



A Study on the domestic price differences of large countries in International Comparison Program: An evidence from China

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Abstract

In 2014, the deviations between the estimation published by the World Bank of 2011 International Comparison Program (ICP) and the real economies of developing countries have raised questions about whether the purchasing power parity of developing countries is being systematically underestimated. In this regard, the World Bank experts believe that price differences in a large country may be the main reason for the deviations. Based on this, this article, on the basis of the expenditure measurement method of ICP, uses the spatial simultaneous autoregressive model to analyze the regional differences of consumer price index in 31 provinces and municipal cities in mainland China between 2005 and 2011 ICPs. The results show that, there are differences between the prices of various regions in China, which greatly limits the credibility of PPP calculation; secondly, there is a spatial correlation between the consumption and investment in regions of China, which will stabilize the volatility of regional prices; thirdly, China's net export expenditure items and investment expenditure items have a greater impact on price volatility.

Keywords: Purchasing power parity; Consumer price index; Moran's I; Simultaneous Auto-Regressive model

1. Introduction

On April 30, 2014, the World Bank released *Purchasing Power Parity and Real Expenditures of World Economy: A Comprehensive Report of the 2011 International Comparison Program*. However, the results have been much questioned upon its publication. Under these questions, the World Bank's report made a special discussion on the limitations of PPP, arguing that sampling and statistical errors of PPP data may make it less suitable for the comparison between economies with greater differences. Experts of the World Bank also believed that the price differences between the prices within a large country may be the main reason for the deviations of PPP results. But so far, there is seldom a research to provide empirical support and response to this conclusion. Only a few of the literature are on the deviation of purchasing power parity: Deaton (2012) calculated the standard error of different methods based on the index theory; Biggerie et al. (2016) calculated the PPP of the basic classifications of 62 categories of goods and services in 31 China regions in 2014 and found that the ratio of maximum to minimum PPP between 31 regions was 1.76, indicating significant regional price differences in China. However, the World Bank's 2011 ICP only announced the PPP data of the GDP level and several major expenditure items, without disclosure of the PPP data of detailed basic categories, which made it difficult to in limited theoretical studies of the PPP bias problem. And nowadays a new round of ICP, that is, 2017 ICP, will start and will be transformed into a permanent conventional statistical program. When the new round of ICP starts, whether there are significant differences in the prices of a large country and what main factors are restricting this difference are essential to the improvement of the accuracy of the PPP calculation of a large country.



As China is one of the world's six largest middle-income economies and a typical country with significant PPP deviation as said in the results published by 2011 ICP. This paper takes China as an example to study the above problems in the prices of a large country in order to provide some factual bases for the new round of ICP to deal with the problem of PPP deviations caused by the price differences in a large country.

2. Theoretical analysis on ICP processing large country internal price differences

From a statistical point of view, PPP is a price index designed by ICP, which is a point estimate of an unknown true value, not an exact value. And as an estimate its reliability will be affected by sampling error, measurement error and estimation methods and other factors. In the case of consistent estimation of the method, for a large country, if there is a price difference inside, sampling error and measurement error will become the decisive factor for PPP accurate calculation. This is also the reason why the World Bank reports that adaptability is affecting the comparison of PPPs in large countries.

Theoretically, the price is determined by the market, the common characteristics of the market mechanism will lead to some common price mechanisms. In large countries, the general price level determined by aggregate supply and aggregate demand is different from the price levels in administrative regions, but it is easier to open a domestic market than an international market. If the domestic market is unobstructed, the price differences between market segments will be stabilized. Thus, even if there is a price difference in the domestic market in the short term, the price difference can also be controlled in the long term. In that case, the calculation error of PPP can be effectively controlled if ICP considers reasonable weights according to the fluctuating range of prices in setting a sampling range when it measures the PPP of a large country. It can be inferred accordingly that accurate judgements about the following points should be made when ICP deals with the deviation of PPP calculation: (1) Whether there are long-term significant price differences within a country. The reason is that, on one hand, the domestic price difference is decisive of the accuracy rate of the PPP of a large country; on the other hand, although the price is a very active variable that changes with the market changes, short-term price fluctuations do not mean that there must be significant price differences in the long term. And each round of ICP's measurement normally takes 5 years. The price fluctuations within such a sampling period are in themselves the objects of ICP's survey. Therefore, domestic price difference in a large country is supposed to mean a price difference of great degree of fluctuation beyond the ICP survey period. Only this difference is what ICP needs to consider when it is calculating PPP. (2) Whether there is a factor stabilizing the price differences in a country. The causes of prices are intricate, containing both supply factors and demand factors. But in a large country, in addition to these two aspects, the role of the geographical space in promoting the domestic price differences should not be overlooked. Although short-term prices fluctuate with the changes of influencing factors, it is difficult to say whether this fluctuation is caused by a factor, making it also difficult to determine the future price trends. However, in the long run, given that a relatively stable economic development situation may appear in a country, the factors affecting prices can be extracted. As the ICP uses the expenditure method to determine the GDP classification system and representative specification products in its calculation of PPP, it is easier to extract the factors affecting the prices in a large country. Once these affecting factors are determined and different weights are given to different representative specification products in the PPP conversion according to the impact of these factors, the calculation and deviation adjustment of the PPP of a large country will be greatly improved.

Based on the above analysis, this paper, taking China for an example, examines whether there is a significant domestic price difference in China and determines the required responses to possible deviations in the measurement of China's PPP in 2017 round of ICP.



3. Analysis on the regional differences between price levels in China

To understand the difference between price levels caused by market segmentation and according to the previous analysis and the needs of ICP's calculation of comparative GDP using the expenditure method, three buyers' price indexes in 31 regions, namely, consumer price index (CPI), commodity the retail price index (RPI) and the fixed asset investment price index (FAIPI) were chosen to examine the factual differences between regional price levels of China. In view of the need for long-term analysis, the sample period is defined to be ICP's seventh and eighth rounds of surveys, i.e. between 2006 and 2015. When presenting price differences, considering the ICP's practice taking the national average annual transaction price as measured data during the collection the price data of participating countries, the difference between CPI, RPI and FAIPI and the corresponding national average price level was calculated, respectively. The smaller the difference was, the smaller the price differences were. Figures 1, 2 and 3 show the difference between CPI, RPI, FAIPI^① and corresponding national average level in 31 regions in China, respectively.

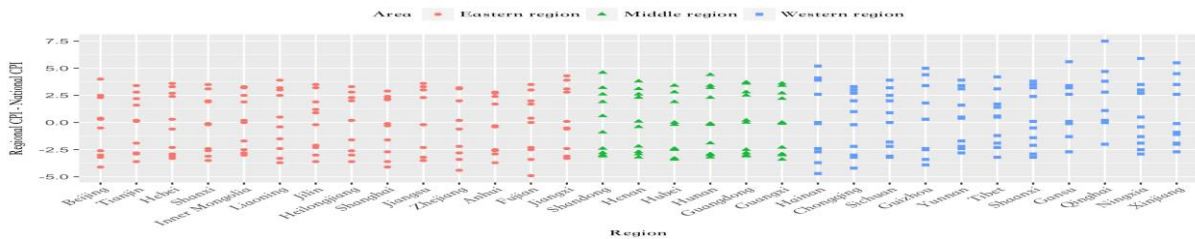


Figure 1 Differences between regional CPIs and national level in 2006-2015

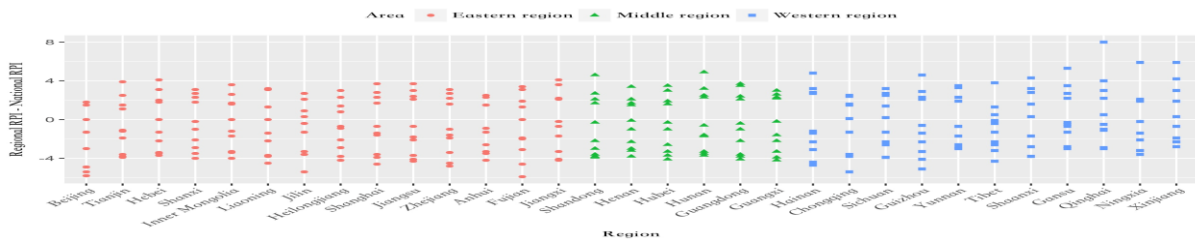


Figure 2 Differences between regional RPIs and national level in 2006-2015

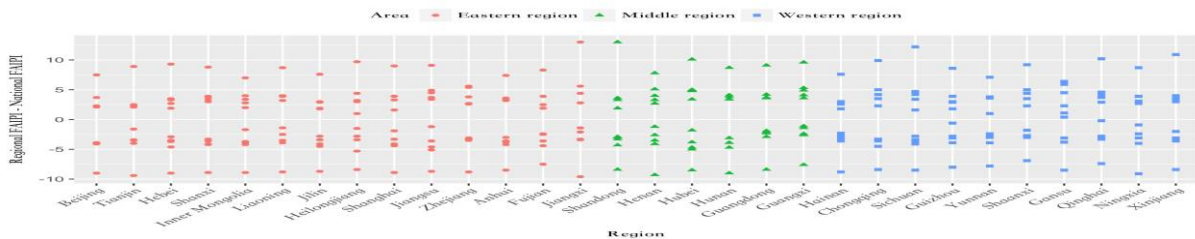


Figure 3 Differences between regional FAIPIs and national level in 2006-2015

It can be seen from Figure 1 that, from 2006 to 2015, the price level difference between the CPI in 31 regions and the national average level shows a divergence overall, indicating that there is a certain difference between the provincial residents' consumer prices in the long-term, where the price difference between eastern coastal areas and central regions is basically volatile in the interval [-5, 5]. But the price fluctuation range in eastern regions is wider than that of the central regions, indicating that the price levels in the eastern regions are more unstable than those in the central regions. The instability also shows individual differences in the eastern provinces, where the residents' consumer prices in Beijing, Guangdong and Hainan fluctuate greater. The volatility of the residents' consumer price in 11 provinces and municipal cities in western regions is more intense between [-5, 8],

^① The fixed capital investment price index of the Tibet Autonomous Region is missing.



especially in Guangxi, Guizhou, Qinghai and Xinjiang, where the price levels are more different from the national average level.

Figure 2 shows the distribution of the differences between national retail commodity prices in 31 regions, which is on the whole similar with the difference between residents' consumer prices and will not be repeated here.

Figure 3 presents the distribution of the differences between fixed asset investment prices in China's 30 provinces and municipal cities. It can be seen from the distribution features of the data points in the figure that the difference between fixed assets investment prices is more divergent than the difference between residents' consumption price and commodity retail price, which is in the range of [-10, 12]. The differences between the fixed asset investment price indexes in eastern, middle and west regions are significant. Fixed asset investment price index is a measure of the trend and the degree of price levels of construction and installation works, equipment purchase and other investment costs involved in fixed asset investment activities; the greater the difference range, the more influence the products related to construction and installation works and equipment will have on the comparable prices of China's expenditure method GDP.

Since the above three indices are related to the calculation of the comparable price of expenditure method GDP, it can be indicated by the analysis on the corresponding price difference from 31 provinces and municipal cities in China that there was a difference between the domestic price levels in China during the seventh and eighth rounds of ICP measurement. If this existing difference is significant and regular, it will be of great benefit for the new 2017 round of ICP to exclude the price differences in a large country on the PPP calculation.

4. Analysis on ICP's responses to regional price differences in China

4.1 Research methods and variables

Geographical space is a factor that cannot be ignored in the study of the price differences in a large country. In order to better detect the regional price level differences in China and show its regularity, this paper introduces the spatial autocorrelation analysis method (Moran, 1950). Spatial autocorrelation refers to the potential interdependence between the observed data of some variables in the same distribution area.

As this article needs to analyze the interdependence of regional price levels in China and it is shown that CPI, RPI and FAIPI have different degrees of difference between 2006 and 2015, in order to highlight their spatial effects, consumption, investment and net exports are used as weight variables to measure spatial distance variables and calculate the spatial correlation between price levels.

In the following text, the word "proximity" will be used to indicate the adjacency in the economic space, which was distinguished from the geographic space. If there is spatial correlation between objects, it is indicated that the objects are not independent of each other and a Simultaneous Auto-Regressive model (SAR) should be used for regression analysis (Bivand & al., 2013). The model is as follows:

$$Y = X^T \beta + B(Y - X^T \beta) + \epsilon \quad (1)$$

In Equation (1), ϵ is independent and conforms to normal distribution, $N(0, \Sigma_\epsilon)$. $B = \lambda W$ is a parameter matrix, where λ is a spatial auto-correlation coefficient and W is a spatial weight matrix. β is a parameter vector. $E(Y) = X^T \beta$ and $Var(Y) = (I - B)^{-1} \Sigma (1 - B^T)^{-1}$.

The variables used in this model include annual CPI, per capita consumption expenditure (PCCE), fixed asset investment (TIFA) and net exports (NE) in 31 provinces and municipal cities in China in 2006-2015, which represent the price level, the consumption expenditure, investment expenditure and net export expenditure in the expenditure method GDP. The data used in the evidence comes from the China National Bureau of Statistics and the CSMAR Solution database.



4.2 Empirical results

4.2.1 Test results of the global spatial auto-correlation between CPIs

Since the selection of the number of samples in proximity will have an effect on the Moran's I test, this paper uses the stepwise input method to select the number of samples in proximity, from 1 to 30. Also, according to Bivand & al. (2013)'s suggestion, Monte Carlo (MC) is used for sampling, and the number of tests is 100, 500 and 1,000. In addition, in order to test the stability of the results, Geary's C test proposed by Anselin (1995) is also used for comparison. If the results of these two tests are significant at 5% level, there is spatial auto-correlation and otherwise not.

The result shows that when the number of samples in proximity is between 3 and 17, the spatial auto-correlation test of 5 years or 6 years is significant in 2006-2015, that is, the CPIs of China's 31 provinces and are spatially auto-correlated under these three factors: consumer demand, investment demand and net export demand. It is further shown that it is possible for ICP to determine the sampling method based on the spatial correlation when it uses the classification system and the representative specification products of the expenditure method GDP for PPP calculation in order to ensure that the sampled specification products are representative of the prices in a large country.

4.2.2 SAR analysis results

In the SAR analysis, the four variables are logarithmically processed because the numerical differences between the data are too large. Meanwhile, the samples of 10 years are merged into cross-sectional data for regression analysis. The regression result is presented in Table 1.

Table 1 SAR regression result

	Estimate	Std Error	Z value	P. z
(Intercept)	4.70985	0.01151	409.1943985	0
log(PCCE)	-0.00551	0.00177	-3.117345815	0.001824874
log(TIEA)	-0.00271	0.00094	-2.885181147	0.003911885
log(NE)	-0.00003	0.00008	-0.401541669	0.688021366

It can be seen from the SAR regression result in Table 1 that both PCCE and TIEA passed the significance test at 1% significance. The estimations of the regression parameters are -0.00551 and 0.00271, respectively, indicating that when the other variables remained constant, the average CPI of neighboring regions was only about 0.0551% down when the average per capita consumption expenditure increased by 10% under the wealth effect; and accordingly, the average CPI of neighboring regions was only about 0.0271% down when the fixed investment increased by 10% on average under the interest rate effect, causing only small fluctuations of the price levels. It is shown that the long-term fluctuations of the prices of neighboring regions are small due to the economic connections, such as investment and consumption, between these regions. In other words, these small fluctuations also demonstrate that the economic connections between neighboring regions stabilize the regional fluctuations between prices. This is a significant characteristic of regional prices in China. The parameters of net export, however, did not pass the significance test, indicating that net export is not significant to the stabilization of the CPIs in neighboring regions.

It can be further known that, when there are price level differences in a large country, the spatial correlation of economic development, if existing, will stabilize the price fluctuations in a large country, and therefore, the ICP does not need to pay too much attention to its price differences in a large country. Even these differences are considered, the weights of the representative specification products used for the PPP calculation can be adjusted according to the degree of fluctuation.

However, by analyzing the residuals of the model using the Breusch-Pagan Test proposed, only the results of 2006, 2009 and 2013 were accepted under the hypothesis at 5% significance, that is, there is



no heteroscedasticity. The results of other years were not accepted under the hypothesis (see Table 2). This shows that there are significant differences between the price levels in 31 regions of China on the whole. It indirectly indicates that we must be careful to deal with internal price differences when the expenditure method is used to calculate China's PPP.

Table 2 Breusch-Pagan test of heteroscedasticity

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
BP	2.9435	11.5951	15.0654	1.7143	16.8930	13.7539	1.0166	9.4791	8.4288	8.3367
P value	0.4004	0.0089	0.0018	0.6338	0.0007	0.0033	0.7972	0.0236	0.0379	0.0395

5. Conclusions

Based on the part related to China of the ICP's measurement results and the actual price of China, this paper studies how the ICP should deal with the price difference in a large country. The conclusions are as follows:

1. Consumer price index, retail commodity price index and fixed asset investment price index of 31 provinces and municipal cities in China are different and further model analysis also confirms the existence of the difference between price levels in China. This shows that it is an established fact that China's PPP was underestimated in 2011. In order to ensure the correctness of PPP in China, it is necessary to pay attention to the price differences in three expenditure items of China used in the expenditure method. In particular, the fixed asset investment price and net export price are the points of considerable interest for ICP to ensure the correctness of PPP in China.

2. Although there are regional differences between the Chinese consumer price index, the retail commodity price index and the fixed asset investment price index during the two rounds of ICPs, spatial correlation will stabilize the volatility of prices as long as spatial correlation exists between consumption and investment, even if there is volatility of domestic prices. In this way, the spatial correlation between the items used in the expenditure method of these countries can be examined in 2017 ICP measurement of the PPP of China and other large countries. If the spatial correlation is strong, the difference between the price levels within a large country will not cause too much influences on the PPP calculation.

3. From the point of view of the expenditure method, it is the net export expenditure items that have a great influence on the difference of the PPP results of China, followed by the investment expenditure categories and finally the consumption expenditure categories. Therefore, the sampling weight can be adjusted according to the role of these expenditure items, as appropriate, in the calculation of China PPP in 2017 ICP, so as to ensure that the sampling error is as far as possible within the control range and thus improve the calculation accuracy of the PPP of China.

However, detailed items of the classification system of the GDP calculated using the expenditure method as said in this article cannot be presented due to the limitations on data, which may restrict further conclusion and which is worthy of further study. In other words, more general laws may be obtained if other countries can participate in the comparison.

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