Does Government Spending Affect the Degree of Embeddedness in the Global Value Chain? - A Case Study of the Pharmaceutical Manufacturing Industry

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Abstract

The pharmaceutical industry, as a high-input, high-risk, and high-return sector, is closely related to human life and health. With the continuous refinement of the global division of labor, the global value chain system of the pharmaceutical manufacturing industry is constantly being perfected, and the government's investment in health is also increasing. This paper uses databases such as UIBE and GHED from 2000 to 2018 to calculate the degree of embeddedness in the global value chain of the pharmaceutical manufacturing industry in 64 countries and empirically tests the internal mechanism by which government health expenditure affects this embeddedness. The study finds that government health expenditure has a "U"-shaped non-linear relationship with the embeddedness of the pharmaceutical manufacturing industry in the global value chain of the home country. The mediating effect shows that government health expenditure can influence the intensity of intellectual property protection, which in turn affects the embeddedness of the pharmaceutical manufacturing industry in the global value chain. Furthermore, the study finds that government health expenditure also has a "U"-shaped non-linear relationship with the strength of intellectual property protection in the pharmaceutical manufacturing industry, and that the intensity of intellectual property protection has a positive impact on its embeddedness in the global value chain.

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1. Introduction

In the context of globalization, the international health care system has accelerated its homogenization, forming a constantly improving global value chain division system for the pharmaceutical manufacturing industry. As a high-tech and high-value-added industry, pharmaceutical manufacturing not only plays an important role in the national economy but is also a significant force in promoting economic transformation, improving industrial levels, and achieving sustainable development. Enhancing the degree of embeddedness in the global value chain of pharmaceutical manufacturing can promote industrial upgrading, drive sustainable development, and improve corporate competitiveness and international discourse power. Therefore, enhancing the embeddedness in the global value chain has become an inevitable trend for the globalization and internationalization of the pharmaceutical manufacturing industry.

To promote the healthy development of the national pharmaceutical industry and improve its position in the global value chain, governments of various countries continue to increase their health expenditure. The World Health Organization's Global Health Expenditure Report (World Health Organization, 2022) pointed out that in 2019, global health expenditure reached 8.5 trillion US dollars, accounting for 9.8% of the global GDP, of which government health expenditure accounted for 60%. As pharmaceutical technology advances, the structure of pharmaceutical production becomes more complex, involving multiple stages such as drug research and development, raw material procurement, intermediate production, and formulation production. Additionally, the processes and equipment for different formulation productions vary. Transnational pharmaceutical companies connect these stages by providing raw materials, technology, and equipment, forming a global value chain for the pharmaceutical manufacturing industry. This leads to a key question: does the increase in government health expenditure help to enhance the position of the country's pharmaceutical manufacturing industry in the global value chain? Is higher health expenditure always better? And through what mechanism does it affect the position in the global value chain?

Regarding the analysis of the global value chain, the academic community mainly focuses on the measurement methods of the global value chain and the analysis of factors affecting the global value chain. In terms of the measurement methods of the global value chain, the statistical methods are continuously updated and perfected. In traditional trade statistics, the export value of a product from a country is directly accounted for by the exporting country. However, as trade globalization deepens and global resource allocation is optimized under the dominance of multinational companies, international production segmentation, outsourcing, and other new trade and production models develop, leading to cross-national or cross-border division of labor and cooperation among products. Therefore, the accuracy of traditional trade value-added measures may be biased in the transmission of trade gains. The existing literature continues to improve and refine the indicators for measuring the decomposition of the global value chain. Hummels et al. (2001) used

the HIY method to propose the Vertical Specialization index (VS), which corrected the bias in the traditional trade estimation methods of export value. However, the HIY method assumes that firms uniformly use imported raw materials for processing and production for both domestic sales and exports. When a firm's imports are largely used for exports, the vertical specialization index will be underestimated. Based on this, Upward et al. (2013) and Kee and Tang. (2016) identified the types of imports by firms, optimizing the vertical specialization index from a heterogeneity perspective. Koopman et al. (2012) proposed the KPWW method to decompose export value, thereby correcting the issue of repeated calculation of export value in the past. In recent years, several scholars have further improved the KPWW method. Wang et al. (2017) decomposed the production activities at the national and sectoral levels into simple domestic demand, traditional international trade, simple global value chain activities, and complex global value chain activities, refining the division of labor in the global value chain trade even further. This paper will use the global value position index defined by Wang et al. (2017) to measure the degree of embeddedness of a country (region)'s pharmaceutical manufacturing industry in the global value chain.

The literature on the factors influencing the global value chain can be divided into the following categories: First, analyzing the factors influencing the global value chain from the perspective of research and development innovation. According to Romer (1991) endogenous growth theory, R&D innovation is a decisive factor for the long-term sustained growth of the economy. Tajoli and Felice (2018), Sorokova and Petrikova (2016), and Zhu et al. (2018) all consider enhancing innovation as an important means for a country's sector to improve its position in the global value chain. Jin and Chen. (2021) analyze the positive impact of industry-university-research cooperation on the domestic value added of corporate exports from the perspective of innovation transformation. The second category is studies on the impact of investment on the global value chain. Through the flow of capital, investment can affect the global value chain position by introducing new technology, cultivating market demand, and increasing product added value. Vrh. (2016) believes that increasing investment in intangible assets for high-knowledge-intensive sectors can better integrate into the global value chain, thus improving the international competitiveness of the sector. Li et al. (2021), Song and Fang. (2022), and Pavlínek (2016) believe that foreign direct investment in trade can promote technological progress and improve trade network status, having a positive effect on the country's global value chain upgrading. The third category studies the impact of trade agreements or policies on the global value chain.

Zhang et al. (2020) believe that trade policies can significantly promote the enhancement of the global value chain, and Sun et al. (2022) believe that economic policy uncertainty will reduce the division of labor position of a country or industry in the global value chain. Flentø and Ponte. (2017) also think that for developing countries, flexible trade and industrial policies are more effective for their development than the trade facilitation provided by the World Trade Organization. Wu and Zhang. (2022) focus on the impact of RTA policy on the global value chain

of productive services, finding that RTA service liberalization has a significant enhancement effect on the global value chain status of productive services. Many scholars have also noticed the positive impact of intellectual property protection on the position of the global value chain. Sun et al. (2021) and Dai et al. (2021) have verified the enhancing effect of the intensity of intellectual property protection on the GVC embeddedness of a country (region) from different perspectives.

Currently, there is considerable research on the position of manufacturing in the global value chain, but less on the pharmaceutical manufacturing industry. Although pharmaceutical manufacturing belongs to the broader category of manufacturing, it is associated with medicine and has special characteristics different from general manufacturing goods. There is a lack of specialized research on pharmaceutical manufacturing both domestically and abroad, and existing results treat it as a sub-sector scattered in related research on technical manufacturing or stop at simple descriptive analysis. This paper attempts to research from the following aspects: First, to explore whether government health expenditure affects the degree of embeddedness of the country's pharmaceutical manufacturing industry in the global value chain; second, to examine the mediating effect of non-linear intellectual property protection, to investigate the mechanism by which government health expenditure affects the degree of embeddedness of the pharmaceutical manufacturing industry in the global value chain and to empirically test the non-linear relationship; third, to reveal the heterogeneous characteristics of the non-linear relationship from two dimensions: national income and geographical location.

2. Theoretical Mechanism Analysis and Research Hypotheses

The pharmaceutical industry is a high-input, high-risk industry because the process of developing new drugs requires a significant investment of capital and time, along with the risk of R&D failure. From the perspective of micro-enterprises, pharmaceutical companies need to bear high costs when developing new drugs, including investments in human, material, and financial resources, and the sunk costs of development failure are also relatively high. Therefore, the demand shock brought about by government spending might lead pharmaceutical companies to first consider producing generic drugs with lower production costs. The production technology of generic drugs is relatively mature, the production process is relatively simple, and the sales of generic drugs in the market are relatively stable. Although generic drugs do not have as large a profit margin as patented drugs, their lower input costs and smaller risks allow them to occupy a certain market share in the global division of labor. However, this production model dominated by generic drugs will reduce the core competitiveness of enterprises in the global value chain of pharmaceutical manufacturing due to the lack of core technology and innovation. As pharmaceutical enterprises continuously accumulate resources, in pursuit of higher profits and market share, they will explore the market and develop more innovative and high-value-added new drugs. The high profits brought by the successful development of patented drugs can not only cover the costs incurred

during R&D but also improve the competitiveness of enterprises in the industry. Therefore, when the government invests funds into the market, they can respond to market demands more quickly and invest more in the R&D of new drugs, and high-value-added drugs can enhance the position of enterprises in the global value chain of pharmaceutical manufacturing. From a macro perspective, due to the existence of adverse selection, consumers tend to choose cheaper generic drugs, while the demand for more effective and expensive innovative drugs may be somewhat suppressed. In addition, the influx of government funds may lead to corruption in some pharmaceutical companies or medical institutions, creating moral hazards, leading to the misallocation of health resources, affecting the innovation and global competitiveness of the country's pharmaceutical manufacturing industry. Therefore, when government health expenditure increases, the market tends to produce drugs with lower added value, but as the share of the country's pharmaceutical manufacturing industry in the pharmaceutical market continues to grow, its profits and influence are gradually expanding. To gain more drug added value and strengthen industrial competitiveness, the country's pharmaceutical manufacturing industry needs to increase investment in innovative R&D. Government funding can provide financial support and R&D guarantees for enterprises, further stimulating the innovation and R&D of domestic enterprises and increasing their embeddedness in the global value chain. This can also promote the transformation of the country's pharmaceutical manufacturing industry from generic drugs to innovative drugs, thereby improving the overall competitiveness and influence of the country's pharmaceutical industry. This leads to the first hypothesis of the text:

Hypothesis 1: Government expenditure on health has a "U"-shaped effect on the degree of embeddedness of the national pharmaceutical manufacturing industry in the global value chain.

When government health expenditure is low, increasing health expenditure may inhibit the development of the national pharmaceutical manufacturing industry and lower its position in the global value chain. However, when health expenditure increases to a certain level, it may have a positive effect on the national pharmaceutical manufacturing industry, improving its position in the global value chain.

Generally, the more developed a country's pharmaceutical industry is, the greater the protection of intellectual property rights. Many scholars have proven that the strength of a country's intellectual property rights protection is positively correlated with its position in the global value chain, meaning the stronger the intellectual property protection, the higher the country's position in the global value chain. However, since intellectual property protection requires the government to establish comprehensive laws and regulations and enforce them strictly, countries with lagging medical conditions may choose to temporarily reduce the strength of patent protection to lower medical costs and increase the supply of generic drugs, given the urgent need to improve medical standards and service coverage. In this case, the

increase in government health expenditure may have a certain negative impact on intellectual property protection. However, for countries with strong influence in the international pharmaceutical market, the increase in government expenditure will stimulate the country to accelerate the establishment of a sound intellectual property protection mechanism, providing safeguards for the innovative research and development of new drugs, thereby enhancing the competitiveness of the national pharmaceutical manufacturing industry and further increasing its embeddedness in the global value chain. Therefore, the second hypothesis of this paper is formulated as follows:

Hypothesis 2: The strength of a country's intellectual property protection will affect the degree of embeddedness of the pharmaceutical manufacturing industry in the global value chain through a mediating effect.

3. Empirical Strategy

3.1 Model construction

To address the first hypothesis of this paper, a quadratic regression equation is constructed to characterize the nonlinear features and to examine the impact of per capita government expenditure on the embeddedness of the pharmaceutical manufacturing industry:

$$GVC\_position_{it} = a_0 + a_1 Pge_{it} + a_2 Pge_{it}^2 + a_3 Control_{it} + u_i + v_t + \varepsilon_{it} \qquad (1)$$

In equation (1), i represents the country, t represents time, $GVC\_position_{it}$ represents the explained variable of global value chain embeddedness. Pge represents per capita government health expenditure, which is the sum of the government's domestic income allocated to health purposes and social insurance contributions divided by the country's population, and then divided by the dollar exchange rate to make the data more comparable. Pge^2 is the square term of per capita government health expenditure. $Control$ is a series of control variables, including foreign direct investment (FDI), service level (service), infrastructure level (basic), and trade openness (free) as control variables in this paper. u_i represents country fixed effects, v_t represents year fixed effects, and ε_{it} represents the random error term.

Considering the continuity and dynamics of a country's global value chain embeddedness, the paper includes the first lag of the global value chain embeddedness $GVC\_position_{i,t-1}$ in the explanatory variables, defining the dynamic panel data model as follows:

$$GVC\_position_{i,t} = \beta_0 + \beta_1 GVC\_position_{i,t-1} + \beta_2 Pge_{it} + \beta Pge_{it}^2 + \beta_4 Control_{it} + \varepsilon_{it}$$
$$(2)$$

In equation (2), $GVC\_position_{i,t-1}$ represents the global value chain embeddedness lagged by one period, and control represents a series of control variables.

To address the second hypothesis of this paper, that government health expenditure can affect the global value chain embeddedness through its impact on the strength of intellectual property protection, a mediating effect model is used to test this hypothesis, with the specific econometric model constructed as follows:

$$Gpindex_{it} = \gamma_0 + \gamma_1 Pge_{it} + \gamma_2 Pge_{it}^2 + \gamma_3 Control_{it} + u_i + v_t + \varepsilon_{it} \qquad (3)$$

$$GVC\_position_{it} = \delta_0 + \delta_1 Gpindex_{it} + \delta_3 Control_{it} + u_i + v_t + \varepsilon_{it} \qquad (4)$$

In equations (3) and (4), i represents the country, t represents time, and $Gpindex_{it}$ indicates the strength of intellectual property protection in country i in year t，with other variables having the same definitions as introduced in equation (1).

3.2   Introduction of key variables

3.2.1   Calculation of the global value chain embeddedness index

This paper draws on the global value chain division of labor accounting system constructed by Wang et al. (2017). The global value chain embeddedness of this paper is derived from the ratio of forward linkages to backward linkages in the global value chain

$$GVC\_position = \frac{GVC_f}{(GVC\_b)'} \qquad (5)$$

Where GVC_f is the forward linkage index of the global value chain based on forward linkages, and GVC_b is the backward linkage index of the global value chain based on backward linkages. The ratio of the two measures the sector's relative position in the global division of labor. The larger the global value chain embeddedness index (GVC_position), the more the sector is biased towards R&D, design, and other high-value-added positions, and the higher the degree of participation in the global value chain division of labor.

3.2.2   Mediator variable

This study employs the G-P index, as a proxy variable to measure the innovation level of a country's pharmaceutical manufacturing industry. The G-P index assesses the strength of a country's (or region's) knowledge protection across five dimensions: the scope of patent coverage, qualifications for international conventions, protection against the loss of rights, and the protection duration of enforcement mechanisms. The index ranges from 0 to 5, with higher values indicating stronger intellectual property rights protection in a country (or region). The choice of the G-P index as a proxy for the level of innovation is because the pharmaceutical manufacturing

industry is a high-tech industry and pharmaceuticals are patent-sensitive products. If a country has comprehensive patent regulations, then its pharmaceutical companies are more confident in producing innovative drugs. Conversely, if a country has weak patent protection for inventors and incomplete patent regulations, then its pharmaceutical companies may be reluctant to engage in R&D innovation, tending instead to participate in the production of generic drugs.

3.3   Data source and processing

For calculating the Global Value Chain (GVC) Embeddedness Index, this study utilizes the UIBE GVC Indicators from the UIBE database. This database provides cutting-edge indicators for the decomposition of the global value chain, facilitating researchers in conducting academic or policy analysis related to global value chains. According to the national economic industry classification (GB/T 4574-2017), the pharmaceutical manufacturing industry includes the manufacturing of chemical pharmaceutical raw materials, chemical pharmaceutical preparations, processing of traditional Chinese medicine slices, production of proprietary Chinese medicines, veterinary drugs manufacturing, biopharmaceuticals manufacturing, and packaging materials. These categories correspond to the manufacturing of pharmaceuticals, medicinal chemicals, and botanical products in the International Standard Industrial Classification (ISIC Rev.4).

The data for Per Capita Government Health Expenditure (Pge) are sourced from the Global Health Expenditure Database (GHED) of the World Health Organization (WHO). This database provides open access data on health expenditures for the past 20 years from 192 countries and regions, monitoring and analyzing the allocation and use of medical resources in various countries, thus aiding the sustainable development of health care worldwide.

Since the Intellectual Property Protection Strength Index (Gpindex), which is a mediator variable, is updated every five years, interpolation methods were used to fill in missing data for this study. Due to data availability, the Gpindex for 56 countries was selected for analysis.

Control variables were selected from the World Bank database. For missing values in Foreign Direct Investment (fdi) and Trade Openness (free), linear interpolation methods were used to process the data.

3.4   Descriptive statistics of variables

As shown in Table 1, the main variables selected for this study have varied descriptive statistics. The GVC_position ranges from 0.5676 to 1.7534 with an average of 0.8621, indicating noticeable differences in the degree of global value chain embeddedness among different countries. Per Capital Government Health Expenditure (Pge) ranges from 0.0005 to 7.8572 with a standard deviation of 1.5342, showing significant heterogeneity in government health spending across different countries. Further empirical analysis is required for a deeper understanding of these variables and their interrelationships.

Table 1: Descriptive statistics of variables

Variable	Mean	Standard Deviation	Minimum	Maximum
GVC_position	0.8621	0.1637	0.5676	1.75335
Pge	1.3381	1.5342	0.0005	7.8572
Gpindex	3.9438	0.5935	1.71	5
fdi	2.4825	5.9595	-34.4375	73.3827
service	62.1115	15.5145	13.57	87.85
Basic	0.5041	0.2893	1.40e-06	0.9901
Free	0.9436	0.6330	0.1186	0.4373

4. Main Results

4.1 Impact of government health expenditure on GVC embedment in pharmaceutical manufacturing

In Table 2, the first column presents the regression results without control variables. The results indicate that in the absence of control variables, both the government health expenditure (Pge) and its squared term (Pge2) are significant at the 1% level. The coefficient of Pge is negative (-0.050), while the coefficient of the squared term Pge2 is positive (0.007). This suggests a "U"-shaped relationship between government health expenditure and the degree of embeddedness in the global value chain. As control variables such as foreign direct investment (fdi), service level (service), infrastructure level (basic), and trade openness (free) are incrementally included in the subsequent columns, it is observed from columns four and five that the significance of the coefficient of government health expenditure (Pge) weakens slightly as more control variables are added. However, the regression results remain significant.

This analysis supports the notion that government health expenditure has a nonlinear impact on a country's embeddedness in the global value chain. Initially, increases in health spending might negatively affect the global value chain embeddedness, potentially due to the diversion of resources. However, beyond a certain level of expenditure, the effect becomes positive, possibly reflecting enhanced infrastructure, improved public health, and overall economic benefits that contribute positively to the country's position in the global value chain. The inclusion of control variables helps to refine this understanding by accounting for other factors that might influence the relationship between government health expenditure and global value chain embeddedness.

Table 2: Baseline regression: The effect of government health expenditure on GVC embedment in pharmaceutical manufacturing

	Explained variable: GVC_position				
	(1)	(2)	(3)	(4)	(5)
Pge	-0.050***	-0.051***	-0.043***	-0.027*	-0.029*
	(-3.30)	(-3.37)	(-2.84)	(-1.78)	(-1.90)
Pge²	0.007***	0.007***	0.006***	0.004**	0.004**
	(3.53)	(3.58)	(3.33)	(2.12)	(2.20)
fdi		0.001*	0.001*	0.001*	0.001*
		(1.88)	(1.78)	(1.84)	(1.67)
service			0.006***	0.007***	0.008***
			(4.44)	(5.10)	(5.30)
basic				0.177***	0.173***
				(-5.54)	(-5.45)
free					0.050***
					(-2.87)
Constant	0.914***	0.913***	0.453***	0.394***	0.388***
	(43.03)	(43.05)	(4.27)	(3.75)	(3.70)
National fixed effects?	Yes	Yes	Yes	Yes	Yes
Time fixed effects?	Yes	Yes	Yes	Yes	Yes
Observation	1,216	1,216	1,216	1216	1216
R-squared	0.772	0.773	0.777	0.783	0.784

Note: *, ** and *** represent significance levels of 10%, 5% and 1% respectively, and the content in brackets is standard error.

4.2   Robust tests

4.2.1   Exclusion of outliers

Given the wide variation in development levels among countries, leading to significant disparities in the data, this study addresses potential estimation biases caused by outliers. By excluding the top and bottom 1% of values in the explanatory variables and re-running the regression, the results (as shown in column 1 of Table 3) indicate a decrease in the regression coefficients. However, the signs of the variable coefficients remain unchanged, suggesting that the exclusion of outliers does not affect the conclusions of the study.

4.2.2 Handling of heteroskedasticity

Given that the panel data in this study is of the "large N, small T" type, there is a potential for heteroskedasticity in the regression. To address this, the study employs robust methods and Bootstrap regression to correct for heteroskedasticity. Columns 2 and 3 of Table 3 present regression results with and without control variables,

respectively. It is observed that after correcting for heteroskedasticity, the impact of the core explanatory variables on the embeddedness of the pharmaceutical manufacturing industry in the global value chain does not change significantly, indicating that the results remain robust even after this correction.

4.2.2   Robustness Test Based on Handling Endogeneity

Considering that the embeddedness of the global value chain might exhibit certain continuous characteristics, the study includes a lag of the global value chain in the model to capture this feature. Although introducing the lag term can reduce biases in the model setup, it also introduces an issue of endogeneity. To effectively address this, the study employs a system GMM estimation. The estimation results are shown in column 4 of Table 3. The p-value for AR (2) is 0.196, which is greater than 0.05, indicating no serial correlation in the error terms of the model setting. The GMM regression results demonstrate a U-shaped non-monotonic relationship between government health expenditure and the embeddedness of the pharmaceutical manufacturing industry in the global value chain, thus validating Hypothesis 1 of the study.

Table 3: Results of robust test

	Outlier eliminator	Heteroscedasticity processing		SYS-GMM
	(1)	(2)	(3)	(4)
L.gvc_position				0.794^{***}
				(12.43)
Pge	-0.0505^{***}	-0.050^{***}	-0.0290^{**}	-0.037^{***}
	(0.018)	(-3.25)	(-2.08)	(-3.20)
Pge^2	0.00653^{***}	0.007^{***}	0.004^{***}	0.004^{**}
	(0.0022)	(4.04)	(2.61)	(2.54)
Constant	0.934^{***}	0.914^{***}	0.388^{***}	0.1259
	(0.0139)	(76.77)	(3.13)	(1.61)
Control	Yes	No	Yes	Yes
National fixed effects?	Yes	Yes	Yes	Yes
Time fixed effect?	Yes	Yes	Yes	Yes
AR (2) value				0.192
Hansen P value				0.273
Observations	1115	1216	1216	1152
After adjustment R^2	0.766	0.772	0.785	

Note: *, ** and *** represent significance levels of 10%, 5% and 1% respectively, and the content in brackets is robust standard error; Due to space limitations, regression results for control variables are not reported in the table.

4.3   Heterogeneity analysis

Considering the significant differences in government health expenditure levels among the observed sample countries, this section conducts a heterogeneity analysis from two perspectives: country type and geographic location. The objective is to explore in depth how government health expenditure impacts the embeddedness of the pharmaceutical manufacturing industry in the global value chain of each country. The results are reported in Table 4.

4.3.1   Heterogeneity analysis based on country type

According to the "Global Health Expenditure Report" mentioned earlier, compared to lower-middle-income and low-income countries, high-income and upper-middle-income countries generally have higher levels of government spending in the health sector. Therefore, this study investigates whether the increase in government health expenditure has different impacts on the embeddedness of the pharmaceutical manufacturing industry in countries with varying income levels. The 64 countries in the study are divided into two types: the first type includes high-income and upper-middle-income countries, and the second type includes lower-middle-income and low-income countries. Columns (1) and (2) of Table 4 report the baseline regression results for these two categories of countries, respectively. In column (1), the coefficients of the first and second terms of the variable Pge are negative and positive, respectively, indicating a "U"-shaped impact of government health expenditure on the global value chain embeddedness of the pharmaceutical manufacturing industry in high-income and upper-middle-income countries, consistent with the conclusion drawn from the full sample. In column (2), the signs of the first and second terms of Pge change to positive and negative, respectively, suggesting that for lower-middle-income and low-income countries, the impact of government health expenditure on the embeddedness of the pharmaceutical manufacturing industry in the global value chain is "inverted U"-shaped. A possible explanation is that for these countries, government health expenditure initially has a "catch-up effect" on the global value chain embeddedness of their pharmaceutical manufacturing industry, but as the expenditure continues to increase, the embeddedness starts to decrease.

4.3.2   Heterogeneity analysis based on geographic location

This study classifies countries based on their geographic location into European and American countries and Asian countries. Columns (3) and (4) of Table 4 report the heterogeneity test results based on different geographic locations. The analysis reveals that for European and American countries, the impact of government health expenditure on the embeddedness of the pharmaceutical manufacturing industry in the global value chain is "U"-shaped. However, for Asian countries, the impact of government health expenditure on the global value chain embeddedness of the pharmaceutical manufacturing industry is not significant.

Table 4: Heterogeneity analysis

	High-income countries, middle-high income countries	Low and middle-low-income countries	European and American countries	Asian countries
	(1)	(2)	(3)	(4)
Pge	-0.042***	5.771***	-0.098***	0.160**
	(-3.28)	(4.60)	(-7.16)	(2.15)
Pge²	0.005***	-3.877***	0.010***	-0.018
	(3.64)	(-4.21)	(6.75)	(-1.29)
Constant	0.646***	-0.510***	1.068***	-1.603***
	(7.34)	(-2.88)	(11.32)	(-4.20)
Control	Yes	Yes	Yes	Yes
National fixed effects?	Yes	Yes	Yes	Yes
Time fixed effect?	Yes	Yes	Yes	Yes
Observations	1,045	171	741	341
R²	0.764	0.798	0.828	0.762

Note: *, ** and *** represent significance levels of 10%, 5% and 1% respectively, and the content in brackets is robust standard error; Due to space limitations, regression results for control variables are not reported in the table.

4.4 Analysis of the mechanism of action

In Hypothesis 2, it was posited that government health expenditure influences the embeddedness of the pharmaceutical manufacturing industry in the global value chain through its impact on the strength of intellectual property (IP) rights protection. To test this, a mediating effect model (Models (3) and (4)) was employed for regression analysis, with results presented in Table 5. Columns 1 and 2 of Table 5 do not include control variables, while columns 3 and 4 present the regression results with control variables included.

From both columns (1) and (3), it can be observed that the coefficient of per capita government health expenditure (Pge) is negative, while the squared term of per capita government health expenditure (Pge2) is also negative, and both are significant at the 1% level. This indicates that government health expenditure has a "U"-shaped impact on the strength of IP rights protection. In columns (2) and (4), the coefficient of the Intellectual Property Protection Strength Index (Gpindex) is positive and significant at the 1% level, suggesting that the strength of IP protection positively influences the embeddedness of the pharmaceutical manufacturing industry in the global value chain. Thus, the Intellectual Property Protection Strength Index acts as a mediating variable, partially mediating the effect of government health expenditure on the global value chain embeddedness of the pharmaceutical manufacturing industry. This finding supports the idea that government health expenditure can promote the embeddedness of the

pharmaceutical manufacturing industry in the global value chain by influencing the strength of IP rights protection, with IP protection strength playing a partial mediating role in this process.

Table 5: Analysis of mechanism of action

	Gpindex (1)	GVC_position (2)	Gpindex (3)	GVC_position (4)
Pge	-0.236***	-0.043***	-0.205***	-0.036***
	(-6.59)	(-3.21)	(-5.66)	(-2.63)
Pge²	0.016***	0.006***	0.014***	0.005***
	(3.74)	(3.72)	(3.29)	(2.98)
Gpindex		0.048***		0.049***
		(3.31)		(7.39)
Constant	3.412***	0.757***	3.284***	0.770***
	(71.39)	(16.15)	(62.65)	(16.44)
Control	No	No	Yes	Yes
National fixed effects?	Yes	Yes	Yes	Yes
Time fixed effects?	Yes	Yes	Yes	Yes
Observations	896	896	896	896
R²	0.926	0.815	0.931	0.823

Note: *, ** and *** represent significance levels of 10%, 5% and 1% respectively, and the content in brackets is robust standard error; Due to space limitations, regression results for control variables are not reported in the table.

5. Conclusion

This study theoretically and empirically analyzed how government health expenditure impacts the embeddedness of the pharmaceutical manufacturing industry in the global value chain. The empirical results suggest that an increase in government health expenditure only enhances the embeddedness of the pharmaceutical manufacturing industry in the global value chain at relatively high expenditure levels. Generally, government health expenditure does not lead to an improvement in the industry's global value chain embeddedness, a finding consistent with the results of robustness tests. The Intellectual Property Protection Strength Index (Gpindex) plays a significant role in mediating the effect of government health expenditure on the global value chain embeddedness of the pharmaceutical manufacturing industry. Therefore, alongside increasing health expenditure, governments should also focus on strengthening intellectual property protection to facilitate technological innovation in the pharmaceutical manufacturing industry and enhance its position in the global value chain.

Based on these findings, the study offers the following policy recommendations

1. Optimize the Efficiency of Government Expenditure: Governments should

allocate health expenditure based on the development stage and market demand of their pharmaceutical manufacturing industry, focusing on investment in healthcare infrastructure, health education, and disease prevention and control. Additionally, governments should strengthen the supervision and management of health expenditure to prevent misuse of funds and corruption

2. Encourage Enterprises to Increase Investment in Innovation and R&D: Governments can provide financial and technical support for innovation and R&D in the pharmaceutical manufacturing industry through tax incentives, innovation funds, and special support measures. This will stimulate the research and development enthusiasm of enterprises. Moreover, strengthening intellectual property protection through legislation and enforcement is crucial to ensure the interests of property owners, fostering confidence in R&D and innovation.

3. Incubate and Nurture Local Brands: Governments can assist local pharmaceutical companies in brand building and market promotion through policy guidance and support. Furthermore, governments can actively promote the internationalization of the local pharmaceutical manufacturing industry, creating well-known brands and enhancing their position and influence in the global value chain.

4. Strengthen International Cooperation: Governments should enhance collaboration with international pharmaceutical companies and institutions to facilitate the exchange of technology and talent. Introducing advanced international technology and management expertise can elevate the competitiveness and innovation capacity of the domestic pharmaceutical manufacturing industry.

These policy recommendations aim to create a conducive environment for the pharmaceutical manufacturing industry, enabling it to thrive and occupy a more significant and influential position in the global value chain.

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