Producer Services Trade Competitiveness and Independent Innovation of Manufacturing Enterprises: An Empirical Study Based on Samples of Chinese Listed Companies

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ABSTRACT

Against rising global economic uncertainty, China's manufacturing sector faces mounting innovation pressure. Knowledge- and technology-intensive producer services have become a key driver of global value chain upgrading. Using 2007–2020 panel data from Chinese firms, this study applies a two-way fixed effects model to examine the impact of producer services trade competitiveness on firms' independent innovation. Results show a significant positive effect, weakened by higher industrial employment shares but strengthened by restructuring and inflation. The effect is stronger for firms in central, western, and northeastern regions, large firms, state-owned enterprises, labor-intensive sectors, competitive industries, and financially constrained firms.

Keywords: Competitiveness of producer service trade; Enterprise independent innovation; Manufacturing industry; Producer service industry; Listed Companies;

INTRODUCTION

Since the reform and opening up, China's manufacturing industry has experienced leapfrog development and has entered the third echelon of global manufacturing, but it is still in the middle and low end of the global value chain. Problems such as high external dependence on high-end equipment and restricted core technology still exist. At the same time, changes in the international economic environment and the superposition of the epidemic have led to growth pressure on the manufacturing industry, and it is urgent to enhance innovation capabilities to form new competitive advantages.

The productive service industry is a high-tech and high-value-added service industry separated from the production service department within the manufacturing industry. It is an important force to promote technological innovation, lead industrial specialization and upgrade the value chain. The improvement of the competitiveness of productive service trade means that China's export structure is gradually approaching that of developed countries, which can provide advanced technology, supporting facilities and intermediate inputs for the manufacturing industry, reduce costs and improve efficiency.

At present, China is actively promoting the high-quality development of the productive service industry. So can the improvement of its trade competitiveness promote innovation in manufacturing enterprises? This article conducts an empirical analysis around this issue.

LITERATURE REVIEW

Many domestic and foreign scholars have conducted relevant research and analysis on the impact of international trade and independent innovation. Representative research results are as follows: For example, Porter (1990) proposed the theory of national competitive advantage, pointing out that trade can improve corporate competitiveness and thus enhance innovation; Coe et al. (1997) based on the new growth theory

found that technology spillovers brought by trade are particularly important for developing countries; subsequent domestic scholars such as Mao Qilin (2010), Yu Guansheng (2011), Liang Dawei (2015), etc., also verified the mutual promotion effect of trade and innovation from the perspectives of imports, exports and regional foreign trade.

Regarding productive service trade, scholars generally believe that its role in promoting manufacturing is more diverse. For example, Zhang Yan et al. (2013), Cheng Dazhong (2008) and Robinson et al. (2002) all pointed out that service trade improves the production efficiency and innovation level of manufacturing enterprises through mechanisms such as providing high-quality intermediate products, reducing costs and promoting technology spillovers.

However, existing literature pays little attention to the micro-impact of the competitiveness of productive service trade on the independent innovation of manufacturing enterprises. Therefore, based on the data of listed manufacturing companies in China, this paper explores the impact of producer service trade competitiveness on enterprise independent innovation, its mechanism of action and differential performance, and provides micro evidence for a deeper understanding of the interactive relationship between producer services and manufacturing enterprises.

Characteristics And Facts Analysis

Characteristics and facts of the competitiveness of producer service trade

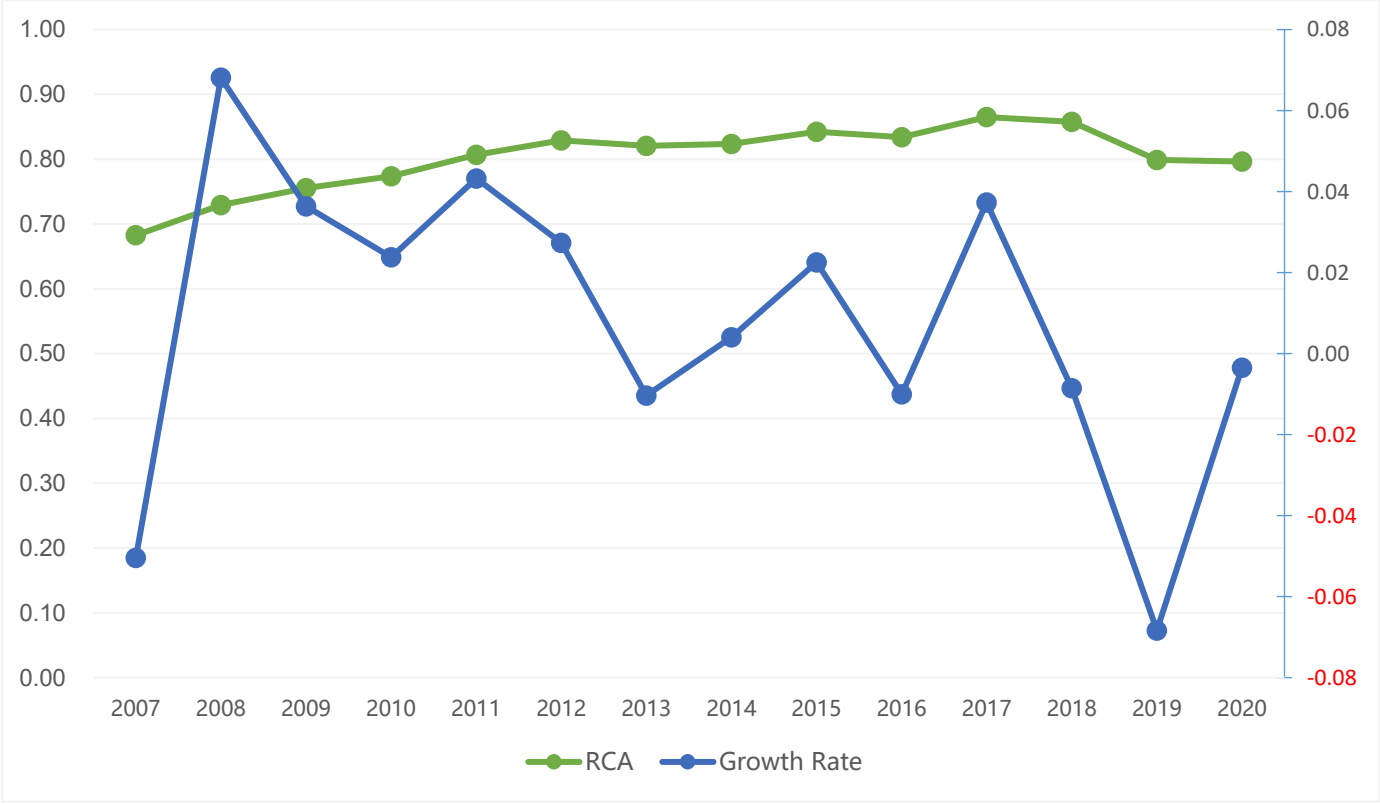

Figure 1. Competitiveness and growth rate of trade in productive services, 2007-2020

Souce: CSMAR database

Figure 1 shows the time series changes of the competitiveness of producer service trade and its growth rate from 2007 to 2020. Overall, China's producer service trade competitiveness increased from 0.68 in 2007 to 0.80 in 2020, an increase of 16.7%, showing a small and stable growth trend. The average level from 2007 to 2020 was only 0.801, which was still weak overall. After 2007, negative growth occurred for the first time in 2019, indicating that the level of competitiveness has declined in recent years and the growth rate has fluctuated greatly.

Characteristics and facts of independent innovation of manufacturing enterprises

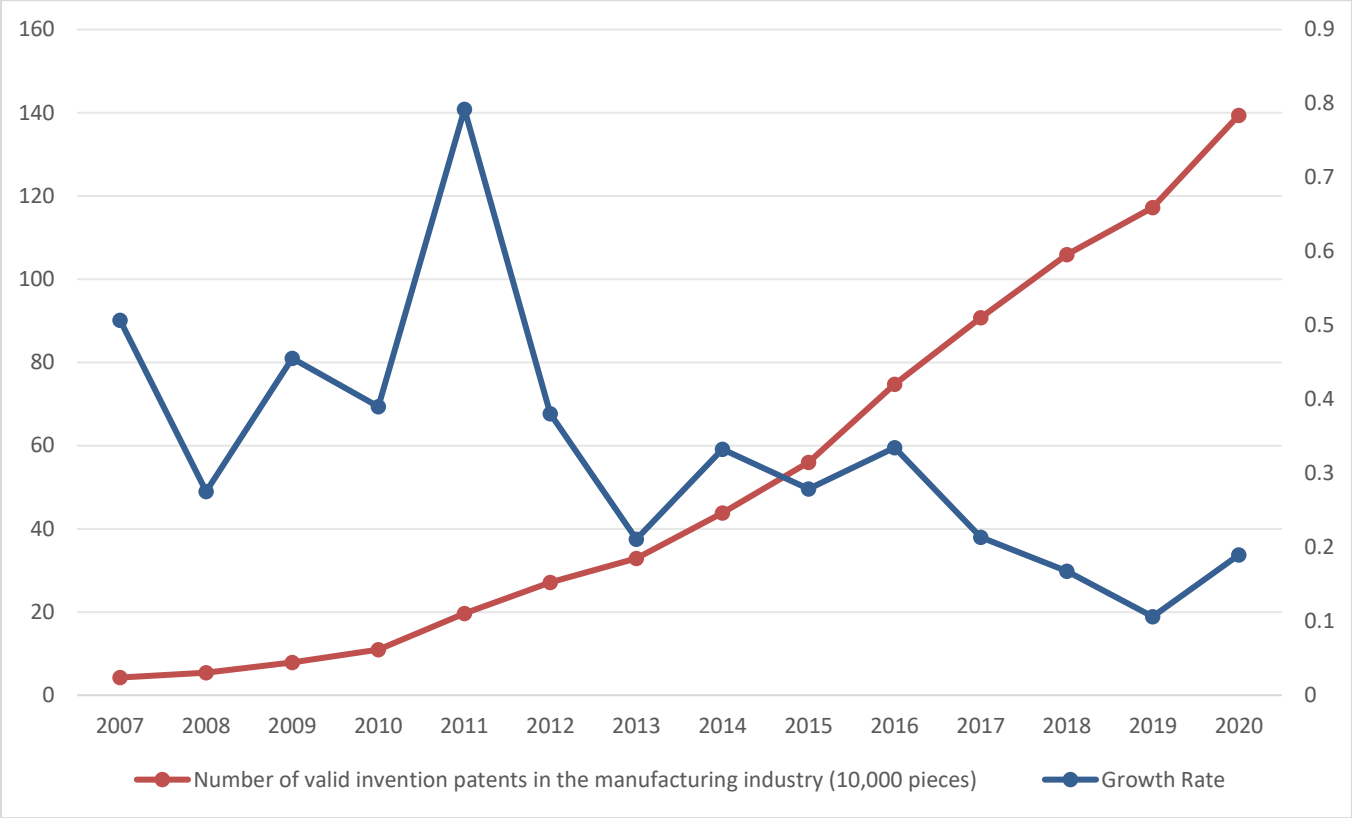

Figure 2. Innovation and growth rate of the manufacturing industry, 2007-2020

Souce: UIBE GVC Database

Figure 2 shows the time series changes of the overall innovation level and growth rate of the manufacturing industry from 2007 to 2020. The overall innovation level increased from 4.25 in 2007 to 139.42 in 2020, an increase of 3180.47%, showing a rapid growth trend. In 2014, China became the country with the largest increase in international patent applications. However, since 2017, the growth rate has gradually slowed down, which may be affected by factors such as Sino-US trade frictions, insufficient domestic demand and falling industrial product prices. The profit space of enterprises has narrowed, performance has declined, and the growth rate of investment and R&D has fallen.

Theoretical Analysis And Research Hypotheses

Further, the theoretical mechanism of this paper is sorted out:

(1)The improvement of the competitiveness of productive service trade means the improvement of the development level of the service industry, which has a positive impact on the independent innovation of manufacturing enterprises, mainly reflected in the following three aspects:

①Productive services help enterprises achieve differentiated competition, enhance brand awareness and product competitiveness, thereby forcing enterprises to innovate technology and improve quality.

②The improvement of the competitiveness of productive service trade brings more market opportunities and potential customers to small and medium-sized enterprises, which helps to drive sales, increase profits, and provide financial support for innovation.

③The integration of manufacturing and service industries is conducive to small and medium-sized enterprises to optimize resource allocation, reduce costs, and invest more high-quality resources in high-value innovation projects, improve innovation efficiency.

Based on the above analysis, this paper proposes the following hypotheses: Hypothesis H1: The competitiveness of producer services trade can promote independent innovation in manufacturing enterprises.

(2) Labor allocation structure, industrial transformation pace, and macroeconomic price environment jointly alter the impact of producer services trade competitiveness on manufacturing firms' independent innovation. Based on a three-dimensional analytical framework of "factor allocation–industrial upgrading–cost constraints," this section examines the heterogeneous moderating effects of these structural factors on the transformation of producer services trade competitiveness into firm innovation.

① Industry employment share

This indicator reflects the internal labor allocation pattern within the manufacturing sector. A higher industrial employment share suggests that labor is likely concentrated in low-end processing segments, which may lead to organizational redundancy and low managerial efficiency. It also implies a misallocation of resources toward production activities that crowd out R&D investment, thereby weakening the technology spillover effects generated by producer services.

② Degree of industrial structural transformation

The growth rate of service value added reflects the pace of economic transition from an industry-dominated structure toward service-oriented and high-technology development. Continuous industrial upgrading may shift market demand toward high value-added products, increasing firms' reliance on R&D design, information technology, and digital services. This enhances firms' absorptive capacity and the efficiency of transforming producer services inputs into innovation outcomes, although such effects remain constrained by firms' internal absorptive capabilities.

③ Inflation level

The inflation level reflects overall price trends and affects firm behavior through both cost constraints and profit compression channels. On the one hand, rising inflation increases factor input costs and heightens uncertainty in the business environment. On the other hand, profit margin compression may, to some extent, strengthen firms' incentives to innovate in order to increase product value-added and offset cost shocks, thereby improving performance. Therefore, the inflation environment essentially reshapes firms' trade-off between "cost pressure and innovation incentives," which in turn influences the responsiveness of firm innovation to producer services inputs.

Based on the above analysis, this paper proposes the following hypotheses:

Hypothesis H2: The industry employment share negatively regulates the relationship between the competitiveness of producer services trade and the level of independent innovation in enterprises.

Hypothesis H3: The degree of industrial structural transformation positively regulates the relationship between the competitiveness of producer services trade and the level of independent innovation in enterprises.

Hypothesis H4: The inflation level positively regulates the relationship between the competitiveness of producer services trade and the level of independent innovation in enterprises.

(3)Heterogeneity at the manufacturing industry level will affect the competitiveness of producer services trade:

①Enterprise location heterogeneity

There are significant differences in the development levels of various regions in China. The eastern coastal areas, relying on a good economic foundation, industrial structure, talent and policy support, have developed rapidly, with more enterprises and more industrial types; while the central and western regions are relatively backward due to the constraints of infrastructure and industrial structure. The economic development between regions shows obvious locational heterogeneity.

②Heterogeneity of enterprise size

Enterprises of different sizes have different abilities to absorb and integrate producer services. Large enterprises usually have more resources such as capital, technology, manpower and market information, and are better able to learn and integrate producer services, providing favorable conditions for product innovation; in contrast, small enterprises have limited resources and are less able to transform and utilize producer services.

③Heterogeneity of enterprise ownership

State-owned enterprises aim at the country's long-term development and social stability, focus on key areas and core technology innovation, and have relatively complete organizational management and resource support; private enterprises pay more attention to short-term benefits and market returns, and emphasize user needs, free innovation and teamwork. Therefore, there are differences in innovation capabilities and concepts between the two.

④Heterogeneity of enterprise factor-intensive types

Labor-intensive enterprises have large labor input and low efficiency, and are in urgent need of upgrading. As the key to introducing professional technology and knowledge capital, productive services play a significant role in their transformation to technology-based and capital-based enterprises. However, capital-intensive enterprises are highly dependent on technical equipment and funds, with slow turnover and long cycles, and the direct promotion effect of productive services on them is relatively limited.

⑤Heterogeneity of enterprise industry competitiveness

The degree of industry competitiveness of an enterprise is an important factor in promoting its competitiveness. Enterprises with low industry competitiveness have little external pressure, weak innovation awareness, and insufficient internal motivation; while enterprises with high industry competitiveness face fierce external competition. In order to survive and develop, enterprises need to actively introduce cutting-edge technologies and develop new products, and have stronger innovation motivation.

⑥Heterogeneity of corporate financing constraints

Enterprises with low financing constraints have more abundant internal and external resources, especially financial support, which can provide good conditions for independent innovation; enterprises with high financing constraints, especially small enterprises, have limited innovation activities and are more dependent on the professional technology and innovation opportunities provided by the productive service industry.

Based on the above analysis, this paper proposes the following hypotheses:

Hypothesis H5: The impact of producer services trade competitiveness on the level of independent innovation of enterprises varies depending on the location of the enterprise.

Hypothesis H6: The impact of producer services trade competitiveness on the level of independent innovation of enterprises varies depending on the size of the enterprise.

Hypothesis H7: The impact of producer services trade competitiveness on the level of independent innovation of enterprises varies depending on the ownership of the enterprise.

Hypothesis H8: The impact of producer services trade competitiveness on the level of independent innovation of enterprises varies depending on the enterprise factor intensity.

Hypothesis H9: The impact of producer services trade competitiveness on the level of independent innovation of enterprises varies depending on the enterprise industry competition.

Hypothesis H10: The impact of producer services trade competitiveness on the level of independent innovation of enterprises varies depending on the financing constraints of enterprises.

METHODOLOGY

Model settings

This paper mainly studies the impact of producer services trade competitiveness on independent innovation of manufacturing enterprises, so the benchmark regression model is established as follows:

$$io_{kit} = \alpha_0 + \alpha_1 rca_t + \beta controls_{kit} + \nu_t + \nu_k + \varepsilon_{kit} \quad (1)$$

Among them, the subscripts k, i, and t represent the enterprise, industry, and year respectively. io_{kit} is the innovation output of enterprise k in industry i in year t. rca_{ki} is the trade competitiveness of producer services industry in year t. controls are enterprise-level control variables. In order to prevent the omission of unobservable variables in the baseline model, the fixed effects of individual(ν_t) and time(ν_k) are also controlled, ε_{kit} is random error term.

Main variables and measurement methods

(1) Explained variable

This paper primarily examines the behavior of enterprise innovation from the perspective of innovation output (IO). The measurement of this indicator mainly refers to the research of Zhang Feng (2019) and Chen Si (2017), etc., and is expressed by the annual number of patent applications of manufacturing enterprises.

Considering the great uncertainty in the competitiveness of productive service trade and innovation input (such as patent protection, absorption and digestion, individual preferences, etc.), this paper only uses innovation output as the explained variable and includes innovation input as a control variable in the analysis.

(2) Core explanatory variables

①The core explanatory variable of this paper is the productive service trade competitiveness (RCA) based on forward value added. The traditional revealed comparative advantage index (RCA) is a commonly used indicator to measure a country's industrial trade competitiveness, but it ignores the domestic and international division of labor and cannot reflect the real competitive advantage of the export industry. This paper draws on the practice of Wang Zhi, Wei Shangjin, Zhu Kunfu et al. (2013) and uses the new RCA index to express the competitiveness of producer services trade. The specific formula used in this calculation is as follows:

$$RCA_{tik} = \frac{exp_{tik}/exp_{ti}}{exp_{tk}/exp_t} \quad (2)$$

Among them, exp_{tik} is the export added value of industry k in country i in year t, and exp_{ti} is the total export added value of service trade in country i in year t. exp_{tk} is the export added value of industry k in the world in year t, and exp_t is the total export added value of world service trade in year t. The revealed comparative advantage index is a very large evaluation index. The greater the RCA_{tik} value, the greater the competitive advantage of industry k in country i in the international market in year t. Specifically, $RCA_{tik}>2.5$ indicates extremely strong international competitiveness. If $2.5\geq RCA_{tik}\geq 1.25$, it indicates strong competitiveness. If $1.25\geq RCA_{tik}\geq 0.8$, it indicates medium competitiveness. If $RCA_{tik}<0.8$, it indicates weak international competitiveness.

②The market share (IMS index) serves as the replacement index for the core explanatory variable in this paper. In a free and open international market, a country's competitiveness in a certain industry in the international market is represented by a higher market share. The calculation formula is as follows:

$$IMS_{tik} = \frac{exp_{tik}}{exp_{tk}} \quad (3)$$

Among them, exp_{tik} is the export volume of industry k in country i in year t, and exp_{tk} is the total export volume of industry k in the world in year t. The larger the IMS_{tik} is, the higher the share of industry k in country i in the world market, indicating that industry k has a more competitive advantage. On the contrary, the smaller the IMS_{tik} is, the weaker the international market share and competitiveness of the industry is. When IMS_{tik}=0, the export of industry k in country i is 0, indicating that industry k does not have a competitive advantage.

(3) Control variables

①Enterprise economic efficiency (E): This indicator is expressed by the growth rate of operating income.

②Enterprise profitability (B): This indicator is expressed in terms of operating profit margin.

③Enterprise development capability (G): This indicator is expressed in terms of sustainable growth rate.

④Enterprise risk level (AL): This indicator is the asset-liability ratio, expressed as the ratio of total assets to total liabilities.

⑤Enterprise innovation investment (II): This indicator is expressed by the proportion of enterprise R&D investment in total sales.

(4) Adjusting variables

①The proportion of industry employment(SIE): that is, the proportion of industrial employment. This indicator refers to the percentage of industrial employment in total employment.

②The degree of industrial structure transformation(GR): that is, the growth rate of added value of the service industry. This indicator refers to the annual growth rate of the added value of the service industry.

③The level of inflation(CPI): that is, the consumer Price Index. This indicator refers to the relative trend and extent of price changes in consumer goods and services purchased by urban and rural residents within a certain period.

5.3 Data sources

(1) The data utilized in this paper primarily originates from three databases: ①The relevant data of listed companies come from the Guotaian CSMAR database. This paper eliminates samples of companies with missing key financial indicators or financial indicators that are inconsistent with generally accepted accounting principles. ②The import and export volume data of the producer services industry comes from the UIBE GVC database. ③Other data sources in this paper also include the World Bank Database (WBG), World Trade Organization Database (WTO), WDI Database, China Patent Database, China Customs Database, CEPII Database, and China Securities Regulatory Commission, etc.

(2) This paper combines the classification of producer service industries in the "2019 National Economic Industry Classification No. 1 Revision" (GB/T4754-2017) and the "Producer Service Industry Classification (2019)" of the National Bureau of Statistics of China. The producer services industry referred to in this paper includes R&D, design, and other technical services provided for production activities, cargo transportation, general aviation production, warehousing and postal express services, information services, financial services, energy conservation and environmental protection services, productive leasing services, business services, human resources management and vocational education and training services, wholesale and trade brokerage agency services, and productive support services, a total of 10 industries.

(3) The sample period of this paper is selected as 2007-2020, and except for dummy variables and some proportional variables, other variables are logarithmically processed.

FINDINGS

Descriptive statistics

Table 1 Descriptive statistics of variables

variable name	Variable meaning	Variable calculation method	N	Mean	p50	SD	Min	Max
LnIO	Enterprise independent innovation capability	The natural logarithm of the annual number of patent applications by manufacturing companies	12092	2.804	2.303	1.393	1.609	9.813
RCA	Producer services trade competitiveness	Revealed comparative advantage index	12092	0.824	0.824	0.028	0.683	0.865
LnE	Enterprise economic efficiency	Natural logarithm of operating income growth rate	12092	1.645	1.632	0.121	1.391	6.508
B	Enterprise profitability	Operating profit margin	12092	0.076	0.092	0.462	-25.94	1.738
G	Enterprise development capabilities	Sustainable growth rate	12092	0.047	0.051	0.661	-59.26	21.17
AL	Enterprise risk level	Asset-liability ratio	12092	0.366	0.348	0.214	0.008	8.009
LnII	Enterprise innovation investment	The natural logarithm of the proportion of R&D investment in total sales	12092	2.259	2.208	0.337	1.61	6.132

Table 1 reports the descriptive statistics of the variables. The results show that the standard deviations of LnIO and RCA are both smaller than the mean, indicating that the degree of data dispersion is not high, and there are no extreme outliers, allowing further empirical analysis.

Benchmark Regression Analysis

Table 2 Benchmark Regression analysis

variables	Explained variable	
	Innovation Output(1)	Innovation Output(2)
RCA	8.924***	8.905***
	(3.099)	(3.074)
controls	no	yes
individual effect	yes	yes

time effect	yes	yes
Adj-R^2	0.023	0.019
N	12,092	12,092

Note: ＊＊＊, ＊＊, and ＊ indicate significance at the 1%, 5%, and 10% levels respectively. Numbers in parentheses are robust standard errors clustered to the firm level. The same below.

Table 2 presents the impact of producer services trade competitiveness on independent innovation within manufacturing enterprises, as measured by innovation output. The Hausman test (p=0.000<0.05) rejects the null hypothesis and the fixed effect model (FE) should be used. The regression results show that: Column (1) shows that producer services trade competitiveness has a significant positive effect on firms' innovation output ($\beta = 8.924$, $p < 0.01$). Column (2) further includes additional control variables, and the core explanatory variable remains highly consistent in both direction and statistical significance, with only a slight change in the coefficient ($\beta = 8.905$, $p < 0.01$). The above regression results indicate that producer services trade competitiveness contributes to enhancing the independent innovation capability of Chinese manufacturing firms, thereby supporting Hypothesis H1.

Robustness check

Table 3 Robustness check

variables	Replace explanatory variables	Replace the explained variable	Adjust control variables
	Innovation Output(1)	Innovation Output(2)	Innovation Output(3)
rca	65.461***	411.217**	9.891**
	(22.598)	(163.209)	(4.380)
controls	yes	yes	yes
individual effect	yes	yes	yes
time effect	yes	yes	yes
Adj-R^2	0.023	0.007	0.023
N	12,092	12,060	12,092

Table 3 reports the robustness test results of producer services trade competitiveness on independent innovation of manufacturing enterprises.This paper conducts a robustness test by replacing key variables and adjusting control variables.

(1) Replace explanatory variable

This paper recalculates explanatory variable based on equation (3) and introduces it into model estimation. The regression results are shown in column (1) of Table 3. The coefficient direction and significance level of the core explanatory variables remain unchanged. The competitiveness of producer services trade, measured by market share (IMS index), has a significant effect on independent innovation in manufacturing enterprises.

(2) Replace the explained variable.

Patents in China are divided into three categories: invention, utility model, and design. Among them, invention patents have higher technical requirements, are more difficult to obtain, and can better reflect the substantive innovation of enterprises. Therefore, this paper draws on the practice of Yu Minggui et al. (2016) and utilizes enterprise data. The number of invention patent applications measures innovation output and is introduced into the model as an explained variable. The regression results are shown in column (2) of Table 3. The

competitiveness of the producer services trade continues to significantly promote the R&D output of enterprises in the form of invention patents.

(3) Adjust control variables

Considering that the factors affecting independent innovation of listed companies are relatively complex, this paper refers to the relevant literature on independent innovation of listed companies, adjusts the control variables, adds two variables: enterprise age and cash flow ratio, and re-examines the benchmark model empirically. The results are shown in column (3) of Table 3. The estimated coefficients of the core explanatory variables are significantly positive, confirming the robustness of the conclusions of this paper.

Endogeneity test

This paper uses static regression (2SLS) and dynamic regression (IV-GMM) to test endogeneity. In 2SLS, the actual RMB exchange rate against the US dollar (measured by the annual average) is used as the instrumental variable of the core explanatory variable; in GMM, the interpolation method is used to lag the explained variable by one period as the instrumental variable. The regression results are shown in Table 4.

Table 4 Endogeneity test

2SLS estimation (heteroscedasticity)		IV-GMM	
variables	Innovation Output(1)	variables	Innovation Output(2)
rca	7.538179***	Liolepolate	0.142***
			(0.040)
	(1.4404)	rca	5.373***
			(1.873)
controls	yes	controls	yes
individual effect	no	individual effect	yes
time effect	no	time effect	yes
Kleibergen-Paap rk LM statistic	875.84***	AR(1)	0.000
Cragg -Donald Wald F statistic	1670.30***	AR(2)	0.160
Adj-R^2	0.009	Hansen	0.850
N	12,092	N	8,901

Note:(1)AR(1) and AR(2) are correlation tests for the difference in disturbance terms, which are divided into first-order autocorrelation and second-order autocorrelation. GMM consistency estimation requires that the disturbance term does not have autocorrelation, but has first-order difference correlation, and has no correlation for second-order and above differences. The null hypothesis is "there is no autocorrelation in the difference of disturbance terms". (2)The validity of dynamic panel parameter estimation depends on whether the instrumental variables are valid, since this test uses a robust test. Therefore, the Hansen test was used to identify its validity.

Table 4 presents the results of the endogeneity test regarding the impact of producer services trade competitiveness on independent innovation in manufacturing enterprises.

(1)2SLS instrumental variable test method

A country's imports and exports will inevitably be affected by exchange rate fluctuations. Therefore, this paper uses the actual exchange rate of the RMB against the US dollar as an instrumental variable to deal with the

endogeneity problem and conducts a 2SLS test when it is determined that heteroskedasticity exists. The results are shown in column 3 of Table 3 (1).The weak IV test results show that the Cragg-Donald Wald F values are greater than the Stock-Yogo 10%-level critical value, and the model passes the weak instrumental variable test. The K-Paark LM statistic of the identification test rejects the null hypothesis at the 1% level and confirms that the instrumental variable can be identified. This means that the choice of the instrumental variable was reasonable. Even though the endogeneity problem was taken into account, the regression coefficient of producer services trade competitiveness on independent innovation of manufacturing enterprises is still significant at the 1% level, which means the conclusion is still correct.

(2) IV-GMM test method

This paper employs the interpolation method, using the one-lag period of the explained variable as the core explanatory variable to test the endogeneity problem in dynamic regression. The results are shown in column (3) of Table 4. For this instrumental variable, the p-value of the Hansen test is 0.850, so it is accepted. The null hypothesis that "all instrumental variables are valid" is established. The p-values of the AR(1) and AR(2) tests are 0.0000 and 0.160, respectively. This means that the difference between the random disturbance terms has first-order autocorrelation but second-order non-autocorrelation, which means it meets the no-autocorrelation condition. The model's instrumental variables and core explanatory variables have coefficient signs and significances that are mostly the same as the benchmark regression results. This means that the estimation results in this paper are robust.

Moderating Effect

Table 5 Moderating effect analysis

variables	Explained variable		
	Innovation Output(1)	Innovation Output(2)	Innovation Output(3)
RCA	299.286**	-8.203*	-330.640**
	(150.077)	(4.710)	(164.999)
SIE	8.838**		
	(4.389)		
GR		-0.837*	
		(0.434)	
CPI			-2.707**
			(1.320)
RCA×SIE	-10.862**		
	(5.453)		
RCA×GR		1.039*	
		(0.543)	
RCA×CPI			3.220**
			(1.608)
controls	yes	yes	yes
individual effect	yes	yes	yes
time effect	yes	yes	yes
R^2	0.024	0.024	0.024

Adj-R^2	0.023	0.023	0.023
N	12,092	12,092	12,092

Table 5 presents the results of the moderating effects of industry employment proportion(SIE), industrial structure transformation degree(GR), and inflation level(CPI) on the relationship between producer services trade competitiveness and enterprise independent innovation levels.

This paper incorporates the SIE,GR and CPI into the model to test hypotheses 2, 3 and 4. On the basis of double fixed effects regression, this paper adds separately the interaction term between producer services trade competitiveness and the proportion of industry employment (RCA×SIE), the interaction term between the competitiveness of producer services trade and the degree of industrial structure transformation (RCA×GR), and the interaction term between producer services trade competitiveness and the level of inflation (RCA×CPI).The econometric models are specified as follows:

$$io_{kit} = \theta_0 + \theta_1 rca_t + \theta_2 sie_t + \theta_3 rca_t \times sie_t + \beta controls_{kit} + \nu_t + \nu_k + \varepsilon_{kit} \quad (4)$$

$$io_{kit} = \theta_0 + \theta_1 rca_t + \theta_2 gr_t + \theta_3 rca_t \times gr_t + \beta controls_{kit} + \nu_t + \nu_k + \varepsilon_{kit} \quad (5)$$

$$io_{kit} = \theta_0 + \theta_1 rca_t + \theta_2 cpi_t + \theta_3 rca_t \times cpi_t + \beta controls_{kit} + \nu_t + \nu_k + \varepsilon_{kit} \quad (6)$$

Overall, the above factors systematically influence the transformation process of producer services inputs into firms' innovation output from three dimensions: resource allocation efficiency, structural upgrading capacity, and cost constraint intensity. Different institutional and structural conditions significantly alter the strength of producer services trade competitiveness in promoting service-driven innovation.

(1) Industry employment share

According to the results in Column (1) of Table 5, the interaction term between producer services trade competitiveness and industry employment share has a significantly negative effect on firms' independent innovation (β = -10.862, $p < 0.05$), indicating that industry employment share weakens the positive impact of producer services trade competitiveness on firms' innovation performance, thereby supporting Hypothesis H2. Specifically, when the industrial employment share is high, labor is concentrated in low-value-added processing activities. This increases resource misallocation and coordination costs between R&D and production processes, thereby weakening the effectiveness of transforming producer services inputs into innovation outcomes.

(2) Degree of industrial structural transformation

According to the results in Column (2) of Table 5, the interaction term between producer services trade competitiveness and the degree of industrial structural transformation has a significantly positive effect on firms' independent innovation (β = 1.039, $p < 0.10$), indicating that industrial structural transformation strengthens the impact of producer services trade competitiveness on firms' innovation performance, thereby supporting Hypothesis H3. Specifically, industrial upgrading reflects the economy's transition toward service-oriented and high-technology development, which shifts demand toward high value-added and knowledge-intensive products. This enhances firms' reliance on and integration capacity for producer services such as R&D design and digital technologies, making it easier to translate such inputs into service-driven innovation outputs and thereby strengthening their marginal effect on innovation.

(3) Inflation level

According to the results in Column (3) of Table 5, the interaction term between producer services trade competitiveness and the inflation level has a significantly positive effect on firms' independent innovation (β = 3.220, $p < 0.05$), indicating that inflation strengthens the impact of producer services trade competitiveness on firms' innovation performance, thereby supporting Hypothesis H4. Specifically, under rising costs and

compressed profit margins, firms are more inclined to respond by upgrading technology and increasing product value-added to offset operational pressures. Therefore, inflation strengthens firms' innovation responsiveness and enhances the marginal effect of producer services inputs on service-driven innovation.

Heterogeneity Analysis

According to the above theory, this part first conducts group regression from the three dimensions of geographical location, enterprise scale and ownership. This paper divides the manufacturing industry into four groups according to geographical location: eastern, central, western and northeastern. Referring to Wang Zhi et al. (2015), it is divided into large and small enterprises according to the median enterprise scale, and divided into non-state-owned enterprises and state-owned enterprises according to ownership. The results are shown in Tables 6 and 7.

Table 6 Heterogeneity analysis

variables	Explained variable			
	Eastern Region(1)	Central Region(2)	Western Region(3)	North-east Region(4)
RCA	6.042	3.665***	18.589***	18.726***
	(3.884)	(1.271)	(4.069)	(2.552)
controls	yes	yes	yes	yes
individual effect	yes	yes	yes	yes
time effect	yes	yes	yes	yes
Adj-R^2	0.024	0.029	0.048	0.020
N	8,571	1,637	1,218	348

Table 6 shows how the RCA index measures the competitiveness of producer-services trade and how it affects the independent innovation of businesses in four different regions: the eastern, central, western, and northeastern. It can be seen from the above table that the estimated coefficient of the competitiveness of productive service trade is positive, but it has no significant promoting effect on the independent innovation capabilities of enterprises in the eastern region, but has a significant promoting effect on enterprises in the central, western and northeastern regions, verifying hypothesis H5.

Table 7 Heterogeneity analysis

variables	Explained variable			
	Small enterprises(1)	large enterprises(2)	Non-state-owned enterprises(3)	State-owned enterprises(4)
RCA	4.056	17.945***	4.005	15.470***
	(2.601)	(4.076)	(3.714)	(4.029)
controls	yes	yes	yes	yes
individual effect	yes	yes	yes	yes
time effect	yes	yes	yes	yes
Adj-R^2	0.022	0.019	0.025	0.033
N	5,887	5,887	9,204	2,570

Columns (1) and (2) of Table 7 present the disparity in the influence of producer services trade competitiveness, as evaluated by the RCA index, on the independent innovation of companies of varying sizes.

The table above indicates that the competitiveness of producer services trade does not significantly enhance the independent innovation capabilities of small enterprises, yet it substantially contributes to the large enterprises, thereby supporting Hypothesis H6.

Columns (3) and (4) of Table 7 present the disparity in the influence of producer services trade competitiveness, as quantified by the RCA index, on the independent innovation of companies with varying ownership structures. The table above indicates that the competitiveness of producer services trade does not significantly enhance the independent innovation capabilities of non-state-owned businesses, yet it substantially contributes to the state-owned businesses, thereby supporting Hypothesis H7.

Table 8 Heterogeneity analysis

variables	Explained variable					
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
RCA	7.437**	12.001	3.247	10.403***	4.279*	12.780**
	(0.029)	(0.135)	(0.511)	(0.001)	(0.089)	(0.033)
controls	yes	yes	yes	yes	yes	yes
individual effect	yes	yes	yes	yes	yes	yes
time effect	yes	yes	yes	yes	yes	yes
Adj-R2	0.030	0.019	0.030	0.030	0.027	0.020
N	5,835	5,835	5,887	5,887	5,887	5,887

Note: Model (1) refers to labor-intensive enterprises; Model (2) refers to capital-intensive enterprises; Model (3) refers to enterprises with low industry competition; Model (4) refers to enterprises with high industry competition; Model (5) refers to enterprises with low financing constraints; Model (6) refers to enterprises with high financing constraints;

Columns (1) and (2) of Table 8 show how the competitiveness of productive service trade, as measured by the RCA index, affects the innovation of different types of factor-intensive businesses in different ways. As can be seen from the above table, the competitiveness of productive service trade has a significant promoting effect on the independent innovation of labor-intensive enterprises, but has no significant promoting effect on the capital-intensive enterprises. Hypothesis H8 is verified.

Columns (3) and (4) of Table 8 show the differences in the impact of the competitiveness of productive service trade measured by the RCA index on the independent innovation of enterprises with different levels of industry competition. As can be seen from the above table, the competitiveness of productive service trade has no significant effect on the independent innovation capabilities of enterprises with low industry competition levels, but has a significant promoting effect on the enterprises with high industry competition levels, verifying hypothesis H9.

Columns (5) and (6) of Table 8 report the differences in the impact of the competitiveness of productive service trade measured by the RCA index on the independent innovation of enterprises with different degrees of financing constraints. As can be seen from the table above, the competitiveness of producer service trade has a more significant effect on the independent innovation capability of enterprises with high financing constraints than on enterprises with low financing constraints, which verifies hypothesis H10.

DISCUSSION

The empirical results show that the competitiveness of productive service trade has significantly promoted the innovation output of manufacturing enterprises as a whole, which is consistent with the research of Li Huijuan and Cai Weihong (2016), Yu Shenghua et al. (2022), Yang Xiaoyun and Zhao Xiaohong (2022), etc.,

indicating that it has enhanced the ability of enterprises to absorb external knowledge and technology by promoting the cross-border flow and allocation of high-end service factors.

The moderating effect analysis found that: ① The proportion of industrial employment has a suppressive effect on the relationship. The excessive concentration of employment structure in labor-intensive industries is likely to hinder the penetration of service factors and restrict the release of innovation; ② The degree of transformation of the service industry has an enhancing effect. The accelerated growth rate of the added value of the service industry can provide more high-quality service resources, amplifying and catalyzing the positive effect of the competitiveness of productive service trade on innovation; ③ The level of inflation also has an enhancing effect. Moderate inflation guides resources to efficient areas through the dual effects of "price pressure" and "price guidance", and promotes enterprises to cope with rising costs through innovation. The above conclusions are consistent with Liu Zhenzhong and Wang Yan (2020), Zhang Feng (2016) and Stiglitz (1997).

Heterogeneity analysis found that: ① Geographical location: The competitiveness of producer service trade has a stronger effect on promoting innovation of enterprises in the central, western and northeastern regions than in the eastern regions. This is related to the differences in industrial structure and innovation factor allocation in different regions. The secondary and tertiary industries in the east account for a large proportion, and the innovation foundation itself is relatively good, so the incremental effect is limited; the primary industry in other regions accounts for a high proportion, and the innovation resources are insufficient, so they rely more on producer services to drive the inflow of external knowledge and technology. ② Enterprise scale: The competitiveness of producer service trade has a more obvious promoting effect on large enterprises because they have sufficient resources such as funds, technology, and manpower. This is because large enterprises usually have more sufficient funds, technology, manpower and information resources, a sound management system, strong coordination and integration capabilities, and can better absorb the innovation factors brought by producer services. ③ Enterprise ownership: The competitiveness of producer service trade has a greater promoting effect on state-owned enterprises because they pay more attention to long-term layout and overall benefits, and can more actively undertake the innovation momentum brought by producer services; while non-state-owned enterprises pay more attention to short-term returns and are relatively cautious in investment. ④ Factor-intensive type: The competitiveness of productive service trade has a more significant promoting effect on labor-intensive enterprises, because their technology level and management are relatively backward and they rely heavily on external services; while capital-intensive enterprises rely more on internal inputs and have a low degree of dependence on external services. ⑤ Industry competition level: The competitiveness of productive service trade has a more significant promoting effect on enterprises with high competition levels, because their market pressure is high and enterprises are more actively introducing cutting-edge services to improve their innovation level; low-competition enterprises lack innovation motivation and have limited demand for external services. ⑥ Financing constraints: The competitiveness of productive service trade has a greater promoting effect on enterprises with high financing constraints, because enterprises with high financing constraints are mostly small and medium-sized or start-up enterprises, which have difficulty in obtaining funds and need to rely more on external services to make up for the lack of resources; while enterprises with low financing constraints are large, well-known brands or high-tech enterprises, with sufficient resources and low external dependence, so the benefits are relatively limited.

CONCLUSION

Based on the micro-panel data of China's listed manufacturing enterprises from 2007 to 2020, this paper systematically analyzes the impact of the competitiveness of productive service trade on the independent innovation of enterprises, its mechanism of action and heterogeneity.

The empirical results show that: ① Overall, the competitiveness of productive service trade significantly improves the level of independent innovation of manufacturing enterprises; ② In terms of mechanism, the proportion of industrial employment has a suppressive effect, while industrial structure transformation and moderate inflation have an enhancing effect; ③ In terms of heterogeneity, this effect is more significant in

large, state-owned, labor-intensive enterprises with high industry competition and strong financing constraints in the central and western regions and the northeast.

Overall, improving the competitiveness of productive service trade will help promote the development of manufacturing industry towards high added value and high innovation, but attention should be paid to the impact of employment structure, industrial transformation and macro environment on this effect.

Implications

For policymakers, the results suggest that they should optimize the opening up of the service industry and the allocation of factors, improve the innovation ecosystem, support the deep integration of services and manufacturing, and enhance the ability of enterprises to utilize external service resources.

For industry observers, this study reveals the differentiated impact of the external environment and enterprise characteristics on innovation capabilities, which is helpful for judging industry trends and resource optimization.

For enterprises, improving the ability to obtain and integrate high-end productive services is the key to promoting innovation, especially for large, state-owned, labor-intensive and financing-constrained enterprises. Enterprises should actively deploy service outsourcing and knowledge transfer, flexibly adjust resources and innovation strategies, and enhance their ability to cope with complex market environments and sustainable development.

Limitations And Future Research

Limitations of this article: ① Due to data availability, this study does not cover non-listed companies, small and medium-sized enterprises and service industry entities, and the sample representativeness and extrapolation are limited. ② The moderating variables do not cover potential mechanisms such as policy support and innovation networks, which need further study. ③ The spatial measurement method is not introduced, which may ignore the innovation spillover effect brought about by the flow of service factors between regions.

Future research expansion: ① Introduce factors such as regional policy support and digital services as mediating or moderating variables to fully reveal the mechanism of action. ② Combine dynamic panel or event research to analyze the long-term and short-term impact of policies or external shocks on corporate innovation. ③ Combine spatial effects to explore the differences in innovation efficiency among regions in advanced productive services.

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Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose.

Ethical Approval

Not applicable.

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