Production Chain Length and PPI-CPI Divergence: Analysis Based on the Global Input-output Price Model

Ni Hongfu[1,2], Yan Bingqian[3*], Wu Liyuan[4]

[1] School of Economics, University of the Chinese Academy of Social Sciences (UCASS), Beijing, China
[2] Institute of Economic Research, Chinese Academy of Social Sciences (IE-CASS)
[3] National Academy of Economic Strategy, CASS (NAES-CASS)
[4] Institute of World Economics and Politics, CASS (IWEP-CASS)

Abstract: *Productivity and international energy price shocks are reflected in PPI and CPI via industrial chains. China's in-depth participation into the global value chains has increasingly lengthened its industrial production chains. The question is how the changing length of production chains will affect CPI and PPI, as well as CPI-PPI correlation? By constructing a global input-output price model, this paper offers a theoretical discussion on the impact of production chain length on the CPI-PPI divergence. Our findings suggest that the price shock of international bulk commodities has a greater impact on China's PPI than that on CPI. The effects on both China's PPI and CPI estimated by using the single-country input-output model are higher than the results estimated with the global input-output model. However, the difference between CPI and PPI variations estimated with the global input-output model is greater than the result estimated with the single-country input-output model, which supports the view that the lengthening of production chains, especially international production chains, leads to a divergence between CPI and PPI. Empirical results based on cross-national panel data also suggest that the lengthening of production chains has reduced the CPI-PPI correlation for countries, i.e. the lengthening of production chains has increased the PPI-CPI divergence. That is to say, policymakers should target not just CPI in maintaining price stability, but instead focus on the stability of both PPI and CPI. Efforts can be made to proactively adjust the price index system, and formulate the industrial chain price index.*

Keywords: *Global value chains, length of production chains, consumer price index, producer price index*

JEL Classification Code: C67

DOI: 10.19602/j.chinaeconomist.2024.05.04

1. Introduction

In recent years, there has been a divergence between China's consumer price index (CPI) and producer price index (PPI), both of which are inflation indicators[1]. Prior to 2008, China's PPI and CPI

* CONTACT: Yan Bingqian, email: yanbingqian2018@126.com.

Acknowledgement: This paper is the result of the Special Project of the National Science Foundation of China (NSFC) "Open Development of China's Trade and Investment: Basic Patterns, Overall Effects, and the Dual Circulations Paradigm" (Grant No. 72141309); NSFC General Project "GVC Restructuring Effect of Emergent Public Health Incidents: Based on the General Equilibrium Model Approach of the Production Networks Structure" (Grant No. 72073142); NSFC General Project "China's Industrialization Towards Mid- and High-End Value Chains: Theoretical Implications, Measurement and Analysis (Grant No. 71873142); the Youth project of The National Social Science Fund of China "Research on the green and low-carbon development path and policy optimization of China's foreign trade under the goal of 'dual carbon'" (Grant No. 22CJY019).

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

followed consistent trends of change, showing a smooth two-way transmission. Since 2008, there has been divergence between the two, with a declining correlation. Since 2011, there has been a decrease in correlation and even an opposite movement between China's PPI and CPI. Over the past decade or so, this divergence has culminated three times without showing any signs of abating. The first lasted from the second half of 2011 to early 2016, when China's PPI steadily fell while the CPI climbed marginally, moving in opposite directions for up to four years. In the second phase of divergence, which lasted about a year, China's PPI began to dip between mid-2019 and the end of 2020, but CPI continued to rise. In the ongoing round of divergence that began at the end of 2020, China's PPI surged at first before collapsing amid high volatility caused by the global pandemic, geopolitical conflict, and price volatility of bulk commodities, in contrast to slow CPI increase (Figure 1).

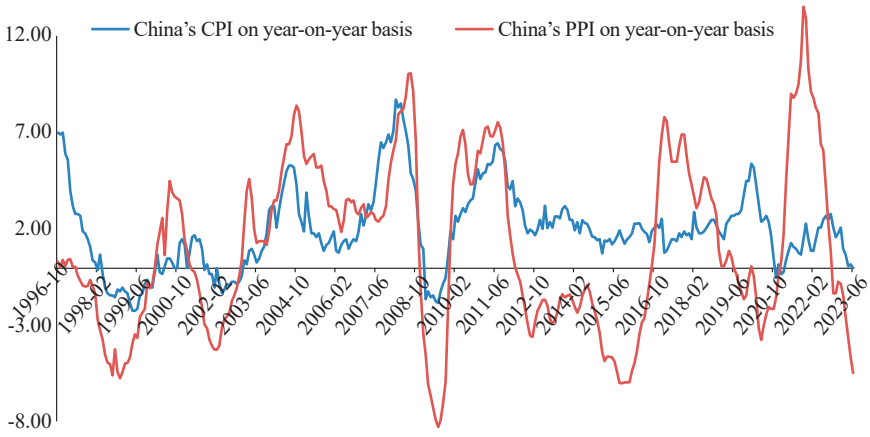

Figure 1: China's Monthly PPI and CPI Growth Rates since 1996

Source: Wind database.

PPI and CPI are two price indices that measure inflation. In general, PPI reflects price changes in relatively upstream products in the manufacturing chain, whereas CPI reflects price changes in downstream final consumer goods and services. In theory, price increases for upstream items ought to be reflected in downstream final products via the cost transmission, resulting in a largely constant trend between PPI and CPI. As a result, the long-term disparity between CPI and PPI appears to be contrary to economic theories, giving rise to the "myth of PPI-CPI divergence". From a theoretical and practical standpoint, the divergence and deviation between CPI and PPI not only complicates how to determine the overall pricing trend and economic situation, but also poses obstacles to macroeconomic policymaking. Inflation is a key indicator for the central bank's monetary policy implementation and response. Maintaining relative stability of the PPI and CPI within a tolerable range is a key goal of the central bank's monetary policy. When CPI and PPI change in the same direction, causing the price level to fall, the central bank may soften monetary policy to support PPI and CPI; when the price level rises too quickly, the central bank may tighten monetary policy to bring PPI and CPI down at the same time. Nevertheless, a predicament arises for conventional monetary policy when the PPI and CPI divergence becomes the norm.

[1] There is no clear definition or criterion for divergence and deviation between PPI and CPI. Divergence between PPI and CPI in this paper refers to the correlated decreases of the two, i.e., the difference between PPI and CPI continues to increase despite changes in PPI and CPI in the same direction over the same period of time with a decreasing positive correlation; deviation means the opposite symbols of year-on-year PPI and CPI growth rates, i.e., change in the opposite direction, which is an extreme situation.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

With the expanding global division of labor, the importance of intermediate inputs has progressively increased in contrast to labor and capital inputs, as has the relevance of PPI compared to CPI. Global economic integration has resulted in production segmentation, which has received a great deal of interest in the domain of international trade and been given various labels such as "slicing the value chains" (Krugman, 1995), "delocalization" (Leamer, 1996), "disintegration of production" (Feenstra and Hanson, 1999), "intra-mediate trade" (Antweiler and Trefler, 2002), and "lengthening of production" (Antras et al., 2012; Wang et al., 2017). After 2001, in particular, a sharp increase in the share of trade in intermediate inputs strongly underscored the phenomenon of production segmentation (Hummels et al., 2001; Koopman et al., 2014). Rapid developments in science and technology, combined with reducing trade costs, have resulted in continual refinements to production chains (Fort, 2016). According to Ni et al. (2016), there has been a lengthening of the global production segmentation, with China's production segmentation showing a notable increase in length. The rise of the global division of labor will influence how international price volatility influences prices in China, resulting in a systematic impact on PPI and CPI. As such, the length of the production chain provides insight into the causes of the current PPI-CPI divergence and serves as the basis for monetary policy adjustments.

Did the lengthening of China's production chains contribute to the PPI-CPI divergence? Theoretically, an increase in the share of foreign intermediate inputs will increase the price volatility of international intermediate inputs (such as energy, minerals, and other international bulk commodities) as overseas production chains lengthen, resulting in more complex effects on domestic producer prices and affecting PPI and CPI. On the other hand, changes in the domestic consumption structure of final consumer products will alter the composition and weights of a basket of commodities used in PPI and CPI calculations. For example, a rise in the proportion of foreign intermediate inputs for domestic production can have an uncertain impact on the CPI-PPI correlation, despite the modest weight of foreign inputs in a basket of final consumer goods. In this paper, we develop a global input-output price model to simulate the potential effects of international price volatility on China's PPI and CPI, and then compare such impacts across years using the international input-output structure to provide a theoretical examination of the impact of global production chain length on the CPI-PPI correlation. Furthermore, actual statistics are used to conduct an empirical investigation of the subject. Our investigation led to the following conclusions: The CPI-PPI correlation has weakened as global supply chain division of labor has deepened; the empirical results are consistent with model simulation results, i.e. the responses of China's PPI and CPI to the exogenous price shock of international intermediate inputs have decreased by 1% since 2001, and the response of CPI has decreased much more significantly than PPI.

Compared to the existing research literature, this paper makes the following marginal contributions: (i) Extending the single-country input-output price model to the global input-output model, as well as explaining the multiple transmission and mechanisms by which price volatility in one nation influences price volatility in another. (ii) Theoretically and empirically analyzing the impact of production chain length on the CPI-PPI divergence, with an explanation of the reasons for the PPI-CPI divergence from a new perspective of production chains, and providing empirical justification for the formulation of optimal monetary policy based on the inflation target. The optimal monetary policy based on PPI and CPI targets should fully account for production chain structure and international trade characteristics. (iii) Introducing a new approach and domain to the growing academic literature on global value chains. Different from the existing research literature which mainly focuses on the measurment or welfare effect of GVCs (Hummels et al., 2001; Yi, 2010; Johnson and Noguera, 2012; Ramondo and Rodriguez Clare, 2013; Koopman et al., 2014; Ni, 2016; Ni et al., 2016; Ni, 2017; Ni and Wang, 2022), this paper investigates how GVCs influence CPI and PPI, as well as their implications for monetary economics.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

The rest of this paper is organized as follows: Section 2 presents stylized facts about CPI and PPI, as well as a literature review. Section 3 elaborates on the global input-output price model. Section 4 includes a simulated analysis of the potential impact of international price volatility on PPI and CPI, as well as a comparative analysis using the global input-output price model. Section 5 is the empirical analysis using actual data. Section 6 provides conclusions and policy recommendations.

2. Stylized Facts and Literature Review

2.1 Myth of China's PPI-CPI Divergence since 1996

In this paper, we will calculate the PPI-CPI correlation coefficients throughout several time periods to better understand how the CPI-PPI correlation has changed[2]. From January 1997 to December 2007, China's monthly PPI-CPI correlation coefficient was 0.74; from January 2008 to December 2018, it was 0.61, with a decrease of 0.13. The correlation coefficient estimates for various time periods all indicate that China's PPI-CPI correlation (synchronicity) has generally decreased with the exception of a brief uptick over the two or three years following 2009. One possible explanation is that the PPI-CPI synchronicity resulted from the combined effects of international and domestic expansive counter-cyclical policies. The global financial crisis of 2008 was followed by a brief decline in international trade, particularly trade in intermediate inputs. In estimating the length of global production segmentation, Ni et al. (2016) observed that China's international production segmentation had generally lengthened, with the exception of a short setback after 2009. This phenomenon is divergent with the trend of change in the CPI-PPI correlation coefficient. The length of production segmentation in Figure 2 and the PPI-CPI correlation coefficient shows a very divergent trend.

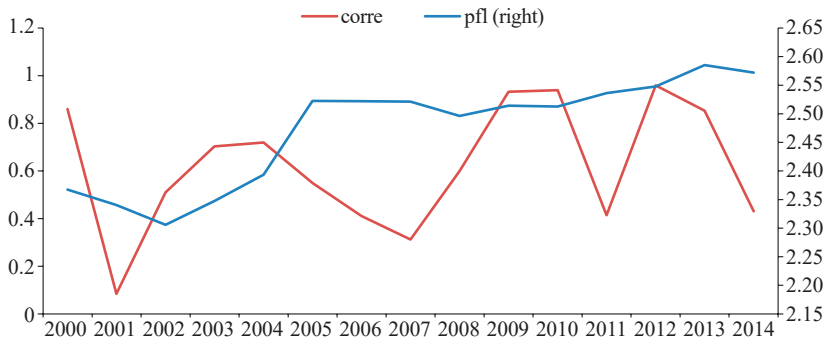

Figure 2: Change in the Length of Production Segmentation and the PPI-CPI Correlation Coefficient between 2000 and 2014

To explain this phenomenon, Wei and Xie (2019) developed a general equilibrium model for multistage production to theoretically demonstrate that discrepancies in PPI and CPI responses to technological shocks in the first stage led to an additional deviation between CPI and PPI. They also used cross-national data to empirically assess the decrease in the sensitivity coefficients of CPI and PPI to the productivity (price) shock, which revealed an divergence between CPI and PPI. Their empirical approach used the length of production segmentation (upstreamness) calculated with the World Input-Output Tables (WIOTs) to represent the number of production stages. However, since the theoretical model does not account for the input-output correlation (sectoral outputs are utilized as both intermediate and final

[2] Detailed information is available on the website of *China Industrial Economics* (http://ciejournal.ajcass.org).

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

products), the number of production stages differs from that computed using the WIOTs. As a result, the length of production segmentation used in econometric empirical study is simply an approximation of the theoretical model's number of production stages.

Hence, this paper performs a simulated analysis of the potential impact of the price shock of international bulk commodities using the global input-output price model. It conducts a simulation and comparative analysis of differences in the international price shocks to CPI and PPI under different production networks structures based on the global input-output tables between 2000 and 2014, so as to uncover how changes in the production networks structure transform the way and degree in which international price shock influences CPI and PPI. That is, whether there is any change in the response of CPI and PPI to the increasing length of production chains, and whether there is any decrease in the CPI-PPI correlation coefficient. The production process created in Wei and Xie's (2019) model is a multistage production function in the snake chain form, which does not take into account the mutual network relations (intermediate inputs provided to each other) between enterprises or industries. In comparison, such network relations are reflected in the global input-output model. As one of this paper's innovations, our global input-output price model is intrinsically different from Wei and Xie's (2019) theoretical model. As another important innovation, this paper employs the PPI and CPI statistics of various countries, as well as the production segmentation lengths estimated by Ni et al. (2016) and Ni and Wang (2020), for an econometric empirical analysis of how PPI and CPI respond to the length of production segmentation.

2.2 Literature Review

This paper is closely related to the following two strands of research literature: first, research literature concerning the input-output price model; second, research literature explaining the reasons behind the CPI-PPI divergence.

With respect to the relevant research on the input-output price model, the classical input-output price model has extensive applications in China[3]. For instance, Ren et al. (2007) employed the input-output price model to estimate the impact of change in crude oil price on China's overall and sectoral price levels. Utilizing the single-country input-output price model, Lin and Wang (2009) simulated the degree of a general price increase resulting from an energy price increase. Ni and Yan (2021) analyzed the price effect of tax cuts and fee reductions using the input-output price model taking the cost transmission ratio into consideration. However, those studies are all based on the single-country input-output model without considering the fact that an international price change not only causes a price change of China's imported intermediate inputs, thereby affecting the overall price level, but also indirectly affects China's price level through its impact of the price levels of third countries. In examining the PPI and CPI effects of exogenous shocks, policymakers should pay attention to the linkages between domestic industries and industrial chain linkages among countries (Ni et al., 2018). In addition, those global input-output price models have yet to be utilized to investigate the relationship between industrial chain analysis and China's PPI-CPI divergence, which will be discussed in this paper.

The second strand of literature gives explanations on the reasons behind the PPI-CPI divergence. The divergence and deviation between China's PPI and CPI have been extensively researched and explained from the following four perspectives.

First, changes in industrial or product structure. This sub-strand of literature stresses the impacts of

[3] The classical input-output price model has two basic assumptions: First, demand effect is not taken into account: the price effect estimated with the input-output price model follows a cost-driven approach without considering the price pulling effect of change in demand. This model estimates the quantitative price effect from a supply-side perspective under the transmission effect of the upstream and downstream relations between the input-output coefficient and industrial chains. Second, the price effect is instantly transmitted through industrial chains without considering the time lag and impediments to transmission. Under this assumption, the rising cost as a result of price increase creates a ripple effect, i.e. the price effect is unimpeded and fully transmitted. Given the complete transmission of product prices, the estimated price shock is the maximum potential impact.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

China's economic and industrial structures on change in the price index. For instance, Lyu and Wang (2015) believed that changing industrial structure would cause the prices of basic industrial goods to climb first and then decreasing gradually, i.e. decrease in the PPI, while inducing a continuous increase in the price level of the processing and service sectors, i.e. an increase in CPI. Mo et al. (2019) considered China's PPI-CPI divergence over the period of 2012-2016 as a structural deflation. They found that such divergence might have resulted from the joint effects of the price volatility of bulk commodities, internal and external economic trends, and other cyclical factors. Among them, structural change plays a fundamental role. Since industrial (product) structure results from the division of labor, therefore, the explanation of the PPI-CPI divergence from the perspective of industrial structure is not the ultimate cause. The underlying reason should be attributed to global value chains and industrial chains of division of labor.

Second, economic shocks from different sources. The same shock may create heterogenous effects on different price indices, causing their differentiation and even deviation. For instance, Zhang et al. (2018) examined the CPI and PPI effects of three types of exogenous shocks using the new Keynesian framework, and found that monetary policy shock, demand shock and supply shock could all affect PPI and the CPI in different ways. Hou et al. (2018) uncovered that negative shock to bulk commodity prices would drive down PPI while negative supply shock in the downstream consumer goods sector would cause CPI to rise, resulting in changes of major indices in opposite directions. Those studies have elaborated the relationship between common economic shocks and price indices, and explained the reasons behind the divergence in terms of the sources of shocks. However, there has been relatively inadequate analysis of the mechanisms and underlying reasons of the different price effects of shocks from different sources. Why are there differences in the PPI and CPI effects of exogenous shocks from different sources? An important reason is that an increasingly complex production structure has fundamentally transformed the way in which PPI and CPI are influenced by exogenous shocks.

Third, production overcapacity. This argument underscores the importance of excessive government investment and overcapacity to China's PPI-CPI divergence or deviation, especially during the period from the end of 2011 to early 2016. For instance, Liu et al. (2017) considered that the divergence between PPI and CPI as the cumulated result of rapid increase of government-led investment goods and consumer goods. After the global financial crisis of 2008, the Chinese government has introduced a stimulus program to boost the economy, but market investment demand remained lukewarm. With the exit of government investment, slowing investment demand has driven down the prices of the means of production, as well as PPI. Slowing investment growth was followed by tepid consumption growth, so that the consumption passively became a key driver of demand. Relatively stable consumer demand has supported the slow growth of CPI, causing a deviation between PPI and CPI.

Fourth, structural frictions of ownership systems. This view stressed that frictions faced by state-owned enterprises (SOEs) and private enterprises have impeded price transmission. For instance, Xu et al. (2019) constructed a DSGE model taking private enterprises and SMEs into consideration, and found that increasing financial frictions during monetary tightening period had raised the cost of financing for private enterprises. Due to implicit guarantee, SOEs could still obtain loans at a relatively low cost. In the production structure, SOEs are primarily engaged in the manufacturing of upstream investment goods, whose prices may represent PPI, and private enterprises mainly produce downstream consumer goods, whose prices may represent CPI. Difference in the cost of financing for the two types of enterprises explains why China's CPI has been higher than PPI. In fact, most of the state-owned enterprises are upstream and most of the private enterprises are downstream. This feature leads to the differentiation of PPI and CPI, which is essentially the reason of the production structure.

In a nutshell, existing studies have explained the divergence or deviation between China's PPI and CPI over different periods of time from different perspectives. However, some inadequacies remain. For instance, their analysis has yet to reach the underlying reasons and deep-seated logic. First, this question has yet to be discussed from the perspective of international comparison; second, there have

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

been a shortage of theoretical and empirical discussions on the reasons for China's CPI-PPI divergence from the perspective of production structure and intermediate inputs. Therefore, this paper will conduct a theoretical and empirical analysis of the CPI and PPI effects based on the global input-output price model from the perspective of production chains.

3. Global Input-Output Price Model

3.1 Global Input-Output Price Model Framework

In this section, we provide an illustration of a three-country, three-sector global input-output model to reflect generality[4]. It is assumed that there are three countries, including China (C), Japan (J), and the United States (U), and that each country has three product sectors, i.e. Industrial Sector 1, Service Sector 2, and Energy Sector 3. Table 1 and Table 3 are the simplified global input-output tables (or international input-output tables).

Table 1: Three-Country, Three-Sector Global Input-Output Tables

		Intermediate inputs									Final inputs			Total output
		C			J			U			C	J	U	
		1	2	3	1	2	3	1	2	3	Y^C	Y^J	Y^U	X
C	1	z_{11}^{CC}	z_{12}^{CC}	z_{13}^{CC}	z_{11}^{CJ}	z_{12}^{CJ}	z_{13}^{CJ}	z_{11}^{CU}	z_{12}^{CU}	z_{13}^{CU}	y_1^{CC}	y_1^{CJ}	y_1^{CU}	x_1^C
	2	z_{21}^{CC}	z_{22}^{CC}	z_{23}^{CC}	z_{21}^{CJ}	z_{22}^{CJ}	z_{23}^{CJ}	z_{21}^{CU}	z_{22}^{CU}	z_{23}^{CU}	y_2^{CC}	y_2^{CJ}	y_2^{CU}	x_2^C
	3	z_{31}^{CC}	z_{32}^{CC}	z_{33}^{CC}	z_{31}^{CJ}	z_{32}^{CJ}	z_{33}^{CJ}	z_{31}^{CU}	z_{32}^{CU}	z_{33}^{CU}	y_3^{CC}	y_3^{CJ}	y_3^{CU}	x_3^C
J	1	z_{11}^{JC}	z_{12}^{JC}	z_{13}^{JC}	z_{11}^{JJ}	z_{12}^{JJ}	z_{13}^{JJ}	z_{11}^{JU}	z_{12}^{JU}	z_{13}^{JU}	y_1^{JC}	y_1^{JJ}	y_1^{JU}	x_1^J
	2	z_{21}^{JC}	z_{22}^{JC}	z_{23}^{JC}	z_{21}^{JJ}	z_{22}^{JJ}	z_{23}^{JJ}	z_{21}^{JU}	z_{22}^{JU}	z_{23}^{JU}	y_2^{JC}	y_2^{JJ}	y_2^{JU}	x_2^J
	3	z_{31}^{JC}	z_{32}^{JC}	z_{33}^{JC}	z_{31}^{JJ}	z_{32}^{JJ}	z_{33}^{JJ}	z_{31}^{JU}	z_{32}^{JU}	z_{33}^{JU}	y_3^{JC}	y_3^{JJ}	y_3^{JU}	x_3^J
U	1	z_{11}^{UC}	z_{12}^{UC}	z_{13}^{UC}	z_{11}^{UJ}	z_{12}^{UJ}	z_{13}^{UJ}	z_{11}^{UU}	z_{12}^{UU}	z_{13}^{UU}	y_1^{UC}	y_1^{UJ}	y_1^{UU}	x_1^U
	2	z_{21}^{UC}	z_{22}^{UC}	z_{23}^{UC}	z_{21}^{UJ}	z_{22}^{UJ}	z_{23}^{UJ}	z_{21}^{UU}	z_{22}^{UU}	z_{23}^{UU}	y_2^{UC}	y_2^{UJ}	y_2^{UU}	x_2^U
	3	z_{31}^{UC}	z_{32}^{UC}	z_{33}^{UC}	z_{31}^{UJ}	z_{32}^{UJ}	z_{33}^{UJ}	z_{31}^{UU}	z_{32}^{UU}	z_{33}^{UU}	y_3^{UC}	y_3^{UJ}	y_3^{UU}	x_3^U
Value-added		va_1^C	va_2^C	va_3^C	va_1^J	va_2^J	va_3^J	va_1^U	va_2^U	va_3^U				
Total input		x_1^C	x_2^C	x_3^C	x_1^J	x_2^J	x_3^J	x_1^U	x_2^U	x_3^U				

Note: Please refer to Dietzenbacher et al. (2013) for the detailed descriptions of global input-output tables. Put simply, rows denote the use of products from the country's product sector as intermediate inputs or final products, and intermediate inputs are divided into those for domestic use and those for overseas use. Columns denote the production composition of the national product sector, including the intermediate input and value-added (compensation to labor and capital factors), and intermediate inputs are further divided into domestic and overseas inputs. Let $g,h\in\{C,J,U\}$,$i,j\in\{1,2\}$, where x_i^g is the total output value of country g's product sector i, va_i^g is the value-added of country g's product sector i, z_{ij}^{gh} is the value of demand from country h's sector j for intermediate inputs from country g's sector i.y_i^{gh} is the value of country h's final consumption of products from country g's sector i. It is further defined that: $A=Z[diag(X)]^{-1}$, where A is the direct input coefficient matrix of the input-output tables, with element $a_{ij}^{gh}=z_{ij}^{gh}/x_j^h$ in A. Z is the intermediate input matrix consisting of z_{ij}^{gh}. $Y_{SN\times S}=[Y^C\ Y^J\ Y^U]$, where S=3, N=2.

(i) General form of the input-output price model. According to the equilibrium of rows in the classical input-output model, it is assumed that the direct consumption coefficient and value-added ratio are constant in the short term, and the cost of intermediate inputs is fully transmitted. In order to investigate how the external price shocks in some countries (sectors) (such as the external energy price

[4] Obviously, the three-country, three-sector model can be extended to the multi-country, multi-sector global input-output model framework.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

volatility in a certain country) influence prices in other countries (sectors), our input-output price model also needs to include the following three assumptions: first, we don't consider possible measures taken by enterprises to reduce inputs used and cost. Second, it is assumed that upfront investments (such as wage, net production tax, operating surplus, and depreciation) have a constant impact on price. The third is partial equilibrium hypothesis, that is, the impact of changes in market demand on prices is not considered. In this section, we will investigate the price effect of exogenous price change in the energy sector (the third sector) on sectors in other countries. Specifically, changes in international energy price may affect prices in country *C*'s sectors under the following two situations: The first situation is that prices in country *C*'s energy sector are endogenous, and prices in the energy sector of country *U* and *J* are exogenous[5]. The second situation is that prices in country *C*'s Energy Sector 3 change almost simultaneously with prices in the overseas Energy Sector 3, and are also exogenous. Under China's current finished oil pricing mechanism, domestic oil price is adjusted and published based on the international oil price assessments in Singapore, New York and Rotterdam every 10 business days. This explains for the consistency between China's oil price and international energy price. Here, we provide an explanation of the second situation (synchronous exogenous change).

First, country *C*'s energy sector price changes almost simultaneously with overseas energy sector price, which is also exogenous. Hence, prices in the Energy Sector 3 of country *C*, *J* and *U* all change exogenously. Then, we arrive at the following form of the block matrix:

$$\begin{bmatrix} \overline{\Delta p^C} \\ \overline{\Delta P^J} \\ \overline{\Delta P^U} \end{bmatrix}_{6\times1} = \begin{bmatrix} \overline{A^{CC}}, & \overline{A^{JC}}, & \overline{A^{UC}}, \\ \overline{A^{CJ}}, & \overline{A^{JJ}}, & \overline{A^{UJ}}, \\ \overline{A^{CU}} & \overline{A^{JU}} & \overline{A^{UU}}, \end{bmatrix}_{6\times6} \begin{bmatrix} \overline{\Delta p^C} \\ \overline{\Delta P^J} \\ \overline{\Delta P^U} \end{bmatrix}_{6\times1} + \begin{bmatrix} \overset{\vee}{A}^{CC}, & \overset{\vee}{A}^{JC}, & \overset{\vee}{A}^{UC}, \\ \overset{\vee}{A}^{CJ}, & \overset{\vee}{A}^{JJ}, & \overset{\vee}{A}^{UJ}, \\ \overset{\vee}{A}^{CU}, & \overset{\vee}{A}^{JU}, & \overset{\vee}{A}^{UU}, \end{bmatrix}_{6\times3} \begin{bmatrix} \Delta p_3^C \\ \Delta p_3^J \\ \Delta p_3^U \end{bmatrix}_{3\times1} \tag{1}$$

The following can be obtained through calculations:

$$\begin{bmatrix} \overline{\Delta p^C} \\ \overline{\Delta P^J} \\ \overline{\Delta P^U} \end{bmatrix}_{6\times1} = \{I_{6\times6} - \begin{bmatrix} \overline{A^{CC}}, & \overline{A^{JC}}, & \overline{A^{UC}}, \\ \overline{A^{CJ}}, & \overline{A^{JJ}}, & \overline{A^{UJ}}, \\ \overline{A^{CU}}, & \overline{A^{JU}}, & \overline{A^{UU}}, \end{bmatrix}_{6\times6} \}^{-1} \begin{bmatrix} \overset{\vee}{A}^{CC}, & \overset{\vee}{A}^{JC}, & \overset{\vee}{A}^{UC}, \\ \overset{\vee}{A}^{CJ}, & \overset{\vee}{A}^{JJ}, & \overset{\vee}{A}^{UJ}, \\ \overset{\vee}{A}^{CU}, & \overset{\vee}{A}^{JU}, & \overset{\vee}{A}^{UU}, \end{bmatrix}_{6\times3} \begin{bmatrix} \Delta p_3^C \\ \Delta p_3^J \\ \Delta p_3^U \end{bmatrix}_{3\times1} \tag{2}$$

Let $\overline{B} \equiv \{I_{6\times6} - \begin{bmatrix} \overline{A^{CC}}, & \overline{A^{JC}}, & 0_{2\times2} \\ 0_{2\times2} & \overline{A^{JJ}}, & 0_{2\times2} \\ 0_{2\times2} & 0_{2\times2} & \overline{A^{UU}}, \end{bmatrix}_{6\times6} \}^{-1} = \begin{bmatrix} \overline{B^{CC}}, & \overline{B^{JC}}, & \overline{B^{UC}}, \\ \overline{B^{CJ}}, & \overline{B^{JJ}}, & \overline{B^{UJ}}, \\ \overline{B^{CU}}, & \overline{B^{JU}}, & \overline{B^{UU}}, \end{bmatrix}$.

The row and column elements of sectors subject to exogenous price change in the direct consumption coefficient matrix A are deleted to obtain $\overline{A}$ and further $\overline{A}'$ through transposition. Then, by extracting the row elements for sectors subject to exogenous price change in matrix A, and deleting the column elements for sectors subject to exogenous price change, we can obtain $\overset{\vee}{A}$. Finally, the inverse matrix of $I-\overline{A}'$ is obtained, so as to further arrive at the equation for the extent to which sectors with exogenous price change will influence sectors subject to endogenous price change $(I-\overline{A}')^{-1}\overset{\vee}{A}'\Delta\overset{\vee}{P}$. This calculation approach provides a unified framework for the input-output price model.

[5] Please refer to appendices on the website of *China Industrial Economics* (http://ciejournal.ajcass.org) for the detailed model derivation of endogenous pricing of country C's Energy Sector 3.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

Second, we proceed with an analysis on the price effect of international energy price volatility. According to the equation for the exogenous price change in the international energy sector derived from equation (2), it can be denoted that country *J*'s energy sector has an aggregate price impact of $\Delta T\, P_{2\times1}^{J\to C}$ on country *C*'s sector (calculation process: Assuming that the exogenous price change is 0 for the energy sectors of countries other than *J*, and then the result is substituted into equation (2) to arrive at the impact of country *J*'s energy price volatility on country *C*'s price). According to equation (2), we consider country *J*'s direct impact on country *C* and the indirect impact through country *J*'s price level under special circumstance (only country *J* provides country *C* with intermediate inputs), so as to separate these two components from the aggregate price impact ($\Delta T\, P_{2\times1}^{J\to C}$). Hence, country *J*'s impact on country *C*'s aggregate price can be divided into three parts, i.e.:

$$\begin{aligned}\Delta T\, P_{2\times1}^{J\to C} &= (I_{2\times2}-\overline{A^{CC}}')^{-1}\hat{A}^{JC}{}'\Delta\hat{P}^{J}+(I_{2\times2}-\overline{A^{CC}}')^{-1}\overline{A^{JC}}'(I_{2\times2}-\overline{A^{JJ}}')^{-1}\hat{A}^{JJ}{}'\Delta\hat{P}^{J}\\ &+[T_{2\times1}-(I_{2\times2}-\overline{A^{CC}}')^{-1}\hat{A}^{JC}{}'-(I_{2\times2}-\overline{A^{CC}}')^{-1}\overline{A^{JC}}'(I_{2\times2}-\overline{A^{JJ}}')^{-1}\hat{A}^{JJ}{}']\Delta\hat{P}^{J}\end{aligned} \tag{3}$$

In equation (3), the first part is the impact mechanism of direct intermediate inputs, and the first term on the right side $(I_{2\times2}-\overline{A^{CC}}')^{-1}\hat{A}^{JC}{}'\Delta\hat{P}^{J}$ denotes the impact of direct intermediate inputs on country *C*. The second part denotes the impact mechanism of indirect intermediate inputs. The second term on the right side $(I_{2\times2}-\overline{A^{CC}}')^{-1}\overline{A^{JC}}'(I_{2\times2}-\overline{A^{JJ}}')^{-1}\hat{A}^{JJ}{}'\Delta\hat{P}^{J}$ represents the impact of country *J*'s energy sector on country *C*'s sectoral prices via country *J*'s price level. The third part depicts the impact of a complex production networks (or complex value chain impact mechanism). The remaining third term on the right side is influenced via the channel in which country *C* provides country *J* with intermediate inputs, and countries *C*, *J* and third-party country *U* provide intermediate inputs to each other. That is, country *C*'s price is influenced through an intricate production network structure. In the subsequent simulated analysis, we will analyze the extent to which international energy price change affects the price level under the above-mentioned three mechanisms.

(ii) CPI and PPI effects of international energy price volatility. After calculating the price effect of energy price change for domestic sectors with endogenous prices, change in the price index can be further estimated according to the definition and weight of the general price index. With the share of each element in total household consumption and final demand in each country as weights , we have calculated the household consumer price index and final demand price index for each and every country. Meanwhile, PPI for each country is calculated with the proportion of each element in gross output of the industrial sectors in each country[6]. Despite differences in the calculation, the price index calculated with this simulation method is essentially the same with the price index of national economic accounting. Although the simulated results cannot accurately reflect change in the general price level calculated by the statistics authority, they are of the same nature, and are reasonable[7].

If the column vector of country *C*'s total demand is: $Y^{C}{}'=[y^{CC}{}'\ y^{JC}{}'\ y^{UC}{}']$, the weight matrix of final demand can be obtained through standardization: $WY^{C}=[wy^{CC}{}'\ wy^{JC}{}'\ wy^{UC}{}']=Y^{C}/(e_{1\times SN}Y^{C})$, where $e_{1\times SN}$ is the S×N dimension vector where all elements are 1. Hence, the CPI for country *C*'s final demand is expressed

[6] Lin and Wang (2009) used the intermediate inputs of an industrial sector as a share of aggregate intermediate inputs as the weight. Judging by the concept of PPI, it should include the ex-factory price of corporate product as the final product. Hence, it is also advisable to adopt the share of gross output as weight.

[7] We thank anonymous reviewers for their suggestions. This paper has estimated the correlation coefficient between the simulated CPI and PPI and actual CPI and PPI of various countries. See the appendices on the website of *China Industrial Economics* (http://ciejournal.ajcass.org). With the exception of estimated data in the input-output tables of a few small countries (without input-output tables), which affects the calculation results, the correlation coefficients are high for the vast majority of countries, indicating a relatively good approximation effect of the input-output price method employed in this paper for the actual change in the price index.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

as:

$$\Delta TCPI^{C} = Y^{C\prime}\Delta P/(e_{1\times SN}Y^{C}) = \sum_{g=C,J.U} wy^{gC\prime}\Delta P^{g} \quad (4)$$

In equation (4), we may obtain country *C*'s CPI for household consumption by calculating the weights according to the column vector for country *C*'s household consumption (including the consumption of final products imported from overseas). Obviously, the CPI for final demand is influenced by change in sectoral prices in all countries other than country *C*. This is similar to the inclusion of change in the price indices of imported products in the calculation of CPI.

The calculation of PPI is solely based on the price changes of industrial sectors in countries with the share of respective output as the weight. The PPI price index thus simulated does not include services and agriculture. Our PPI simulation is not the "ex-factory price index for industrial producers" defined by the NBS in the strict sense[8]. As simulated research and theoretical discussion, such approximation is acceptable, and an empirical test will be carried out based on the actual statistical data. According to the three-country, three-sector model in this paper, country *C*'s PPI is the price weighted index of the country's Industrial Sector 1 and Energy Sector 3, and the core PPI is the price change of Industrial Sector 1. If Industrial Sector 1 is further divided into subsectors, PPI will be the weighted price index of those subsectors. $X^{C\prime}=[x_1^C\ x_2^C\ x_3^C]$ is column vector of country *C*'s total output. As such, country *C*'s PPI can be defined as:

$$\Delta PPI^{C} = \sum_{i=2,3} x_i^C \Delta p_i^C / \sum_{i=2,3} x_i^C = \sum_{i=2,3} wx_i^C \Delta p_i^C, \text{ where } wx_i^C = x_i^C / \sum_{i=2,3} x_i^C, i = 2,3$$

With a special case (country *J* is the only country that provides country *C* with intermediate inputs) as an example, country *U*'s energy price change will only cause a price change in country *U*'s sectors. Generally speaking, country *C* will consume products from country *U*'s sectors to satisfy its final demand. Since neither country *C* nor country *J* uses intermediate inputs from country *U*, price volatility in country *U*'s energy sector will only cause CPI change in country *C* without affecting its PPI. Hence, energy price volatility in country *U* will cause a deviation between country *C*'s PPI and CPI, reducing their correlation.

Country *C*'s price index can be affected under the following situations: First, CPI change incurred by the provision of final goods to country *C*. If country *J* accounts for a small weight in country *C*'s final consumption, country *J*'s energy price change will have a relatively small impact on country *C*'s CPI, and vice versa. Second, since country *J* provides country *C* with intermediate inputs, energy price volatility in country *J* will incur price change in country *C*, thereby incurring changes in country *C*'s PPI and CPI, and the impact on PPI outweighs that on CPI. On the temporal dimension, country *J*'s energy price volatility will have a greater impact on country *C*'s sectoral prices with the increasing sophistication of the production networks as the production chains lengthen. Different weights of CPI and PPI will, to some extent, reduce the CPI-PPI correlation. An increase in the intensity in the provision of intermediate inputs to country *C* by country *J*'s sectors, especially the energy sector, will cause country *C*'s sectoral prices to be affected more heavily by country *J*'s energy sector volatility, thereby further reducing country C's PPI-CPI correlation. Under special cases, price changes in country *J*'s energy sector has an ambiguous impact on country *C*'s PPI-CPI correlation, and the increasing input-output correlation and production networks sophistication have an ambiguous impact on PPI, CPI and their correlation. Subsequently, the World Input-Output Database (WIOD) data will be employed for a

[8] Since January 2011, the National Bureau of Statistics has implemented a new survey system for industrial producer price statistics, renaming "industrial goods price statistics" into "industrial producer price statistics" and "ex-factory price index of industrial goods" into "industrial producer ex-factory price index".

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

simulation analysis to uncover how international energy price change affects China's PPI, CPI and their correlation in the context of the global production network. Furthermore, actual statistics will be used to test the relationship of the length of production chains and the PPI-CPI correlation.

Before investigating the impact of production chain length on the CPI-PPI divergence, it is necessary to conduct a reasonable depiction and measurement of the length of global production chains. In this respect, the length of production chains has already been measured in the existing research literature. Hummels et al. (2001) first proposed to measure the degree of international production segmentation by the share of imported intermediate inputs. Subsequently, Liu et al. (2010) and Egger et al. (2001) carried out further studies based on this indicator (or its improvements). However, such an indicator cannot reflect a real picture of economic or industrial structural complexity, nor can they reflect the number of production stages (Ni, et al., 2016). In this context, Fally (2012) put forth and measured the length of production segmentation (or the number of production stages) based on the single-country input-output model. Ni, et al. (2016) further created indicators that distinguish the lengths of domestic and international production segmentation, and analyzed the evolving path and determinants of the length of production segmentation. The production segmentation length indicator captures the deepening of the global production system, or changes in the complexity of the production structure, and is therefore used in this paper to depict and measure the length of global production chains[9]. Specifically, N_i^k is defined as the length of production segmentation in country k's sector i (or the number of production stages), which gives us: $N_i^k = 1 + \sum_{r,j} a_{ji}^{rk} N_j^r$. Under the global input-output model involving n countries and m sectors, the column vector $N^k$of $m \times 1$ denotes the length of production segmentation for various sectors of country k. Then, we have the following matrix for calculating the length of production segmentation:

$$\underbrace{\begin{bmatrix} N^1 \\ \vdots \\ N^n \end{bmatrix}}_{N} = \underbrace{\begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}}_{U} + \underbrace{\begin{bmatrix} A^{11'} & \cdots & A^{1n'} \\ \vdots & \ddots & \vdots \\ A^{n1'} & \cdots & A^{nn'} \end{bmatrix}}_{A'} \underbrace{\begin{bmatrix} N^1 \\ \vdots \\ N^n \end{bmatrix}}_{N} \tag{5}$$

Through further simplification, we obtain the equation for calculating the length of production segmentation: $N'=U'+N'A$, i.e. $N'=U'\underbrace{(\mathrm{I}-A)^{-1}}_{L}$, where ' denotes matrix or vector transposition, I is the unit matrix of the corresponding dimension, and L is the Leontief inverse matrix. After the length of production segmentation in each sector of a country is obtained, we calculate the sum of the lengths of production segmentation in various sectors of the country weighted by the output of each sector of the country as a share of the country's gross output, which is used as the indicator for measuring the country's length of production segmentation (*pfl*), i.e. country k's length of production segmentation is

[9] In addition to using Fally's (2012) length of production segmentation as the core explanatory variable, this paper has also used other production lengths as core explanatory variable for robustness tests, including the average propagation length (APL) developed by Dietzenbacher et al. (2007). In fact, Ni et al. (2016) also demonstrated through theoretical derivation that the upstreamness indicators defined by Fally (2012), Dietzenbacher et al. (2007) and Antras et al. (2012) could be derived from each other. Ni and Wang (2022) further improved the estimation method for individual enterprise locations developed by Chor et al. (2021). In a nutshell, these methodologies are essentially consistent with each other, and all of them are the weighted sums of production stages in the input-output model. They share generally consistent trends of various production chains estimated based on the input-output methods. We would like to thank anonymous reviewers for their valuable comments.

[10] In the main text, we have investigated the relationship between the length of cross-border production segmentation and the CPI-PPI divergence. Following the advice of anonymous reviewers, which is highly appreciated, we further examined the relationship between domestic production segmentation and the CPI-PPI divergence. Please refer to the appendices on the website of *China Industrial Economics* (http://ciejournal.ajcass.org) for the results, which demonstrate no significant correlation between the length of domestic production segmentation and the CPI-PPI divergence. This explains that under the exogenous shock of international bulk commodities, cross-border production segmentation is the primary channel through which the length of production chains affects the CPI-PPI divergence.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

given by: $pfl^k = \sum_i \frac{x_i^k}{\sum_i x_i^k} N_i^k$[10].

As can be learned from the above discussions, the Leontief inverse matrix is a major component of the expressions of production chain length and price transmission in the global input-output model. Both of them are closely related to such parameters as the direct input coefficient in the input-output matrix. Not only will the sophistication of production networks lengthen production chains, but it will also change the extent to which a country's energy price volatility affects another country's sectoral prices due to the sophistication of production network. Different weights of CPI and PPI will, to some extent, diminish the CPI-PPI correlation. Such correlation will be further diminished if a country's sectors, especially the energy sector, provide another country with a greater intensity of intermediate inputs, thereby causing the energy sector volatility of the supplying country to affect the sectoral prices of the purchasing country more sharply and further reducing the PPI-CPI correlation between the two countries.

3.2 Data Explanations

The World Input-Output Database (WIOD) contains rich socio-economic and environmental satellite accounts, and features open and transparent methods of formulation and limited errors. These advantages have led to its broad applications. Our models employ the global input-output tables of 2000-2014 from the WIOD, and China's actual PPI and CPI data are from the Wind database. Since our simulation analysis is primarily concerned with how change in the input-output structure affects the extent to which CPI and PPI are influenced by the energy price shock, our simulation adopts the assumption of a 10% change in energy price[11]. In the WIOD, three out of 56 sectors are related to energy, including mining and quarrying (C04), manufacture of coke and refined petroleum products (C10), and supply of electricity, gas, steam and air conditioning (C24). In the simulation of PPI[12], we ensure that the inclusion of industrial sectors roughly corresponds to the national statistical accounting of industrial sectors for the calculation of ex-factory price index for industrial producers[13]. Simulation of core PPI excludes mining and quarrying (C04), manufacture of food, beverage and tobacco products (C05), manufacture of coke and refined petroleum products (C10), and supply of electricity, gas, steam and air conditioning (C24).

Calculation of the simulated CPI for household consumers and the simulated CPI for aggregate final demand encompasses all industrial sectors (44 countries and regions with 56 sectors for each country). Further calculation of core CPI excludes six sectors, including crop and livestock production, hunting and related activities (C01), fishery and aquatic industry (C03), mining and quarrying (C04), manufacture of food, beverage and tobacco products (C05), manufacture of coke and refined petroleum products (C10), and supply of electricity, coal gas, air conditioning (C24).

In addition, we also carried out a simulated analysis of the CPI and PPI effects of international agricultural product price volatility. Based on the WIOD data of 2000-2014, we have calculated the

[11] In utilizing the single-country input-output price model, Lin and Wang (2009) also assumed energy price change to be 10%.

[12] In order to differentiate from PPI and CPI published by the NBS, we refer to the model-estimated PPI and CPI as simulated PPI and simulated CPI.

[13] Simulated PPI encompasses the following industrial sectors: mining and quarrying (C04), manufacture of food products, beverage and tobacco (C05), manufacture of textiles, apparels, leather and related products (C06), manufacture of timber, timber products and cork products (except for furniture), manufacture of straw products and weaving materials (C07), manufacture of paper and paper products (C08), manufacture of recording media and reproduction (C09), manufacture of coke and refined petroleum products (C10), manufacture of chemicals and chemical products (C11), manufacture of essential pharmaceutical products and medical preparations (C12), manufacture of rubber and plastic products (C13), manufacture of other non-metal mineral products (C14), manufacture of basic metals and metal products (C15) manufacture of metal products excluding manufacture of mechanical equipment (C16), manufacture of computers, electronic products, and optical products (C17), manufacture of electrical equipment (C18), manufacture of unclassified machinery and equipment (C19), manufacture of automobiles, trailers and semitrailers (C20), manufacture of other transportation equipment (C21), manufacture of furniture and other manufacturing (C22), machinery and equipment repair and installation (C23), supply of electricity, coal gas, steam and air-conditioning (C24), water collection, treatment and supply (C25), wastewater treatment, waste collection, treatment and disposal, material recycling, reparation and other waste management services (C26).

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

production chain length and its components over the same period referencing Wang et al. (2017) and Ni et al. (2016) for measuring production chain position, and performed an empirical analysis.

4. Analysis of Simulation Results

4.1 Impact of Energy Price Volatility on China's CPI and PPI

Table 2 presents the impact on China's PPI and CPI arising from a 10% energy price increase in 2014 based on equation (2)[14]. As can be learned from the table, an exogenous energy price increase for all countries by 10% causes China's price indices to rise in the following descending order: PPI (3.2828%) > Core PPI (2.7281%) > CPI for final total demand (1.6165%) > CPI for core final demand (1.6165%) > CPI for household consumption (1.1864%) > CPI for core household consumption (0.9752%). This order is consistent with common sense. Since the core price index excludes the energy sector and five other sectors where the price increase is greater, the increase of the core price index should be smaller than the increase of the non-core price index. Obviously, the exogenous energy price shock has magnified the impact on PPI through a complex production network while the impact on CPI is relatively modest[15]. For such PPI-CPI divergence, fiscal and monetary policies should focus on sectors most vulnerable to the energy price shock in order to implement targeted policies to curb PPI increase and the overall price increase.

Table 2: Impact of a 10% Energy Price Increase on China's Price Index (%)

Countries subject to exogenous energy price hike	Change in China's price index					
	CPI for household consumption	CPI for aggregate final demand	CPI for core household consumption	CPI for core aggregate final demand	PPI	Core PPI
All countries	1.1864	1.6165	0.9752	1.6004	3.7828	2.7281
China	0.9990	1.3326	0.7898	1.3034	3.4305	2.2615
Australia	0.0077	0.0188	0.0084	0.0204	0.0289	0.0388
South Korea	0.0167	0.0185	0.0141	0.0181	0.0199	0.0260
The United States	0.0118	0.0120	0.0113	0.0120	0.0100	0.0124
Japan	0.0089	0.0118	0.0092	0.0123	0.0118	0.0155
Russia	0.0064	0.0112	0.0065	0.0119	0.0146	0.0195
The United Kingdom	0.0016	0.0023	0.0019	0.0024	0.0012	0.0027
Germany	0.0037	0.0046	0.0039	0.0047	0.0031	0.0040
France	0.0016	0.0017	0.0017	0.0017	0.0012	0.0016
Canada	0.0022	0.0030	0.0020	0.0030	0.0032	0.0041

Notes: Figures in this table denote the impact of a 10% energy price increase in countries in the corresponding rows on China's price indices. For instance, 1.1864 in the first row and the first column means that when the energy prices of all countries increase by 10%, China's CPI for household consumption will rise by 1.1864%. The same below.

In this paper, we have also carried out a simulated analysis of the impact of a 10% energy price increase in individual countries on China's CPI and PPI, and Table 2 includes the results for most countries. It can be found that (i) among other countries, Australia's energy price change has the biggest impact on China's PPI and CPI of final aggregate demand, causing them to rise by 0.0289 and 0.0188 percentage points, respectively. South Korea's energy price change has the biggest impact on the CPI of

[14] Please refer to the website of *China Industrial Economics* (http://ciejournal.ajcass.org) for the detailed process, data, and the analysis of agricultural price volatility's impact on China's CPI and PPI.

[15] Considering that change in the core price index is close to the corresponding change in the price index, we will not separately stress and explain change in the core price index except for special explanations in subsequent paragraphs.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

China's household consumption, causing it to rise by 0.0167 percentage points. The underlying reason is that Australia is among China's major energy suppliers, and its energy price increase has significant ramifications for China's PPI as reflected in the production cost of various sectors and the CPI of final aggregate demand. (ii) except for Australia and South Korea, Russia's energy price change has the biggest impact on China's PPI, while energy price changes in the United States and Japan have the greatest impact on China's CPI.

One of the differences between the single-country input-output price model and the global input-output price model is whether the orgin-of-country of intermediate input is distinguished. Based on the international input-output tables of three countries, China's intermediate input coefficient matrix can be expressed as: $A^{single} = A^{CC} + A^{JC} + A^{UC}$, and according to equation (2), the price impact based on the single-country input-output model can be given as: $\Delta P_{(N-M)\times 1} = [I_{(N-M)\times(N-M)} - A^{single}_{(N-M)\times(N-M)}{}']^{-1}[A^{single}_{M\times(N-M)}]'\Delta p^{*}_{\mathrm{M}\times 1}$. Table 3 presents change in China's price index calculated with the single-country input-output price model and the global input-output price model. Our results indicate that when the energy prices of all countries increase by 10%, the impact on China's price index calculated with the single-country input-output model is higher than the results calculated with the global input-output model. The reason is that the single-country input-output model cannot distinguish intermediate inputs from the home country and foreign countries; instead, it will consider change in the energy price of other countries as change in the home country's energy price, and transforms the change in foreign energy prices into the home country's exogenous energy price change, thereby over-estimating the impact of change in the energy prices of other countries on China's price index. Meanwhile, it can be found that the difference between changes in CPI and PPI calculated with the global input-output price model is greater than the results calculated with the single-country input-output price model. The reason is that the increasing input-output links between countries and lengthening production chains have diminished the CPI-PPI correlation. Similarly, using the non-competitive single-country tables with the distinction of imported intermediate inputs, i.e. $A^{single} = A^{CC}$, we have re-estimated the results, which are shown in the last row of Table 3. It can be found that the difference between changes in CPI and PPI calculated with the global input-output price model is also greater than the result calculated with the single-country non-competitive input-output model. Once again, it proves that the sophistication of the production networks structure between countries has diminished the CPI-PPI correlation.

Table 3: Impact of a 10% Energy Price Hike in All Countries on China's Price Index (%)

Model specification	Change in China's price index					
	CPI for household consumption	CPI for aggregate final demand	CPI for core household consumption	CPI for core aggregate final demand	PPI	Core PPI
Global input-output model	1.1864	1.6165	0.9752	1.6004	3.7828	2.7281
Single-country input-output model	1.2225	1.6737	1.0232	1.6648	3.8148	2.7705
Non-competitive single-country input-output model	1.0641	1.3916	0.8457	1.3573	3.4196	2.2471

4.2 Average Impact of Energy Price Volatility on the Price Indices of Various Countries

In this section, we further estimate the average impact of a 10% energy price increase in each country on the price indices of other countries, i.e. the arithmetic average of changes in the price indices of all countries resulting from a 10% energy price increase in an individual country, as shown in Table 4. Results suggest that: (i) Energy price changes in Russia, Norway and Australia have the biggest impact on the PPI of other countries chiefly due to the abundant energy resources in the three countries as major global energy suppliers. Energy price increase in those three countries becomes transmitted to

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

downstream countries in the global production chains, causing significant PPI change in other countries. (ii) Energy price changes of China, Russia, Germany, the United States, Spain, Norway, and South Korea have the biggest impact on the core PPI of other countries, causing their core PPI to rise by an average of 0.04%. Since core PPI does not include energy and food prices, a country may have a greater impact on the core PPI of other countries if it has a higher level of participation in GVCs, supplies more intermediate goods to the world (non-energy and food), and maintains closer manufacturing relations with other countries, thus exerting a greater impact on their product cost. Price increase in such countries may serve as a leading indicator for domestic PPI change in order to forecast significant change in domestic PPI. (iii) As far as the CPI index is concerned, energy price changes in China, Russia, the United States, Germany, Poland and South Korea have the biggest impact on CPI in other countries. There is a major overlap between the above-mentioned countries and countries with the biggest impact on other countries' core PPI . A possible reason is that the CPI index is calculated based on the weights of final consumption or household consumption while products in the energy sector seldom go into household consumption directly.

Table 4: Average Influence of a 10% Energy Price Increase on the Price Indices of Various Countries (%)

Sources of energy price hike	Mean change of price indices for all countries					
	CPI for household consumption	CPI for aggregate final demand	CPI for core household consumption	CPI for core final demand	PPI	Core PPI
Australia	0.0143	0.0155	0.0078	0.0105	0.1235	0.0398
China	0.0655	0.0774	0.0645	0.0791	0.1241	0.1175
Germany	0.0495	0.0397	0.0269	0.0261	0.0656	0.0511
Spain	0.0301	0.0248	0.0161	0.0161	0.0805	0.0430
Indonesia	0.0233	0.0255	0.0151	0.0221	0.0920	0.0356
India	0.0238	0.0222	0.0160	0.0162	0.0614	0.0284
South Korea	0.0321	0.0272	0.0227	0.0223	0.0625	0.0409
Norway	0.0207	0.0267	0.0098	0.0109	0.1457	0.0415
Poland	0.0404	0.0323	0.0236	0.0218	0.0751	0.0375
Russia	0.0528	0.0517	0.0404	0.0426	0.1715	0.0984
The United States	0.0431	0.0398	0.0269	0.0275	0.0930	0.0477

4.3 Impact of Energy Price Volatility on China's Price Index

We decomposed the three determinants of energy price volatility's impact on prices in China (as illustrated in Table 5) based on equation (3), which include direct intermediate inputs, indirect intermediate inputs, and complex production networks. Our findings suggest that (i) direct and indirect intermediate inputs have a generally equivalent impact on the mechanism in which China's energy price changes affect its own price index. In the PPI's impact mechanism, direct and indirect intermediate inputs are the primary channels of impact, which are 128 times that of complex production networks. Conversely, complex production networks are the primary channels for CPI's impact mechanism, accounting for 48% and 82% of changes in CPI for household consumption and CPI for aggregate final demand, respectively. The reason is that products in energy-related sectors are seldom used in final consumption, and a large portion of final demand and consumption are services, so that energy price changes affect CPI primarily through production networks and seldom through direct and indirect intermediate inputs. (ii) Impact of energy price volatility in Australia, Russia and Canada on China's price index. The impact of direct intermediate inputs outweighs the impact of indirect intermediate inputs. Since these countries are China's primary energy suppliers, their energy price changes tend

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

to affect China's price level through indirect intermediate inputs. (iii) Indirect intermediate inputs are the primary channel through which energy price changes in South Korea, the United States and Japan affect China's price index. Although these countries are not China's primary sources of intermediate energy inputs, they are the primary trading partners along China's supply chains and major sources of other intermediate inputs. Hence, the energy sector of those countries affects China's sectoral prices by influencing their own price levels. In contrast, complex production networks are the primary channel through which energy price changes in countries such as the United Kingdom, Germany and France influence China's price index. In other words, energy price changes in those countries tend to influence China's price level through complex production networks in which intermediate inputs are provided to third countries. (iv) In general, energy price changes in some countries such as Russia affect China's PPI more than they affect CPI whereas energy price changes in some other countries like the United States and France affect China's PPI to a lesser degree compared with CPI. As can be once again proven by the disparate PPI and CPI effects of various countries, international energy price volatility will lead to the deviation between PPI and CPI in the context of global production networks, and the sophistication of the production networks has magnified the impact of a country's price change on other countries.

Table 5: Impact of International Energy Price Change on China's Price Level (%)

Countries with energy price increase	Decomposition of PPI structure			Decomposition of household consumption CPI			CPI for aggregate final demand		
	Direct	Indirect	Complex	Direct	Indirect	Complex	Direct	Indirect	Complex
China	1.7086	1.7086	0.0133	0.2611	0.2632	0.4747	0.1186	0.1217	1.0924
Australia	0.0233	0.0033	0.0024	0.0050	0.0012	0.0015	0.0138	0.0031	0.0019
South Korea	0.0050	0.0114	0.0035	0.0070	0.0097	0.0000	0.0055	0.0088	0.0042
The United States	0.0023	0.0038	0.0039	0.0022	0.0053	0.0043	0.0022	0.0050	0.0048
Japan	0.0014	0.0073	0.0031	0.0018	0.0047	0.0024	0.0016	0.0061	0.0041
Russia	0.0077	0.0016	0.0053	0.0028	0.0014	0.0022	0.0053	0.0017	0.0042
The United Kingdom	0.0005	0.0006	0.0000	0.0003	0.0004	0.0009	0.0004	0.0007	0.0012
Germany	0.0005	0.0013	0.0013	0.0008	0.0013	0.0016	0.0008	0.0016	0.0023
France	0.0001	0.0005	0.0006	0.0002	0.0006	0.0009	0.0001	0.0006	0.0009
Canada	0.0016	0.0007	0.0009	0.0005	0.0008	0.0009	0.0011	0.0008	0.0010

4.4 Impact of Energy Price Volatility on the PPI-CPI Correlation

From a dynamic perspective, the lengthening of production chains in the context of economic globalization may reduce the impact of a country's energy price volatility on the sectoral prices of other countries, and may also diminish the CPI-PPI correlation. Based on the WIOD input-output tables, we have estimated the dynamic impact of a 10% energy price increase in all countries (regions) on the CPI and PPI of each country over the period between 2000 and 2014, and calculated the CPI-PPI correlation coefficient of each country[16].

As can be learned from a comparison of the CPI-PPI correlation coefficient of each economy under the energy price shock in the first half (2000-2007) and the second half (2008-2014) during the sample

[16] Given that the anti-globalization trend has reduced production networks linkages between countries and sectors since 2014, which may have curbed the CPI-PPI divergence, we further perform a simulated estimation of the dynamic impact of a 10% energy price increase in all countries (regions) on the CPI and PPI of each country over the period between 1995 and 2018, and calculated the CPI-PPI correlation coefficient of each country. We performed a robustness test for the argument that the length of production segmentation increased the CPI-PPI divergence from another perspective, i.e. the decreasing length of production segmentation has reduced the CPI-PPI divergence. Please refer to appendices on the website of the *China Industrial Economics* (http://ciejournal.ajcass.org).

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

period, all countries or regions have experienced declining CPI-PPI correlation coefficients after 2008, which is consistent with the trend of lengthening global production chains. According to Ni et al. (2016), the length of global production segmentation generally increased over the period between 2000 and 2014 with the exception of the Internet bubble burst in 2002 and the global financial crisis in 2008. Our simulated estimation results prove that lengthening production segmentation has diminished the CPI-PPI correlation for each economy.

5. Empirical Analysis of CPI-PPI Divergence and Production Chain Length

In this section, we utilize actual CPI and PPI statistics and estimated production segmentation data for an econometric empirical analysis to further verify the above conclusions of simulation analysis. As can be found from the analysis of the impact of energy price change on China's price level, lengthening production chains have diminished the CPI-PPI correlation under the external energy price shock. In this section, we will perform an empirical analysis of the impact of production chain length on the CPI-PPI divergence at the national level.

5.1 Econometric Model and Data Explanations

In this paper, our econometric model is specified as follows:

$$corre_{ct}=\alpha+\beta_1 X_{ct}+\beta_2 Z_t+\varepsilon_{ct} \quad (6)$$

where, c denotes country, t denotes year, and $corre_{ct}$ is the CPI-PPI correlation coefficient for country c in year t; X_{ct} is the length of production segmentation for country c in year t; Z_t is a set of control variables, including GDP growth rates for various countries in year t, growth rate of M2 as a share of GDP, price level[17], and the price index of bulk commodities. Bulk commodities refer to homogeneous commodities extensively used as basic industrial ingredients, such as crude oil, nonferrous metals, steel, and agricultural products. In this paper, changes in the price index of bulk commodities is denoted by the price index of crude oil and steel. Crude oil price index is denoted by the British Brent crude spot price, and the steel price index is denoted by the international steel price index. In both cases, data are obtained from the Wind database.

5.2 Results of Econometric Estimation[18]

Table 6 provides the baseline regression results obtained from the measurement of industrial chain length according to the length of production segmentation. In Table 6, Columns (1) through (3) present the results of mixed OLS regression, fixed-effect regression, and random-effect regression, respectively, and all regressions have adopted robust standard error regression. Results indicate that all the coefficients of the production segmentation length are significantly negative no matter which regression model is adopted. That is to say, the longer the production chains, the smaller the CPI-PPI correlation coefficient will be. This is consistent with the assumption in the aforementioned theoretical model, i.e. longer

[17] Notably, since the length of production segmentation as the core explanatory variable (pfl) is based on time series data, the introduction of the fixed-effect of time will cause the problem of multicollinearity, offsetting the impact of the dummy variable of time and the variable of production segmentation length on the CPI-PPI correlation coefficient. Therefore, the fixed effect of time is not controlled for in the original model. However, some important unobservable factors could be omitted if the dummy variable of year is not controlled for. Referencing Zhang and Liu (2018) and Tian and Li (2020), we have introduced macroeconomic variables such as GDP growth rate, M2 growth rate, and price index to minimize the problem of omitted variables. According to the suggestion of anonymous reviewers, we have further included macroeconomic variables such as exchange rate and interest rate, as well as the explained variable with a one-phase lag, into the regression, and the results remain robust: The regression coefficient of the core explanatory variable is significantly negative, and the increased length of production segmentation has reduced the CPI-PPI correlation. Please refer to appendices on the website of *China Industrial Economics* (http://ciejournal.ajcass.org) for details.

[18] In addition to Fally's (2012) length of production segmentation as the core explanatory variable, we have used other production chain lengths such as Dietzenbacher et al. (2007) as the core explanatory variable for a robustness test. Results suggest that whichever core variable and regression model are adopted, the regression coefficient is significantly negative, which explains that the conclusions of the main text are robust, i.e. the lengthening of production chains will reduce the CPI-PPI correlation.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

Table 6: Baseline Regression Results (Production Chain Length Measured by Production Segmentation)

	(1)	(2)	(3)
	corre	corre	corre
	Pooled OLS	FE	RE
pfl	-0.3666***	-1.1194*	-0.4192***
	(0.13)	(0.53)	(0.15)
gdpr	0.0249**	0.0225	0.0257
	(0.01)	(0.02)	(0.02)
m_r	1.8052***	1.7940***	1.8066***
	(0.44)	(0.61)	(0.54)
gdpdef	0.0210***	0.0191**	0.0197***
	(0.01)	(0.01)	(0.01)
steel	0.0075***	0.0086***	0.0076***
	(0.00)	(0.00)	(0.00)
oila	-0.0038**	-0.0038*	-0.0038**
	(0.00)	(0.00)	(0.00)
constant	0.2483	1.7257	0.3515
	(0.34)	(1.10)	(0.29)
Robust	'Yes'	'Yes'	'Yes'
N	225	225	225
Ad-R-sqr	0.189	0.138	
dfres	218	18	

Notes: *, ** and *** respectively denote significance at the 10%, 5% and 1% confidence intervals; all the models have adopted robust standard error regressions, and numbers in parentheses are robust standard errors of the estimated coefficients. *pfl*, *gdpr*, *m_r*, *gdpdef*, *steel*, *oila*, and *constant* respectively represent Production fragmentation length, GDP growth rate, Broad money to GDP ratio, GDP deflator, CRU Index, Brent crude oil spot price, and constant term.

production chains will weaken the CPI-PPI correlation.

Furthermore, we estimated categorized upstreamness (including overall upstreamness, upstreamness of the production stage for intermediate inputs, and upstreamness of the production stage for domestic and foreign intermediate inputs), as well as categorized downstreamness (including overall downstreamness, downstreamness of the production stage for intermediate inputs, and downstreamness of the production stage for domestic and foreign intermediate inputs). Results indicate that the coefficients of overall upstreamness and upstreamness of the production stage for intermediate inputs are all significantly negative at the 1% significance level, and the coefficients of upstreamness of the production stage for domestic and foreign intermediate inputs remain negative, though no longer significant. This means that the more an economy is situated in the upstream stage, the longer the global production chains, and the smaller CPI-PPI correlation coefficient will be. Similarly, the downstreamness of the production stage for intermediate inputs and the downstreamness of the production stage for domestic and foreign intermediate inputs are both significantly negative at the 1% significance level, while the coefficient of overall downstreamness is significantly negative at the 5% significance level. That is, the more an economy is situated at the downstream stage of industrial chains, i.e. the longer the global production chains, the smaller the CPI-PPI correlation coefficient will be. According to the results of robustness regression analysis, the results of baseline regression are robust.

6. Conclusions and Policy Suggestions

6.1 Key Conclusions

Productivity and international energy price shocks are transmitted to PPI and CPI through industrial chains. With China's deepening participation in global value chains (GVCs), China's

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

industrial production chains have lengthened, and change in the length of production chains has altered the mechanism and extent to which CPI and PPI are influenced by exogenous shocks, as well as the correlation between the two. By constructing a global input-output price model, this paper offers a simulated analysis of the potential impact of the price volatility of international bulk commodities on China's CPI, PPI and their divergence, along with a theoretical discussion of the length of production chains in relation to the CPI-PPI divergence. Actual CPI and PPI statistics are further utilized to empirically test the impact of production chain length on the CPI-PPI divergence. Our findings suggest that: (i) The price shock of other countries has a greater impact on China's PPI than on its CPI. A 10% exogenous energy price increase in all countries in the world will cause China's price indices to increase by the following order: PPI > core PPI > CPI for final aggregate demand > CPI for core final aggregate demand > CPI for household consumption > CPI for core household consumption. (ii) There is a great heterogeneity in the impact of energy price change in various countries on China's PPI and CPI for final aggregate demand. For instance, energy price volatility in Australia and Russia has the biggest impact on China's PPI while energy price change in the United States and Japan has the biggest impact on China's CPI. (iii) For both PPI or CPI, the exogenous shock calculated with the single-country input-output model has a greater impact on China's price indices compared with the results correlated with the global input-output model. However, the difference between CPI and PPI changes calculated with the global input-output price model is greater than the result calculated with the single-country-output price model, which supports the view that lengthening production chains will diminish the CPI-PPI correlation. (iv) Both the global input-output price model simulation and the empirical analysis using cross-national panel data suggest that lengthening production chains have diminished the CPI-PPI correlation for various countries, i.e. lengthening production chains have intensified the PPI-CPI divergence.

6.2 Policy Suggestions

(i) Reconsidering the optimal inflation target. An important goal of the central bank is to stabilize inflation, but the PPI-CPI divergence has created challenges to the assessment of whether the economy is inflationary or deflationary. When PPI is increasing (decreasing) and CPI is decreasing (increasing), the central bank will be faced with a dilemma as to adopt a tightening monetary policy to stabilize PPI or an easy monetary policy to stabilize CPI. Many studies have pointed out that the central bank should target the weighted inflation between PPI and CPI (Hou et al., 2018). According to the classical neo-Keynesian monetary policy, the central bank needs to stabilize inflation given the fact that inflation will cause efficiency losses. The reason is that resource allocation is optimal under flexible prices. Yet price stickiness generally exists in the economic reality. In most cases, businesses cannot adjust prices freely, and price adjustment carries a cost. Hence, inflation will incur efficiency losses, and the monetary policy should reduce the need for price adjustment by stabilizing aggregate demand and maintain price stability. In other words, both upstream and downstream inflation will incur efficiency losses, and the central bank should stabilize both PPI and CPI. As for their respective weight, a simple guideline is to consider the relative magnitude of upstream and downstream price stickiness and industrial chain length. The greater the price stickiness of intermediate inputs, the greater the weight should be given to PPI; meanwhile, the more refined production chain division of labor and the longer chains, the greater weight should be given to PPI.

(ii) China should proactively adjust its price index system and formulate the industrial chain price index. In order to better incorporate PPI into the inflation target system, we may adjust the PPI statistical system. First, enhancing PPI statistics based on industrial chains. China's current PPI statistics tend to be based on industrial categories and sectors, and cannot reflect the reality of production chain lengthening . It is suggested to refine the segregation of production processes to adapt to the reality of lengthening industrial chains. For instance, the United States has formulated PPI based on demand for intermediate inputs in four stages. The Research and Statistics Department of Japan's central bank has

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

also adopted this statistical system to recalculate Japan's PPI (Inoue, et al., 2021). The specific approach of formulation is as follows: estimating the share of each sector's industrial output sold to satisfy final demand; dividing all sectors into four production stages according to the share by a certain criterion; calculating the weight of each production stage based on the input-output tables; and calculating the PPI of intermediate demand through weighted average. This PPI formulation method based on the industrial chain production stage and input-output tables offers a better reflection of the real weights of various industrial chains and the impact of industrial chain lengthening. Such methods can be referenced to improve China's PPI statistics. Second, formulation and improvement of the producer price index for the service sector, including the price index based on final demand. With the transition of demand structure, the service sector has gained importance, and with the sophistication of industrial chains, the linkage between manufacturing and services has become closer than ever. The incorporation of services into PPI offers a better reflection of changes in the producer price. Policymakers are advised to reference Japanese and US experiences. For instance, Japan formulated the service producer price index, and the United States has switched to a PPI statistical system based on final demand and intermediate demand, fully incorporating services into PPI statistics.

(iii) Lastly, our simulation analysis based on the global input-output price model also has intrinsic methodological flaws, leaving room for further research in many areas. For instance, a multi-sector and multi-region general equilibrium model for an open economy can be created to discuss the CPI and PPI effects of international price volatility; future research may introduce tariffs and other domestic taxes (such as VAT) to study the interaction between tariffs and domestic taxes.

References:

Antras P., Chor D., Fally T., Hillberry R. Measuring the Upstreamness of Production and Trade Flows[R]. NBER Working Paper, 2012.

Antweiler W., Trefler D. Increasing Returns and All That: A View from Trade[J]. American Economic Review, 2002(1): 93-119.

Chor D., Manova K., Yu Z. Growing Like China: Firm Performance and Global Production Line Position[J]. Journal of International Economics. 2021,130,103445.

Dietzenbacher E., Romero I. Production Chains in An Interregional Framework: Identification by Means of Average Propagation Lengths[J]. International Regional Science Review, 2007(4): 362-383.

Egger P., Pfaffermayr M., Wolfmayr-Schnitzer Y. The International Fragmentation of Austrian Manufacturing: The Effects of Outsourcing on Productivity and Wages[J]. The North American Journal of Economics and Finance, 2001(3): 257-272.

Fally T. Production Staging: Measurement and Facts[R]. University of Colorado Boulder, Working Paper, 2012.

Feenstra R., Hanson G. The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for The United States, 1979-1990[J]. Quarterly Journal of Economics, 1999(3): 907-940.

Fort T. Technology and Production Fragmentation: Domestic Versus Foreign Sourcing[J]. Review of Economic Studies, 2016(2): 650-687.

Hou C.Q., Luo Q.T., Wu T. Continuous Deviation Between PPI and CPI and the Choice of Monetary Policy[J]. The Journal of World Economy, 2018(7): 49-74.

Hummels D., Ishii J., Yi K. M. The Nature and Growth of Vertical Specialization in World Trade[J]. Journal Of International Economics, 2001(1): 75-96.

Inoue M. et al. Final Demand-Intermediate Demand Aggregation System of Japan's Producer Price Index[R]. Monetary And Economic Studies, Institute for Monetary and Economic Studies, Bank of Japan, 2021, 39: 143-190.

Johnson R., Noguera G. Accounting for Intermediates: Production Sharing and Trade in Value Added[J]. Journal Of International Economics. 2012(2): 224-236.

Koopman R., Wang Z., Wei S. J. Tracing Value-Added and Double Counting in Gross Exports[J]. American Economic Review. 2014(2): 459-494.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net

Krugman P. Growing World Trade: Causes and Consequences[J]. Brookings Papers On Economic Activity, 1995(1): 327-377.

Leamer E. Wage Inequality from International Competition and Technological Change: Theory and Country Experience[J]. American Economic Review, 1996(2): 309-314.

Lin B. Q., Wang F. Impact of Rising Energy Price on China's General Price Level [J]. Economic Research Journal, 2009(12): 66-79+150.

Liu F. L., Zhang X. M., Yu Z. High Investment, Structural Imbalance and Price Index Divergence[J]. Journal of Financial Research, 2017(2): 54-69.

Liu Q. L., Gao Y., Han J. W. Productivity Effect of International Production Segmentation [J]. Economic Research Journal, 2010(2):32-43+108.

Liu Q. Y. Input-Output Analysis [M]. Beijing: China Renmin University Press, 1998.

Lyu J., Wang G. W. Structural Explanation of the CPI-PPI Deviation [J]. Economic Research Journal, 2015(4):136-149.

Mo W. G., Yuan J., Wei L. et al. Cyclical and Structural Issues in China's Structural Deflation [J]. Journal Of Financial Research, 2019(3): 37-52.

Ni H. F. Does the 'Smile Curve' Really Exist in the Global Value Chains? Based on the Average Propagation Length of Value-Added [J]. The Journal of Quantitative & Technical Economics (JQTE), 2016(11):111-126.

Ni H. F. Dynamic Change And International Comparison of China's Export Technology Content[J]. Economic Research Journal, 2017(1):44-57.

Ni H. F., Gong L. T., Chen X. J. Cost Effectiveness of Tariffs in Global Value Chains: Price And Welfare Effects Of China-Us Trade Frictions [J]. The Journal of Quantitative & Technical Economics (JQTE), 2018(8):74-90.

Ni H. F., Gong L. T., Xia J. C. Evolving Path and Determinants of Production Segmentation: Based on An Examination of the Number of Production Stages [J]. Management World, 2016(4):10-23+187.

Ni H. F., Wang H. C. Firm Position in Global Value Chains and Structural Change [J]. Economic Research Journal, 2022(2):107-124.

Ni H.F., Yan B. Q. Price and Welfare Effects of Tax Cuts and Fee Reductions: Input-Output Price Model Analysis with the Introduction of the Cost Transmission Ratio [J]. Journal Of Financial Research, 2021(2): 38-55.

Ramondo N., Rodriguez-Clare A. Trade, Multinational Production, and the Gains from Openness[J]. Journal Of Political Economy, 2013(2): 273–322.

Ren Z. P., Pan W. Q., Liu Q. Y. Impact of Crude Oil Price Volatility on Prices in China: Based on The Input-Output Price Model [J]. Statistical Research, 2007(11):22-28.

Tian G. Q., Li S. J. Uncertainty of Economic Policy and the Creation of Bank Liquidity: Empirical Evidence from China [J]. Economic Research Journal, 2020(11):19-35.

Wang Z., Wei S. J., Yu X. D., Zhu K. F. Measures of Participation in Global Value Chains and Global Business Cycles[R]. NBER Working Paper, 2017.

Wei S.J., Xie Y.X. The Wedge of the Century: Understanding A Divergence Between CPI and PPI Inflation Measures[R]. NBER Working Paper, 2019.

Wi L. Y., Liu Y. Z., Zhao F. Y., Gong L. T. PPI-CPI Deviation, Heterogeneity of Financial Friction, and Monetary Policy Choice[J]. Modern Economic Science, 2021(3):1-15.

Wu L. Y., Ni H. F. Revisiting China's PPI and CPI Transmission and Divergence [J]. Study & Exploration, 2022(11):134-145.

Xu Z. Y., Yan P., Wu H. B. Price Index Deviation, Financial Friction and Deleveraging[J]. Economics (Quarterly), 2019(4):1187-1208.

Yi K. M. Can Multistage Production Explain the Home Bias in Trade[J]. American Economic Review. 2010(1): 364-393.

Yi K. M. Can Vertical Specialization Explain the Growth of World Trade[J]. Journal Of Political Economy. 2003(1): 52-102.

Zhang C. S., Liu G. C. Study on the Investment and Financing Decision-Making Mechanism of China's Real-Economy Sectors: Based on the Perspective of Economic Policy Uncertainty and Financial Constraint Heterogeneity [J]. Economic Research Journal, 2018(12):51-67.

Zhang X. L., Yang Y. Y., Zhang Y. W. Structural Explanation of Continuous PPI-CPI Deviation [J]. China Economic Studies, 2018(1):15-26.

(C)1994-2024 China Academic Journal Electronic Publishing House. All rights reserved. http://www.cnki.net