Empirical Study on the Manufacturing Enterprises Servitization and Environmental Protection Investment in Manufacturing Enterprises

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Abstract:

Environmental protection is one of the hot topics in the world under the trend of manufacturing servitization, it is of great theoretical significance and practical value to study how enterprises servitization affect environmental protection investment. Therefore, this paper collects China's A-share non-ST manufacturing listed companies from 2007 to 2019 as samples, and finds that the manufacturing enterprises servitization has highly negative impact on environmental protection investment. Among them, the efficiency mechanism is as follow: the manufacturing enterprises servitization obviously reduces the environmental protection investment by improving the production efficiency of the whole factor; the crowding mechanism is as follow: under the resource constraint condition, the large amount of capital occupation of the servitization forces the enterprise to reduce the investment of environmental protection. Furthermore, from the perspective of industry characteristics and national servitization strategy, this paper discusses the influence of efficiency and crowding on the relationship between servitization and environmental protection investment. The research results are of great significance for manufacturing enterprises to realize green development and improve environmental protection level.

Keywords: Manufacturing enterprises servitization, environmental protection investment, efficiency mechanism, crowding mechanism

I. INTRODUCTION

According to the Externality, enterprises pursuing the maximum of their own interests by conducting negative externality activities will lead to social losses. It can be seen that the pollution behavior of enterprises has typical negative externalities [1]. The way to solve the negative externality of environmental cost is to internalize the external cost. Therefore, China has implemented the *Environmental Protection Law of the People's Republic of China* and the *Environmental Protection Tax Law of the People's Republic of China*. Enterprises implement environmental laws and regulations and internalize environmental cost is

an important method to optimize resource allocation [2], but it will increase production and operation cost of enterprise. Therefore, as the main pollution enterprises, manufacturing enterprises need to increase the investment in environmental protection investment, comply with relevant laws, so as to reduce the environmental protection tax, and the expenditure of violating relevant laws on environmental protection. Development servitization is the development trend of manufacturing enterprises. What is the impact on environmental protection investment? There are few relevant literatures

This paper selects the A-share non-ST manufacturing companies from 2007 to 2019 as a sample to study the impact of manufacturing enterprises servitization level on environmental protection investment. It is found that there are efficiency mechanism and crowding mechanism that make the environmental protection investment decrease with the improvement of service level. Among them, the efficiency mechanism is as follows: the improvement of manufacturing servitization degree can promote technological progress, which is to use more green technology, improve the production process, so as to increase enterprise resource utilization efficiency, reduce pollutant emission, and then decrease enterprise environmental protection investment.

The crowding mechanism is as follows: under the restriction of resources, the investment of servitization and environmental protection needs a large amount of funds to support. Whether the environmental protection investment cycle is long-term or short-term, servitization can bring economic benefits; However, the environmental protection investment cycle is long, the short-term benefits are poor, and the long-term benefits are easily overlooked. Enterprises tend to invest limited resources into servitization and reduce environmental protection investment, which results in making it occupy the investment of environmental protection.

The main contributions of this paper are as follows: Different from other scholars' research on the environmental performance of manufacturing enterprises servitization from the macro-level, this paper studies the impact of manufacturing enterprise service on environmental protection investment from the micro-enterprise level, further reveals the relationship between the two, and lays a solid foundation for the macro-level research. On this basis, this paper analyzes the impact mechanism of manufacturing enterprise service on environmental protection investment deeply, discusses it from two perspectives of efficiency and crowding, and clarifies the impact mechanism of manufacturing enterprise service on environmental protection investment. At last, this paper discusses the impact of different manufacturing industry servitization on environmental protection investment, and the influence of national servitization policy on the relationship between them, which makes the relationship between manufacturing enterprises servitization and environmental protection investment closer to reality, and provides more ideas and perspectives for the follow-up research.

II. STUDY ASSUMPTIONS

At first, the manufacturing enterprises servitization refers to the transformation process from the operation mode that only provides tangible product or tangible product and its after-sales service to the

operation mode that provides "product + service" package. This complete product service package includes services, self-service, products, support activities and related knowledge [3]. Later, scholars at home and abroad gradually comprehensively and deeply understood the service orientation of manufacturing industry. Xu Zhenxin and other researchers(2016) [4] proposed that manufacturing servitization refers to the process of returning manufacturing products and servitization to manufacturing enterprises under the support of modern information technology, and promoting the evolution of the manufacturing industry form from product-based manufacturing to service-based manufacturing.

The increasingly fierce market competition and the differentiated demands of consumers promote the service-oriented manufacturing industry [5]. To better meet the differentiated needs of consumers, manufacturing needs to invest in innovation in the design and R&D of products and services [4]. Therefore, the service process of manufacturing enterprises needs a large amount of capital investment.

The manufacturing enterprises servitization can improve the production efficiency of all factors such as energy and materials, and then reduce the emission of pollutants. In terms of energy, manufacturing enterprises servitization can promote technological progress, improve enterprise energy utilization efficiency [6, 7] and reduce energy consumption intensity [8, 9]. At the same time, the service of manufacturing enterprises can improve the production process, promote green production, improve the efficiency of all kinds of resources, reduce resource consumption and decrease pollutant discharge. To sum up, the service of manufacturing enterprises significantly reduces the investment in environmental protection of enterprises.

The servitization of manufacturing enterprises needs a large amount of capital investment, and thus occupies the environmental protection investment of enterprises. Firstly, the resource view holds that there exists complementarity, substitution, gain and suppression relationship among enterprise resources [10]. A large amount of capital investment is needed for the servitization and environmental protection investment of manufacturing enterprises, which inevitably results in the crowding out of each other under the condition of limited resources. Servitization is the trend of the development of manufacturing industry, which is required by the survival and development of enterprises, and the investment in environmental protection mainly comes from the pressure of environmental regulation. Therefore, enterprises tend to invest resources into servitization rather than environmental protection investment, resulting in crowding out effect. Moreover, servitization investment can produce benefits in both short-term and long-term. Environmental protection investment is not conducive to improving economic benefits in the short term [11, 12]. In the long run, it is also uncertain and risky; even if benefits are generated, such benefits are not clearly attributed to enterprises because of externalities of environmental pollution [13], i. e. the costs of environmental protection investment shall be borne solely by the enterprises, while the environmental benefits shall be shared by the society [14, 15]. Therefore, under the condition of limited resources, manufacturing enterprises tend to invest a large amount of capital into the servitization rather than the environmental protection investment in order to pursue higher economic benefits, that is to say, servitization investment over environmental protection investment. In conclusion, this paper proposes the following assumptions:

H1: The environmental protection investment of manufacturing enterprises is negatively correlated with the service level.

III. STUDY DESIGN

3.1 Sample Selection and Data Sources

This paper takes A-share listed companies from 2008 to 2019 as the research object. In order to ensure the validity of empirical analysis, this paper carries out the following screening:(1) excluding the samples with missing relevant financial data;(2) excluding the samples of finance, ST and PT;(3) excluding the samples whose listing years are less than 1; (4) excluding the samples whose growth rate of total assets and operating income exceeds 100%; (5) to avoid the influence of extreme abnormal values, the continuous variables involved in the regression are subjected to Winsorize by 1%.

Enterprise service data source. This article gathers the composition data of main business income of listed companies by industry by hand. Then, the service data of this paper is finalized, according to the *Classification Standard of National Economy Industry* (GB/T4754-2017) and *Notice of National Bureau of Statistics on Amending the Provisions on Three Industrial Divisions (2012)*, combining with the definition of service scope by Hockerts & Weaver (2002) and Neely (2008) [16, 17] , including: agriculture, forestry, animal husbandry, fishery and ancillary activities, mining profession and ancillary activities, wholesale and retail trade, transportation, warehousing and postal industry, accommodation and catering industry, information transmission, software and information technology service industry, financial industry, scientific research and technical service industry, water conservancy, environment and public facilities management industry, resident service, repair and other service industry, education, health and social work, culture, sports and entertainment industry, real estate, public management, social security and social organizations, and international organizations.

Data source of enterprise environmental protection investment. In this paper, the part of "Notes to Consolidated Financial Statements" in the annual report of enterprises is collected by hand, including the items of assets and liabilities in the balance sheet. The data used in this paper come from CSMAR database, and other receivables in environmental protection investment come from Wind database.

3.2 Selection of Variables

(1) Environmental Protection Investment (EPI)

Environmental protection investment (EPI) is derived from the balance sheet items, mainly including the project under construction, long-term deferred expenses and other receivables. In terms of specific details of each project, the project under construction mainly includes various details such as sewage treatment project, desulfurization and dust removal project, waste gas reconstruction and expansion project, waste recovery and recycling project, environmental treatment project, etc.; long-term deferred expenses

mainly include the greening fee, pollution discharge right usage fee, resource use and compensation fee, environmental protection renovation cost, environmental treatment fee, etc.; other receivables mainly include environmental treatment recovery deposit collected by the debtor party, energy conservation and emission reduction fund, security deposit of environmental protection company, etc.

Considering the elimination of scale effect and regression coefficient display, the environmental cost shall be calculated by dividing enterprise environmental cost by operating income by 10000.

(2) Service of manufacturing enterprises

On the basis of the methods of Fang et al. (2008) [18], Chen Man and Zhang Xinguo (2016) [5], Chen Lixian and Shen Hong (2017) [19], the service level of manufacturing enterprises is measured by using the proportion of service income to total income:

Firstly, the main business income composition data of listed companies classified by products are collected from CSMAR database of Guotai'an. Then, according to the *Classification Standard of National Economy Industry* (GB/T 4754-2017) and *Notice of National Bureau of Statistics on Amending the Provisions on Three Industrial Divisions (2012)*, combining with the definition of service scope by Hockerts & Weaver (2002) [16] and Neely (2008) [17], the service scope of this paper is finally determined. At last, compare the scope of products and services to determine the products that belong to service, and then sum up the proportion of annual service income of the sample companies, expressed by Serve.

(3) Other variables

On the basis of existing studies [20, 21] , the following variables are controlled: Age, natural logarithm of the number of years of establishment; Size, natural logarithm of total assets of the company; Financial performance (Roa), ratio of net profit to total assets; Financial leverage (Lev), i. e. asset-liability ratio; Ownership concentration (Top), shareholding proportion of the largest shareholder; Dual. If the value of CEO and Chairman is 1, otherwise, the value is 0.

In addition, industry and annual dummy variables are set to control the impact of industry differences and unobservable time factors. See Table I for description of variables.

TABLE I. DEFINITION AND DESCRIPTION OF VARIABLES

Variable Name	Symbol of variable	Variable Description
Environmental protection investment	EPI	They are derived from asset items in the balance sheet and expense items and loss items in the income statement. Among them, the asset items mainly include construction in progress, long-term deferred expenses and other receivables. In terms of specific details of each project, the project under construction mainly includes various details such as sewage treatment project, desulfurization and dust removal project, waste gas reconstruction and expansion project, waste recovery and recycling project, environmental treatment project, etc.; long-term deferred expenses mainly include greening fee, pollution discharge right usage fee, resource use and compensation fee, environmental protection renovation cost, environmental treatment fee, etc.; other receivables mainly include environmental treatment recovery deposit collected by the debtor party, energy conservation and emission reduction fund, security deposit of environmental protection company, etc. Considering the elimination of scale effect and regression coefficient display, the accounting for environmental protection investment shall be divided by operating income and multiplied by 10,000.
Service level	Serve	Proportion of service income to operating income
Enterprise Age	Age	The natural logarithm shall be taken for the number of years of establishment of the enterprise.
Enterprise size	Size	The total assets of the Company shall be natural logarithm.
Financial performance	Roa	Ratio of net profit to total assets
Ratio of assets to liabilities	Lev	Proportion of total liabilities at the end of the period to total assets at the end of the period
Asset turnover	Turn	Operating income/total assets
Two posts in one	Dual	Both CEO and Chairman: 1. Part-time; 0. part-time
Ownership concentration	Top	Shareholding proportion of the largest shareholder

3.3 Model design

Based on existing studies, in order to investigate the impact of service level on environmental protection investment of enterprises, this paper constructs Model 1 to verify the above research assumptions, as follows:

$$EPI_{i,} = \beta_0 + \beta_1 Serve_{i,} + \beta_j \sum Controls_{ji,t} + \varepsilon_{i,t} \qquad (1)$$

Among them, $Controls_{i,}$ are control variables reflecting firm characteristics and $\varepsilon i,$ are random error terms.

IV. EMPIRICAL RESULTS AND ANALYSIS

4.1 Descriptive Statistics

Table II reports the results of descriptive statistics for the main variables, the mean value of the enterprises' environmental protection investment is 14.93, the standard deviation is 63.76, and the median is 0. The maximum and minimum values of environmental protection investment differ significantly, which indicates that there is a significant difference in environmental protection investment between enterprises during the sample period. The mean value of servitization level is 23.74% and the median is 12.66%, which indicates that the distribution of servitization level is uneven. In terms of other control variables, there are significant differences in the financial performance, firm age, firm size, financial leverage, equity concentration, and two-job coincidence.

TABLE II. DESCRIPTIVE STATISTICS

variable	N	mean	sd	min	max	p25	p50	p75
EPI	5515	14.93	63.76	0	488.0	0	0	0
Serve	5515	23.74	27.14	0.0100	99.63	2.890	12.66	35.92
Age	5515	2.710	0.370	1.610	3.430	2.480	2.770	3
Size	5515	22.01	1.170	19.84	25.55	21.15	21.86	22.66
Roa	5515	0.0400	0.0600	-0.240	0.190	0.0100	0.0400	0.0700
Lev	5515	0.410	0.200	0.0500	0.860	0.260	0.400	0.560
Dual	5515	0.310	0.460	0	1	0	0	1
Turn	5515	2.240	1.330	0.430	8.240	1.370	1.930	2.690
Ac	5515	0.100	0.0600	0.0100	0.370	0.0500	0.0800	0.120
Top	5515	16.07	20.82	0	71.54	0	2.520	31.10

4.2 Correlation Analysis

Table III presents the Pearson correlation coefficient matrix of the main variables. The results indicate that the level of servitization of manufacturing firms' output, Serve, is significantly and negatively correlated with environmental protection investment, EPI, at the 1% level. The hypothesis of this paper is tentatively confirmed that the EPI of enterprises is negatively correlated with the level of servitization. In addition, the selection of control variables is more reasonable, and the correlation between each variable and EPI is in line with expectations basically.

TABLE III. PEARSON CORRELATION COEFFICIENT MATRIX

	EPI	Serve	Age	Size	Roa	Lev	Dual	Turn	Ac	Top
EPI	1									
Serve	-0.054***	1								
Age	-0.00100	0.032**	1							
Size	0.025*	-0.045***	0.210***	1						
Roa	-0.035***	0.0110	-0.108***	-0.045***	1					
Lev	0.059***	-0.048***	0.141***	0.506***	-0.352***	1				
Dual	-0.062***	0.023*	-0.040***	-0.163***	0.0170	-0.156***	1			
Turn	0.0210	0.104***	-0.0220	-0.088***	-0.229***	-0.201***	0.088***	1		
Ac	-0.033**	0.130***	-0.119***	-0.359***	-0.126***	-0.336***	0.127***	0.579***	1	
Top	-0.033**	0.079***	-0.227***	-0.372***	0.163***	-0.354***	0.246***	0.097***	0.180***	1

Note: ***,**and*respectively represent significance levels of 1%, 5% and 10%.

4.3 Analysis of Regression Results

Table IV presents the results of the regression analysis for the primary hypothesis. Table (1) indicates that, when there are no control variable, year and industry, the regression coefficient of service level and environmental protection investment of enterprises is -0.126, which is significantly different from 0 at 1% level; after adding control variable, the regression coefficient of both is -0.119, and is significantly not 0 at 1% level; further, after controlling year and industry effect, the regression coefficient of both is -0.0676, at around 1% level and significantly not 0. The above results indicate that there is a negative correlation between environmental protection investment and its service level, that is, the higher the service level, the lower the environmental protection investment. The hypothesis in this paper is confirmed.

TABLE IV. REGRESSION ANALYSIS

VARIABLES	(1)	(2)	(3)
	EPI	EPI	EPI
Serve	-0.126***	-0.119***	-0.0676**
	(-4.970)	(-4.684)	(-2.477)
Age		-1.679	0.186
		(-0.671)	(0.0732)
Size		-1.401*	-1.062
		(-1.842)	(-1.382)
Roa		-6.893	-0.416
		(-0.530)	(-0.0298)
Lev		18.05**	12.81*
		(2.548)	(1.815)
Dual		-7.710***	-7.063***
		(-4.247)	(-4.166)
Turn		3.285***	2.823***
		(3.978)	(3.357)
Ac		-50.34***	-12.04
		(-3.272)	(-0.741)
Top		-0.0116	0.0493
		(-0.238)	(1.036)
year	No	No	Yes
industry	No	No	Yes
Constant	17.91***	46.11***	38.66**
	(14.96)	(2.853)	(2.365)
Observations	5,515	5,515	5,515
R-squared	0.003	0.012	0.089
r2_a	0.00268	0.0106	0.0811
F	24.70	8.409	6.261
Robust t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

4.4 Robustness test

In order to ensure the robustness of the regression results, the instrumental variable method, the fixed effect model and the substitution of primary variables are used to test the robustness of the regression results.

4.4.1 Endogenous test

(1) Tool variable method

This paper still considers the endogenous problem caused by the two-way causality that the enterprise performance affects the servitization level and the environmental protection investment influences the enterprise performance. The control variables in the model have included Roa, which measures the performance of enterprises. In this paper, the service variables with a lag period are still introduced as the servitization tool variables, and 2SLS is used for estimation. Table V shows that the environmental protection investment and service level of enterprises are significantly correlated with the service level at 1% level negatively, which is consistent with the research conclusion of this paper.

(2) Controlling fixed effects from the perspective of the whole company

Although the regression model of this paper controls many influencing factors, there may still be the problem of missing variables. Therefore, the two-way fixed effect model is used to re-estimate the model. Table V indicates that there is a significant negative correlation between enterprise environmental protection investment and service level at 1% level, which further verifies the hypothesis.

TABLE V. ENDOGENOUS TEST

	Instrumental variable method	Two-way fixed effect model
VARIABLES	EPI	EPI
serve	-0.0690*	-0.137**
	(-1.828)	(-2.210)
Constant	38.49**	-72.42
	(2.367)	(-0.972)
Control variables	Yes	Yes
year	Yes	Yes
industry	Yes	Yes
Observations	5,515	5,515
R-squared	0.089	0.006
r2_a	0.0811	0.00192
F	5,515	5,515
Number of stkcd		1,150
Robust z-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

(3) Other robustness tests

On the basis of endogenesis, this paper continues to test the robustness of empirical results and assumptions by replacing core variables.

First, the approach taken in this paper to the measure the environmental protection investment is to use the absolute amount of environmental protection investment divided by operating income, so as to control for size differences. This paper uses the absolute amount of environmental protection investment divided by total assets at the beginning of the period to remove these effects. The first column of Table VI indicates that corporate environmental protection investment is related to servitization at the 5% level, further validating the hypothesis of this paper significantly and negatively.

Second, the real estate industry has its own special traits compared to other service industries, and is fundamentally different from manufacturing companies that expand and develop their service business by extending upstream and downstream in the industrial chain beyond their own main business. Therefore, we further exclude the real estate industry from the service business and analyze the influence of the level of service business Serve1 on corporate environmental protection investment in the servitization of the manufacturing industry that does not include real estate. The second column of Table VI shows that corporate environmental protection investment is significantly and negatively correlated with the level of servitization at the 1% level, further validating the hypothesis of this paper.

TABLE VI. OTHER ROBUSTNESS TESTS

VARIABLES	Replace interpreted variable	Replace Interpretative Variables
	EPI_a	EPI
Serve	-0.0137**	
	(-2.072)	
Serve1		-0.0366***
		(-3.424)
Constant	25.21***	38.65**
	(2.664)	(2.364)
Control variables	Yes	Yes
year	Yes	Yes
industry	Yes	Yes
Observations	5,515	5,515
R-squared	0.096	0.089
r2_a	0.0880	0.0811
F	6.934	6.254
Robust t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

V. INFLUENCE MECHANISM TEST

5.1 Efficiency Mechanism Inspection

As mentioned above, servicization affects environmental protection investment by increasing the total factor productivity of enterprises, that is, total factor productivity plays an intermediary effect in the relationship between servitization and environmental protection investment. Based on the above procedure, a step-by-step test model 2 and model 3 are constructed based on model 1 as shown below.

$$\text{LP}_{i,} = \beta_0 + \beta_1 \text{Serve}_{i,} + \beta_j \sum Controls_{ji,t} + \varepsilon_{i,t} \tag{1}$$

$$EC_{i,} = \beta_0 + \beta_1 \text{Serve}_{i,} + \beta_2 \text{LP}_{i,t} + \beta_j \sum Controls_{ji,t} + \varepsilon_{i,t} \tag{2}$$

For the measurement of firm efficiency, we use the method of Levinsohn and Petrin (2003) [22] to calculate the total factor productivity of firms (referred to as LP method). Following the steps of the mediation effect test summarized by Zhonglin Wen et al. (2004) [23], this section first respectively conducts OLS regressions on model 1, model 2, and model 3, to test whether the mediating variable total factor productivity (LP) is significant in the relationship between servitization and environmental protection investment, and the results are reported in columns (1), (2), and (3) of Table VII, in that order.

TABLE VII. EFFICIENCY MECHANISM INSPECTION

VARIABLES	(1) EPI	(2) LP	(3) EPI
Serve	-0.0676**	0.0029**	-0.0376
	(-2.477)	(1.963)	(-2.479)
Lp			-0.752
			(-2.169)**
Constant	38.66**	-20.30***	23.41
	(2.365)	(-45.76)	(1.219)
Control variables	Yes	Yes	Yes
year	Yes	Yes	Yes
industry	Yes	Yes	Yes
Observations	5,515	5,515	5,515
R-squared	0.089	0.709	0.089
r2_a	0.0811	0.707	0.0812
F	6.261	168.8	6.113
Robust t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Column (1) of Table VII reports the results of the first step of model 1, the mediating effect, on the

total effect, which is crucial since the total effect is significant as a prerequisite for the subsequent mediating effect test procedure. The results indicate that the regression coefficient of the total effect of servitization on environmental protection investment is -0.0676, which is significant at the 5% level, i.e., there is a direct effect between servitization and corporate environmental protection investment, and they are negatively correlated.

Column (2) is a test of the relationship between service and total factor productivity of medium variable. Servitization is positively correlated with total factor productivity at the significance level of 5% and the coefficient value is 0.0029. In other words, the higher the service level of the enterprise, the higher productivity the total factor will have.

On the basis of simultaneously significant above test, the coefficient of total factor productivity in column (3) is significantly negative at the level of 5%, which not only shows that the negative correlation between total factor productivity and environmental protection investment is established, but also means that the total factor productivity passes the intermediary effect test, that is, higher service is to improve the level of total factor productivity and then affect its environmental protection investment.

5.2 Occupancy Mechanism Inspection

Under the condition of limited resources, funds will be invested in servitization, which is a matter of corporate survival and development, rather than environmental protection investment, thus producing a crowding-out effect of servitization investment on environmental protection investment. In order to verify the above mechanism, financing is introduced to constrain SA. When the corporate financing constraint is greater than the median, it is taken as 1, or otherwise, it is taken as 0, and then the sample companies are divided into two groups for testing. Table VIII indicates that servitization is negatively related to environmental protection investment in both the high and low financing constraint groups: in the high financing constraint group, the regression coefficient is -0.0794 and significant at the 5% level; in the low financing constraint group, the regression coefficient is -0.0117 and insignificant. It confirms that the regression coefficients are significantly different between the high financing constraint group and the low financing constraint group, i.e., corporate servitization can reduce more capitalized environmental expenditures under the high financing constraint situation.

TABLE VIII. OCCUPANCY MECHANISM INSPECTION

	High financing constraints	Low financing constraints
VARIABLES	EPI	EPI
Serve	-0.0794**	-0.0117
	(-2.010)	(-0.346)
Constant	60.04*	49.51***
	(1.695)	(2.638)
Control variables	Yes	Yes

year	Yes	Yes
industry	Yes	Yes
Observations	2,758	2,757
R-squared	0.090	0.169
r2_a	0.0738	0.154
F	3.325	4.123
Robust t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

VI. FURTHER ANALYSIS

6.1 Analysis of industry heterogeneity

Heavy polluting enterprises have always been the focus of attention, facing various environmental policies issued by the government, enterprises have to standardize their own behavior, increase investment in environmental protection. Therefore, compared with non-heavy pollution manufacturing enterprises, heavy pollution manufacturing enterprises have higher environmental protection investment and are more motivated to reduce environmental protection investment. In order to test the above hypothesis, this part divides the samples into heavily polluted enterprises and non-heavily polluted enterprises.

Table IX indicates that the servitization of non-heavy polluting enterprises is negatively correlated with environmental protection investment, but not significantly; servitization of heavily polluting enterprises is negatively correlated with investment in environmental protection, and it is significantly not 0 at the 5% level It is indicated that the heavy pollution enterprises may invest more innovative resources in the service process, which improves the enterprise productivity and the resource use efficiency and reduces the investment in environmental protection.

TABLE IX. ANALYSIS OF INDUSTRY HETEROGENEITY

	Non-heavy pollution enterprises	Heavy pollution enterprises
VARIABLES	EPI	EPI
Serve	0.00464	-0.218**
	(0.177)	(-2.490)
Constant	20.21	56.48
	(1.437)	(1.106)
Control variables	Yes	Yes
year	Yes	Yes
industry	Yes	Yes
Observations	3,998	1,517
R-squared	0.058	0.097

r2_a	0.0477	0.0701
Robust t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

6.2 Influence of Made in China 2025

Made in China 2025 has strongly guided the service expectation of manufacturing enterprises and is going to promote the development of enterprise service rapidly. Therefore, this paper assumes that after the issue of *Made in China 2025*, a large number of enterprises will start or accelerate the implementation of servitization, with more sample enterprises and wider service level, thus strengthening the impact of service process on environmental protection investment. Table X shows the influence of *Made in China 2025*. Before the introduction, the service level of manufacturing enterprises was low and uneven, which was negatively correlated with environmental protection investment, but the impact was not significant. After the introduction, it greatly improves the service motive power of manufacturing enterprises, continuously increases capital investment, technology development, and gradually improves the total factor productivity, so as to reduce the investment in environmental protection. The data also show that the manufacturing enterprises servitization is negatively correlated with the investment in environmental protection at the level of 1%. It can be seen that *Made in China 2025* has strongly promoted the service-oriented development and decreased the investment in environmental protection.

TABLE X. INFLUENCE OF *MADE IN CHINA 2025*

	Before the issue of *Made in China 2025*	After the issue of *Made in China 2025*
VARIABLES	EPI	EPI
Serve	0.0246	-0.0855***
	(0.505)	(-3.047)
Constant	64.43***	11.78
	(2.674)	(0.514)
Control variables	Yes	Yes
year	Yes	Yes
industry	Yes	Yes
Observations	2,459	3,056
R-squared	0.114	0.081
r2_a	0.0983	0.0685
F	.	4.065
Robust t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

VII. RESEARCH CONCLUSIONS AND PROSPECTS

7.1 Study Conclusion

This paper studies the relationship between servitization and environmental protection investment in manufacturing enterprises, which has certain theoretical significance for enriching the research of service and environmental protection investment in manufacturing enterprises, and has crucial practical value for promoting the service development of manufacturing enterprises and protecting ecological environment. It is found in this paper that the service of manufacturing enterprises has a significant negative impact on environmental protection investment. Firstly, it is reflected as efficiency mechanism, that is, the improvement of manufacturing service degree is beneficial to promote technological progress, improve total factor productivity and thus improve enterprise energy efficiency, reduce pollutant emission and decrease enterprise environmental protection investment.

Secondly, it is embodied in the crowding mechanism: under the restriction of resources, the investment of servitization and environmental protection needs a large amount of funds to support. Whether the environmental protection investment cycle is long-term or short-term, servitization can bring economic benefits; However, the environmental protection investment cycle is long, the short-term benefits are poor, and the long-term benefits are easily overlooked. Enterprises tend to invest limited resources into servitization and reduce environmental protection investment, which results in making servitization squeezing corporate environmental protection investment.

Furthermore, this paper discusses its influence on the relationship between service and environmental protection investment according to the external factors such as the characteristics of the relevant industry, the manufacture in China 2025 and the two mechanisms of efficiency and crowding.

7.2 Research Outlook

Environmental protection is a key topic, attracting global attention. In this regard, besides investing in environmental protection, enterprises will also pay certain taxes and fees according to relevant laws. Therefore, it is worth studying to discuss how the manufacturing enterprises servitization affects environmental protection taxes and fees, so as to make enterprises seek a balance between profits and environmental protection laws. This paper mainly discusses the impact of the level of output servitization on the environmental protection investment of manufacturing enterprises. From the perspective of the input of relevant service elements, analyzing the impact of servitization on the environmental protection investment of manufacturing enterprises is of great significance to the integration of the service industry and the manufacturing industry to promote economic development, which is also a topic worthy of study.

REFERENCES

[1] Zhou Shouhua, Tao Chunhua. Environmental Accounting: Theoretical Overview and Enlightenment. Accounting Research, 2012(02): 3-10+96.

[2] He Lilong, Zhu Fangming, Chen Zhongwei. Definition and Evaluation of Enterprise Environmental Responsibility: Perspective of Environmental Resource Allocation. Managing the World, 2014(03): 180-181.

[3] Vandermerwe S, Rada J. Servitization of Business: Adding Value by Adding Services. European Management Journal, 1988, 6(4):314-324.

[4] Xu Zhenxin, Mo Changwei, Chen Qilin. Servitization of Manufacturing Industry: A Practical Choice for Upgrading of China's Manufacturing. Economist, 2016(09): 59-67.

[5] Chen Man, Zhang Xinguo. Service Transformation of Chinese Manufacturing Enterprises under Economic Cycle: Embedded or Mixed. China Industrial Economy, 2016(08): 93-109.

[6] Yang Zhijiang, Zhu Guilong. Technological Innovation, Environmental Regulation and Energy Efficiency_-An Empirical Test Based on Interprovincial Panel Data in China. Research and Development Management, 2017, 29(04): 23-32.

[7] Garbaccio, R.F., Ho, M.S. and Jorgenson, D.W. Why has the energy-output ratio fallen in China?. The Energy Journal, 1999: 63-91.

[8] Fisher-Vanden, K., Jefferson, G.H., Jingkui, M. and Jianyi, X., Technology development and energy productivity in China. Energy Economics. 2006, 28(5-6), pp.690-705.

[9] Wang Banban, Qi Shaozhou. Partial Technology Progress, Factor Substitution and Industrial Energy Intensity in China. Economic Research, 2014, 49(02): 115-127.

[10] Amit R, Schoemaker P J H. Strategic assets and organizational rent. Strategic management journal, 1993, 14(1): 33-46.

[11] Yang Jisheng, Xu Juan. Unfairness of Environmental Income Distribution and Its Transfer Mechanism. Economic Research, 2016, 51(01): 155-167.

[12] Hu Jun, Tang Taijie, Song Xianzhong. Research on Driving Mechanism of Enterprise Environmental Governance: Perspective of Environmental Officer Change. Nankai Management Review, 2019, 22(02): 89-103.

[13] Zhang Qi, Zheng Yao, Kong Dongmin. Regional Environmental Treatment Pressure, Executives' Experience and Enterprise Environmental Protection Investment_-A Quasi-Natural Experiment Based on Ambient Air Quality Standards (2012) [J]. Economic Research, 2019, 54(06): 183-198.

[14] Orsato R J. Competitive environmental strategies: when does it pay to be green?. California management review, 2006, 48(2): 127-143.

[15] Shen Hongtao, Zhou Yankun. Environmental Law Enforcement Supervision and Enterprise Environmental Performance: Quasi-Natural Experimental Evidence from Environmental Protection Interview [J]. Nankai Management Review, 2017, 20(06): 73-82.

[16] Hockerts, Kai, and N. Weaver. Towards a theory of sustainable product service systems—what are the dependent and independent variables of S-PSS. Proceedings of the INSEADCMER research workshop Sustainable product service systems—key definitions and concepts. 2002.

[17] Neely A. Exploring the Financial Consequences of The Servitization of Manufacturing. Operations Management Research, 2008,1(2):103-118.

[18] Fang E., Palmatier R. W., Steenkamp J. B. E. M.. Effect of Service Transition Strategies on Firm Value. Journal ofMarketing, 2008, 72(5): 1- 14.

[19] Chen Lixian, Shen Hong. How Servitization Manufacturing Affects Enterprise Performance and Factor Structure? An Empirical Analysis of PSM-DID Based on Listed Company Data. Economics Trends, 2017(05): 64-77.

[20] Tang Guoping, Li Longhui, Wu Dejun. Environmental Regulation, Industry Attribute and Enterprise Environmental Protection Investment. Accounting Research, 2013,(06): 83-89+96.

[21] Jili, Su Meng. Enterprise Environmental Cost Internalization Motivation: Compliance or Benefit?_Empirical Evidence from Listed Companies in the Heavy Pollution Industry. Accounting Research, 2016, (11): 69-75+96.

[22] Levinsohn, J. and Petrin, A.,. Estimating production functions using inputs to control for unobservables.The review of economic studies. 2003, 70(2), pp.317-341.

[23] Wen Zhonglin, Zhang Lei, Hou Jietai, Liu Hongyun. Intermediate effect test procedure and its application. Journal of Psychology, 2004(05): 614-620.