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ABSTRACT

This study considers the price convergence in different regions of China, which is the largest developing country in the world and a country in which the regional difference is much larger between provinces. Whether there is price convergence between regions in one country is an important economic issue according to the Law of One Price (LOP) theory. Compared to previous studies, this article operates with the Sequential Panel Selection Method (SPSM) to explore the non-stationary properties of the LOP in China's regions. We provide robust evidence to specify that the LOP holds true for two-thirds of the provinces in China, mainly in the Western and Central regions. This means that the Eastern region's price fluctuation is non-stationary and that the consumer price index (CPI) levels of the Western, Central and Northeastern regions are relatively convergent in China. The conduction path of the CPI level is from the Eastern region to the other regions. It shows that prices can converge with each other by LOP and the values of the same goods in the Western and Central regions are equal and if there is a price difference, then it can be eliminated by interregional trade.

1. Introduction

The issue of price convergence between countries belonging to a common currency or trade area or between regions in the same country has attracted considerable interest in recent years (Busetti, Fabiani, & Harvey, 2006). Given that the barriers to trade and the distortions within a country are typically smaller than those between countries, there is a better chance that the Law of One Price (LOP) will hold in an intra-national rather than an international context (Dayanandan & Ralhan, 2005). The economic reforms initiated by Chinese authorities in the late 1970s promoted spatial domestic market incorporation alongside the state withdrawal, economic advancement and international exploration. The scale of regional incorporation in China and the conversion of the country into a united,

just, and regulated market as it has joined the World Trade Organisation (WTO) has a substantial weight, since China's international opening can only be effective if unbound access and the free movement of goods are granted between provinces (Poncet, 2005). Analysing the consumer price index (CPI) convergence and the regional transmission mechanism for national macroeconomic regulation and control is of great significance.

There are few studies concerning China's regional price differences, but the research on this problem has important significance (Liu, 2013; Wang, 2012). First, since the 1990s, although China's market economy has experienced high-speed development, China is a typical socialist country, and to a large extent, regional economic development is subject to administrative supervision and intervention. This means that the planned economy makes competition between regions very difficult for the free market to manage. Second, China's local protectionism is serious, and the local government blockade and monopoly prevent the formation of a unified national market. If the price levels between regions do not accord with the LOP, then it is evident that the flow of production factors and the configuration mechanism between regions may be the inhibited by local protectionism. Third, China presents a unique and significant opportunity to analyse regional inequality and is also a nation in the process of evolving, noticeably altering its institutions and economy at a rapid pace but with undeniable and observable differences across its provinces (Candelaria, Daly, & Hale, 2010). The development of an internal market was fostered by a series of mechanisms that were intended to reduce the scope of state intervention. A key element of the strategy was the progressive lifting of price controls (Fan & Wei, 2006). This policy has great significance in understanding, from the perspective of macroeconomic transformation, whether China's economy has realised interregional competition.

In recent years, China's CPI has been more volatile. In 2006, the CPI increased 1.5%, whereas in 2007, the CPI rose 4.8% over the previous year. Since 2008, the CPI has been rising every month. Although the CPI fell in 2010, the price level in 2011 jumped to 6.4% (Ma & Huang, 2013). Due to various areas in the resource assignment, economic growth, industrial structure, residents' income level and consumption structure, the changes in the CPI and the conduction mechanism are not entirely consistent in different regions. The provinces whose CPI growth rate is higher than the national average are mainly concentrated in the Central and Western regions (Wang, 2010). After nearly a decade, with the strategy of Western development and the rise of Central China and other regional coordinated development strategies, China's regional commodity flow has freely ascended, and the market segmentation degree in the Central and Western regions has gradually been narrowed, promoting price-level convergence in the regions (Liu, 2013). Whether the LOP holds for the CPI has some implications for the econometric estimation and testing procedures of commodity prices. If the LOP holds true, then the markets involved must be modelled simultaneously. Otherwise, there may be biased estimation from disregarding price movements in the other markets (Jung & Doroodian, 1994). Due to factors such as transaction costs, taxation, subsidies, real or susceptible trade restrictions, the reality of goods that are not yet tradeable, imperfect competition, foreign exchange market interventions, and the differential constitution of market baskets and price indices across regions, one may expect the LOP to be valid only in the long-run (Baum, Barkoulas, & Caglayan, 2001).

The contributions of this study are as follows. First, we use the Sequential Panel Selection Method (SPSM) proposed by Chortareas and Kapetanios (2009) to test whether there is evidence for the LOP in China's provinces. The method has more power to detect U-shaped

breaks and smooth breaks than the linear method and can classify the entire panel into a group of stationary series and a group of non-stationary series, particularly when there are sudden structural breaks from the effects of economic events. Second, the previous research on the evidence of the LOP has mainly had an international focus, but little attention has been given to the regions inside of one country. This article analyses the LOP theory using the CPI. China has a vast area, and the regional difference is much larger between provinces. This article can test whether regional transportation and trade barriers hinder the formation of free competitive markets. Third, we find that the LOP holds true for two-thirds of the provinces in China, mainly in the Western and Central regions. This finding means that regional competition in the Eastern provinces is evident and that the price differences have been caused by regional barriers and higher transaction costs. The CPI level in the Western and Central regions is stationary, which shows that there is the basic formation of perfect competition market at the regional level.

The remainder of this study is organised as follows. Section 2 provides the literature review. Section 3 presents the LOP theory. Section 4 describes the methodology of the SPSM test proposed by Chortareas and Kapetanios (2009). Section 5 presents the data used in our study and discusses the empirical findings. Finally, Section 6 reviews the conclusions we draw.

2. Literature review

Previous studies on this topic focus on the convergence of price, particularly for CPI in one country. Sonora (2005) finds that Mexican city relative prices are stationary and that, although there is substantial proof of a regional price convergence, the regional homogeneity does not guarantee indisputably faster convergence. Busetti et al. (2006) find that all pairwise contrasts of inflation rates have converged or are in the process of converging. Only 24% of price-level contrasts appear to be converging, but a multivariate test provides strong evidence of overall convergence in Italy. Choi and Matsubara (2007) also consider that heterogeneity is substantive across cities in each CPI item, and their findings are robust to a subsample analysis, though it points to the presence of a structural change around 1985 in Japan. Sonora (2008) finds substantial proof for refuting a unit root process in most cases of US city relative prices over the full sample period and two subperiods. Stationarity tests applied to sections of the US are less successful. Huang, Liu, and Yeh (2012) find overwhelming evidence in support of price-level convergence over time across 17 major cities in the US over the 1918–2008 period. Hegwood and Nath (2013) find that the speed of convergence with the structural break is faster than that reported by previous panel studies with no structural break using similarly long time-series data in the US. Multiple empirical studies have made use of threshold-type procedures to model nonlinearities in deviations from the LOP (see O'Connell & Wei, 2002; Taylor, 2010). Sarnoa, Taylor, and Chowdhuryd (2004) find strong evidence of nonlinear mean reversion in deviations from the LOP with plausible convergence speeds. Goldberg and Verboven (2005) find surprisingly strong evidence of convergence toward both the absolute and the relative versions of the LOP for price convergence. Pippenger and Phillips (2008) find no empirical evidence that would reject the LOP in commodity markets. Crucini and Shintani (2008) find a positive cross-sectional relationship between LOP persistence and the distribution margin, which they measure using sectoral US data, as suggested by the classical dichotomy. Akram, Rime,

and Sarno (2009) find that, on average, the LOP holds but numerous economically significant violations of the LOP arise. The duration of these violations is sufficiently high to make it worthwhile to search for one-way arbitrage opportunities to minimise borrowing costs and/or maximise earnings on given funds.

Regarding China, Fan and Wei (2006) find strong evidence in support of price convergence in the Chinese domestic market. Mehrotra, Peltonen, and Rivera (2010) find that the forward-looking initiation component is significant in 22 of the 29 provinces, highlighting the importance of this variable for the initiation formation process in China. Lan and Sylwester (2010) find half-lives of only a few months or less, supporting the hypothesis that convergence rates within a country are faster than the rates estimated in an international context. Wang (2012) notes that, although evidence has been found for inter-regional price-level convergence in China, the convergence speed is much slower. Although the article finds evidence of price-level convergence for some poor tradable goods or services, similar evidence has not been found for some tradable products. Zhang, Guo, and Shen (2016) suggest that the product market integration degree in China has been high and increasingly growing since 2003.

Compared to the previous studies, our study is different as follows. First, the transitional studies on the LOP are mainly on the national level for different countries. Furthermore, they typically neglect this issue at the regional level in only one country such as China, which is the largest developing country in the world and a country in which the regional difference is much larger between provinces. Whether there is price convergence between regions in one country is an important economic issue. It also provides an important test on the degree of market freedom or regional obstacles for one country in diverse provinces. Second, the previous studies are not concerned with the mechanism of price convergence. In this article, we consider the convergence order and how prices converge in the process. Finally, the new method that we use in this article is different from the methods of previous studies. The method has more power to detect U-shaped breaks and smooth breaks than the linear method, and it can classify the entire panel into a group of stationary series and a group of non-stationary series, particularly when there are sudden structural breaks from the effects of economic events. Also, China's provinces have much diversities and regional interaction. Compared with the other analysis framework the panel unit root testing procedure could consider the spatial dependence and the influence in different provinces.

Taylor and Taylor (2004) show that the recent methodological refinements of the test by Levin, Lin, and Chu (2002) fail to fully address the 'all-or-nothing' disposition of the assessment. Because they are joint assessments of the null hypothesis, they are not revealing with regard to the number of stationary process series when the null hypothesis is refuted. Similarly, when the unit root null hypothesis is rejected, mistaken conclusions may be reached for the stationarity of each and every series in the panel. Perron (1989) claims that, if there is a structural break, then the force of rejecting a unit root declines when the stationary alternative is valid and the structural break is disregarded. Consequently, the price level may be affected by internal and external shocks generated by structural changes, which may be subject to considerable short-run variation. It is important to know whether the price level has any tendency toward a long-run equilibrium level. If the price level is found to be stationary by using the unit root test with structural break(s), then the implication is that the consumption level differences between regions that cause deviations from a mean value or deterministic inclination are only provisional.

Recently, there has been a growing consensus that macroeconomic variables exhibit nonlinearities and, consequently, conventional unit root tests, such as the (Augmented Dickey-Fuller, 1981) test, have low power in detecting mean reversion. To solve this problem, non-stationary tests based on a nonlinear framework must be applied. Ucar and Omay (2009) have proposed a nonlinear panel unit root test by combining the nonlinear framework in Kapetanios, Shin, and Snell (KSS, 2003) with the panel unit root testing protocol of Im, Pesaran, and Shin (2003), which has been useful in testing the mean reversion of time-series data. Additionally, Su, Chang, Chang, and Yin (2014) apply SPSM to indicate that uncovered interest parity holds true for six of the eight East Asian countries. There are mainly two advantages according to this approach. One is that it applies the procedures to a set of tests that account for a number of other potential pitfalls in panels such as cross-sectional dependence. The other advantage is that the SPSM can scale the entire panel into a group of stationary series and a group of non-stationary series. We clearly identify how many and which series in the panel are stationary processes. Additionally, the convergence order can be obtained by the procedures and apply more power to reject the null hypothesis by the non-linear framework (Chortareas & Kapetanios, 2009).[1]

3. The Law of One Price

The LOP states that all firms face the same prices for their inputs and outputs under market equilibrium. In its absolute version, this law asserts that, in the presence of a competitive market structure, the prices of identical products traded in different markets will be the same when expressed in the same currency (Iregui & Otero, 2013). This law is an immediate consequence of the absence of arbitrage and, similar to the absence of arbitrage, follows from individual rationality. Departures from the no-arbitrage condition imply that there are profit opportunities. These opportunities arise because it would be profitable for arbitrageurs to buy a good in a country in which it is less expensive and transport it to a country in which it is more expensive and, in doing so, profit from trade.

According to the LOP, commodity arbitrage in efficient markets implies that, for a single homogenous commodity, assuming no transportation cost or obstacles to the flow of factors and production, prices in different markets are equal under a common currency (Ardeni, 1989). According to Low, Harms, Mutic, and Purdy (1998), this situation can be expressed as follows:

$$E_t = P_{it} - P_{jt} \tag{1}$$

where P_{it} and P_{jt} represent the commodity price level of i and j province and E is an endogenous parameter. If E is stationary, then the prices in the two provinces can be in equilibrium in the long-run, and they are in accord with the LOP. However, if E is non-stationary, then there are regional trading costs that obstruct commodity price equalisation, and the regions face economic financing obstacles, particularly with regard to regional trade.

4. SPSM and panel KSS unit root test with a Fourier function

As discussed above, long-established unit root tests become less powerful if structural breaks are disregarded in unit root testing. Several authors, including Gallant (1981), Becker, Enders, and Lee (2006), Christopoulos and León-Ledesma (2010), and Enders

and Lee (2012), note that a Fourier approximation can frequently capture the behaviour of an unknown function even though the function itself is not periodic. The authors highlight that their testing protocol requires nothing other than the specification of the adequate frequency in the approximating equations. By reducing the number of estimated parameters, they ensure for their tests a good size and force regardless of the time or form of the break.

In accordance with Kapetanios et al. (2003), the KSS unit root test depends on detecting the incidence of non-stationarity against a nonlinear but globally stationary exponential smooth transition autoregressive (ESTAR) process. The model is given by

$$\Delta E_t = \gamma E_{t-1}\left\{1 - \exp(-\theta E_{t-1}^2)\right\} + v_t \tag{2}$$

where E_t is the data series of the CPI, v_t is an *i.i.d.* error with a zero mean and constant variance, and $\theta \geq 0$ is the transition parameter of the ESTAR model and governs the speed of transition. Under the null hypothesis, E_t follows a linear unit root process; however, under the alternative, E_t follows a nonlinear stationary ESTAR procedure. One deficiency of this framework is that the parameter γ is not identified under the null hypothesis. Kapetanios et al. (2003) use a first-order Taylor series approximation for $\left\{1- \exp(-\theta E_{t-1}^2)\right\}$ under the null hypothesis $\theta = 0$ by using the following auxiliary regression:

$$\Delta E_t = \xi + \delta E_{t-1}^3 + \sum_{i=1}^{k} \theta_i \Delta E_{t-1} + v_t \, t \; = \; 1, \, 2, \, ..., \, T \tag{3}$$

In this framework, the null hypothesis and alternative hypotheses are expressed as $\delta = 0$ (non-stationarity) vs. $\delta < 0$ (non-linear ESTAR stationarity). Thus, Ucar and Omay (2009) expand a nonlinear panel data unit root test based on equation (2). The regression is as follows:

$$\Delta E_{i,t} = \gamma_i E_{i,t-1}\left\{1 - \exp(-\theta_i E_{i,t-1}^2)\right\} + v_{i,t} \tag{4}$$

Ucar and Omay (2009) also apply a first-order Taylor series approximation to the Panel ESTAR model around $\theta_i=0$ for all i and obtained the following auxiliary regression:

$$\Delta E_{i,t} = \xi_i + \delta_i E_{t-1}^3 + \sum_{j=1}^{k} \theta_{i,j} \Delta E_{i,t-j} + v_{i,t} \tag{5}$$

where $\delta_i = \theta_i \gamma_i$ and the hypotheses established by them for unit root testing based on equation (5) are as follows:

$$
\begin{aligned}
H_0 : &\delta_i = 0, \text{ for all } i \left(\text{linear non} - \text{stationarity}\right); \text{ and} \\
H_0 : &\delta_i < 0, \text{ for some } i \left(\text{nonlinear stationarity}\right)
\end{aligned} \tag{6}
$$

Furthermore, the system of the KSS equations with a Fourier function that we estimate here is the following:

$$\Delta E_{i,t} = \xi_i + \delta_i E_{t-1}^3 + \sum_{j=1}^{k} \theta_{i,j} \Delta E_{i,t-j} + a_{i,1} \sin\left(\frac{2\pi kt}{T}\right) + b_{i,1}\cos\left(\frac{2\pi kt}{T}\right) + \varepsilon_{i,t} \tag{7}$$

where $t = 1, 2, ..., T$, k represents the frequency selected for the approximation, $[a_i, b_i]'$ measures the amplitude and displacement of the frequency component, and the rationale for selecting $[\sin(2\pi kt/T), \cos(2\pi kt/T)]$ depends on the detail that a Fourier expression has the capability of approximating absolutely integrable functions to any proposed degree of precision. It also follows that at least one frequency component must be present if there is a structural break. Since there is no previous knowledge linked to the shape of the breaks in the data, a grid-search is first performed to find the most appropriate frequency.

5. Data and empirical results

In this study, we use monthly data on the CPI for 30 provinces in China from January 2003 to January 2015 to examine the convergence in China's consumer market relative to Shanghai. Shanghai was one of 14 cities and one of four municipalities directly under the control of China's central government when it opened its markets in 1984, and Shanghai is the most open city in China. As the birthplace of the Chinese national industry, Shanghai is the economic and financial centre of China and was China's first free trade area. From 1998 to 2003, China experienced a long period of price deflation. Since 2003, the price fluctuation has been shortened because structural inflation and deflation have been alternating and no longer form a lasting wave channel. The source of the data is China's CEinet statistics database. The CPI is a measure of the average change over time in the prices paid by consumers for a market basket of goods and services. It is widely used to measure modifications in the cost of preserving a certain standard of living. The goods and services commonly procured by the population enclosed are priced with a certain periodicity, and their prices are combined in accordance with the weight of their relative importance.

In our study, we use the CPI as a consumer market index (Putnam & Allshouse, 1996). The CPI is an important indicator for measuring inflation, and to some degree, its discretion can explain the level of inflation. To balance the regional economy, the provinces are divided into four groups on the State Council by the government based on their location and level of economic development: the Eastern region (Tianjin, Hebei, Shandong, Jiangsu, Zhejiang, Shanghai, Fujian, Guangdong, Guangxi, and Hainan), the Central region (Shanxi, Henan, Anhui, Hubei, Hunan, and Jiangxi), the Western region (Shaanxi, Inner Mongolia, Xinjiang, Qinghai, Gansu, Ningxia, Chongqing, Sichuan, Guizhou, Yunnan, and Tibet) and the Northeastern region (Heilongjiang, Jilin, and Liaoning). In China, most high-income provinces are located in the Eastern region, and the low-income provinces are located in the Western region.

As discussed above, panel-based unit root tests are unified tests of a unit root for all members of a panel and are not designed for the determination of the mix of I(0) and I(1) series in a panel setting. Thus, if we fail to incorporate the structural breaks into the model, then the model will have low power in detecting the mean reversion of the CPI. Therefore, we proceed to utilise the SPSM, combining the Panel KSS unit root test with a Fourier function, to investigate the time series for the 30 provinces relative to Shanghai. The SPSM classifies the entire panel into a cluster of stationary series and a cluster of non-stationary series. As a result, we can definitively indicate the number and exact series in the panel that are stationary processes. We opt for the Panel KSS unit root assessments with a Fourier

function. Primarily, a grid-search is performed to research and define the best frequency since there is no previous knowledge related to the shape of the breaks in the data. We estimate equation (7) for each integer $k = 1, ...5,$ following the recommendations of Enders and Lee (2012), and the asymptotic p-values are computed by means of bootstrap simulations using 10,000 replications. For the sequences, we find that the best frequency is ($k=1$), which works best for eleven series (see the fifth column of Table 1). The residual sum of squares (RSS) indicates that a double frequency ($k=2$) works best for six of the series, and the sequences are 6, 7, 18, 21, 25 and 28. Table 1 reports the results of the Panel KSS unit root test with a Fourier function in which we also give a sequence of the Panel KSS statistics with their bootstrap p-values on a reducing panel, the individual minimum KSS statistic, and the stationary series identified by this procedure each time.

As shown in Table 1, the null hypothesis of unit root in the CPI was rejected when the Panel KSS unit root test was first applied to the entire panel, producing a value of −4.685, significant at the 1% level. After implementing the SPSM procedure, we found that Henan is stationary, with the minimum KSS value of −9.741 of the panel. Thus, Henan was removed from the panel, and the Panel KSS unit root test was implemented again on the remaining set of series. Subsequently, we found that the Panel KSS unit root test still rejected the unit root null with a value of −4.511, and this time, Jiangxi was found to be stationary with the minimum KSS value of −9.490 among the panel. As a result, Jiangxi was removed from

Table 1. Results of Panel KSS with Fourier Test on CPI.

Sequence	OU Statistic	p-Value	Min KSS	k	Series	Regions
1	−4.685***	0.000	−9.741	1	Henan	Central
2	−4.511***	0.000	−9.490	1	Jiangxi	Central
3	−4.333***	0.000	−8.627	3	Liaoning	Northeastern
4	−4.174***	0.000	−8.484	3	Xinjiang	Western
5	−4.008***	0.000	−7.771	3	Shandong	Eastern
6	−3.857***	0.000	−7.249	2	Qinghai	Western
7	−3.716***	0.000	−6.782	2	Hei Longjiang	Northeastern
8	−3.583***	0.000	−6.448	3	Hebei	Eastern
9	−3.452***	0.000	−6.246	1	Shaanxi	Western
10	−3.319***	0.000	−5.378	3	Inner Mongolia	Western
11	−3.217***	0.000	−5.375	1	Tibet	Western
12	−3.103***	0.000	−5.233	1	Shanxi	Central
13	−2.985***	0.000	−5.048	1	Gansu	Western
14	−2.863***	0.000	−4.922	3	Fujian	Eastern
15	−2.735***	0.000	−4.437	1	Hainan	Eastern
16	−2.621***	0.000	−4.097	1	Ningxia	Western
17	−2.516***	0.002	−4.019	1	Yunnan	Western
18	−2.400***	0.006	−4.002	2	Chongqing	Western
19	−2.266**	0.021	−3.739	3	Guizhou	Western
20	−2.133*	0.065	−3.600	3	Sichuan	Western
21	−1.986	0.145	−3.339	2	Jilin	Northeastern
22	−1.835	0.273	−2.645	1	Beijing	Eastern
23	−1.734	0.372	−2.148	3	Guangxi	Eastern
24	−1.675	0.458	−2.145	1	Anhui	Central
25	−1.597	0.511	−2.136	2	Jiangsu	Eastern
26	−1.489	0.566	−2.076	3	Hubei	Central
27	−1.342	0.638	−1.677	1	Tianjin	Eastern
28	−1.230	0.695	−1.610	2	Guangdong	Eastern
29	−1.040	0.795	−1.572	3	Hunan	Central
30	−0.508	0.833	−0.508	3	Zhejiang	Eastern

Notes: ***, ** and * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively. The asymptotic p-values are computed by means of bootstrap simulations using 10,000 replications.
Source: It has been draw by the authors according to the calculation results.

the panel, and the Panel KSS unit root test was implemented again on the remaining set of series. We found that the Panel KSS unit root test still rejected the unit root null with a value of −4.333, and Liaoning was found to be stationary with the minimum KSS value of −8.627 among the panel. Liaoning was removed from the panel, and the Panel KSS unit root test was implemented again on the remaining set of series. The protocol was performed until the Panel KSS unit root test failed to refute the unit root null hypothesis at the 1% significance level, and finally, we found that this procedure stopped at the twentieth sequence, when the CPI convergence for 20 provinces, including Henan, Jiangxi, Liaoning, Xinjiang, Shandong, Qinghai, Hei Longjiang, Hebei, Shaanxi, Inner Mongolia, Tibet, Shanxi, Gansu, Fujian, Hainan, Ningxia, Yunnan, Chongqing, Guizhou and Sichuan, which are mainly in the Central, Western and Northeastern regions of China, were removed from the panel. To verify the robustness of our test, we pursued the protocol until the last sequence. Our findings show that the Panel KSS statistic failed to reject the unit root null hypothesis for the remaining sequences. Seemingly, the SPSM procedure using the Panel KSS unit root test with a Fourier function has provided some evidence for stationarity in the CPI convergence for these 20 provinces. This leads us to the conclusion that the unit root in CPI convergence only holds true for 20 of the 30 provinces in China, with the exception of Jilin, Beijing, Guangxi, Anhui, Jiangsu, Hubei, Tianjin, Guangdong, Hunan and Zhejiang, which are mainly in the Eastern regions. Taken together, our results provide strong support for the LOP in two-thirds of the provinces in China and suggest that these provinces are non-linear stationary, implying that deviations from CPI convergence are the result of the mean reverting toward the LOP equilibrium.[2]

Figure 1 shows that China's regional CPI convergence is present in two-thirds of the country. This result means that, without considering the transport barriers and administrative interference conditions, consumer prices show a trend of price convergence in the regions – that is, the prices of the same product are consistent with each other. During the 2003–2015 period, the relative price fluctuations have gradually declined, and the relative price variance has gradually approached zero, with product market integration moving step by step to completion (Zhang et al., 2016). The reasons are as follows. First, since China's reform and opening up, China has gradually changed central planning measures, such as the government's setting prices, managing production and planning the allocation of resources, and it has moved toward a market economy system. China's domestic regional market liberalisation has gradually increased, particularly with its membership in the WTO and the convergence of foreign direct investment, which has promoted CPI convergence in China's regions (Cui & Liu, 2000). Second, the local protection of Chinese provinces is on the decline, and the domestic market is being integrated. With the downward trend of local protectionism, the barriers to regional trade are lower than ever before, which has increased the degree of freedom regarding the flow of goods and labour, ultimately resulting in the convergence of price levels between regions (Jia & Qin, 2014). In addition, with the development of the transportation infrastructure, the regional transportation cost has diminished, and transport efficiency has gradually increased, which also provides objective support for the convergence of the price level among regions.

The results of this study also show significant differences across the regional markets of China in nearly all dimensions and reveal the heterogeneity in China's CPI level. The CPI level of most Eastern regions, including Beijing, Guangxi, Jiangsu, Tianjin, Guangdong and Zhejiang, has not been convergent during this period. On the one hand, the price change

Figure 1. Regional CPI Convergence. Source: It has been draw by the authors according to the calculation results.

Notes: The green colour means the regional CPI convergence, while the yellow colour means the regional CPI non-convergence and The Taiwan's data is missing. Also we put Sichuan and Chongqing into one region in the Figure.

frequency of clothing, food and other products is higher and typically shows weaker stickiness compared to the service industry. The consumption level in the Eastern region is higher than that in the Central, Western and Northeastern regions because it mainly focuses on the development of its service industry, whose price adjustment has a strong stickiness (Qu, Wu, & Xia, 2012). The consumer price fluctuation in these regions is more prevalent for food and industrial products. The marketisation degree of food and industrial products in consumer goods is higher, whereas the marketisation degree of services is lower. The fact that services have a low degree of marketisation indicates that a certain degree of market failure exists. On the other hand, the Eastern region's degree of international openness is higher, but the trade barrier in the Eastern region is also higher than that in other regions. This situation means that international openness and the regional market integration process in China's Eastern region are not synchronous (Wan, Yang, & Wang, 2009). The higher barriers to trade hinder the convergence of price levels, and the high openness also means that the price fluctuation law has been determined by foreign direct investment, which is different from the law of price-level changes in the Central, Western and Northeastern regions. At present, the degree of labour market and capital market segmentation is still significant in the Eastern regions, which shows that the factors of labour and capital cannot directly flow into the fastest economically growing region of China and that the market

segmentation situation has remained spatially significant. The administrative intervention and local protection in inter-district bank loans, interregional inter-district mergers, acquisitions of enterprises, enterprise financing, and technology transfer have also existed in the Eastern regions (Zhang et al., 2016). Additionally, according to Huang, Shu, and Zheng (2013), the border effect of provinces has conducted the obstacles to market freedom in the flow of factors in this region.

Regarding the Western, Central and Northeastern regions, the CPI of more than half of the provinces has been convergent relative to Shanghai, including Henan, Jiangxi, Xinjiang, Shandong, Qinghai, Hei Longjiang, Shaanxi, Inner Mongolia, Tibet, Shanxi, Gansu, Ningxia, Yunnan, Chongqing, Guizhou and Sichuan. Although the Central and Western regions of China are relatively larger and more backward than the Eastern region, the consumer price change trend has been toward convergence in these regions. This result indicates that the LOP holds in the Western, Central and Northeastern regions. Compared to the Eastern region, these regions cannot be affected by foreign import and export trade and are mainly at a medium consumption level. However, the Eastern region's investment scale is larger than that of the other regions, and the price volatility of rising investment and labour wages is also much larger than that of the other regions, which increases market pressure for consumer goods and services, thereby resulting in fluctuations and increases in consumer prices. This situation means that, compared to the Central and Western regions, the Eastern region will more easily experience inflation and the CPI in the Eastern region shows a divergent trend. On the other hand, the Central and Western regions have a lower degree of division of labour in the regional industrial structure, and the elements of homogeneity are more noticeable. Provinces cannot fully exploit their comparative advantage, which may be an important factor that causes regional price convergence. Lan and Sylwester (2010) argue that a lower degree of specialisation and market differentiation in developing countries creates a greater potential for price convergence.

From the view of intra-regional trade between Chinese regions, over the past 30 years, China's economy has been the extensive growth pattern which depends on the natural resources and labours, but the growth model is unsustainable. Through the development of provincial trade form a unified domestic market, it could promote the network building and deepening of labour division. Zhang and Li (2013) collect the China regional input-output table during 1987–2007 and find Chinese provincial trade has maintained high growth, while, the amount of provincial total trade in 2007 is two times of the total amount of international trade. In 1987 the amount of Chinese provincial trade has been 1.01 trillion Yuan and it has been further increased to 29.27 trillion Yuan in 2007. In the past 20 years, China's provincial trade volume increased by 28 times, and the average growth rate is 143% in every five years. Also, the Eastern region has always been the main body of a provincial trade and the Eastern provincial trade dependency is higher than the Central and Western regions. However, the Eastern provinces trade proportion is far less than the Central and Western regions (Zhang and Li, 2013). We find the implications as follows. First, with the provincial trade barriers and transaction cost reducing, the rapid development of the Chinese provincial trade promotes the formation of domestic unified market. It proves the LOP theory has been established in most of China's provinces which also accords with our results. Second, the open economy and market integration are not a simple linear correlation. On the one hand, because the Eastern region is a relatively superior investment environment, it is easy for the region to oscillate between the repeated investment and excessive investment,

leading to the strengthening of regional competition and the degree of trade protection. On the other hand, the regional production organisational efficiency of the Eastern region is relatively high, and self-sufficiency is at an appropriately high degree, embodied in a provincial trade that is more replaced by regional trade in the province. Simultaneously, with the increase in the degree of extroversion, the increase in international trade may 'crowd out' trade between domestic provinces. Thus, the trade barrier in the Eastern region is higher than that in the Central and Western regions (Liu, 2010; Wan et al., 2009), which suggests the result that the LOP holds true for two-thirds of the provinces in China, mainly in the Western and Central regions.

The SPSM can also show the sequential order of CPI convergence in regions, which means that there is transitivity of inflation among the regions in China. The results show that inflation is diverted from the Eastern to the Central, Western and Northeastern regions. The reasons for this trend are as follows. The Eastern region has become a grain-importing region, shifting from self-sufficiency, and the prices of food and some grocery products have risen. As a result, the Eastern region has been more prone to inflation, and the price volatility will tend to cause the price level in this region to spread (Qin & Luo, 1997). Due to its geographical advantages and for historical reasons, the price fluctuation of the Eastern region is mainly affected by global commodity prices, and its changes have been affected by external causes, including international consumer market price trends. The provinces in which both the forward-looking inflation component and the output gap are significant are situated on China's coastline. These provinces share some common characteristics: they are more open to international trade; they have the lowest share of state-controlled enterprises in their total output; they have experienced high rates of economic and labour productivity growth; and they have attracted large net inflows of immigrants from other provinces. All of this suggests that excess demand pressures, proxied by the output gap, have had a significant impact on inflation formation only in some provinces, suggesting that market-based inflation mechanisms are fully operational in Eastern regions (Mehrotra et al., 2010). The price fluctuations in the Central, Western and Northeastern regions of China have been affected by the Eastern region, which can explain why the CPI in the Central, Western and Northeastern regions of China is convergent, and inflation has disseminated from the Eastern region to these other regions.

The results are in accordance with Fan and Wei (2006), who hold that prices converge to the LOP in China for most provinces, whereas the results are different from Young's (2000) proposition that the economic reform has led to the fragmentation of Chinese domestic markets. Compared to Young's (2000) research, we focus on the comparison of the spatial difference at the provincial level, and his research focuses on overall and industry segments across the country. Additionally, the period that we considered in this article is from 2003 to 2015, whereas his studies focus on the year mainly before 1900. After the twenty-first century, regional integration and the flow of spatial elements have gradually strengthened, according to Zhang et al. (2016). However, our method is the non-linear unit root test framework, which has more power to detect the problem compared to Young's (2000) conventional econometric approach.

6. Conclusion

In this empirical study, we assess the non-stationary properties of the LOP with the CPI for the 30 provinces in China by applying the SPSM approach proposed by Chortareas and

Kapetanios (2009) to investigate the non-stationary properties of the LOP in China's regions. In particular, this study provides further insights into the regional integration in this country. We can clearly identify how many and which series in the panel are stationary processes. The combined use of the Panel KSS test with a Fourier function and the SPSM procedure allows us to convey clear conclusions on the stationarity of individual CPIs in our study. Compared to previous studies, the method considers a number of other potential pitfalls in panels such as cross-sectional dependence. Additionally, we provide the convergence order of the LOP, which has not been shown in the literature before. We find that the SPSM provides robust empirical evidence that supports the LOP, suggesting that two-thirds of the provinces in China, mainly in the Western, Central and Northeastern regions, experience a CPI level adjustment trend characterised in terms of a mean reversion toward equilibrium values. Given the evidence of a strong LOP, this finding means that the Eastern region's price fluctuation is mainly affected by foreign investment and international market and that the CPI levels of the Western, Central and Northeastern regions levels are relatively convergent in China. The conduction of the CPI level is from the Eastern region to the other regions.[3]

Notes

1. However, the method requires the proper frequency in the estimating process and neglects the breaks in the deterministic time trend.
2. We also do the robust test by Enders and Lee (2012) and find the similar results with our research.
3. Our research only focuses on the province level, and we can add city-level research in the future.

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