Dynamic causality between PPI and CPI in China: a rolling window bootstrap approach

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Sun, J., Xu, J., Cheng, X., Miao, J. and Mu, H. 2021. Dynamic causality between PPI and CPI in China: a rolling window bootstrap approach. *International Journal of Finance & Economics*.

24 January 2021

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KEYWORDS:Rolling window; Bootstrap; Dynamic causality; PPI; CPI

Abstract

The relationship between PPI and CPI is one of the hot spots in the study of macroeconomics. Taking China as an example, the paper tests dynamic causality between PPI and CPI during the period of 2000:M1-2019:M12. In view of structural mutations in time series variables, the bootstrap rolling-window causality test is applied to restudy the dynamic causal relationship. As a result, it exists bidirectional transmission mechanism between CPI and PPI, both positive transmission of PPI to CPI and reverse transmission of CPI to PPI. In addition to putting more emphasis on transmission mechanism and causality between PPI and CPI, formulation of macroeconomic policy needs to focus on the correlation between PPI and CPI, and then the government can implement more targeted measures, such as strengthening the comprehensive application of monetary policy and fiscal policy, further deepening the supply-side reform, optimizing the industrial structure to strengthen internal relationship between CPI and PPI.

1 INTRODUCTION

The industrial producer price index (PPI) and the consumer price index (CPI) reflect changes in overall price level of the production link and the consumption link respectively, and they are the representative price indexes of the two links (Sun *et al.*, 2016). The relationship between PPI and CPI is one of the hot topics in macroeconomic research and price stability is an important goal of macroeconomic policy, therefore, price transmission mechanism becomes the key issue of economic analysis. During the critical period of economic policy regulation and control from demand-side stimulus to supply-side structural reform, to clarify that the dynamic transmission mechanism between CPI and PPI is obviously significant in the new normal. It not only affects the implementation of supply-side structural reform, but also affects choice of monetary policy regulation and control mode (Zhang and Liu, 2018). Generally speaking, the direction and range of rise and fall of PPI and CPI are roughly same. Before 2011, PPI and CPI had experienced deviations over a period of time, but it was a shorter duration and a smaller deviation. However, from the end of

2011 to the beginning of 2016, PPI continued to decline and CPI continued to rise, with a departure from the two for nearly four years (Hou *et al.*, 2018).

We use monthly year-on-year data and the period is 2000:M1-2019:M12. We set the year 2000 as the base year, then PPI and CPI from 2000 to 2019 is shown in Figure 1. In Figure 1, we can see that the fluctuation mode of PPI and CPI in China before 2012 is basically consistent, with long-term consecutive positive growth, but there are significant differences after 2012. On one hand, from 2012 to 2015, PPI experienced long-term negative growth, with monthly year-on-year growth dropping to a minimum of 1.7%; however, from 2016 to 2019, PPI has bottomed out, with monthly year-on-year growth with a peak of 4.4%. On the other hand, the trend of CPI remains stable, CPI growth did not fall significantly with PPI downturn, with an average growth of 0.2%. Since 2012, the price transmission mechanism has shown some new characteristics. The overall level of PPI and CPI index is rising, the range of rise and fall of PPI is significant, and the correlation between them is weakened (Lv and Wang, 2015; Long and Yuan, 2016; Zou, 2016; Liu J. Q. and Zhang D., 2017).

< Figure 1 is inserted about here >

PPI and CPI are usually considered to be the core indicators to reflect the economic cycle and market prosperity, and they are also important reference variables for macro-economic control, which have been widely concerned by all sectors of society. PPI and CPI are usually affected by macroeconomic variables such as economic growth, money supply, industrial structure, etc. At the same time, they will also have an interrelationship with each other. From the perspective of industrial chain, the price change in the field of industrial production will be transmitted to the downstream through the industrial chain, and finally reach the consumption link, resulting in the price change of consumer goods, which is manifested as the positive transmission from PPI to CPI. From a demand-inducing perspective, the price of consumer goods will lead to the demand changing of the upstream industrial products, the relationship changing between supply and demand and the price changing of

upstream industrial products. Theoretically, because of the influence of common factors and the existence of mutual transmission relationship, the trend of PPI and CPI shows convergence or a strong correlation. The present literature shows that there is unidirectional or bidirectional, linear or nonlinear transmission relationship between PPI and CPI (Zhou *et al.*, 2006; Lv and Yang, 2013; Sun *et al.*, 2015; Hou *et al.*, 2018; Xiao *et al.*, 2019). However, due to the different economic environment and the uncertainty of inflation risk, there is also some uncertain order about the orientation and degree of volatility between PPI and CPI (Su *et al.*, 2018). So far, native and foreign scholars hasn't form a unified opinion on the relationship between the two and there are still significant disputes about the transmission mechanism between PPI and CPI, both theoretically and empirically.

This study has five sections and it proceeds as follows. The next section describes the literature review, then it explains the methodology followed by the data and empirical findings and the last section concludes the study.

2 LITERATURE REVIEW

About transmission relationship between CPI and PPI, many scholars at home and abroad have done a lot of research, while the conclusions are different because of the different methods used and different study period.

With regard to the price transmission mechanism, most of the earlier studies used correlation analysis or linear regression. Some literature shows the positive transmission from PPI to CPI is unobstructed (Silver and Wallace, 1980; Caporale *et al.*, 2002; Bloch *et al.*, 2004; Liu *et al.*, 2005; Zhou *et al.*, 2006). However, the others indicate no direct relationship between PPI and CPI (Clark, 1995; Xiao and Chang, 2005).

With the development of measurement methods, such as Vector Auto-regressive (VAR), Vector Error Correction Model (VECM) and corresponding Granger causality test, the amount and scope about this research has been enriched. Some literature shows unidirectional causality between PPI and CPI, with a finding that CPI is the Granger cause of PPI (He *et al.*, 2008 & 2010; Koutroumanidis *et al.*, 2009; Cui and

Zhang, 2011; Liu and Lu, 2011; Lv and Yang, 2013; Sun, 2016). Tiwari (2012) demonstrates the reverse transmission of CPI to PPI by using the Australian data, under the frequency domain approach, which shows that CPI may be a significant predictor for PPI in Australian. However, there are some findings that one-way causal relationship from PPI to CPI also exists. Based on empirical test, Ghazali *et al.* (2008) and Sidaoui *et al.* (2009) demonstrate the positive transmission of PPI to CPI in Malaysia and Mexican, respectively. Besides, the Research group about Micro-foundation of Price Rise (2012) also finds that PPI is the Granger cause of CPI. Using traditional Vector Auto-regressive (VAR) and Bayesian Vector Auto-regressive (BVAR), Ivo (2019) verifies that CPI could be well predicted by PPI in Brazil. In addition, there is also some literature showing two-way causal relationship between PPI and CPI (Xu, 2010; Zhang, 2010; Cui and Li, 2012; Cui and Zhang, 2012; Sun *et al.*, 2015; Hou *et al.*, 2018; Zhang and Liu, 2018). Shahbaz *et al.* (2010) use VECM to reiterate the link between PPI and CPI, find two-way causality result in Pakistan. Woo, Lee and Ng (2018) analyze the dynamic causality between PPI and CPI to show the bidirectional long-run causal relationship in France, Germany and UK. While, the relationship between the two indices varies in different countries or different time periods. Based on the VAR model, Liu (2014) examines the transmission relationship by Granger test. The study reveals the two-way transmission in the early and late stages of 2000-2013, the one-way transmission during the period of 2007:M1-2009:M12 and there is no transmission relationship during the period of 2004:M1-2006:M12. Some scholars also verify the causality between CPI and PPI in Slovakia (Su *et al.*, 2016) and Romania (Khan *et al.*, 2017) using a bootstrap rolling approach. The Granger full sample test suggests positive transmission of PPI to CPI, but the Sub-sample rolling window test proves that two-way causality exists in sub-sample intervals. Subsequently, Khan *et al.* (2018) use the bootstrap panel Granger causality to analyze the relationship between PPI and CPI in ten Central and Eastern European (CEE) countries. In the sense of Granger causality, PPI

significantly influences CPI in Latvia, Lithuania, Romania, Slovakia and Slovenia, but CPI influences PPI only in Hungary.

The above studies are conducted on the basis of linear systems, but few studies have noted that the linear approach has limitations in explaining the relationship of macroscopic variables, even leading to conclusions bias (Kyrtsou and Labys, 2006). And the linear Granger causality test is difficult to discover and interpret the nonlinear relationship between time series (Nishiyama *et al.*, 2011). Therefore, the nonlinear Granger causality test proposed by Hiemstra and Jones (1994) and Diks and Panchenko (2006) begins to be widely used. Based on Threshold Vector Error Correction Model (TVECM), Su and Cai (2010) empirically explain the phenomenon of hanging upside-down between China's CPI and PPI. The results show that there exists a different Granger causality in different intervals. When CPI is about two percentage points less than PPI, only unidirectional Granger causal relationship exists instead of bidirectional Granger causal relationship. Subsequently, based on Threshold Vector Error Correction Model (TVECM), Alemu (2012) takes South Africa as an example to prove that there exists co-integration of threshold between PPI and CPI, and results show that there exists dynamic relationship between PPI and CPI, characterized by unidirectional causality running from PPI to CPI. Yang *et al.* (2013) also note that the existing literature ignores the nonlinear characteristics of price conduction, which leads to the deviation of the research conclusions. Therefore, under the nonlinear frame, they study the transmission mechanism between PPI and CPI in depth and examines the dynamic evolution trajectory of the two nonlinear transmission mechanisms. As a whole, PPI is the nonlinear Granger cause of CPI change. Subsequently, in the application of nonlinear Granger causality test method, Fan *et al.* (2013) and Huang (2014) also restudy the causality between the two variables, and the conclusion remains the same. However, Sun *et al.* (2016) and Sui and Li (2019) find that the positive driving effect of PPI on CPI and the reverse forcing effect of CPI on PPI exist simultaneously. By the nonlinear Granger causality test, Xiao *et al.* (2019) compare and analyze changes of PPI, CGPI and CPI

transmission mechanism in China under the new normal. It shows that the transmission mechanism between PPI and CPI in China before the new normal is relatively smooth. After entering the new normal, the transmission mechanism between PPI and CPI in China has been blocked, and the price transmission mechanism of industrial chain has changed obviously, which is mainly manifested in the fact that the transmission relationship between CGPI and CPI is not significant. This proves the decisive effect of data selection interval on empirical results.

Although some literature has conducted lots of academic analysis and empirical research about dynamic transmission mechanism of PPI and CPI, few empirical analysis carry out stability test of estimated parameters after causality test. Therefore, this study uses the Bootstrap LR statistic based on Monte Carlo simulation to test the causality between CPI and PPI. First of all, in the whole sample interval, Bootstrap full-sample test method verifies the long-term causal relationship between two variables, and then performs the stability test on estimation model of parameters. If these parameters are unstable, it indicates that there is no stable causality between PPI and CPI during the sample period. Therefore, the bootstrap rolling-window causality test is used to test the variation of the PPI and CPI causality with the change of time.

3 METHODOLOGY

3.1 Bootstrap Full-sample Causality Test

The standard causality test statistics include standard asymptotic distribution statistics Wald, Lagrange Multiplier (LM) and Likelihood Ratio (LR). However, if these basic time series data estimated by VAR model are non-stationary, standard asymptotic distribution may not exist. In this case, estimation of VAR model will be difficulty by the Granger causality test (Toda and Phillips, 1994). Shukur and Mantalos (1997) suggest that effectiveness of critical value is significantly enhanced due to the use of the residual-based bootstrap (RB) method. Furthermore, in many Monte Carlo simulation studies, it has been proved that the RB method is superior to standard asymptotic test, regardless of whether the two time series are co-integrated (Balcilar *et al.*, 2010). Especially, with smaller number of samples, modified LR

statistic can show better verification (Shukur and Mantalos, 2000). As a result, the RB method based modified LR statistic is applied to examine the causal relationship between PPI and CPI.

To highlight results of the causality test, we use two-variable VAR model, (p) process being considered as follows:

$$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \cdots + \varphi_p Y_{t-p} + \varepsilon_t, t = 1,2,\cdots,T \quad (1)$$

In this, $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})$ is a white noise process with a mean of zero and a covariance matrix of zero. The optimal lag length p is determined according to the Schwarz information criteria (SIC). By splitting into two sub-vectors, Y_{PPI} and Y_{CPI}, Equation (1) can be further represented as:

$$\begin{bmatrix} Y_{PPI\,t} \\ Y_{CPI\,t} \end{bmatrix} = \begin{bmatrix} \varphi_{10} \\ \varphi_{20} \end{bmatrix} + \begin{bmatrix} \varphi_{11}(L) & \varphi_{12}(L) \\ \varphi_{21}(L) & \varphi_{22}(L) \end{bmatrix} \begin{bmatrix} Y_{PPI\,t} \\ Y_{CPI\,t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (2)$$

$\varphi_{ij}(L) = \sum_{k=1}^{p+1} \varphi_{ij,k} L^k$, i, j=1, 2 and $L^k x_t = x_{t-k}$ is to define L.

From Equation (2), null hypothesis that PPI does not Granger cause CPI can be verified under the restrictive condition $\varphi_{12,\,k} = 0$ for k=1, 2,⋯, p, similarly, null hypothesis that CPI does not Granger cause PPI can be verified under the restrictive condition $\varphi_{21,\,k} = 0$ for k=1, 2,⋯, p. As mentioned above, results of the full sample causality test are verified by using modified LR statistics and boot P values. When this result rejects null hypothesis, it proves that causal relationship exists.

3.2 Parameter Stability Test

One assumption of full sample causality test is that parameters of VAR model are constant throughout the period. Nevertheless, Balcilar and Ozdemir (2013) believe that as the number of samples increases, structural mutations will occur in time series variables throughout the sample period, and the previous assumptions are not true. Consequently, the results of the full sample causality test are invalid. And the relationship between the two variables will show unstable effect throughout the sample period. Therefore, short-term and long-term parameter stability tests need to

be valued. In this paper, the short-term stability of these parameters is examined by the application of Sup-F, Mean-F and Exp-F tests (Andrews and Ploberger, 1994) which required for 15% trimming (Andrews, 1993). However, it should be noted that when the original variable is co-integration, VAR model after first difference is wrong unless error correction is allowed. Therefore, it is essential to test whether the relationship is co-integrated as well as whether these parameters are stable for a long time. We use the Fully Modified ordinary least squares (FM-OLS) statistics developed by Phillips and Hansen (1990) to examine co-integration of the relationship. After that, we can examine the stability of the long-term parameters by Lc test (Nyblom, 1989; Hansen, 1992), in addition, p-values and critical values can be obtained by the parameter bootstrap program (Andrews, 1993; Andrews and Ploberger, 1994).

3.3 Sub-sample Rolling-window Causality Test

The structural changes of time series can be pre-identified and estimated by technical estimation method, such as sample segmentation and virtual variable substitution. But all the above techniques have the disadvantages of pre-test deviation. Considering instability of parameters and the pre-test deviation, the paper introduces the sub-sample rolling-window causality test based on modified boot-pulling estimation. The rolling-window techniques can divide the full sample into fixed-size sub-samples. Specifically, if fixed-size of the sub sample is set to the observation of l, the full sample will be divided into $T-l$ sub-samples, which are $t-l+1, t-l, \cdots, T$ for $t = l, l+1, \cdots, T$. Next, we perform the RB method based modified LR for the above sub-sample. Then, we calculate the bootstrap p-values of observed LR statistics of sub-samples, and observe the result of the causal test between PPI and CPI of sample rolling window. The influence of PPI on CPI can be described by $N_{\mathrm{b}}^{-1}\sum_{k=1}^{p}\varphi^{*}_{12,k}$, where N_{b} represents the number of bootstrap repetitions; the influence of CPI on PPI is same to the above equation. The paper uses the 90% confidence intervals, where the lower limit equals the 0.05 quantiles of $\varphi^{*}_{12,\,\mathrm{k}}$ and the upper limit equals the 0.95 quantiles of the $\varphi^{*}_{12,\,\mathrm{k}}$ (Balcilar *et al.*, 2010). The

accuracy of empirical results in rolling windows depends on the window size and each incremental interval in the regression. If the window width is too small, the representativeness will be improved, but the accuracy of the parameter estimation will be reduced by increasing the standard deviation estimation. Otherwise, the the results will be accurate, but the representativeness is reduced. Therefore, the choice of window size needs to be weighed between the accuracy and representativeness.

4 DATA AND EMPIRICAL RESULTS

Since 2000, China's economy has begun to get rid of the adverse effects of the Asian financial crisis, the economic growth rate has steadily recovered, the economic benefits of enterprises have improved significantly, and there has been a better turn both in the macro-economics and micro-economics. Since 2000, the total consumer price level of residents shows a trend of recovery. Compared with the same period last year, the total consumer price level of residents has increased by 0.2% in the first three quarters. Affected by factors such as the rise in international oil prices, factory prices for industrial products continued to rise, rising 4% in the third quarter, 1.3% and 3% higher than the second quarter and the first quarter, respectively. However, the total supply and demand and structural contradictions that affect the total price level of our country have not changed fundamentally (Bai *et al.*, 2000)[1]. The data of CPI and PPI comes from the National Bureau of Statistics of China and it starts since the year of 2000. We use monthly year-on-year data, the research period is 2000:M1-2019:M12 and the base year is 2000. All variables are seasonally adjusted by Census X-12 approach and be transformed to natural logarithms form.

ADF, PP, KPSS are the common methods of unit root test for variables. Table 1 shows that PPI and CPI can not reject the null hypothesis in the ADF and PP tests, indicating that the two variables are not stable, but the null hypothesis can be rejected in first difference. The null hypothesis of KPSS test is opposite to that of ADF and PP. Therefore, the result of this test method is that the original data reject the null hypothesis, but the data after first difference accept the null hypothesis. In a word, these three different unit root tests have obtained the consistent result, that is, the

original data of PPI and CPI are not stable, but the stationary sequence is obtained by taking the first difference. In other words, both PPI and CPI are I (1).

< Table 1 is inserted about here >

After unit root test, a two-variable VAR model of PPI and CPI after first difference is in Equation (2). Therefore, the RB method based modified LR is applied to estimate causal relationship between PPI and CPI. Then, based on the Schwarz information criterion (SIC), we get an optimal lag period of 2. Table 2 shows the results of causality tests based the RB method. These results suggest that PPI does not influence CPI, but CPI significantly influence PPI in Granger causality test, which are consistent with the existing literature (He *et al.*, 2008 & 2010; Koutroumanidis *et al.*, 2009; Cui and Zhang, 2011; Liu and Lu, 2011; Tiwari, 2012; Lv and Yang, 2013; Sun, 2016).

< Table 2 is inserted about here >

If structural mutations occur in time series variables, the relationship between PPI and CPI will show unstable effect. Hence, the full-sample causality test makes the single causal relationship throughout the sampling period no longer reliable (Zeileis *et al*., 2005). Then with the goal of ensuring the accuracy of these result, we consider the bootstrap rolling-window causality test. We use the short parameter stability test and describe these results in Table 3. The null hypothesis of the Sup-F test is that the parameters are stable, the Mean-F and Exp-F tests are to verify whether there is a slow change process in the parameters, the Lc test is to judge whether the parameters have the characteristics of random slow walking and divergence. The Sup-F the Mean-F and Exp-F tests suggest that the null hypothesis is rejected for CPI equation, which indicates that parameters of CPI are not stable. According to the unit root test, both PPI and CPI time series are I (1), which means that when the co-integration relationship exists, the VAR model formed by the first difference of these variables will be unreasonable. Therefore, the paper tests the co-integration of relationship and the stability of long-term relationship. FM-OLS estimators are applied to judge whether variables are co-integrated and Sup-F, Mean-F, Exp-F and Lc test are used to

estimate the long-term stability of these parameters. Table 4 reports these results. Lc statistics reject the null hypothesis that the original sequence is co-integrated at a significant level of 5%; Sup-F statistics prove that structural mutations may exist in the long run at a significant level of 10%; Mean-F statistics and Exp-F statistics also show that parameters may have a gradual change over time in the long run at a significant level of 5%. Therefore, there not exists stable co-integration relationship between PPI and CPI, indicating that the previous VAR model is reasonable. To sum up, taking structural mutations in PPI and CPI into consideration, the full sample causality test is proved unreliable. Therefore, the RB method based modified LR is applied to examine the causal relationship. The optimal window size depends on persistence and size of the interrupt (Pesaran and Timmerman, 2004). With the aim to balance the accuracy and representativeness, we select 24-months as fixed sub-sample width[2].

< Table 3 and 4 is inserted about here >

Figure 2 highlights that the null hypothesis that CPI does not have Granger cause PPI is rejected at the 10% significance level during several sub-sample periods[3]: 2006:M5-2006:M8, 2008:M3-2008:M7, 2008:M9-2008:M11, 2014:M5-2014:M10 and 2016:M3-2016:M10. During these sub-periods, only one window is distributed before 2008, and the remaining are in the economic crisis of 2008 and the post-crisis times. Figure 2 shows that most of the periods in which CPI affects PPI are periods of economic volatility. Figure 3 reveals that the influence of the CPI on the PPI is all positive during these sub-periods. During 2006:M5-2006:M8 and 2008:M3-2008:M7, the influence of the CPI on the PPI is positive. The rise of labor costs is one of the main factors leading to inflation. Under the conditions of tight labor supply and demand, the government began to speed up the improvement of worker welfare, therefore, wages achieved double-digit growth in 2003-2007 and labor costs increased price level, resulting in a coordinated change between the CPI and PPI (Du and Han, 2011). And with a surge demand for housing and cars, as well as a severe drop in the supply of certain foods from 2006, the existing balance of supply and demand was

broken. There was a clear surplus of otherwise stable demand compared to supply, which has led to a sharp rise in these food prices. The combination of these factors eventually led to a rapid rise in CPI, then pull PPI up fast (Zhang, 2009). During 2008:M9-2008:M11, the influence of the CPI on the PPI is positive. In the second half of 2008, China's macro-policy was gradually adjusted to “expand domestic demand and ensure growth”, therefore, the government implemented active fiscal policy and loose monetary policy. Then the State Council took ten primary measures to increase domestic demand and economic growth in November. The global financial crisis has forced our government to invest 4 trillion dollars in 2008[4]. With the increasing investment and the implementation of stimulating consumption policies such as “home appliances to the countryside”, PPI and CPI began to recover rapidly from August 2009. Higher costs, associated with higher upstream commodity prices and a blowout increase in downstream demand, have contributed to a stronger linkage between the two, and then the whole economy is at risk of inflation (Wang *et al.*, 2015). During 2014:M5-2014:M10, the influence of the CPI on the PPI is positive. PPI and CPI showed a moderate positive correlation during 2014-2015 with a significant correlation coefficient (Cang *et al.*, 2019). During 2016:M3-2016:M10, the influence of the CPI on the PPI is positive. In 2016, because of loose international environment, the government's policy of “destocking and cutting overcapacity” has achieved remarkable results, and demand for investment has been transformed into demand for consumer. The gap between CPI and PPI becomes more narrow, which reflects that divergence between the two begins to decrease (Liu X. C. and Zhang X. J., 2017).

< Figure 2 and 3 are inserted about here >

Figure 4 indicates that the null hypothesis that PPI does not have Granger cause CPI is rejected at the 10% significance level during several sub-sample periods: 2003:M4-2003:M8, 2006:M5-2006:M10, 2007:M2-2007:M10, 2010:M2-2010:M10, 2012:M2-2012:M10 and 2013:M1-2013:M5. Further, the results of Figure 4 show that the period in which PPI has an impact on CPI belongs to the period of economic

fluctuation. Figure 5 reveals that PPI has not only positive effects on CPI, but also negative effects on CPI. The distribution of its negative effect is concentrated during 2006-2007, whereas the distribution of its positive effect is more scattered. During 2003:M4-2003:M8, the influence of the PPI on the CPI is positive. Since 2002, the market economy system has gradually improved, the links between various sectors of the economy have been strengthened, the price mechanism has begun to play a regulatory role, the linkage mechanism of PPI and CPI has begun to reflect, and the correlation coefficient has gradually increased (Wang *et al.*, 2015). PPI and CPI showed a moderate positive correlation in 2003 with a significant correlation coefficient (Cang *et al.*, 2019). During 2006:M5-2006:M10 and 2007:M2-2007:M10, the influence of the PPI on the CPI is negative. From July 2006 to October 2007, the price of meat, poultry and eggs and their processed products significantly increased, which directly raised the entire consumer price. And the rise in refined oil and fuel prices also further pushed CPI up. However, PPI remained relatively the same (Chen and Yang, 2008). During 2010:M2-2010:M10, the influence of the PPI on the CPI is positive. From June 2008 to December 2009, affected by the international financial crisis, both the international price level and the demand for investment fell sharply, which directly caused the decline of PPI. Then from January 2010 to November 2011, the bail-out policy alleviated the influence of the economic crisis on economic growth of China, and weakened the positive deviation between PPI and CPI (Liu X. C. and Zhang X. J., 2017). During 2012:M2-2012:M10 and 2013:M1-2013:M5, the influence of the PPI on the CPI is positive. Since 2012, with the overall macroeconomic recovery, both power generation and steel production data have improved. It is found that in the raw materials, fuel and power input link, there are significant natural monopoly characteristics and high market entry threshold in the manufacturing industry, therefore, most of them are concentrated in a small number of enterprises, which have a strong overall pricing power and is easy to transfer the cost to the downstream (He *et al.*, 2008).

< Figure 4 and 5 are inserted about here >

Above all, taking China as an example, we found the bidirectional transmission mechanism between PPI and CPI, both positive transmission of PPI to CPI and reverse transmission of CPI to PPI.

5 CONCLUSIONS

In the application of bootstrap full-sample causality test and the sub-sample rolling window causality test, this paper empirically analyzes the causality between PPI and CPI. The bootstrap full-sample causality test demonstrates unidirectional transmission mechanism between PPI and CPI in China, which is the reverse transmission of CPI to PPI. However, the sub-sample rolling window causality test proves that a two-way causality exists. The influence of CPI to PPI is all positive. Positive effects are a result of consumer demand for housing and cars, loose monetary policy and the relaxation of the international environment. PPI has not only positive effects on CPI, but also negative effects on CPI. Positive effects are a result of increased power generation and steel production. International financial crisis and decline of economic growth caused negative effects. And there are different characteristics between two for the reasons and changing trend of price rise in different periods. Since the drivers of PPI and CPI change and the degree of influence vary, there are sometimes transmission block between PPI and CPI and even deviation. Therefore, in addition to focusing on the causality and transmission mechanism between PPI and CPI, formulation of macroeconomic policy needs to focus on the correlation between PPI and CPI, and then the government can implement more targeted measures. First, in order to stabilize the price level, the government should strengthen the comprehensive application of monetary policy and fiscal policy. Second, the government should further deepen the supply-side reform and optimize the structure of supply and demand, which can fundamentally resolve the deviation between CPI and PPI caused by economic structural imbalance. Finally, the government can optimize the industrial structure to strengthen the internal relationship between CPI and PPI and weaken the role of external shocks in price-driven mechanisms.

ACKNOWLEDGMENTS

This work was supported by Shandong Social Science Planning Project (19CHYJ03), Research on the Construction of Index Evaluation System of Marine Strong Provinces in Shandong Province, 2019.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in [National Bureau of Statistics of China] at [http://data.stats.gov.cn/].

ENDNOTES

[1] Economic Situation Analysis Group of the Macroeconomic Research Institute of the State Planning Commission, 2000.

[2] Based on Monte Carlo simulations, the minimum of window size is 20. Hence, we respectively selected 24 months and 30 mouths as fixed window size for empirical analysis. The results demonstrate that the windows size of 24 mouths is more appropriate.

[3] Because short duration is not representative, the minimum duration of window is three months.

[4] The Central People's Government of the People's Republic of China, China's fiscal and monetary policy simultaneously adjusts 4 trillion funds to pry domestic demand, 2008.

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Data citation:

[dataset] Sun, J., Xu, J. H., Cheng, X., Miao, J. C. and Mu, H. R.; 2020; PPI & CPI; National Bureau of Statistics of China; http://data.stats.gov.cn/.

APPENDIX

Table 1. Unit Root Tests

Variable		ADF	PP	KPSS
Level	PPI	-1.423(2)	-1.366[9]	1.448[12]***
	CPI	1.200(0)	0.714[8]	1.944[12]***
1st difference	PPI	-6.432(1)***	-5.241[9]***	0.142[9]
	CPI	-8.546(1)***	-15.061[8]***	0.194[8]

Notes: *** denote significance at the 1% level. The number in parenthesis indicates the lag order selected based on the recursive t-statistic, as suggested by Perron (1989). The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by the Newey-West test (1987). These tests are used by Eviews software.

Table 2. Full-sample Granger-causality Tests

Tests	H0: PPI does not Granger cause CPI		H0: CPI does not Granger cause PPI	
	Statistics	*p*-value	Statistics	*p*-value
Bootstrap *LR* test	4.428	0.120	6.058*	0.070

Notes: * denote significance at the 10% level. These tests are used by Eviews software.

Table 3. Short Parameter Stability Tests

	PPI Equation		CPI Equation		VAR System	
	Statistics	*p*-value	Statistics	*p*-value	Statistics	*p-value*
Sup-F	12.81	0.274	21.051**	0.017	19.818	0.326
Mean-F	4.118	0.609	8.110*	0.082	10.611	0.366
Exp-F	2.768	0.556	7.019**	0.021	7.466	0.258
L_c^b					1.631	0.358

Notes: *, ** denote significance at the 10% and 5% level, respectively. Hansen-Nyblom parameter stability test for all parameters in the VAR jointly.

Table 4. Long Parameter Stability Tests

	Sup-F	*Mean-F*	*Exp-F*	*Lc*
PPI=α+β*CPI	11.375*	6.434**	3.784**	0.947**
Bootstrap p-value	0.053	0.013	0.027	0.018

Notes: *, ** denote significance at the 10% and 5% level, respectively.