8.** Regression results of re-measuring the export of firms.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.072*** (0.013)	0.064*** (0.015)		
<i>Servnum* Mp</i>		0.385*** (0.006)		
<i>Servreve</i>			0.142*** (0.029)	0.096*** (0.034)
<i>Servreve* Mp</i>				0.299*** (0.103)
<i>Mp</i>		1.413*** (0.079)		1.418*** (0.079)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	17754	17754	17754	17754
<i>Pseudo R<sup>2</sup></i>	0.325	0.335	0.324	0.335

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.

interaction between servitization and market power on the export of firms is significantly positive at the level of 10% at least. The above fact implies that the regression results are still valid after remeasuring the export of firms.

d) Exclude special service firms

In the process of servitization of manufacturing firms, the real estate and related services of some firms are mostly provided in the form of capital accumulation, which is quite different from the traditional servitization model of manufacturing firms from producing products to providing services. In order to reduce the error in estimation results caused by the improper selection of samples, this further excludes the firms providing real estate services and performs another empirical analysis to the relationship among servitization, market power and export of firms. The regression results are shown in **Table 9**. In this table, column (1) and column (2) show the regression results with servitization breadth as the core explanatory variable, and column (3) and column (4) show the regression results with servitization depth as the core explanatory variable. In light of the regression results in **Table 9**, the effect of servitization on the tendency of firms to export is significantly positive after the special service firms are

**Table 9.** Regression results after excluding real estate service firms.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.061*** (0.013)	0.053*** (0.015)		
<i>Servnum* Mp</i>		0.353*** (0.009)		
<i>Servreve</i>			0.116*** (0.029)	0.069** (0.033)
<i>Servreve* Mp</i>				0.298*** (0.101)
<i>Mp</i>		1.483*** (0.077)		1.490*** (0.077)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	19413	19413	19413	19413
<i>Pseudo R<sup>2</sup></i>	0.318	0.330	0.318	0.329

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.

excluded. Moreover, servitization breadth causes a significantly greater effect on the export of firms than servitization depth and the effect caused by the interaction between servitization and market power on the export of firms is significantly positive at the level of 10%. The above fact implies that the regression results are still valid after excluding special service firms.

### 5.3. Extended Analysis

The effect of servitization on the export of firms and the interaction mechanism of servitization and market power on the export of firms are verified above. Based on such verification, this paper considers whether the marginal effect of servitization is influenced by types of corporate servitization, levels of digitization, thresholds of international market, etc.

#### 1) Distinguish between different types of servitization

In order to find out the difference of regression results caused by different types of servitization, this paper divides servitization into product support servitization and non-product support servitization based on the definition of servitization by Kowalkowski et al. (2015) and Mathieu et al. (2011) as well as whether the service activities involving firms is directly related to products. Product support services mainly include after-sales services related to core products to ensure the normal operation of products and the best experience of users while non-product support services mainly include consulting services and financing services not related to the core products of firms. Column (1) and column (2) of **Table 10** show the effect of product support servitization on the export of firms while column (3) and (4) show the effect of non-product support servitization on the export of firms. As reflected by the regression results, product support servitization causes a significantly greater marginal effect on the export of firms than non-product support servitization no matter whether the service business strategies of manufacturing firms are described using servitization breadth or servitization depth. The following aspects lead to the above situation: The increase of firm investment in service business activities is accompanied by the decrease of product investment. The process of shifting the focus of corporate business activities from products to services is inevitably accompanied by the resource crowding-out effect of firms' products, thereby having a significant inhibitory effect on the tendency of firms to export. Although different types of servitization can have a positive promotive effect on the export of firms, non-product support servitization is not related to products, and has greater crowding-out effect and sunk cost effect on the export of firms. Therefore, the effect of product support servitization on the export of firms is more significant.

#### 2) Distinguish between levels of digitization

Different from non-service manufacturing firms, servitized firms require good data processing and data analysis abilities for the consumer market to respond to consumers' diversified preferences (Cenamor et al., 2017). Servitized firms are also required to have good communication skills and strong market feedback

**Table 10.** Regression results of distinguishing between types of servitization.

Variable	(1)	(2)	(3)	(4)
	Product support servitization		Non-product support servitization	
	Breadth of servitization	Depth of servitization	Breadth of servitization	Depth of servitization
<i>Pservnum</i>	0.133** (0.061)			
<i>Pservnum*Mp</i>	1.000** (0.423)			
<i>Pservreve</i>		0.188*** (0.067)		
<i>Pservreve*Mp</i>		0.428*** (0.001)		
<i>NPservnum</i>			0.073*** (0.027)	
<i>NPservnum*Mp</i>			0.448** (0.183)	
<i>NPservreve</i>				0.101*** (0.030)
<i>NPservreve*Mp</i>				0.248*** (0.008)
<i>Mp</i>	1.482*** (0.077)	1.477*** (0.077)	1.487*** (0.077)	1.484*** (0.077)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	19360	19360	19360	19360
<i>PseudoR<sup>2</sup></i>	0.329	0.329	0.329	0.329

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.

abilities with consumers (Eloranta & Turunen, 2016) so as to accurately find out consumer needs. The application of digital information tools has improved the data collection and processing abilities of servitized firms, and helped establish an effective communication and interaction platform between servitized firms

and consumers. In order to analyze the effect caused by different levels of digitization on the effect of servitization, this paper takes the density of regional digitization as the proxy variable of corporate digitization. In detail, this paper takes the  $\text{sum}^3$  (logarithm) of three indicators, including the numbers of fixed telephone users, mobile phone users and Internet users per capita in a city, to test whether the level of digitization is higher than the average. The regression results are shown in **Table 11**, where column (1) and column (2) present the regression results for the sample of firms with a higher level of digitization, and column (3) and column (4) present the regression results for the sample of firms with a lower level of digitization. In general, the servitization of the firms with a higher level of digitization causes a significantly greater marginal effect on the export of firms than that of the firms with a lower level of digitization no matter whether the service business strategies of manufacturing firms are described using the breadth or depth of servitization. This fact implies that the improved

**Table 11.** Regression results of distinguishing between levels of digitization.

Variable	(1)	(2)	(3)	(4)
	High level of digitization		Low level of digitization	
	Breadth of servitization	Depth of servitization	Breadth of servitization	Depth of servitization
<i>Servnum</i>	0.110*** (0.026)		0.033*** (0.001)	
<i>Servnum* Mp</i>	0.206*** (0.005)		0.393*** (0.002)	
<i>Servreve</i>		0.194*** (0.059)		0.035*** (0.001)
<i>Servreve* Mp</i>		0.233*** (0.006)		0.289*** (0.023)
<i>Mp</i>	1.517*** (0.139)	1.523*** (0.139)	1.411*** (0.093)	1.418*** (0.093)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	6132	6132	13228	13228
<i>Pseudo R<sup>2</sup></i>	0.273	0.272	0.354	0.354

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.

<sup>3</sup>Data source of the information infrastructure density: *China City Statistical Yearbook*.

level of digitization has reduced the search cost and friction cost caused in the process of firm servitization and enhanced the marginal effect on the export of firms.

### 3) Distinguish between international market thresholds

According to the above theoretical model, we can infer that the international trade cost of goods and services is a significant factor affecting whether export firms choose the service business strategy. The closer a firm is to the international market, the lower the fixed cost it faces, the higher the abundance of its service factor input will be. In order to analyze the effect of international trade cost on the marginal effect of servitization, this paper adopts the practice of Baum-Snow et al. (2020). Based on the electronic map of transportation infrastructure, the recursive equation is combined with the geographical algorithm to calculate the international market threshold index of each prefecture-level city and then measure the international trade cost of firms. By determining whether the international market threshold for the city where in the firm is located in is higher than the average value, this paper divides the sample and conducts another empirical analysis on the relationship among servitization, market power and export of firms. The regression results are shown in Table 12. In Table 12, column (1) and column (2) show the effect of firm servitization on exports when the international market threshold is lower than the average value while column (3) and column (4) show the effect of firm servitization on exports when the threshold is higher than the average value. According to the regression results, a lower international market threshold for firms corresponds to a stronger effect caused by servitization to the export of firms no matter whether the service business strategies of manufacturing firms are described using the breadth or depth of servitization whether other conditions remain unchanged. A lower international market threshold helps reduce the fixed cost of firms on exporting goods and services to international markets and the crowding-out effect and sunk cost caused by the input of service factors and enhance the marginal effect of servitization on the export of firms.

## 5.4. Mechanism identification

### 1) Technology spillover effect

This paper measures the technology spillover effect using the number of firms' invention patents (expressed with *Patent*). In most cases, the more patents the firm owns, the higher technical level the firm has. As reflected by the regression results in Table 13, the effect caused by the interaction between servitization and patent on the export of firms is significantly positive at the level of 10% no matter whether the service business strategies of manufacturing firms are described using the breadth or depth of servitization. This fact implies that the technology spillover effect caused by servitization significantly improves the tendency of firms to export. Servitization promotes the fusion of service and manufacturing sectors, produces technology spillover effects through knowledge transfer and information sharing, improves the productivity of firms and reduces the unit

**Table 12.** Regression results of distinguishing between international market thresholds.

Variable	(1)	(2)	(3)	(4)
	Low international market threshold		High international market threshold	
	Breadth of servitization	Depth of servitization	Breadth of servitization	Depth of servitization
<i>Servnum</i>	0.083*** (0.021)		0.035*** (0.001)	
<i>Servnum* Mp</i>	0.941*** (0.310)		0.001*** (0.354)	
<i>Servreve</i>		0.125*** (0.047)		0.067*** (0.001)
<i>Servreve* Mp</i>		0.555*** (0.130)		0.050*** (0.005)
<i>Mp</i>	1.425*** (0.114)	1.431*** (0.114)	1.522*** (0.105)	1.522*** (0.105)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	8160	8160	11,200	11,200
<i>Pseudo R<sup>2</sup></i>	0.275	0.275	0.374	0.374

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.

production cost, and thus enhancing the tendency of firms to export. Moreover, the effect caused by the interactions among servitization, patents and market power on the export of firms is significantly positive at the level of 10%. This fact implies that for the firms with a stronger market power, the technology spillover effect caused by servitization will produce a more significant positive promotive effect on the export of firms.

## 2) Scope economy effect

This paper measures the scope economy effect using the types of products exported by firms (expressed with *Pnum*). In most cases, the more types of products the firm exports, the more products are produced by the firm. As reflected by the regression results in **Table 14**, the effect caused by the interaction between servitization and the product types of firms on the export of firms is significantly positive at the level of 10% no matter whether servitization breadth or servitization depth is referenced to describe the service business strategies of



**Table 13.** Test results of the technology spillover effect mechanism.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.061*** (0.017)	0.068*** (0.017)		
<i>Servnum* Patent</i>	0.014* (0.009)	0.017* (0.009)		
<i>Servnum* Patent* Mp</i>		0.001* (0.134)		
<i>Servreve</i>			0.117*** (0.038)	0.124*** (0.038)
<i>Servreve* Patent</i>			0.021* (0.020)	0.027* (0.021)
<i>Servreve* Patent* Mp</i>				0.010* (0.053)
<i>Mp</i>		1.370*** (0.078)		1.365*** (0.078)
<i>Patent</i>	0.245*** (0.009)	0.233*** (0.009)	0.244*** (0.009)	0.231*** (0.009)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	19360	19360	19360	19360
<i>Pseudo R<sup>2</sup></i>	0.336	0.346	0.336	0.346

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. The regression results of interaction by multiplying every two other variables are not reported in the column (2) and (4) of **Table 13**. Data source: The author calculated based on the database of listed companies in China.

manufacturing firms. This fact implies that the scope economy effect caused by servitization significantly enhances the tendency of firms to export. Servitization improves the information capture ability of firms in the product market. By learning about the differentiated market needs, firms can increase the types and unit added values of products, build up advantages in the international product market, and enhance the export tendency. Moreover, the effect caused by the interactions among servitization, types of product and market power on the export of firms is significantly positive at the level of 10%. This fact implies that for the

**Table 14.** Test results of the crowding-out effect mechanism.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.059** (0.025)	0.067*** (0.025)		
<i>Servnum* Pnum</i>	0.013*** (0.001)	0.009*** (0.001)		
<i>Servnum* Pnum * Mp</i>		0.103*** (0.004)		
<i>Servreve</i>			0.115** (0.056)	0.126** (0.056)
<i>Servreve* Pnum</i>			0.013*** (0.003)	0.075*** (0.005)
<i>Servreve* Pnum * Mp</i>				0.046*** (0.006)
<i>Mp</i>		0.975*** (0.081)		0.970*** (0.081)
<i>Pnum</i>	0.543*** (0.006)	0.543*** (0.006)	0.543*** (0.006)	0.543*** (0.006)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	19360	19360	19360	19360
<i>Pseudo R<sup>2</sup></i>	0.415	0.419	0.415	0.419

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. The regression results of interaction by multiplying every two other variables are not reported in the column (2) and (4) of **Table 14**. Data source: The author calculated based on the database of listed companies in China.

firms with a stronger market power, the scope economy effect caused by servitization will produce a more significant positive promotive effect on the export of firms.

### 3) Crowding-out effect

It is very difficult to describe the crowding-out effect using direct indicators. Therefore, this paper divides sample firms according to the level of corporate financing constraints and then identifies the crowding-out effect. For the firms with a higher level of financing constraints, they have a lower level of capital

adequacy. If they choose the service business strategies, they will face a stronger crowding-out effect. If the crowding-out effect is the mechanism by which servitization affects the export of firms, the greater the crowding-out effect caused by servitization to the firms with a higher level of financing constraints, the weaker effect of servitization on the export of firms will be. This paper selects the typical indicators of firms (size, asset-liability ratio, return on assets and paid-in capital), divides each indicator into five levels and scores each level with 1 to 5, thus formulating the corporate financing constraint score indexes. A higher score index indicates a higher level of corporate financing constraints. The samples are divided accordingly. As reflected by the regression results in **Table 15**, the firms with a lower level of financing constraints have a greater effect coefficient for the export of firms than the firms with a higher level of financing constraints no matter whether the service business strategies of manufacturing firms are described using the breadth or depth of servitization. This fact implies that the servitization of manufacturing firms has a certain crowding-out effect. Due to the shortage of funds, the firms with a higher level of financing constraints will face

**Table 15.** Results of crowding-out effect mechanism test.

Variable	(1)	(2)	(3)	(4)
	Firms with a low level of financing constraints		Firms with a high level of financing constraints	
<i>Servnum</i>	0.074*** (0.021)		0.021*** (0.001)	
<i>Servnum</i> * <i>Mp</i>	0.044*** (0.006)		1.012*** (0.331)	
<i>Servreve</i>		0.145*** (0.047)		0.056*** (0.001)
<i>Servreve</i> * <i>Mp</i>		0.093* (0.002)		0.593*** (0.138)
<i>Mp</i>	1.464*** (0.105)	1.463*** (0.105)	1.402*** (0.121)	1.417*** (0.121)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	8709	8709	10651	10651
<i>Pseudo R</i> <sup>2</sup>	0.375	0.375	0.351	0.352

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. Data source: The author calculated based on the database of listed companies in China.

a more significant crowding-out effect than the firms with a lower level of financing constraints, thereby reducing the marginal effect of servitization on the export of firms. With a high input, servitization crowds out the factor input that would have been put into product business, reduces the core market competitiveness of products and consequently inhibits the export of firms. However, it is noticeable that the interaction between servitization and market power of the firms with a higher level of financing constraints has a greater effect coefficient on the export than the firms with a lower level of financing constraints. This fact implies that market power reduces the crowding-out effect of servitization and enhances the marginal effect of servitization on the export of firms.

#### **4) Sunk cost effect**

It is also very difficult to describe the sunk cost effect using direct indicators. Therefore, this paper uses the difference between product profit margin and service profit margin as a proxy variable of sunk cost. The annual reports of listed firms disclose the business scope information of each listed firm in detail and provide the income, profit and cost of each business. The product profit margin and service profit margin of firms are formulated by identifying each business. The difference between product profit margin and service profit margin (expressed with *Sink*) is used as a proxy variable for the sunk cost of servitization in manufacturing firms. If the product profit margin is higher than the service profit margin, it indicates that the servitization of manufacturing firms reduces the profit margin of producing single products compared with the situation of not choosing the service business strategy. A larger difference represents a greater sunk cost of servitization. According to the results in **Table 16**, the effect coefficient of the interaction between servitization and sunk cost is significantly negatively no matter whether the service business strategy of manufacturing firms is described using the breadth or depth of servitization. This fact implies that the input of service factors aggravates the profitability risk, reduces the profit margin and causes sunk costs to a certain extent, thereby inhibiting the export of manufacturing firms. However, the effect coefficient of the interactions among servitization, sunk cost and market power is positive. This fact implies that the firms with a stronger market power has a stronger ability to bear the sunk cost and consequently the sunk cost caused by servitization produces a smaller negative effect on the export of firms.

As proven by the above mechanism identification, both the technology spillover effect and scope economy effect caused by servitization promote the export of firms while the crowding-out effect and sunk cost effect inhibit the export of firms. Furthermore, the effect of servitization on the export of firms is significantly positive, indicating the positive effects (technology spillover effect and scope economy effect) caused by servitization on the export of firms, which are significantly greater than the negative effects (crowding-out effect and sunk cost effect). In brief, servitization significantly promotes the export tendency of firms.

**Table 16.** Test results of the crowding-out effect mechanism.

Variable	(1)	(2)	(3)	(4)
	Breadth of servitization		Depth of servitization	
<i>Servnum</i>	0.247*** (0.025)	0.229*** (0.025)		
<i>Servnum*Sink</i>	-0.074*** (0.010)	-0.067*** (0.010)		
<i>Servnum* Sink * Mp</i>		0.053*** (0.002)		
<i>Servreve</i>			0.545*** (0.056)	0.493*** (0.057)
<i>Servreve* Sink</i>			-0.172*** (0.022)	-0.161*** (0.024)
<i>Servreve* Sink * Mp</i>				0.065*** (0.008)
<i>Mp</i>		1.332*** (0.078)		1.330*** (0.078)
<i>Sink</i>	-0.230*** (0.013)	-0.196*** (0.013)	-0.232*** (0.013)	-0.196*** (0.013)
<i>Variable</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>Firmid</i>	Yes	Yes	Yes	Yes
<i>N</i>	19360	19360	19360	19360
<i>Pseudo R<sup>2</sup></i>	0.326	0.335	0.326	0.335

Note: \*, \*\* and \*\*\* represent the significance levels of 10%, 5% and 1%, numbers in parentheses represent the robust standard errors for clustering at the city level, and Year and Firmid represent the fixed effect at the level of year and firm. Lack of space forbids the presentation of regression results for non-core control variables. The regression results of interaction by multiplying every two other variables are not reported in the column (2) and (4) of **Table 16**. Data source: The author calculated based on the database of listed companies in China.

## 6. Conclusions and Recommendations

As an important trend of global economic development, servitization has gradually become a critical path to promote the integrated development of advanced manufacturing and modern service industries and accelerate the process of building China into a manufacturing power. Starting with the selection of corporate servitization business strategies, this paper formulates servitization indicators at two microscopic levels (breadth and depth of servitization), integrates

the effect of market power on corporate servitization and export decision into the theoretical model and elaborates on the relationship among servitization, market power and export of firms.

The research findings are as follows: 1) Servitization significantly enhances the export tendency of firms and the depth of servitization has a greater effect on the export of firms than the breadth of servitization; 2) Improved market power reduces the negative effect caused by servitization on the export of firms but promotes the marginal effect of servitization on the export of firms; 3) Servitization significantly enhances the export firms characterized by a higher level of product support servitization, a higher level of digitization and a lower international market threshold; 4) Both the technology spillover effect and scope economy effect caused by servitization promote the export of firms while the crowding-out effect and sunk cost effect inhibit the export of firms.

Now, the export of manufacturing firms is facing double pressure. Under such circumstance, servitization gradually plays a decisive role in promoting the international competitiveness of manufacturing firms. Based on the above analysis, this paper provides the following policy recommendations: First, accelerate the servitization process of manufacturing firms. Manufacturing firms should adjust business strategies to promote the level of servitization, broaden the new path of transformation and upgrading for the traditional manufacturing industry, enhance the competitive advantage in the international market and finally promote the export tendency. Second, promote the innovation of manufacturing firms to a higher level. It is recommended to promote the innovation and productivity to a higher level by increasing the R&D investment, further reduce the production cost and enhance the market power of manufacturing firms, thus increasing the promotive effect of servitization on the export of firms. Third, work hard to promote the level of product support servitization. Manufacturing firms should increase the added value and differentiation of products by promoting the product support servitization in an effort to relieve the competitive effect from homogeneous product markets and promote export.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

### References

- Ariu, A., Mayneris, F., & Parenti, M. (2016). *Providing Services to Boost Goods Exports: Theory and Evidence*. ECARES Working Papers, No. 243160. ECARES.
- Baum-Snow, N., Henderson, J. V., & Turner, M. A. (2020). Does Investment in National Highways Help or Hurt Hinterland City Growth? *Journal of Urban Economics*, 115, 104-124. <https://doi.org/10.1016/j.jue.2018.05.001>
- Berlingieri, G. (2014). *Outsourcing and the Rise of Services*. CEP Working Paper, No. 1199. CEP.
- Bernard, A. B., Eaton, J., Jensen, J. G. et al. (2003). Plants and Productivity in Interna-

- tional Trade. *American Economic Review*, 93, 1268-1290.  
<https://doi.org/10.1257/000282803769206296>
- Blanchard, P., Fuss, C., & Mathieu, C. (2017). *Why Do Manufacturing Firms Produce Services? Evidence for the Servitization Paradox in Belgium*. NBB Working Paper, No. 330. NBB.
- Breinlich, H., Soderbery, A., & Wright, C. G. (2018). From Selling Goods to Selling Services: Firm Responses to Trade Liberalization. *American Economic Journal: Economic Policy*, 10, 79-108. <https://doi.org/10.1257/pol.20150116>
- Cenamora, J., Sjödin, D. R., & Parida, V. (2017). Adopting a Platform Approach in Servitization: Leveraging the Value of Digitalization. *International Journal of Production Economics*, 192, 54-65. <https://doi.org/10.1016/j.ijpe.2016.12.033>
- Coreynen, W., Matthyssens, P., & Gebauer, H. (2018). Are You Ready for Servitization? A Tool to Measure Servitization Capacity. In M. Kohtamäki, T. Baines, R. Rabetino, & A. Bigdeli (Eds.), *Practices and Tools for Servitization* (pp. 25-39). Palgrave Macmillan.  
[https://doi.org/10.1007/978-3-319-76517-4\\_2](https://doi.org/10.1007/978-3-319-76517-4_2)
- Eloranta, V., & Turunen, T. (2016). Platforms in Service-Driven Manufacturing: Leveraging Complexity by Connecting, Sharing, and Integrating. *Industrial Marketing Management*, 55, 178-186. <https://doi.org/10.1016/j.indmarman.2015.10.003>
- Gebauer, H., Edvardsson, B., Gustafsson, A., & Witell, L. (2010). Match or Mismatch: Strategy Structure Configurations in the Service Business of Manufacturing Companies. *Journal of Service Research*, 13, 198-215.  
<https://doi.org/10.1177/1094670509353933>
- Greenstein, S. (2020). *Digital Infrastructure*. NBER Working Paper, No. 14360. NBER.
- Heuser, C., & Mattoo, A. (2017). *Services Trade and Global Value Chains*. The World Bank Working Paper Series, No. 8126. World Bank.  
<https://doi.org/10.1596/1813-9450-8126>
- Humbeck, P., Pfähler, K., Wiedenmann, M., & Herzwurm, G. (2019). The Impact of Servitization and Digital Transformation—A Conceptual Extension of the IPOO-Framework. *Procedia CIRP*, 81, 914-919.  
<https://doi.org/10.1016/j.procir.2019.03.227>
- Jang, K. K., Bae, J., & Kim, K. H. (2021). Servitization Experience Measurement and the Effect of Servitization Experience on Brand Resonance and Customer Retention. *Journal of Business Research*, 130, 384-397. <https://doi.org/10.1016/j.jbusres.2020.03.012>
- Ju, X. N., Zhao, X. K., & Sun, B. W. (2020). What Trade Costs Have Cross-Border E-Commerce Platforms Overcome?—Empirical Evidence from “DHgate” Data. *Economic Research Journal*, 55, 181-196. (In Chinese)
- Kindström, D., & Kowalkowski, C. (2009). Development of Industrial Service Offerings: A Process Framework. *Journal of Service Management*, 20, 156-172.  
<https://doi.org/10.1108/09564230910952753>
- Kohtamäki, M., Partanen, J., Parida, V., & Wincent, J. (2013). Non-Linear Relationship between Industrial Service Offering and Sales Growth: The Moderating Role of Network Capabilities. *Industrial Marketing Management*, 42, 1374-1385.  
<https://doi.org/10.1016/j.indmarman.2013.07.018>
- Kowalkowski, C., Windahl, C., Kindström, D., & Gebauer, H. (2015). What Service Transition? Rethinking Established Assumptions about Manufacturers’ Service Led Growth Strategies. *Industrial Marketing Management*, 45, 59-69.  
<https://doi.org/10.1016/j.indmarman.2015.02.016>
- Li, J. Z., Chen, Q. Y., & Qian, X. F. (2020). Non-Homothetic Preferences, Non-Linear

- Home Market Effects and Service Exports. *Economic Research Journal*, 55, 133-147. (In Chinese)
- Li, L. B., Yan, L., & Huang, J. L. (2019). Transportation Infrastructure Connectivity and Manufacturing Industries in Peripheral Cities in China: Markup, Productivity and Allocation Efficiency. *Economic Research Journal*, 54, 182-197. (In Chinese)
- Lightfoot, H., Baines, T. S., & Smart, P. (2013). The Servitization of Manufacturing: A Systematic Literature Review of Interdependent Trends. *International Journal of Operations and Production Management*, 33, 1408-1434. <https://doi.org/10.1108/IJOPM-07-2010-0196>
- Liu, B., Wei, Q., Lv, Y., & Zhu, K. F. (2016). Servitization of Manufacturing and Value Chain Upgrading. *Economic Research Journal*, 51, 151-162. (In Chinese)
- Loecker, J. D., & Warzynski, F. (2012). Markups and Firm-Level Export Status. *American Economic Review*, 102, 24-37. <https://doi.org/10.1257/aer.102.6.2437>
- Loecker, J. D., Eeckhout, J., & Unger, G. (2020). The Rise of Market Power and the Macroeconomic Implications. *The Quarterly Journal of Economics*, 135, 561-644. <https://doi.org/10.1093/qje/qjz041>
- Manova, K., & Yu, Z. (2017). Multi-Product Firms and Product Quality. *Journal of International Economics*, 109, 116-137. <https://doi.org/10.1016/j.jinteco.2017.08.006>
- Mao, Q. L. (2020). Have Trade Policy Uncertainties Affect the Export of Chinese Firms? *Economic Research Journal*, 55, 148-164. (In Chinese)
- Mathieu, V. (2001). Product Services: From a Service Supporting the Product to a Service Supporting the Client. *Journal of Business and Industrial Marketing*, 16, 39-58. <https://doi.org/10.1108/08858620110364873>
- Melitz, M. J., & Ottaviano, G. I. P. (2008). Market Size, Trade, and Productivity. *Review of Economic Studies*, 75, 295-316. <https://doi.org/10.1111/j.1467-937X.2007.00463.x>
- Miroudot, S., & Cadestin, C. (2017). *Services in Global Value Chains: From Inputs to Value Creating Activities*. OECD Trade Policy Papers, No. 197. OECD Publishing.
- Partanen, J., Kohtamäki, M., Parida, V., & Wincent, J. (2017). Developing and Validating a Multi-Dimensional Scale for Operationalizing Industrial Service Offering. *Journal of Business and Industrial Marketing*, 32, 295-309. <https://doi.org/10.1108/JBIM-08-2016-0178>
- Pelli, P. (2018). Services and Industrial Development: Analysis of Industrial Policy, Trends and Issues for the Forest-Based Sector. *Journal of Forest Economics*, 31, 17-26. <https://doi.org/10.1016/j.jfe.2017.11.003>
- Reiskin, E. D., White, A. L., Johnson, J. K., & Votta, T. J. (2000). Servicizing the Chemical Supply Chain. *Journal of Industrial Ecology*, 3, 19-31. <https://doi.org/10.1162/108819899569520>
- Santos Silva, J. M. C., & Tenreyro, S. (2006). The Log of Gravity. *The Review of Economics and Statistics*, 88, 641-658. <https://doi.org/10.1162/rest.88.4.641>
- Shah, S. A. A., Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2020). Servitization and Supply Chain Integration: An Empirical Analysis. *International Journal of Production Economics*, 229, Article ID: 107765. <https://doi.org/10.1016/j.ijpe.2020.107765>
- Song, C. (2021). Opening up of Foreign Capital, Digitization and Servitization. *Collected Assays on Finance and Economics*, No. 7, 14-24. (In Chinese)
- Vandermerwe, S., & Rada, J. (1988). Servitization of Business: Adding Value by Adding Services. *European Management Journal*, 6, 314-324. [https://doi.org/10.1016/0263-2373\(88\)90033-3](https://doi.org/10.1016/0263-2373(88)90033-3)



- Visnjic, I., Neely, A., & Jovanovic, M. (2018). The Path to Outcome Delivery: Interplay of Service Market Strategy and Open Business Models. *Technovation*, 72, 46-59.  
<https://doi.org/10.1016/j.technovation.2018.02.003>
- White, A. L., Stoughton, M., & Feng, L. (1999). *Servicizing: The Quiet Transition to Extended Product Responsibility*. Tellus Institute.
- Xu, H. L., Cheng, L. H., & Sun, T. Y. (2017). The Effect of the Input Servitization of Manufacturing on Upgrading Export Domestic Value Added of Enterprises—Empirical Evidence from Chinese Micro-Enterprise. *China Industrial Economics*, No. 10, 62-80. (In Chinese)