Has Global Division of Labor Increased Markup of Chinese Enterprises?

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The paper calculates the number of production stages for measurement of production segmentation, and discusses and depicts the microscopic impacts and effects of production segmentation of labor division of the global value chain on enterprise markup. The DLW method is used to calculate the markup of Chinese enterprises, the fixed-effect model is used to analyze the impact of labor division of the global value chain on enterprise markup, and an instrumental variable method is constructed to relieve endogeneity. The research findings show that enterprises have significantly increased their markup by choosing global production segmentation, international production segmentation and domestic production segmentation. Global production segmentation can significantly increase the markup of low-productivity enterprises, hi-tech enterprises and private enterprises. Particularly, low-productivity enterprises choose international production segmentation and hi-tech enterprises choose domestic production segmentation. Production segmentation can offset to a certain extent low markup of export enterprises and domestic-oriented enterprises caused by the "competition effect". In addition, enterprises' "technological progress effect" and "trade cost effect" are two possible channels by which production segmentation facilitates the increase of markup. The paper enriches and expands the literature about the impacts of labor division of the global value chain on enterprise markup, the robustness is analyzed from the perspectives of enterprise heterogeneity, industrial & technical heterogeneity and structure, and the impact mechanism is validated through the intermediate effect model. Our important findings are of important implications for solving the "low markup trap" of Chinese enterprises and enhancing labor division of the global value chain of enterprises.

Keywords: enterprise markup, number of production stages, technological progress effect, trade cost effect, global value chain

1. Introduction

Against the backdrop of economic globalization, there is a constant stream of new-

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type production and trade models including international market segmentation, global procurement, outsourcing, and intra-corporation trade. Meanwhile, the production process becomes increasingly discrete and fragmented, causing the global value chain to continue to extend among different countries and become more refined, and production segmentation has become an important organizational form by which all countries take part in the global value chain. Production segmentation makes enterprises shift from centralization, vertical integration and single business premise to geographical dispersion. R&D, manufacture and marketing of product are carried out in different countries and regions, and "functional separation" and "spatial separation" of the production process have been realized (Romero *et al*., 2009). The phenomena of production globalization, production segmentation and detailed division of labor have attracted wide attention of a number of scholars (Hummels *et al*., 2001; Liu, 2011; Fally, 2011, 2012; Johnson and Noguera, 2012; Koopman *et al*., 2014; Ni *et al*., 2016; Liu *et al*., 2017). Interestingly, according to the research results of Chinese and foreign scholars, there is phenomenon of "low markup trap" or "puzzle of low-price export" (Sheng and Wang, 2012; Huang *et al*., 2016; Kee and Tang, 2016) when Chinese enterprises take part in international division of labor, and it goes against the new-new trade theory, which holds that non-export enterprises tend to have higher profitability than export enterprises (Melitz and Ottaviano, 2008). Currently, the world economy is at the phase of adjustment of international financial crisis and is faced with a series of problems such as weak global aggregate demands, dual restrictions of domestic resources and environment, and increasing costs of production factors including labor, etc. Particularly, since the China-US trade war launched by the Trump Administration in 2018, Chinese enterprises' international competitiveness have been faced with enormous challenges.

To tackle China's "low markup trap", the priority is to make clear the reasons for the low markup of Chinese enterprises. As is seen from previous studies, one reason for this is the policy factor, such as the policies on export rebates and subsidies (Sheng and Wang, 2012), exchange rate fluctuations (Sheng and Liu, 2017); the other reason is the microscopic behaviors of Chinese enterprises, such as market competition of enterprises (De Loecker and Warzynski, 2012; Sheng and Wang, 2012; Liu and Huang, 2015), enterprise innovation (Liu and Huang, 2015; Zhu *et al*., 2017; Huang *et al*., 2018), and factor cost (Zhu *et al*., 2017; Huang *et al*., 2018). To solve the problem of China's "low markup trap", the key is to explore the internal mechanism for increasing markup. Based on the analyses of Melitz and Ottaviano (2008) related to constructing models for monopolistic competitions of heterogeneous enterprises, enterprises with higher export intensity and productivity have higher markup. Kugler and Verhoogen (2012) prove that enterprises producing high-quality products have relatively high markup. On the one hand, according to empirical analyses, China's investments in high-income countries can significantly increase the

markup, while transnational corporations influence markup of domestic enterprises (Mao and Xu, 2016, 2017) through horizontal spillover and vertical spillover; on the other hand, trade liberalization of intermediate goods significantly enhances markup by reducing marginal cost of products (De Loecker *et al*., 2016). Undoubtedly, the above documents provide useful references for understanding increase of enterprise production efficiency and welfare against the backdrop of deepening division of labor in the global value chain, production chain extensions at home and abroad, and the increasingly complicated production structure.

In recent years, the introduction of the policies on trade liberalization and technological advances have reduced the trade costs such as customs duties and transportation fees, sped up spatial separation of production activities, and facilitated global deployment of different production processes. Moreover, innovation-driven enterprises tend to engage in high value-added R&D activities and outsource processing and production processes to other enterprises, thereby causing more intermediate links between production and trading, longer production chain and more complicated production structure. Production segmentation, as an important measurement of division of the global value chain, measures the breadth or lengthen of the global value chain that a country takes part in. Most studies focus on the measurement of production segmentation as well as the impacts of production segmentation on productivity, employment and income distribution, etc. (Egger *et al*., 2001; Grossman and Helpman, 2005; Liu *et al*., 2017). Nevertheless, Smith (1774) believes that wealth is closely related to division of labor and it increases production efficiency and welfare level as it becomes more specialized. The enterprise markup determines the benefits that a country can obtain from international trade, and directly determines the benefits that a country can obtain from the global value chain in the current wave of globalization. Existing documents are seldom related to how production segmentation influences the product pricing capability of Chinese enterprises. As Chinese enterprises have relied excessively on export and are lack of product pricing rights, it is extremely urgent to get away from the "low markup trap" against the backdrop of adjustment of the economic structure and transformation of development pattern.

2. Theoretical Analysis and To-Be-Tested Hypotheses

As global economic activities become more detailed and specialized, enterprises are more closely linked with each other, the industrial structure becomes more and more complicated, the number of intermediate links between production and trade increase, the number of production stages of products increases, the production chain lengthens, and the system of division of labor keeps deepening. As is seen from the analysis of the evolution mechanism of production segmentation, the theory of Romero *et al*. (2009) considers the production process of enterprise as a combination of functions

(R&D, production, and marketing, etc.). The higher the technical level of an enterprise, more refined, modular and standardized the production functions are. Some stages of the production process are likely to be separated, that is, when the production technology reaches a certain level, it will cause "functional separation". The reduction of the trade costs thanks to liberation of trade policies, transportation, and information technology will cause "spatial separation" of products and redeployment of production spaces worldwide. "Functional separation" makes enterprises engage in high value-added processes such as R&D and design to a greater extent. Take Apple and Intel for example, such enterprises have relatively high product pricing rights and can acquire great trade benefits as they have technological monopoly. "Spatial separation" urges local enterprises to learn and imitate advanced production technologies and management practices of their parent companies, while transnational corporations reduce the marginal production cost and increase the cost markup pricing capability of local enterprises by means of technical R&D and cooperation and learning exchanges, etc. Based on the above analyses, we have put forward Hypothesis 1: If other conditions remain unchanged, the longer the length of production segmentation, the better for increase in enterprise markup.

The possibility and degree of production segmentation mainly depend on technology. As production technology keeps evolving, some production links are separated from other production links in enterprise, and it can save more costs than vertically integrated production, only in this way enterprises are likely to choose production segmentation (Hanson *et al*., 2005; Desai, 2009). The most direct way by which an enterprise chooses production segmentation is to make an impact on its productivity through a variety of channels. Amiti and Wei (2009) believe that enterprise productivity can be increased by enhancing the average output through the transfer of low-efficient production stages abroad ("static efficiency gain"), the transfer of production technology frontiers enables more efficient local production process ("recombination effect"), learning and improving production mode ("learning externality"), and the use of new and diversified elements ("diversification effect"). Based on the analyses of data of Irish firms, Görg *et al.* (2008) found that production segmentation has significantly enhanced the productivity and it is particularly so for export enterprises. On the one hand, the "learning effect" generated by enterprises' participation in the production segmentation enhances the productivity. Advanced technologies and management experience of transnational corporations can be gained through cooperation and exchanges among enterprises and circulations within transnational corporations, and it is helpful to reduce the marginal production cost; on the other hand, the "technical spillover effect" of participation in production segmentation also increases enterprise productivity. It works mainly through the forward linkage and backward linkage of vertical spillover. Transnational corporations increase the scope of intermediate products of enterprises in the

downstream industry by expanding the product category, increase the production efficiency of the enterprises, intensify competitions with the upstream industry, and reduce the market price of intermediate products, thereby reducing the production costs (Mao and Xu, 2016). According to this, we can see that the deepening production segmentation increases enterprises' production efficiency, while enterprise productivity further influences the marginal production cost (Melitz and Ottaviano, 2008), that is, the higher the productivity, the higher the production technology, the lower the marginal production cost, and the higher the markup. The following internal mechanism can be obtained: extension of production segmentation → enhancement of enterprise production technology→ reduction of enterprise marginal cost→ increase of enterprise markup. For this, we put forward the Hypothesis 2: The enterprise chooses a way of production segmentation, narrows the technical gap between enterprises and increases its level of markup, namely, there is a kind of "technological progress effect".

At the microscopic level, enterprise transforms capital, labor, raw materials and intermediate inputs into outputs through a series of functional combination in the production process. The nature of the extension of production segmentation is to functionally group the continuous stages of product R&D, manufacturing and marketing through internal trading and outsourcing. It is to a greater extent distributed in different enterprises and is completed through market transactions. Particularly, transregional selection of functional group is limited by trade costs (transportation, management, quality control). According to the results of theoretical analyses, on the one hand, given the cost of production factors, the enhancement of the level of specialized production can reduce the quantity of consumed factors; on the other hand, some production activities may also be transferred to countries or regions with lower costs, so that production in at least one link can be carried out by using low-cost elements (Liu, 2011). Although the enhancement of the technical level of an enterprise urges the enterprise to choose a way of production segmentation and may help it increase production efficiency and reduce production costs, such detailed division of labor means increased trade costs for the enterprise. The increase of trade costs will affect spatial separation of production links and production stages. It is mainly because that different production stages need follow-up service coordination and contacts after spatial separation, such as transportation and management, etc. Particularly, if a transnational corporation outsources some production links to foreign enterprises, it will be restricted by trade liberalization, transportation cost, management cost and organizational cost, etc. Therefore, the reduction of trade cost may help large-scale enterprises or transnational corporations redeploy their production links and stages and deploy their production spaces worldwide, so as to reduce their marginal production costs and increase their profitability. For this, we put forward Hypothesis 3: The way by which an enterprise chooses its production

segmentation is affected by trade cost, and the declining trade cost helps increase the enterprise markup.

3. Description of Research Design and Data

3.1. Setting of Measurement Model

In accordance with the above theoretical analyses and the research target of this paper, we set the basic measurement model as below so as to analyze the effects of production segmentation on the enterprise markup:

$$Markup_{ijt} = \alpha_0 + \alpha_1 psl_{mjt} + \theta_1 Z + \theta_2 \sum region + \theta_3 \sum indus + \theta_4 \sum year + \varepsilon_{ijt} \quad (1)$$

Wherein, i, j and t repesent enterprise, industry and year, respectively. $Markup_{ijt}$ represents enterprise markup. psl_{mjt} represents the number of m-type production stages in the 2-digit industry to which enterprise i belongs in the period t, of which $m \in \{\text{global}, \text{domestic}, \text{international}\}$.

Control variables: (1) Size of enterprise (*size*), it is measured by the logarithm of enterprise's sales volume. It is generally believed that the larger an enterprise is, the greater advantages it has in terms of economy of scale, production technology or external financing, and for this it can gain higher markup. Whether the effect exists needs to be tested through empirical study. (2) Age of enterprise (*age*), it is represented by the interval between the year of enterprise registration and establishment and the year of enterprise sample. (3) Corporate capital intensity (*ki*), it is measured by the logarithm of the specific value between the net value of fixed assets and enterprise employees after price deflation of the enterprise. Industries with higher capital intensity tend to have higher entry threshold, thereby resulting in less competitions and higher profitability. (4) Level of industrial competition (*compt*), this paper uses the logarithms of the number of enterprises in different (quartile) industries in different years as proxy variables. (5) Corporate financing support (*finance*), it is measured by the ratio between corporate interest expense and fixed assets. The higher the value, the larger the financing scale of the enterprise. (6) Per-capita wage (*wage*). Per-capita wage is a explicit index of employment of an enterprise, it reflects the human capital of an enterprise. Therefore, the increase in per-capita wage may increase enterprise markup. (7) Export density (*exp*), it is measured by the proportion of the export shipment value to the sales volume of an enterprise. Heterogeneous theory stresses that the "self-selection effect" makes high productivity enterprises enter the export market. From the perspective of a single country, enterprises take part in more international division of labor and achieve globalization of processing and production in the form of global value chain. The higher the export intensity of enterprise, the longer the number of

international production stages, and it may increase the enterprise markup. In addition, dummy variables such as "industry" and "year" are added to control fixed effect factors that have not been observed.

3.2. Measurement of Core Variables

3.2.1. Measurement of the Length of Production Segmentation

(1) Production segmentation in closed condition, index of the number of production stages in the global value chain measures the breadth and length of a country's participation in the global value chain. In accordance with the accounting framework of Fally (2012), assuming that the average number of production stages for production of product i is N_i, to measure the number of production links in the production process of product i, the value is the weighted value of the enterprise participating in the production of product i, namely $N_i = 1 + \sum_j a_{ji} N_j$. Wherein, a_{ji} represents that a_{ji} units of product j need to be directly consumed for production of one unit of product i, and its calculation relies on the direct consumption coefficient matrix ($[a_{ji}]$) in the input-output table. If it does not need any intermediate inputs to produce product i, the number of production stages N_i is equal to 1; if intermediate inputs are needed, the number of production stages N_i depends on the quantity of intermediate inputs and the number of production stages of relevant intermediate products. The matrix form is:

$$N = \left(I - A\right)^{-1} I \tag{2}$$

N represents the matrix of number of industrial production stages (n×1), I represents the unit matrix (n×1), A represents the n×n matrix of a_{ji}, while $(I–A)^{-1}$ is a Leontief inverse matrix. It is an input-output measurement based on a single country and is for analysis of the length of production segmentation of the country, while international production relationship needs to be measured on the basis of the global input-output model.

(2) Production segmentation under the global input-output model. Ni *et al.* (2016) defined the global production segmentation based on the framework of Fally (2012). The number of production stages of the industry i in country n, namely N_i^n [1] can be expressed as $N_i^n = 1 + \sum_{mj} a_{ji}^{mn} N_j^m$. The length of production segmentation of M sectors of N countries can be expressed as $N^T = U^T + N^T A = U^T \left(I - A\right)^{-1} = U^T B$. Wherein, $n, m \in \{1, 2 \cdots N\}$ represents different countries, T represents transposition,

[1] The superscript represents the country, while the subscript represents the industry.

and $B=(I-A)^{-1}$. Therefore, the number of production stages of country n is expressed below:

$$N^{nT}=u^{T}L^{nn}+u^{T}\left(\sum_{m\neq n}L^{nn}A^{nm}B^{mn}\right)+u^{T}\sum_{m\neq n}B^{mn} \tag{3}$$

N^{n} is the number of global production stages of country n, $u^{T}L^{nn}$ represents number of domestic production stages, and L^{nn} represents the local Leontief inverse matrix of country n. From the perspective of global trade, $u^{T}L^{nn}$ represents that there is no intermediate trade in country n, which does not import intermediate products from abroad. The final demand of country n gives rise to output increase of the country, which is consistent with the definition of the length of production segmentation in the closed condition of Fally (2012). Therefore, $u^{T}L^{nn}$ is called "number of domestic production stages".

$u^{T}\left(\sum_{m\neq n}L^{nn}A^{nm}B^{mn}\right)$ or $\sum_{m\neq n}B^{nm}A^{mn}L^{nn}$ represents the number of production stages of country n caused by the country's intermediate demands for overseas product production. Wherein, B^{nm} depicts the increase of the final products of country n leading to the increase of product output of country m. As is seen from the international input-output table, the production of final products of country n requires import of intermediate products from country m, meanwhile, the production of final products of country m requires import of intermediate products from country n. $L^{nn}A^{nm}B^{mn}$ brings the export of intermediate products with the output increase of country n. $u^{T}\left(\sum_{m\neq n}L^{nn}A^{nm}B^{mn}\right)$ indicates the trade mechanism by which products from different countries serve mutually as intermediate products. The higher the value of the item, the stronger the international trade representing intermediate products, the more frequent of the transactions among different countries, and the higher the number of production stages. $u^{T}\sum_{m\neq n}B^{mn}$ represents the increase of the product output of other countries caused by the production of final products in country m, as well as the existence of the international trade of intermediate products. Therefore, the two parts are collectively called "number of international production stages".

3.2.2. Measurement of Enterprise Markup

The practices of De Loecker and Warzynski (2012) (hereinafter referred to as the DLW method) are used for reference. The structural equation model is used to measure the markup of Chinese enterprises by estimating the production function and output elasticity. The advantages of the above measurements are: using Levinsohn and Petrin

(2003) semi-parametric estimation to reduce the deviation of markup estimation caused by unobservable factors, released returns to scale remain unchanged, and being independent of corporate investments.

3.2.3. Measurement of "Technological Progress Effect"

This paper, by referring to the analytical thinking of Aghion *et al.* (2005), measures and calculates technological progress effect $Techpro_{it}$ caused by knowledge spillover among enterprises when choosing the way of production segmentation. It is mainly an index for measuring the productivity gap between leading enterprises and other enterprises. Specifically, $Techpro_{ijm} = \left(TFP_{ijm} - TFP_{jm}^{\min}\right) \Big/ TFP_{jm}^{\min}$. TFP_{ijm} represents the total factor productivity (calculation by LP method) of enterprise i of industry m in region (city) j; TFP_{jm}^{min} represents the enterprise with the lowest total factor productivity in the industry m in region (city) j. It shows that the technical progress of the enterprise with the lowest productivity in the industry is 0, the higher the enterprise productivity, the greater the technological progress effect.

3.2.4. Measurement of "Trade Cost Effect"

The way of production segmentation is directly affected by technical advances, and the production links and stages are affected by trade cost. Particularly, for the spatial layout for production of large enterprises, to achieve spatial separation, product production is generally influenced by trade cost since it needs services of transportation, management and quality control to coordinate spatial transfer of products. In this paper, trade cost *Trade_cost* is calculated by the proportion of the industrial marketing expenses and management expenses to the industrial sales revenue.

3.3. Data Source and Processing Key Variables

The basic data in this paper are from the database of Chinese industrial enterprises between 1998 and 2011, covering enterprises with main business income (namely sales amount) exceeding RMB 5 million. By using the practices of Song and Wang (2020) as references, we have handled the problem such as sample matching disorder, abnormal variable size, and fuzzy definition of variable, etc., and cancelled enterprise markup larger than 10, less than 0 and missing value. There are a total of 2481667 observed values from 508081 enterprises in the adjusted database. The second data source is a WIOD database. The two databases have been combined in accordance with the 29 manufacturing industries determined by the method of two-category industry.

4. Estimated Results and Analyses

4.1. Production Segmentation and Enterprise Markup: Results of Benchmark Estimation

Table 1 summarizes the basic test results of the influence effects of global production segmentation, international production segmentation and domestic production segmentation on enterprise markup. Through the Hausman test result, the random effect model has been significantly rejected, so column (1)~(7) show the results of the fixed-effect model and use enterprise-level clustering robustness estimation to remove the heteroscedasticity problem of panel data. The column (1) of Table 1 shows the estimated results of all enterprise samples. Under the condition that a series of relevant influence factors are under control, the estimated coefficient of global production segmentation (*ppsl*) for enterprise markup is significantly positive. It indicates that if the enterprise takes part in more production links of the global value chain and the division of product production is more detailed, the deep global production segmentation can increase the enterprise markup to a greater extent. We pay more attention to the markup of Chinese enterprises. In consideration of the deviations of sample selectivity, we have re-estimated the markup of Chinese enterprises after removing foreign-funded enterprises from column (2) and foreign-funded enterprises and enterprises funded by investors from China Hong Kong, Macao and Taiwan from column (3). The results show that the global production segmentation has a significantly positive effect on the markup of Chinese enterprises. Whenever the global production segmentation increases by one unit, it will increase the level of markup by 0.196 units. It preliminarily supports the research hypothesis (1). The global production segmentation is further divided into international production segmentation (*pfpsl*) and domestic production segmentation (*pdpsl*). Column (4), column (5) and column (6) show their influences on the markup. Both international production segmentation and domestic production segmentation have significantly increased the cost markup pricing ability of Chinese enterprises. As is seen from the regression results of which the result of foreign-funded enterprises and enterprises funded by investors from China Hong Kong, Macao and Taiwan has been removed, the effect of the extension of domestic production segmentation on markup is greater than that of international production segmentation, whenever the domestic production segmentation increases by one unit, it will help markup increase by 0.131 units, whenever the domestic production segmentation increases by one unit, it will help markup increase by 0.185 units. To sum up, participation in global production segmentation promotes the markup of Chinese enterprises, and the effect of local enterprises taking part in domestic production segmentation on markup is much higher than that of them taking part in international production segmentation. That is, the above Hypothesis 1 has been validated.

Table 1. Production Segmentation and Enterprise Markup: Benchmark Regression

	(1)	(2)	(3)	(4)	(5)	(6)
	Global production segmentation			International production segmentation and domestic production segmentation		
Variable	All enterprises	Excluding foreign-funded enterprises	Excluding foreign-funded enterprises and enterprises funded by investors from China Hong Kong, Macao and Taiwan	All enterprises	Excluding foreign-funded enterprises	Excluding foreign-funded enterprises and enterprises funded by investors from China Hong Kong, Macao and Taiwan
ppsl	0.194*** (0.001)	0.196*** (0.001)	0.196*** (0.001)			
plv						
pfpsl				0.120*** (0.003)	0.133*** (0.003)	0.131*** (0.003)
pdpsl				0.183*** (0.001)	0.186*** (0.001)	0.185*** (0.001)
Control variable	Control	Control	Control	Control	Control	Control
Year, region and industrial effects	Control	Control	Control	Control	Control	Control
N	2405782	2165076	2157188	2405782	2165076	2157188
Hausman test	70589.85 *P* value<0.00	67647.96 *P* value<0.00	66852.37 *P* value<0.00	66653.45 *P* value<0.00	63714.05 *P* value<0.00	62863.90 *P* value<0.00
R^2	0.152	0.157	0.155	0.152	0.157	0.155

Note: The values within brackets represent the standard errors of cluster robustness at the enterprise level; ***, ** and * represent significance levels of 1%, 5% and 10%, respectively. All models are fixed-effect models with year, region and industrial effects under control.

4.2. Heterogeneity Analysis of Production Segmentation and Enterprise Markup

Next, we make analyses from the perspectives of productivity heterogeneity, industries with different technical densities, and enterprises with different systems of ownership. Table 2 shows the impacts of enterprise productivity heterogeneity and production segmentation of industries with different technical densities on enterprise markup. In column (1)~(4), whenever the global production segmentation extends by one unit, low productivity enterprises will increase enterprise markup by 0.242 units, while high productivity enterprises will only increase by 0.101 units, it shows that as the global production process becomes increasingly disperse and the division of labor becomes more detailed, the production chain extends at home and abroad, global production segmentation has a greater effect on increasing the markup of China's low-

productivity enterprises. As is seen from domestic and international division of labor, whenever enterprise participation in international production segmentation increases by 1 unit, low productivity enterprises will significantly increase markup by 0.244 units, while high productivity enterprises significantly increases markup by 0.035 units; whenever enterprise participation into domestic production segmentation extends by 1 unit, low productivity enterprises will significantly increase markup by 0.237 units, and high productivity enterprises will significantly increase markup by 0.092 units. It indicates that the more Chinese low-productivity enterprises participate in international division of labor and domestic division of labor, the higher the markup will be. Particularly, it has an obvious effect for low-productivity enterprises to take part in international division of labor. While the effect of high-productivity enterprises taking part in domestic and international division of labor on markup increase is much lower than that of low-productivity enterprises, the effect of high productivity enterprise taking part in domestic division of labor is higher than that taking part in international division of labor.

Table 2. The Heterogeneity Analysis of Production Segmentation for Enterprise Markup

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High productivity enterprise		Low-productivity enterprise		Hi-tech industries		Low-tech industries	
	Mol1	Mol2	Mol3	Mol4	Mol5	Mol6	Mol7	Mol8
ppsl	0.101***		0.242***		0.218***		0.173***	
	(0.001)		(0.001)		(0.001)		(0.001)	
pfpsl		0.035***		0.244***		0.141***		0.142***
		(0.005)		(0.005)		(0.004)		(0.006)
pdpsl		0.092***		0.237***		0.207***		0.166***
		(0.001)		(0.001)		(0.001)		(0.001)
exp	−0.003***	−0.003***	−0.008***	−0.008***	−0.006***	−0.005***	−0.006***	−0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
compt	−0.060***	−0.057***	−0.101***	−0.101***	−0.098***	−0.094***	−0.105***	−0.105***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Other variables	Control	Control	Control	Control	Control	Control	Control	Control
Year, region and industrial effects	Control	Control	Control	Control	Control	Control	Control	Control
N	1083646	1083646	1081430	1081430	1102692	1102692	1186281	1186281
R^2	0.054	0.054	0.251	0.251	0.171	0.171	0.142	0.143

Note: The values within brackets represent the standard errors of cluster robustness at the enterprise level; ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively; all models are fixed-effect models of control year, region and industrial effects and have passed Hausman effect test; other control variables are the same as that in Table 1, and the results are available on request.

Column (5)~(8) show the information on hi-tech industries and low-tech industries. Specifically, *ppsl, pfpsl* and *pdpsl* are significantly positive at the statistical level of 1%,

whenever 1 unit is increased, enterprise markup of low-tech industries will increase by 0.173 units, 0.142 units and 0.166 units, respectively. The possible reason for this is that China has become a "big manufacturing country" and "production plant" after it integrates into the global value chain, while enterprises participating in international division of labor are mostly in low-technology labor-intensive industries. However, for a long time, Chinese enterprises, by relying on their "demographic dividend" of lower labor cost, facilitate themselves to extend forward or backward the industrial chain to maintain their market positions and acquire higher profits. The enterprise markup of hi-tech industries has been increased by 0.218 units, 0.141 units and 0.207 units, respectively. It shows that hi-tech enterprises are much better than low-tech enterprises in terms of extension of the global industrial chain, increase in the level of industrial division, and the level of promoting the increase of markup. Hi-tech enterprises have obvious advantages in domestic industrial division mainly because such enterprises pay more attention to technical innovations, keep making investments in R&D, and make joint efforts for R&D and innovation activities. Their relations become more and more complicated, the number of production stages of products increases, the production chain of products lengthens and increases the production efficiency, and enterprises have obtained higher profit.

Next, we divide enterprises into export enterprise and domestic-oriented enterprises and recheck SOEs and private enterprises, as shown in Table 3. There is a phenomenon that needs special attentions, that is, the "selection effect" of Chinese high productivity enterprises has not been brought out, and there is a long-standing "productivity paradox". The reality is that there is an obvious "competition effect" in the export market, and the export enterprises fall in the "low markup trap" (Liu and Huang, 2015) as the "competition effect" of the export market is larger than "selection effect". As is seen from the estimated results of export enterprises and domestic-oriented enterprises in column (1) and column (3), both the extensions of production segmentation of export enterprises and domestic-oriented enterprises significantly increase the markup level. Export enterprises take part in the international market, while domestic-oriented enterprises mainly take part in the division of labor of the domestic chain value. In order to more accurately analyze the production segmentation effect of the two types of enterprises, the results of column (2) and column (4) show that the extension of international production segmentation of export enterprises is significantly positive for the estimated coefficient of markup, while the extension of domestic production segmentation of domestic-oriented enterprises is also significantly positive for the estimated coefficient of markup. Another key variable is market competition *comp*. It can be found that the estimated coefficients of market competitions of both domestic enterprises and international enterprises are significantly negative. It indicates that the greater the "competition effect" in the domestic and international markets, the markup of export enterprise and domestic-oriented enterprises will be restrained to a greater

extent. For a long time, export enterprises rely more on the cost advantages of low-level elements, and take part in international division of labor by means of production and processing. The extension of the low-productivity enterprises taking part in the division chain has offset the low markup caused by "competition effect" to a certain extent; as it evolves, the comparative advantage of a strong domestic market has formed on the basis of ultra-large country, thereby further creating the competitive advantages of scale production, low cost, refined & specialized division of labor, and independent innovation, etc. Domestic-oriented enterprises continue to extend their production segmentation, increase the markup and offset the adverse impact of "competition effects" in the domestic market, in other words, the extending production segmentation has avoided or restrained from falling into the "low markup trap".

As is seen from the estimated results of column (5) and column (7), the estimated coefficients of international production segmentation and domestic production segmentation are significantly positive in private enterprises. Although domestic production segmentation is significantly positive, the coefficients of international production segmentation of SOEs are significantly negative. It indicates that SOEs and private enterprises take part in labor division of the global value chain, extend the production chain, significantly enhance their markup, and private enterprises have a more obvious effect.

Table 3. Heterogeneity Analysis of Production Segmentation and Enterprise Markup

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Export enterprise		Domestic-oriented enterprises		SOEs		Private enterprise	
	Mol1	Mol2	Mol3	Mol4	Mol5	Mol6	Mol7	Mol8
ppsl	0.119***		0.189***		0.097***		0.199***	
	(0.002)		(0.001)		(0.004)		(0.001)	
pfpsl		0.265***				−0.025**		0.171***
		(0.005)				(0.010)		(0.004)
pdpsl				0.157***		0.092***		0.193***
				(0.001)		(0.004)		(0.001)
exp	−0.072***	−0.073***	0.021***	0.027***	−0.003***	−0.003***	−0.006***	−0.006***
	(0.000)	(0.000)	(0.003)	(0.003)	(0.001)	(0.001)	(0.000)	(0.000)
compt	−0.064***	−0.053***	−0.080***	−0.073***	−0.036***	−0.031***	−0.103***	−0.102***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Other variables	Control	Control	Control	Control	Control	Control	Control	Control
Year, region and industrial effects	Control	Control	Control	Control	Control	Control	Control	Control
N	546094	546094	1618982	1618982	248151	248151	1909037	1909037
R^2	0.195	0.189	0.098	0.096	0.025	0.026	0.178	0.178

Note: the same as Table 2.

4.3. Robustness Analysis

Previous studies have proved that R&D intensity, capital intensity and high proportion of technical labor have a significant relationship with production segmentation (Ni *et al*., 2016). Therefore, enterprises with high markup have an effect on division of labor, causing difference in the number of industrial production stages. Enterprises with higher number of production stages or relatively complicated division of labor may obtain higher profits, thus explaining the endogeneity problems caused by the possible reverse causality between explanatory variables and explained variables. In order to reduce endogeneity, on the one hand, we use different econometric methods to increase the robustness of results; on the other hand, we try to look for instrumental variables of number of production stages. It needs to meet the following two conditions: the instrumental variable is highly related to China's number of production stages; instrumental variable does not directly influence the markup of Chinese enterprises. Based on the above considerations, we select production segmentation of Brazil, India, Japan and South Korea as instrumental variables of China's production segmentation. The numbers of production stages of the four countries are calculated in accordance with the inputs and outputs of the respective countries. There are no necessary relationship between this and the markup of Chinese enterprises, namely meeting the requirements on strict exogeneity. Specifically, Japan is geographically adjacent to China, while Brazil and China are members of the BRICS. As an important emerging market, its import & export volume keeps rising. The trade relevancy of the four countries is closely related to China's production segmentation, namely meeting the condition of being highly related to explained variables. Table 4 shows estimation by means of the IV-2SLS model. In column (1), (3) and (5), *F* values of Stage 1 have passed the test. All the estimation coefficients of column (2), (4) and (6) are significantly positive. It indicates that as enterprises continue to take part in international division of labor in a more detailed way, the enterprise markup keeps rising. Therefore, the instrumental variable method has further validated the robustness of all conclusions made in this paper.

Table 4. Robustness Analysis: Instrumental Variable Method

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Stages 1	Stages 2	Stages 1	Stages 2	Stages 1	Stages 2
	ppsl	*Markup*	*pfpsl*	*Markup*	*pdpsl*	*Markup*
ppsl	0.108***	0.108***				
	(0.001)	(0.031)				
pfpsl			0.378***	0.024***		
			(0.001)	(0.009)		
pdpsl					0.042***	0.203**
					(0.001)	(0.098)

Variable	(1) Stages 1 *ppsl*	(2) Stages 2 *Markup*	(3) Stages 1 *pfpsl*	(4) Stages 2 *Markup*	(5) Stages 1 *pdpsl*	(6) Stages 2 *Markup*
exp	−0.000 (0.000)	−0.004*** (0.000)	0.000*** (0.000)	−0.004*** (0.000)	−0.000*** (0.000)	−0.004*** (0.000)
compt	0.005*** (0.000)	0.002*** (0.001)	0.000*** (0.000)	0.003*** (0.001)	0.003*** (0.000)	0.002*** (0.001)
Other variables	Control	Control	Control	Control	Control	Control
Year, region and industrial effects	Control	Control	Control	Control	Control	Control
N	2080891	2080891	2080891	2080891	2080891	2080891
F	27399.50	35314.5	46883.98	35337.2	2418.37	35327.39

Note: The values within brackets represent the standard errors of robustness; ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively; the instrumental variables in column (2) and column (4) use the Japanese number of production stages, while instrumental variables in column (6) use the Indian number of production stages; the weak instrumental variable test is carried out when instrumental variables are used for regression, and the Cragg Donald Wald *F* statistic is much larger than the critical value (5%) of Stock-Yogo weak instrumental variable.

5. An Analysis of the Mechanism of Influence of Production Segmentation on Enterprise Markup

5.1. Setting of Mediating Effect Model

The above regression models have effectively solved endogenous problems that production segmentation influences markup, and preliminarily discussed the relationship between production segmentation and markup. This paper uses a mediating effect model to effectively identify its internal mechanism, so as to test the impacts of production segmentation on enterprise markup through the transmission mechanisms of "technological progress effect" and "trade cost effect". Specifically:

$$Markup_{ijt} = \alpha_0 + \alpha_1 psl_{mjt} + \theta_1 Z + \theta_2 \sum region + \theta_3 \sum indus + \theta_4 \sum year + \varepsilon_{ijt} \quad (4)$$

$$X = \beta_0 + \beta_1 psl_{mjt} + \eta_1 Z + \eta_2 \sum region + \eta_3 \sum indus + \eta_4 \sum year + \varepsilon_{ijt} \quad (5)$$

$$Markup_{ijt} = \gamma_0 + \gamma_1 psl_{mjt} + \gamma_2 \sum X + \phi_1 Z + \phi_2 \sum region + \phi_3 \sum indus + \phi_4 \sum year + \varepsilon_{ijt} \quad (6)$$

Wherein, $X = \left\{ Techpro_{ijt}, Trade\_cost_{ijt} \right\}$

5.2. The Impact Mechanism of "Technological Progress Effect"

As is seen from the regression result of number of global production stages,

the regression coefficient of *ppsl* in column (1) is significantly positive, and *pfpsl* and *pdpsl* in column (4) are significantly positive, indicating that the extension of global production segmentation, international production segmentation and domestic production segmentation has significantly increased the enterprise markup. Therefore, the mediating effect may continue. Column (2) shows the influence of *ppsl* on the mediating variable *Techpro*, the regression coefficient is significantly positive, and the estimation coefficients of *pfpsl* and *pdpsl* in column (5) are also significantly positive, indicating that the extension of production segmentation can help promote technical advances of enterprises. The main reason for this is shown below. On the one hand, before the outbreak of the global financial crisis, China has long been plagued by insufficient domestic demand, however, the demand of the export market remains robust, causing a number of enterprises to enter the export market. The price cut of low-cost and high-subsidies export enterprise causes higher "competition effect". In the post financial crisis era, a strong domestic market has formed on the basis of ultra-large country, the increased market competitions at home and abroad help enhance the R&D activities and the capability of independent innovation of enterprises, further created the competitive advantages of scale production, low cost, refined & specialized division of labor, and independent innovation, etc. On the other hand, as China's industrial structure improves, foreign investment in China and Chinese investment overseas further increase, production technology, communication technology and transport technology develop rapidly, enterprises take part in production segmentation to a greater extent and strengthen ties among them. By means of the "learning effect", enterprises learn advanced technologies and management practices so as to enhance their learning and innovation abilities, make technical progresses and increase profitability. Column (3) and column (6) show the results of dependent variables for basic independent variables and mediating variables. All the estimation coefficients of the intermediate variable *Techpro* are significantly positive, indicating that technical progress can significantly increase the enterprise markup. It is mainly because that as enterprises keep making technological progress, they continue to improve their technological progress of production and increase product quality. As a result, the features and functions of their products become richer, the increased product quality increases the consumption demands and the enterprise's monopoly capability, thereby the enterprise can ensure that the price is at a relatively high level. According to the results of further analyses, compared with the estimated results of the benchmark groups in column (1) and column (4), the estimated coefficient value of global production segmentation has dropped from 0.183 to 0.178, the estimated coefficients of international production segmentation and domestic production segmentation have dropped from 0.148 and 0.177 to 0.122 and 0.169, respectively, and the estimated coefficients of independent variables with added mediating variables have passed the significance test. It preliminarily shows the existence of "technological progress effect", namely the Hypothesis 2 of this paper has been validated.

Table 5. The "Technological Progress Effect" of Production Segmentation on Enterprise Markup

Variable	(1) *Markup* Mol1	(2) *Techpro* Mol2	(3) *Markup* Mol3	(4) *Markup* Mol4	(5) *Techpro* Mol5	(6) *Markup* Mol6
ppsl	0.183*** (0.001)	0.026*** (0.000)	0.178*** (0.001)			
pfpsl				0.148*** (0.004)	0.103*** (0.001)	0.122*** (0.004)
pdpsl				0.177*** (0.001)	0.032*** (0.000)	0.169*** (0.001)
Techpro			0.192*** (0.004)			0.198*** (0.004)
Control variable	Control	Control	Control	Control	Control	Control
Year, region and industrial effects	Control	Control	Control	Control	Control	Control
N	1662282	1662282	1662282	1662282	1662282	1662282
R^2	0.177	0.099	0.179	0.177	0.104	0.179

Note: the same as Table 2.

5.3. Analysis of Enterprise "Trade Cost Effect" and "Dual Effect"

Table 6 shows the test results of "trade cost effect" and "dual effect" of production segmentation. Column (1) and column (4) show the estimated results with trade cost *Trade_cost* as outcome variables. From the columns we can see that the estimated coefficients of the number of global production stages, the number of international production stages and the number of domestic production stages are significantly negative. It indicates that the extension of enterprise production segmentation significantly reduces the trade cost among enterprises. Through further analyses, we find that, compared with the extension of domestic production segmentation, that of international production segmentation has lower trade cost. It is mainly because that, as the relationship among economic entities become more complicated, the number of production stages becomes larger, and the product production chain becomes longer, inter-product division of labor shifts to intra-product trade, enterprises in different areas operate by using their advantages of factor cost, and the division of labor becomes more detailed and specialized. Such an organizational form has greatly reduced the trade cost among enterprises. From column (2) and (5) we can see that the coefficients of the *Trade_cost* variable are significantly negative, it indicates the reduction of trade cost among enterprises can effectively enhance the markup level of enterprises. It is mainly because that in the process of division of labor, enterprise's marginal cost is subject to its factor cost and trade cost among enterprises. When the trade cost declines and thus lowering the marginal cost, the price remains unchanged or at a higher level,

and the enterprise markup keeps rising. In column (3) and (6), *Techpro* and *Trade_cost* are added, and the estimated coefficient of *Techpro* is significantly positive, and the estimated coefficient of *Trade_cost* is significantly negative. We also find that, after the addition of mediating variables, the estimated coefficient value and significant levels of the number of global production stages *ppsl* (column 3 of Table 5 and column 2 of Table 6), the number of international production stages *pfpsl* and number of domestic production stages *pdpsl* (column 6 of Table 5, column 5 of Table 6) decline compared with those of the benchmark group (column 1 and 4 of Table 5). It indicates the existence of the mediating effects of "technological progress effect" and "trade cost effect". After mediating variables *Techpro* and *Trade_cost* (column 3 and 6 of Table 6) are added, the estimated coefficient values of the number of global production stages *ppsl*, the number of international production stages *pfpsl* and the number of domestic production stages *pdpsl* decline. It further indicates that the extension of production segmentation increases the enterprise markup by means of technical advances and reduction of trade cost. It has proved the Hypothesis 3 of this paper.

Table 6. The "Trade Cost Effect" and "Dual Effect" of Production Segmentation on Enterprise Markup

Variable	(1) *Trade_Cost* Mol1	(2) *Markup* Mol2	(3) *Markup* Mol3	(4) *Trade_Cost* Mol4	(5) *Markup* Mol5	(6) *Markup* Mol6
ppsl	−0.015*** (0.000)	0.165*** (0.001)	0.167*** (0.001)			
pfpsl				−0.055*** (0.000)	0.065*** (0.003)	0.044*** (0.004)
pdpsl				−0.019*** (0.000)	0.152*** (0.001)	0.151*** (0.001)
Trade_cost		−1.376*** (0.009)	−1.388*** (0.009)		−1.415*** (0.009)	−1.430*** (0.009)
Techpro			0.048*** (0.003)			0.059*** (0.003)
Control variable	Control	Control	Control	Control	Control	Control
Year, region and industrial effects	Control	Control	Control	Control	Control	Control
N	2119349	2119349	2074079	2119349	2119349	2074079
R^2	0.093	0.171	0.176	0.103	0.171	0.177

Note: the same as Table 2.

6. Conclusion and Enlightenment

The product pricing capability of Chinese enterprises reflects the competitiveness of the enterprises in the global value chain system and is an important research topic for Chinese scholars. Research findings show that: larger number of production

stages and longer production chain can significantly increase the markup of Chinese enterprises; from the perspective of enterprise heterogeneity, the way by which an enterprise chooses a global production segmentation has an obvious effect on increase the markup of low productivity enterprises. It is particularly so when low-productivity enterprises take part in international division of labor. The effect of high productivity enterprise taking part in domestic division of labor is higher than that taking part in international division of labor. As is seen from industrial & technical heterogeneity, hi-tech enterprises is much higher than low-tech enterprises in terms of extension of global industrial chain, increase in industrial division, and enhancement of enterprise markup; the "competition effect" in the domestic and international markets restrains the markup of export enterprises and domestic-oriented enterprises; SOEs and private enterprises take part in labor division of the global value chain, which significantly enhances the enterprise markup. In the end, we have validated that "technological progress effect" and "trade cost effect" are two possible channels for enterprise markup increase by lengthening the production chain, these findings offer a new perspective for Chinese enterprises to get rid of the "low markup trap".

From this paper we can draw the following inspirations. First, create an environment for Chinese enterprises to take part in global production segmentation and create necessary support conditions for China's manufacturing industry to increase its status in the global value chain, of which export structure and the R&D in production are very important environmental factors. Second, enterprises intensify their efforts in innovation by taking part in division of labor in the global value chain, actively absorbing innovative resources through forward linkage and backward linkage, keeping increasing their product quality and offering more competitiveness, and increasing their profitability. Third, cost, particularly labor cost is a key factor for driving international division of labor, forcing Chinese enterprises to speed up to shift to high-end and high-technology fields, conduct more specialized production, focus on production of complicated products with higher R&D and technical capabilities, seek to enhance production quality, innovation ability and differentiated competitive abilities, and further recreate the advantages of Chinese enterprises in international competitions.

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