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Research on the Influence of Innovation Capability on the International Participation of Chinese Manufacturing Industry from the Perspective of GVC

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Abstract: The manufacturing industry in China has been developing rapidly in recent years with increasingly stronger competitiveness in international market. Numerous factors could influence manufacturing participation in international competition. This paper focuses on the impact of innovation capability on international participation of manufacturing industry, it first constructed the manufacturing innovation capability index system, and the Entropy Method was adopted to calculate the manufacturing innovation capability index (MICI) of domestic industry segments and other global economies from 2008 to 2018. then, the global value chain (GVC) participation index was used to measure the international participation (GVC) of manufacturing industry in China and other economies from 2008 to 2018; finally, with the introduction of eight variables, including the explained variable GVC and the core explanatory variable MICI, it is empirically proved that MICI does have a significant effect on the promotion of international participation of manufacturing industry. On this basis, this paper takes enterprises and the government as the two main bodies, and puts forward corresponding suggestions based on the indicators used in the literature, hoping that the international participation of China's manufacturing industry in the global division of labor can be enhanced in the future.

1. Introduction

The Minister of the Ministry of Industry and Information Technology said at the press conference of the State Council Office: In 2021, the added value of manufacturing industry increased by 9.8%, with an average increase of 6.6% in two years; The added value of manufacturing industry accounted for 27.4% of GDP; The added value of manufacturing industry reached 31.4 trillion yuan, ranking first in the world for 12 consecutive years[1]. The remarkable achievements of China's manufacturing industry are one of the most important achievements in the past 44 years of reform and opening up. However, China is a big manufacturing country, not a powerful manufacturing country, and the situation of being big but not strong needs to be changed urgently. Under the background of the new development pattern of "double circulation",

Technological breakthrough is an urgent problem to be solved at present, and high-quality development with innovation and development as the core gives a solution, that is, taking industrial innovation as the top priority at present can solve the dilemma under the current situation, realize the sustainable development of manufacturing industry and continue to deepen the international division of labor under the global value chain[2]. Therefore, whether improving the innovation capability of manufacturing industry can enhance the international participation of China's manufacturing industry and how to enhance the international participation of manufacturing industry through innovation capability have become a valuable research topic[3].

2. Literature Review

From the perspective of global value chain, scholars at home and abroad mainly study the influence of innovation capability on the international participation of China's manufacturing industry from three aspects: manufacturing innovation capability, manufacturing international participation and the influence of manufacturing innovation capability on its international participation.

2.1 Innovation Capability of Manufacturing Industry

Schumpeter, an economist, put forward the "innovation theory" for the first time, holding that innovation is to establish a new production function, that is, to recombine production factors. With the deepening of the relationship between industry and innovation, Porter introduced innovation drive into the theory of international competitive advantage. With the deepening of scholars' research on innovation, the empirical research on innovation ability emerges in front of everyone's eyes. At present, scholars generally use the methods of building index system, DEA model, entropy method and principal component analysis to measure innovation ability. Chen Kai (2016) used DEA model to measure the technological innovation and management innovation of aviation manufacturing industry in 20 provinces of China, and put forward the innovation path of different aviation manufacturing industry in combination with technological innovation and management innovation[4]; Zhai Chaoying and Gong Chen (2017) used principal component analysis to study the innovation capability of China's high-tech industries from the perspective of innovation input, output and supporting capacity[5]. Based on the research of scholars, this paper chooses entropy method as the research method, constructs an index system from innovation resources, innovation technology and innovation output, and calculates the innovation ability level of each subdivided industry in China; The innovation ability of China and different economies is measured from four first-level indicators: innovation creation, resources, environment and transformation.

2.2 International Participation of Manufacturing Industry

The term international participation is quoted from Koopman's two concepts of global value chain participation index and status index in 2010, which indirectly leads to the concept of global value chain. The formation of global value chain theory originated from Gereffi and Korzeniewicz. Later, through the efforts of Hummels and Daudin, Koopman provided a concrete calculation formula for global value chain theory[6]. Li Xiaolu (2017) used GVC participation index and status index to measure 19 countries and regions in Asia-Pacific and domestic manufacturing sub-sectors respectively[7]; Huang Qinqi (2019) focuses on China's service industry by using GVC participation index and status index[8]. On this basis, this paper chooses GVC Participation Index as the representative of international participation to measure the international participation of domestic sub-sectors and manufacturing industries in China and different economies.

2.3 The Impact of Manufacturing Innovation Capability on its International Participation

In view of the relevant research on the impact of manufacturing innovation capability on its international participation, Wang Pan (2020) uses factor analysis to calculate innovation capability, and through empirical research, it is concluded that innovation capability can really promote the promotion of international division of labor[9]; Fu Wenren (2019) calculated the reconstructed explicit comparative advantage index, and concluded through empirical analysis that innovation, foreign investment and foreign demand can significantly promote the competitiveness of China's manufacturing industry[10]. In this paper, MICI calculated by entropy method is used as the core explanatory variable, human resources, R&D protection and other six indicators are used as control variables, and international participation is used as explanatory variable. Through regression and endogenous test, it is concluded that innovation ability has a significant impact on the promotion of international participation.

3. The Evaluation of Manufacturing Innovation Capability

3.1 The Evaluation System of Manufacturing Innovation Capability

This paper mainly constructs the innovation capability index system of China's manufacturing industry sub-sectors and different economies from domestic and international dimensions. From a domestic perspective, according to the strategy of manufacturing power in 2025 and the realistic background, three first-level indicators of innovation resources, innovation technology and innovation output are put forward; At the industry level, six secondary indicators, such as human resources, R&D investment, technology acquisition and transformation, patented products and new product development, have become important conditions for improving the innovation capability of manufacturing sub-sectors and necessary factors for future development; Based on the principles of scientific selection and availability of data, 12 three-level variables are selected in this paper, as shown in Table 1 below.

Table 1: Index system of innovation ability of China's manufacturing sub-sectors

First-class Index	Secondary Index		Tertiary Index	Attribute
Innovative resources	Human resource input	X1	R&D personnel equivalent to full-time equivalent	Forward
		X2	Number of enterprises with R&D activities	Forward
	Input of R&D resources	X3	Internal expenditure of R&D funds	Forward
		X4	Enterprise funds	Forward
Innovative technology	Technology acquisition	X5	Expenditure on technology introduction	Forward
		X6	Expenditure on purchasing domestic technology	Forward
	Technical transformation	X7	Digest and absorb expenditure	Forward
		X8	Expenditure on technical transformation	Forward
Innovation output	Patented product	X9	Number of patent applications	Forward
		X10	Number of effective invention patents	Forward
	New product development	X11	Number of new product development projects	Forward
		X12	Expenditure on new product development	Forward

3.2 Evaluation Methods

3.2.1 Evaluation Methodology

The purpose of this section is to evaluate the innovation ability of manufacturing industry. Through the index system constructed above, the next step is to determine the weight of each index. Considering the characteristics of the data synthetically, this paper chooses the entropy method to calculate the index based on the principle of objective facts.

Step1. Data standardization:

Positive indicators:

$$x_{ij} = \frac{x_{ij} - \min\{x_j\}}{\max\{x_j\} - \min\{x_j\}} \tag{1}$$

Negative indicators

$$x_{ij} = \frac{\min\{x_j\} - x_{ij}}{\max\{x_j\} - \min\{x_j\}} \tag{2}$$

Among them, it is the maximum value corresponding to all sub-sectors or economic indicators and the minimum value corresponding to all sub-sectors or economic indicators.

Step2. Calculate the proportion of j industry (country) in index i:

$$w_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{3}$$

Step3. Calculate information entropy:

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} w_{ij} * \ln w_{ij} \tag{4}$$

Where m is the number of sub-sectors or economies

Step4. Calculate redundancy:

$$d_j = 1 - e_j \tag{5}$$

Step5. Calculate the index weight:

$$\varphi_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{6}$$

Step6. Calculate the development level of manufacturing innovation capability (MICI) by using standardized and index weights:

$$MICI = \sum_{j=1}^{m} \varphi_j * w_{ij} \tag{7}$$

By using this formula, we can calculate the manufacturing innovation capability level index (MICI), which is between 0 and 1. The higher the MICI, the higher the manufacturing innovation capability level, and vice versa[11].

3.2.2 Evaluation and Analysis of Manufacturing Innovation Capability Index

According to the results of China's manufacturing innovation capability index (MICI) from 2008 to 2018 calculated by entropy method, MICI has significant differences in the dimension spanning ten years. As shown in Figure 1 below, on the whole, MICI of high-tech industry is at the leading level, with the strongest innovation ability, which has developed rapidly in the past ten years. The average annual growth rate of its innovation ability is 2.403%, far ahead of other industries, followed by 1.077% of medium and low, 1.172% of low technology, and 3.28% of medium and

high. From MICI's point of view, the innovation ability of high-tech manufacturing industry is the highest, among which the innovation ability of computer, electronics and optical products (D26T27) is much higher than that of other three sub-sectors, and its average annual growth rate of innovation ability is 2.72%, which shows that the industry is developing rapidly and still has good development prospects, which is also in line with the current actual situation. However, there is a big gap between the middle and high-tech manufacturing industry with the second innovation ability and the high-tech manufacturing industry, ranging from 0.095 to 0.195, and after 2014, it began to show a downward trend, which is mainly due to the large decline of chemical products and pharmaceutical industry (D20T21), which decreased by 5.98% year-on-year. On the other hand, the low-tech manufacturing industry and low-tech manufacturing industry have been growing slowly in the past ten years, which indirectly reflects the objective fact that these industries are not strong in innovation ability and lack of competitiveness.

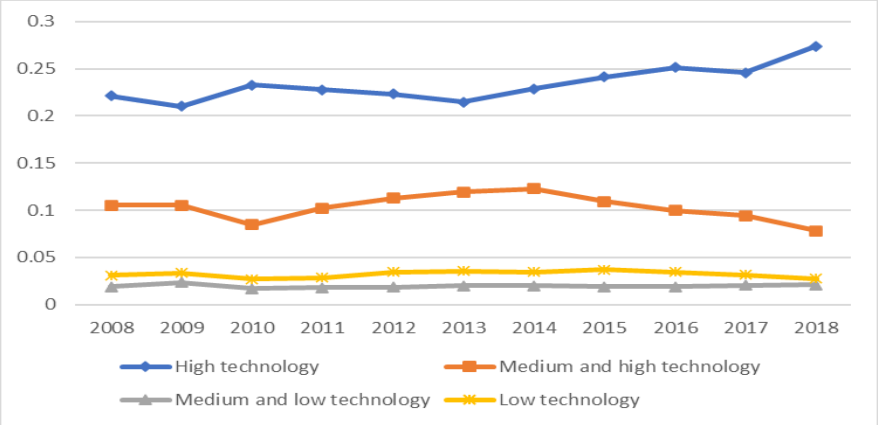

Figure 1: Innovation Capability Index Level of China's Manufacturing Sub-sectors

4. The Measurement of International Participation Index of Manufacturing Industry

4.1 Measurement Methods and Data Sources

Under the background of global value chain (GVC) division of labor, scholars prefer the decomposition method of trade value added to measure the participation of a country's industry in international division of labor.

Koopman decomposes the total export into[6]:

$$E = DVA + FV \tag{8}$$

Among them, E is the total export, DVA is the domestic added value, and FV is the foreign added value;

$$DVA = DVA_{\_e} + IVA_{\_e} + EI_{\_rh} = DVA_{\_e} + IV + EI_{\_rh} \tag{9}$$

Among them, it is direct added value export, indirect added value export, and can also be expressed as IV, which is the domestic added value of products used by importers to produce and sell back to exporting countries;

Koopman proposed to use GVC embeddedness to measure the degree of a country's industry participating in the global value chain division of labor, and proposed GVC participation index, which is as follows:

$$GVC - Participation_{ir} = \frac{IV_{ir}}{E_{ir}} + \frac{FV_{ir}}{E_{ir}} \tag{10}$$

Among them, R is a country and I is an industry, which indicates the participation index of R country I industry in the global value chain division of labor. It indicates the proportion of indirect export added value to total export, and the higher the proportion, the higher the forward participation of R country I industry in international division of labor; It indicates the proportion of foreign added value to total exports, and the higher the proportion, the higher the backward participation of I industry in R country.

The data in this chapter comes from the Trade Value Added Database (TiVA) jointly released by the Organization for Economic Cooperation and Development (OECD) and the World Trade Organization (WTO), and the data in this paper uses the latest version of TiVA database released in 2021 from 2008 to 2018.

4.2 Measurement and Analysis of GVC Participation Index in Manufacturing Industry

Based on TiVA database, the GVC participation index, forward participation and backward participation in China's manufacturing sub-sectors and international division of labor from 2008 to 2018 are calculated. First of all, starting from China, As shown in Figure 2, The overall participation of China's sub-sectors remains between 0.628 and 0.777, High-tech manufacturing industry bears the brunt of the high participation, which has been stable between 0.759 and 0.777, while high-tech manufacturing industry bears the brunt of the high participation, which has been stable between 0.759 and 0.777, indirectly reflecting that there is a big gap in the import and export of intermediate products in domestic high-tech manufacturing industry, and this industry does not occupy an advantage in the industrial chain. However, the participation of middle and high-tech industries is at the low end, which reflects that chemical products and pharmaceutical industry (D20T21), coke petroleum fuel processing industry (D05T0), textile, clothing and leather industries (D13T15) undertake international transfer through labor and domestic resources [12].

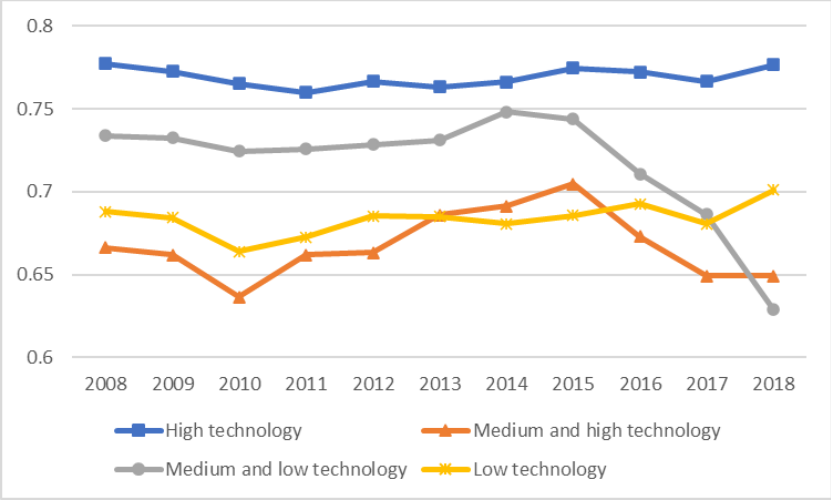

Figure 2: GVC participation index of China's manufacturing sub-sectors

5. Empirical Research

5.1 The Empirical Model

5.1.1 Variable Selection and Data Description

This paper focuses on the impact of innovation ability on international participation, so the explanatory variable is international participation index, which is recorded as GVC; The core

explanatory variable is manufacturing innovation capability index, which is recorded as mici. In addition, after combing the literature and data availability, human resources (hr), R&D protection (prot), R&D intensity (str), R&D output, market competition (com) and openness level (open) are selected as the control variables affecting international participation[9].

In view of the current OECD database updated to 2018, in order to ensure the integrity and availability of data, this paper takes China, the United States, South Korea, Japan, India and Indonesia as research objects from 2010 to 2018. By selecting seven indicators and considering the possible heteroscedasticity, this paper takes logarithm for stepwise regression of all data. See Table 2 for specific index data.

Table 2: Indicator interpretation and data sources

Variable name	Variable definition	Measuring method	Data source
gvc	International participation index of manufacturing industry	GVC-participation	OECD database
mici	Manufacturing innovation capability index	Entropy method calculation	International Statistical Yearbook & UN Comtrade & China Statistical Yearbook
hr	Human resources	Number of researchers per million people	
prot	Research and development protection	Intellectual property protection index	
str	R&D intensity	Proportion of R&D expenditure to GDP	
output	R&D output	Number of patent applications	
com	Market competition	Number of enterprises above designated size	
open	Open level	Dependence on foreign trade = (X + M)/GDP	

5.1.2 Model Setting

The model in this paper is set as follows:

$$lngvc_{it} = \beta_0 + \beta_1 lnmici_{it} + \beta_2 lnhr_{it} + \beta_3 lnprot_{it} + \beta_4 lnstr_{it} + \beta_5 lnoutput_{it} + \beta_6 lncom_{it} + \beta_7 lnopen_{it} + \varepsilon_{it} \quad (11)$$

Where β_0 is the constant term, ε_{it} is the error term, i is the country, and t is the year

5.2 Empirical Analysis

This paper adopts stepwise regression method, that is, the explanatory variables and each explanatory variable are regressed one by one. Firstly, we test the influence of logarithm of manufacturing innovation capability (lnmici) on logarithm of its international participation (lngvc), and get the model (1); After that, human resource logarithm (lnhr), R&D protection logarithm (lnprot), R&D intensity logarithm (lnstr), R&D output logarithm (lnoutput), market competition logarithm (lncom) and openness level logarithm (lnopen) are introduced one by one, and the models (2), (3) … (7) are obtained in turn. This paper uses stata16.0 to calculate, and the results are shown in Table 3 below[13].

Model (1) shows that the innovation capability of manufacturing industry in various countries

has a positive effect on international participation at a significant level of 5%, and the international participation increases by 5.19% for every 1% increase in innovation capability. After gradually adding control variables, from the overall perspective, the impact of manufacturing innovation capability on international participation has changed to varying degrees, but on the whole, variables have a certain impact on its international participation. Specifically, after the introduction of human resources (hr) and R&D protection (prot) in models (2) and (3), both of them are significantly negative at a significant level of 1%, and the level of international participation decreases by 8.81% and 0.42 respectively for every 1% increase of them; When R&D intensity (str) is added, model (4) ensures that R&D intensity has a significant and positive relationship with the promotion of international participation, but it leads to the core explanatory variable manufacturing innovation capability (mici) is no longer significant; When the R&D output is introduced, it is significantly positive at the level of 1%, that is, for every 1% increase in output, the international participation will increase by 4.82% in turn. Model (6) is not significant when market competition (com) is added. Finally, when the open level is introduced, it is significantly positive at the level of 1%, that is, for every 1% increase in open, the international participation will increase by 17.1% in turn.

Table 3: Empirical Analysis of the Influence of Manufacturing Innovation Capability on International Participation

Variable name	Models						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
lnmici	0.0519*	0.191***	0.123**	-0.0545	-0.167**	-0.174**	-0.155***
	(0.0241)	(0.0455)	(0.0374)	(0.0340)	(0.0519)	(0.0523)	(0.0355)
lnhr		-0.0881***	0.0828*	-0.0620*	-0.0546	-0.0415	-0.0950***
		(0.0252)	(0.0353)	(0.0303)	(0.0285)	(0.0313)	(0.0223)
lnprot			-0.420***	-0.227***	-0.201***	-0.193***	-0.0615
			(0.0720)	(0.0546)	(0.0521)	(0.0527)	(0.0397)
lnstr				0.243***	0.243***	0.185**	0.158***
				(0.0312)	(0.0293)	(0.0643)	(0.0437)
lnoutput					0.0482**	0.0487**	0.0805***
					(0.0175)	(0.0175)	(0.0126)
lncom						0.0551	0.0436
						(0.0538)	(0.0364)
lnopen							0.171***
							(0.0228)
_cons	-0.379***	0.594*	0.342	0.340*	-0.638	-1.438	-2.245***
	(0.0632)	(0.284)	(0.226)	(0.152)	(0.382)	(0.869)	(0.598)
R2	0.082	0.259	0.559	0.802	0.829	0.833	0.925

Standarderrorsinparentheses
*p<0.05,**p<0.01,***p<0.001

6. Conclusions

First, by constructing the index system of manufacturing innovation capability at home and abroad, and using entropy method to calculate mici scores of various industries and economies, we can find that: vertically, China's high-tech manufacturing industry has the strongest innovation capability and strong development momentum, especially computer, electronic and optical products have developed well in recent years; The innovation ability of medium-high, medium-low and low-tech manufacturing industries is arranged in turn, but there is a problem that the development

of high-tech and low-tech is extremely unbalanced, and the innovation ability of weak industries has basically not improved in the past 11 years; Horizontally, China's manufacturing industry has made gratifying achievements in the past 10 years, especially in 2013, when China implemented the Belt and Road Initiative, which brought substantial progress to the improvement of China's manufacturing innovation capability. But from 2016 to 2018, The average annual growth rate of innovation capability of China's manufacturing industry is only 0.38%, The average annual growth rate of emerging market economies represented by India is as high as 8.43%, while that of other developing countries represented by Vietnam is 2.84%, which indirectly shows that China's demographic dividend advantage is becoming less and less obvious, and also enlightens us to explore new ways to enhance the competitiveness of China's manufacturing industry[10].

Secondly, by measuring the international participation of domestic and foreign manufacturing industries through the global value chain participation index, we can find that: vertically, the international participation level of high-tech manufacturing industries is the highest, and various industries mainly participate in the international division of labor[14]. However, there is a big gap between different industries, and the development of each industry is uneven. Horizontally, China has been deeply embedded in the division of labor in the international value chain, and its international participation ranks first among different economies.

Thirdly, through empirical research, we can find that innovation ability, R&D intensity, R&D output and openness level of manufacturing industry have a significant and positive correlation with the promotion of international participation, while human resources and R&D protection have a negative relationship[15]. China's manufacturing industry should increase investment in research and development, create a suitable environment, promote international exchanges, and further enhance the competitiveness of China's manufacturing industry.

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