



**Regionalization Approach in International Comparison Program and
Its Impact on China's International Comparison Results**

Yan Wang

(Beijing Normal University at Zhuhai)

Shaomin Liu

(Dongbei University of Finance and Economics)

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Regionalization Approach in International Comparison Program and Its Impact on China's International Comparison Results

WANG Yan¹ LIU Shaomin²

1. Institute of Advanced Studies in Humanities and Social Sciences, Beijing Normal University at
Zhuhai. Jinfeng Road, Tangjiawan, Zhuhai, 519087. China (ofse@163.com)

2. School of Statistics, Dongbei University of Finance and Economics. Jianshan Street, Dalian,
116025. China

Abstract: Based on the systematic review of the regionalization approach used by the International Comparison Program(ICP), this paper compares the two sets of global comparison results obtained in the Country Approach with Redistribution (CAR) method and analyzes the differences and reasons lying behind it. Furth more, the direction and extent of the impact of the regional grouping on China's purchasing power parity (PPP) and real aggregate are simulated and analyzed based on the CAR method. The study found that: For the Asia-Pacific region, the ratio of PPP obtained using global GEKS without fixity to PPP obtained using CAR with fixity shows a significant positive correlation with GDP per capita. This difference can be explained by the extent to which the bridge PPP obtained in global GEKS deviates from the regional comparison results. The economies using as the bridge in GEKS are determined by how we group the region. This means that the regional grouping will have an important impact on the results obtained from CAR method. From the simulation results of the regional grouping, when China is located in the EU-OECD region, PPP will increase by 2.56%, and real GDP will be reduced by 2.49% compared to the original regional grouping. This shows that under the current methodology, the global comparison results are not “neutral” for regional grouping.

Key Words: International comparison program; regional linking; purchasing power parity; real GDP

1 Introduction

The International Comparison Program (ICP) is currently the largest statistical initiative in the world. Measuring the Purchasing Power Parity (PPP) and real economic size in each economy is its core job. Currently, PPP has been widely used in many areas including the comparison of economic aggregates, price level, productivity, as well as global poverty monitoring, and the calculation of economic aggregate weights in the IMF's SDR. Angus Deaton, the 2015 Nobel Prize winner in Economics, talked about the importance of ICP data. He said that so far, no macro data is more

important than the data provided by ICP.

Calculating PPP requires collecting price data for comparable and representative items for each economy and corresponding expenditure data. Due to the huge differences in consumption habits, expenditure structure, and price structure of participating economies in different regions, as the number of economies participating in ICP expands rapidly, the comparability and representativeness of items between economies are increasingly difficult to meet. In general, economies in the same region have more similar consumption habits and price structures, and the comparability between items is stronger. Based on the above considerations, in order to ensure that the comparison of the price of the item is carried out on a more homogeneous basis, the ICP has started the process of regional comparison since the fourth round of comparison in 1980. In the process of development, the regionalization method has had a profound impact on ICP and directly contributed to the major changes in the ICP governance structure.

The two most important methods and practical arrangements in the regionalization approach are the requirement to maintain the within-region Fixity¹ and the regions to which the economies belong (World Bank, 2013). From the history of ICP, the regional linking method adopted to achieve the fixity and the regional affiliation of an economy are not set in stone. In fact, these regional linking methods and regional grouping arrangements have been changing in different periods (Yu, 2017). We need to clarify the possible impact of regional linking methods and regional grouping arrangements on the results from the perspective of quantitative analysis. The core content of this paper is to explore the direction and impact of the two most important methods and practical arrangements in the 2011 and 2017 round on China's PPP and real economic size.

2 Evolution of ICP regionalization method

(1) Background of ICP regionalization method

Since the first round of ICP comparison activities started in 1968, the influence of ICP has been increasing, and it has received extensive support and participation from more and more economies (see Table 1 for information on participating economies). This new change has brought new challenges to ICP. This challenge is reflected in two aspects: on the one hand, in the third round of the ICP report, it has been pointed out that if there is a large gap between the economic structure of the newly added economies and the participating economies, which will lead to an overestimation of the real economic strength of economies (especially developing economies) that differ greatly from the world's average economic structure (Kravis et al., 1982); On the other hand, since the beginning of the European Union Comparative Project (ECP) in 1980, EU has required independent regional comparisons and requires intra-regional comparisons to remain unchanged in global

¹ The within-region Fixity requires that the relative economic scale calculations of the economies obtained in the comparison within the region remain unchanged in the global comparison results.

comparisons in order to meet the policy needs² (Eurostat-OECD , 2012).

Table 1 The economies participates in the ICP quantity table (by region)

Region	Research phase			Operational stage				
	First round 1970	Second round 1973	Third round 1975	Fourth round 1980	Fifth round 1985	Sixth round 1993	ICP 2005	ICP 2011
Africa	1	1	3	15	22	22	48	52
the Middle East	—	—	1	—	—	8	11	13
Asia and Oceania	2	6	9	8	13	16	27	43
North America	1	1	1	2	2	2	2	2
Central and South America	1	1	5	16	7	—	11	41
Europe	5	7	15	19	20	35	47	48
total	10	16	34	60	64	83	146	199
Data release time	1975	1978	1982	1986	1994	—	2007	2014

Source: Eurostat - OECD Purchasing Power Parity Method Manual

(2) The development of ICP regionalization

a. Method and practice of the initial stage of regionalization

In response to these challenges, ICP began its regionalization process in 1980. According to the similarity of economic structure of different economies, the fourth round of comparison divides 60 participating economies into 6 regions, each region first compares within the region, and then the United Nations Statistics Division uses the “Core Country Method” to link results from different regions to get a global comparison results. One to three core economies will be selected in each region, and a total of 20 core economies will be selected. Each core economy needs to collect prices on all basic headings, and to ensure that there is overlap in the collecting items in each of the basic headings. According to the data collected by the above method, the purchasing power parity (PPP) of each of the 20 core economies in each basic heading is calculated, and the basic headings of PPP for non-core economies acquired in regional comparisons must be linked through the basic headings of PPP in the core economy for global comparison. Finally, the United Nations Statistics Division uses the GK method to aggregate the PPP and the expenditures at the basic heading level, and calculate the GDP level PPP at the global level (United Nations and Eurostat, 1986).

The regionalization process started with the fourth round of ICP encountered thorny problems in its operation. Due to the lack of a unified management at the global level, the regional comparisons have resulted in inconsistencies, which directly led to serious problems in the aggregation of global results. Due to the above problems, the ICP of 1993 was subject to numerous

² The EU allocates structural funds between member states based on the real GDP aggregates obtained after PPP adjustment. Structure funds account for about one-third of the total budget of the European Commission.

questions and the results of the comparison were not released. Afterwards, the United Nations organized the expert group to conduct a special review of the ICP, and the expert group headed by Ryten submitted a report to the United Nations (United Nations, 1998). Since then, ICP has entered a period of ten years of adjustment and rectification, and it was not until 2005 that a new round of comparison was restarted.

b. Regionalization method for the 2005 round of ICP

In the first six rounds of ICP, each economy needs to collect prices based on a uniform list of items, but in fact the items in the list are unlikely to be representative of all economies. From a more practical point of view, the 2005 round of ICP divided all participating economies into six regions, and each region's price experts developed a list of items based on the consumption characteristics of the region's economies. The adoption of the regional list of items makes the items more comparable and representative for the economies within the same region (World Bank, 2008).

In 2005 round of ICP, ring approach was adopted as the regionalization method. The regionalization of the list of item makes it possible to have certain differences in the pricing items of different regions. When such differences are large enough, it will bring difficulties to comparison between regions. To solve this problem, Diewert (2010) developed a new regional linking method for the 2005 round of ICP - the ring approach, to deal with this problem. There are three steps of the ring approach: First, the within region comparison. Each region will independently calculate the PPP and the volume of GDP for each economy within the region. Second, calculating the inter-regional linking coefficient. The ring approach requires 2-3 economies to be selected in each of the regions. A total of 18 economies are selected as "Ring countries" and an additional list of items for these countries is designed. Calculating the basic heading linking coefficients between regions using the price of these items collected by the countries. Then, the basic heading PPP will be linked. The regional comparison results are linked to the global level by multiplying the basic heading linking coefficients between the regions by the comparison results in the corresponding regions. Finally, measuring PPP at the global level. Using the linking coefficient of each basic heading of each region and the total regional expenditure of the corresponding basic heading, the regional linking coefficient at the GDP level is calculated by the GEKS method. The advantage of the global results obtained by the ring approach is that the relative of both PPP and volume of each economy within the region will be preserved at the global level.

c. Regionalization method for the 2011 round of ICP

The 2011 round of ICP used Global Core List (GCL) to address regional linking issues. Sergeev's (2010) study shows that the Ring approach used in the 2005 round does not satisfy base country invariance (the selection of base economy within the region will affect the final global results). In response to this question, Hill (2011) suggested that the 2011 round of ICP use GCL and CAR method for inter-regional linking. GCL requires each economy to price the core list for regional linking.

The main steps of the CAR method are as follows: First, construct a global matrix of PPP and expenditure at the basic heading level; Second, the global matrix is aggregated by the GEKS method to obtain PPP and real expenditure at the GDP level; The third step is to add the real expenditure of all the economies in the same region and calculate the sum of the real expenditure of each region; Finally, according to the principle of fixity, the regional total expenditures are redistributed among

the economies in the region (the proportion depends on the regional comparison on the relative volume of each economy within the region). The GCL and CAR method ensure that the global aggregated results are invariant to the base economy and overcome the problem of the Ring approach.

Table 2 ICP important event chronology

1950-1960	1954 and 1958: OEEC conducted an experimental comparison between nine European countries and the United States.
1960-1970	1968: The International Comparison Project was initiated by the University of Pennsylvania and the United Nations Statistics Division.
1970-1975	Established a methodology that allows for regular worldwide comparisons and conducted the first three rounds of research: 1970 ICP First round: 10 economies; 1973 ICP Second round: 16 economies; 1975 ICP Third round: 34 economies
1975-1980	ICP is headed by the United Nations Statistics Division. ICP begins regionalization process
1980	The fourth round of ICP: 60 economies; The PPP calculation below the base heading uses CPD, and the above uses GK.
1985	The fifth round of ICP: 64 economies
1990	ICP changed its name to International Comparison Programme
1993	The sixth round of ICP: 83 economies; in the end only regional comparisons were implemented while global results were not released
1996-1998	Ryten Report 1998: ICP should be strengthened at the economy, regional and global levels, and restarted at these three levels with more adequate resources.
2002-2003	Restart ICP: Established the Global Office at the World Bank; 2005 as a base year
2005	The 2005 round of ICP: The PPP calculation below the base heading uses CPD, and the above uses EKS.; the region links through 18 bridge countries
2008	2005 round of ICP results published
2011	The 2011 round of ICP: 199 economies participated; each economy must price the products in Global Core List for inter-regional linking
2014	2011 round ICP results published
2017	The 2017 round of ICP start: 176 economies participated
2020	2017 round of ICP results published

Source: Eurostat - OECD Purchasing Power Parity Method Manual

3 The idea and steps of using CAR method for regional linking

(1) The basic idea of CAR method for regional linking

In order to solve the problem that the Ring approach used in the 2005 round of ICP does not satisfy base country invariance, the 2011 round of ICP uses GCL and CAR method to deal with regional linking³. Figure 1 shows the measurement framework of the 2011 round of ICP, which includes the main steps of the CAR method.

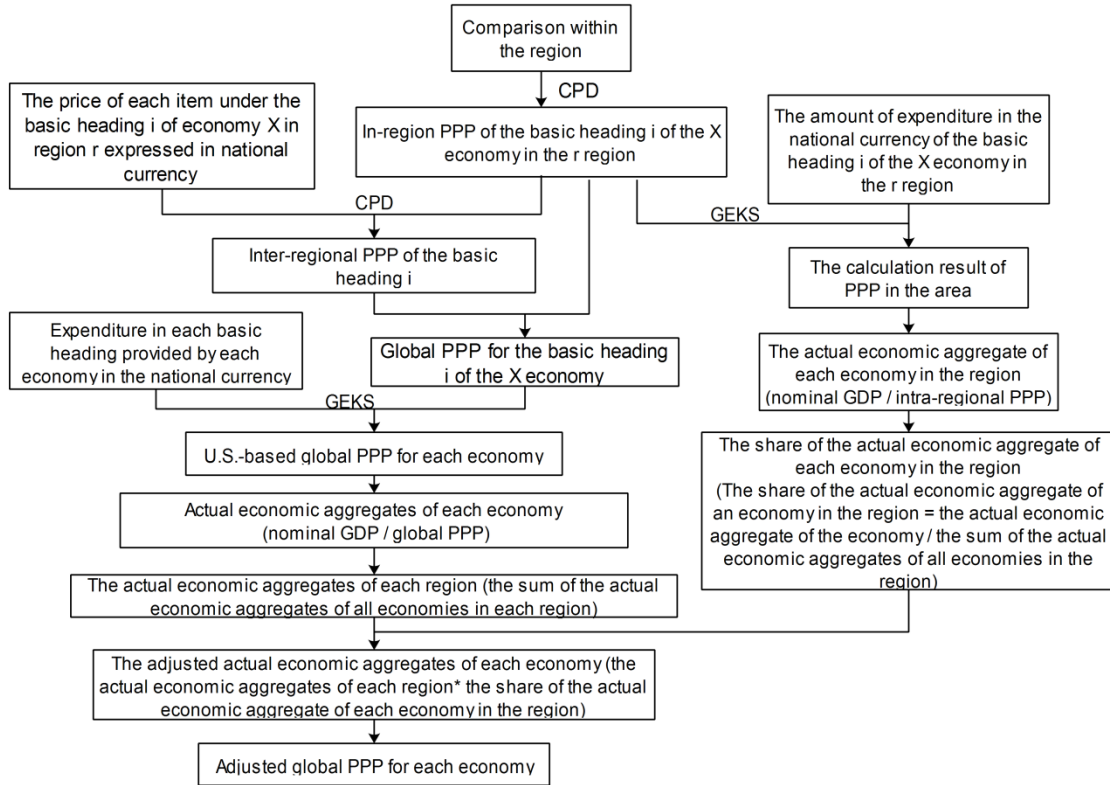


Figure 1 The logical framework of the 2011 round of ICP measurement method

(2) Main steps

Step 1: Comparison within the region

Each economy in the region conducts item pricing based on the list of items identified by the regional coordination agency and submits the annual average price⁴ of each item to the regional coordination agency. The price data submitted mainly include household price, mechanical equipment and construction prices, housing rent and government salary. The regional coordination agency will use the tool to validate⁵ the price data submitted by each economy. After the data validation is completed, the PPP of each basic heading is calculated based on the price data on items. For the basic headings which PPP cannot be calculated by the price of the item, it will be processed by the method of reference PPP⁶. Eventually, a matrix of 155 basic headings PPP for each economy

³ The 2017 round of ICP regional linking method still adopts the CAR method, and fine-tunes only on the link methods such as the difficult comparison field.

⁴ The annual average price is generally calculated by the arithmetic mean, which is the arithmetic average of the price data of a certain product of an economy at all the price points and all the time of the price.

⁵ In general, the regional coordinating body will use the Dikhanov table for data review. EU-OECD region uses the Quaranta table for data review

⁶ Reference PPP method and the specific application in ICP can refer to Chapter 24 of the 2011 round ICP

in the region will be formed. Combining the expenditure data of 155 basic headings submitted by each economy, using the GEKS method to calculate the PPP, one can get the PPP at the GDP level of each economy in the region. (PPP_{region}^{Xr} represents the PPP at the GDP level of the X economy in the r region). By dividing the nominal GDP by the PPP at the GDP level, one can get the real GDP. The formula is:

$$Q_{region}^{Xr} = \frac{GDP_{nominal}^{Xr}}{PPP_{region}^{Xr}} \quad (1)$$

Where Q_{region}^{Xr} represents the volume of X economy in the r region; $GDP_{nominal}^{Xr}$ is the nominal GDP of the X economy in the r region; PPP_{region}^{Xr} is the PPP at the GDP level of X economy in the regional comparison.

The share of the volume of each economy in the region is:

$$s_{region}^{Xr} = \frac{Q_{region}^{Xr}}{\sum_X Q_{region}^{Xr}} \quad (2)$$

Where s_{region}^{Xr} is the share of the volume of the X economy in the r region; $\sum_X Q_{region}^{Xr}$ is the sum of the volume of the economies in the r region.

Step 2: The linking of the basic headings

The comparison within the region only obtains the PPP and real expenditure of each economy based on the regional base economy (the PPP of the base economy in the region is set to 1 and the real expenditures of each economy are expressed in the currency unit of the base economy). For example, the base economy in the Asia-Pacific region is Hong Kong, the base currency unit is Hong Kong dollar. If we want to make a global comparison, we also need to know the conversion factor between the currency units of the regional base economies, so that the comparison results at the regional level can be linked to the global level. Based on GCL, the 2011 round of ICP uses the improved CPD method to calculate the conversion factor of the currency unit between the base economies in each region.

Table 3 shows the basic data needed to calculate the inter-regional linking coefficient of the basic heading i. For the convenience, we will take two regions in Table 3 as an example for illustration⁷. Suppose the A economy is the base economy of Region I and the E economy is the base economy of Region II. Specifically, Table 3 shows the prices of the three GCL items in the basic heading i of countries A to D in Region 1 and countries E to G in Region 2. p_{ij}^{Xr} is the price of the GCL item j under the basic heading i of the X economy in the r region, which is expressed in the national currency. The last column of Table 3 shows the PPP of the basic heading i for each economy within the region.

operation guide 《Operational Guidelines and Procedures for Measuring the Real Size of the World Economy: 2011 International Comparison Program》.

⁷ The same treatment is used in Tables 4 to 7 below.

Table 3 Price data of each region used to calculate the inter-regional link coefficient of the basic heading and PPP of the basic heading within the corresponding region

Annual average price – the basic heading i	Region one				Region two		
	Economy A	Economy B	Economy C	Economy D	Economy E	Economy F	Economy G
1	P_{i1}^{A1}	P_{i1}^{B1}	P_{i1}^{C1}	P_{i1}^{D1}	P_{i1}^{E2}	P_{i1}^{F2}	P_{i1}^{G2}
2	P_{i2}^{A1}	P_{i2}^{B1}	P_{i2}^{C1}	P_{i2}^{D1}	P_{i2}^{E2}	P_{i2}^{F2}	P_{i2}^{G2}
3	P_{i3}^{A1}	P_{i3}^{B1}	P_{i3}^{C1}	P_{i3}^{D1}	P_{i3}^{E2}	P_{i3}^{F2}	P_{i3}^{G2}
Basic heading PPP (within the region)	$1(PPP_i^{A1})$	PPP_i^{B1}	PPP_i^{C1}	PPP_i^{D1}	$1(PPP_i^{E2})$	PPP_i^{F2}	PPP_i^{G2}

Based on the data in table 3, the improved CPD method can be used to calculate the interregional PPP of the given basic heading. Before using the improved CPD method, the price of the GCL items for each region needs to be converted to use the currency unit of the base economy in the region. This is done by dividing the price of GCL items for each economy by the PPP of the basic heading, and converting the price of the GCL items for each region into a unified intra-regional base economy currency unit:

$$P_{ij}^{*Xr} = \frac{P_{ij}^{Xr}}{PPP_i^{Xr}} \quad (3)$$

The adjusted prices are shown in Table 4.

Table 4 Core product list item price matrix adjusted by the basic heading PPP in the region

Annual average price – the basic heading i	Region one				Region two		
	Country A	Country B	Country C	Country D	Country E	Country F	Country G
1	P_{i1}^{*A1}	P_{i1}^{*B1}	P_{i1}^{*C1}	P_{i1}^{*D1}	P_{i1}^{*E2}	P_{i1}^{*F2}	P_{i1}^{*G2}
2	P_{i2}^{*A1}	P_{i2}^{*B1}	P_{i2}^{*C1}	P_{i2}^{*D1}	P_{i2}^{*E2}	P_{i2}^{*F2}	P_{i2}^{*G2}

3	P_{i3}^{*A1}	P_{i3}^{*B1}	P_{i3}^{*C1}	P_{i3}^{*D1}	P_{i3}^{*E2}	P_{i3}^{*F2}	P_{i3}^{*G2}
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To calculate the interregional linking coefficient for a given basic heading, an improved CPD approach is required:

$$\ln p_{ij}^{Xr} - \ln PPP_i^{Xr} = \beta_{ri} + \gamma_{ij} + \varepsilon_{ij}^{Xr} \quad (4)$$

Where p_{ij}^{Xr} is the price of the GCL item j under the basic heading i of the X economy in the r region, which is expressed in the national currency; PPP_i^{Xr} is the intra-region PPP of the basic heading i of the X economy in the r region; β_{ri} is the overall price level of the basic heading i of the r region; γ_{ij} is the overall price level of the core product list item j under the basic heading i; ε_{ij}^{Xr} is the error term.

In order to estimate (4), the equation (4) is transformed into:

$$\ln p_{ij}^{Xr} - \ln PPP_i^{Xr} = \beta_{ri} * D_{ri} + \beta_{i1} * D_{i1} + \gamma_{ij} * D_{ij}^* + \mu_{ij}^{Xr} \quad (5)$$

Where R represents the total number of regions; N represents the total number of items under the basic heading i. D_{ri} and D_{ij}^* are the dummy variables for regions and items, respectively.

When the price of the item on the left side of the formula (5) is p_{ij}^{Xr} , only the dummy variables of the region r and the item j are $1(D_{ri}=1, D_{ij}^*=1)$, and all the other dummy variables are 0.

The estimated value of β_{ri} can be obtained by using OLS to estimate equation (5). And $\exp(\beta_{ri})$ is the inter-regional PPP of the given basic heading we require, that is, the inter-regional linking coefficient.

$PPP_i^r = \exp(\beta_{ri})$ represents the linking coefficient of the basic heading i of the r region. When region 1 is selected as the base region, the regional linking coefficient of the basic heading i obtained is shown in table 5.

Table 5 Regional Link Coefficients of Basic Heading

Link coefficient (PPP)		
method	Region one	Region two
CPD	$1(PPP_i^1)$	PPP_i^2

Based on the basic heading PPP at the regional level given in step 1 and the regional linking coefficient given in Table 5, the global PPP of this basic heading for each economy can be obtained:

$$PPP_i^X = PPP_i^{Xr} * PPP_i^r \quad (6)$$

PPP_i^X represents the global PPP of the basic heading i of the X economy.

The linking process and the linked results of the basic heading i between region one and region two are given in Table 6. The global PPP after the linking is given in the last column of Table 6.

Table 6 Global Links to Basic Heading PPP

Economy	Region	Basic heading PPP (within the region)	Regional link coefficient	Linked global PPP
A	One	PPP_i^{A1}	PPP_i^1	PPP_i^A
B		PPP_i^{B1}		PPP_i^B
C		PPP_i^{C1}		PPP_i^C
D		PPP_i^{D1}		PPP_i^D
E	Two	PPP_i^{E2}	PPP_i^2	PPP_i^E
F		PPP_i^{F2}		PPP_i^F
G		PPP_i^{G2}		PPP_i^G

Step 3: Calculate the total volume of each region based on the global GEKS method

Table 7 shows the PPP and corresponding expenditure data after 155 basic headings were linked.

Table 7 Basic heading PPP and expenditure matrix after global linking.

Economy Basic headings	Region one				Region two		
	A	B	C	D	E	F	G
1	PPP_1^A	PPP_1^B	PPP_1^C	PPP_1^D	PPP_1^E	PPP_1^F	PPP_1^G
	e_1^{A1}	e_1^{B1}	e_1^{C1}	e_1^{D1}	e_1^{E2}	e_1^{F2}	e_1^{G2}
2	PPP_2^A	PPP_2^B	PPP_2^C	PPP_2^D	PPP_2^E	PPP_2^F	PPP_2^G
	e_2^{A1}	e_2^{B1}	e_2^{C1}	e_2^{D1}	e_2^{E2}	e_2^{F2}	e_2^{G2}

⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
155	PPP_{155}^A e_{155}^{A1}	PPP_{155}^B e_{155}^{B1}	PPP_{155}^C e_{155}^{C1}	PPP_{155}^D e_{155}^{D1}	PPP_{155}^E e_{155}^{E2}	PPP_{155}^F e_{155}^{F2}	PPP_{155}^G e_{155}^{G2}

Based on the above-mentioned basic headings of PPP and expenditure, the GEKS method can be used at the global level to obtain PPP at the GDP level for each economy (PPP_{global}^{Xr} represents the PPP at the GDP level of the X economy in the r region).

$$PPP_{global}^{XY} = \prod_{L=1}^M [F_{XL} * F_{LY}]^{\frac{1}{M}} \quad (7)$$

Where M is the total number of economies participating in the international comparison; F_{XY} is the bilateral PPP of the economy X and the economy Y calculated based on the Fisher index, F_{XY} is calculated as:

$$F_{XY} = PPP_{Fisher}^{XY} = \left[\frac{\sum_{i=1}^{155} PPP_i^Y * q_i^X}{155} * \frac{\sum_{i=1}^{155} PPP_i^Y * q_i^Y}{155} \right]^{\frac{1}{2}} * \left[\frac{\sum_{i=1}^{155} PPP_i^X * q_i^X}{155} * \frac{\sum_{i=1}^{155} PPP_i^X * q_i^Y}{155} \right]^{\frac{1}{2}} \quad (8)$$

Where PPP_i^X is the global PPP of the basic heading i of X economy; q_i^X is the volume of the basic heading i of X economy, $q_i^X = \frac{e_i^X}{PPP_i^X}$

By dividing the nominal GDP by the PPP obtained in Eq. (7), we can get the volume of the economy in the global comparison:

$$Q_{global}^X = \frac{GDP_{no\,minimal}^{Xr}}{PPP_{global}^{Xr}} \quad (9)$$

Where Q_{global}^X represents the GDP volume of the r-region X economy calculated in the global comparison; $GDP_{no\,minimal}^{Xr}$ is the nominal GDP of the r-region X economy.

The GDP volume of all economies in each region is summed to obtain the GDP volume of the region:

$$Q^r = \sum_{i=1}^m Q_{global}^{ir} \quad (10)$$

Where Q^r is the total GDP volume of all economies in the r region; m is the total number of economies participating in the international comparison in the r region; Q_{global}^{ir} is the GDP volume of economy i in the r region.

Step 4: Calculate the adjusted volume and PPP using the national redistribution method

In order to ensure the principle of the fixity, the total GDP volume of all the economies in the r region obtained in Eq. (10) is distributed according to the share determined in Eq. (2), then we can get the distributed volume of each economy:

$$Q_{CAR}^X = Q^r * s_{region}^{Xr} \quad (11)$$

Where Q_{CAR}^X is the volume of X economy obtained through distribution.

At this point, the volume distributed to each economy (real GDP) is obtained, and a global comparison can be made.

Dividing the nominal GDP of each economy by the volume distributed (real GDP) is the adjusted global PPP for the economy:

$$PPP_{CAR}^X = \frac{GDP_{nominal}^{Xr}}{Q_{CAR}^X} \quad (12)$$

Where PPP_{CAR}^X is the adjusted global PPP for the economy X.

4 Analysis of the Differences Between Two Global Comparison Results in CAR

Method and Its Causes

(1) Thoughts on the Linking Process of CAR Method

It can be seen that in the calculation process using the CAR method, we obtained two global comparison results. The first comparison results are calculated based on the linked 155 basic heading PPP and the corresponding expenditure, but the results do not meet the fixity requirements. We call this the global GEKS comparison result. The second comparison uses the CAR method to incorporate the regional fixity into the calculation process, and obtains the comparison results that meet the regional fixity requirement. We call this the CAR comparison result. Dikhanov and Vogel (2013) and Hill (2016) show that for some regions, the global GEKS comparison results are significantly different from the CAR comparison results. According to Dikhanov and Vogel (2013), from the simulation results of the 2005 round, the results of maintaining global fixity (the CAR comparison result) and the results of not applying the intra-regional fixity requirements (the global GEKS comparison result) are very different for some economies. (see Figure 2). Hill (2016)'s research further found that for the Asia-Pacific region, the difference measured by real per capita GDP was 3.57%, and for the CIS region, the difference was as high as 12.29%.

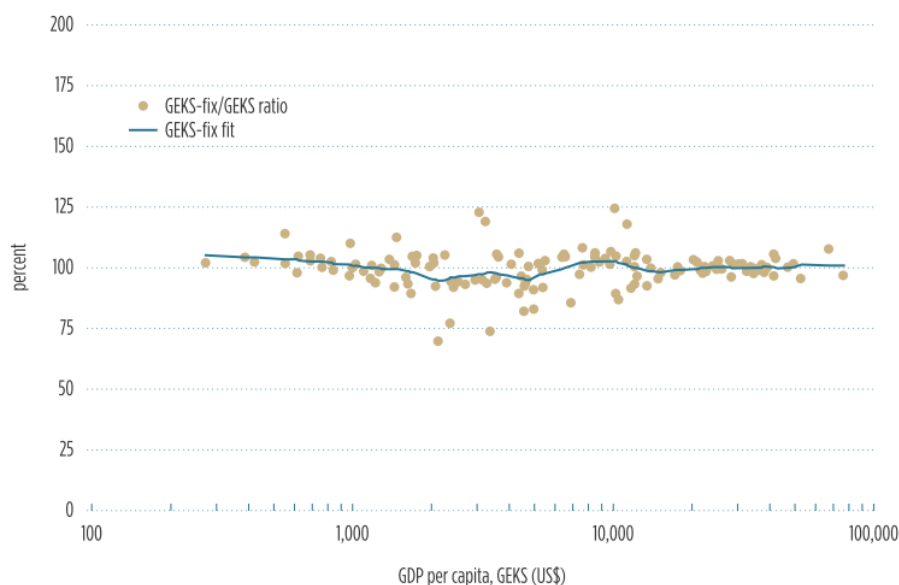


Figure 2 Simulation analysis of 2005 round results

Source: Measuring the Real Size of the World Economy: The Framework, Methodology, and Results of the International Comparison Program—ICP, 2013.

Hill (2016)'s study only analyzes the overall difference between the global GEKS comparison result and the CAR comparison result in terms of regions. He does not analyze the differences in a more detailed manner within each region. In fact, the above detailed analysis is crucial to our understanding of the nature of the CAR method.

(2) Correlation analysis of two global comparison results obtained by CAR method

The empirical research and simulation data in this paper are derived from the 2011 ICP researcher data set (ICP 2011 Data for Researchers) provided by the world bank. The data used in this study including the PPP and nominal expenditure data for 155 basic headings in 154 economies⁸, as well as the regional affiliation data for each economy.

In order to explore the similarities and differences⁹ between the two global comparison results, we calculated the PPP based on the global GEKS method when the economies in the Asia-Pacific region do not have a fixity constraint, and the CAR method based on the fixity constraint. The scatter plot on the ratios of two sets of PPP and per capita GDP (exchange rate method adjustment) is shown in Figure 3. It can be seen that there is a significant positive correlation between the ratio of global GEKS PPP and CAR PPP and per capita GDP in Asia-Pacific economies. That is to say, with the increase of per capita GDP, the ratio of global GEKS PPP to CAR method PPP in various economies shows an upward trend.

⁸ The six regions are: Africa (AFR), Asia and the Pacific (ASP), Commonwealth of Independent States (CIS), Latin America and the Caribbean (LAC), West Asia (WAS) and the European Union – OECD. In view of the low quality of the data in the Caribbean and the Pacific island countries and the low share of the global economy, the economies of the above regions were not included in the measurement process.

⁹ Given that the focus of this study is to explore the impact of regional approaches on China's international comparison results, the analysis below is based primarily on data from 23 economies in the Asia Pacific region. For the sake of analysis, we set the base economy for the comparison between the global GEKS and CAR methods as Hong Kong.

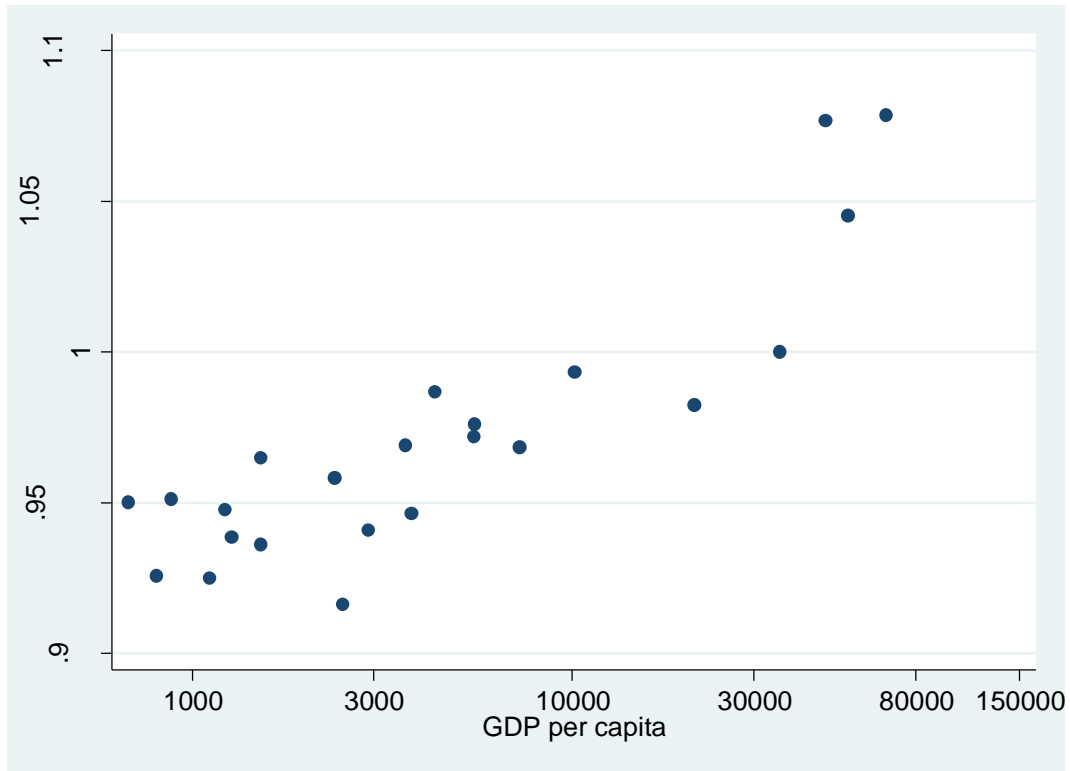


Figure 3 Relationship between two PPPs obtained in the CAR method

Hill (2016)'s research shows that there is a close relationship between the CAR comparison results and the regional comparison results. Taking the Asia-Pacific region as an example, PPP (Hong Kong dollar as the base currency) obtained by each economy through intra-regional comparison multiplied by a regional linking coefficient (conversion factor between Hong Kong dollar and US dollar) in each economy region to obtain PPP (US dollar as the base currency) under the CAR method. This means that when we adjust the PPP obtained by the CAR method to the Hong Kong dollar as the base currency (that is, Hong Kong PPP=1), the PPP of the CAR method in the Asia-Pacific region is the same as the results from the Asia-Pacific regional comparison. Therefore, Figure 3 can be understood from another perspective as the systematic difference between the global GEKS PPP and the PPP in the Asia-Pacific region. The analysis of this perspective can help us further explore the reasons for the difference between the two global comparison results.

When calculating the global GEKS results and the Asia-Pacific regional results, the GEKS method is used for aggregation. The basis of constructing the GEKS method is the bridge PPP. For example, in the intra-regional comparison between China and Hong Kong, the calculation process of bridge PPP is based on the Fisher index to calculate the bilateral PPP between China and an economy in the region, and then calculate the bilateral PPP between the economy and Hong Kong based on the Fisher index. Finally, the two bilateral PPPs are multiplied to obtain the bridge PPP. In order to obtain transitive PPP, all the economies in the region need to be used as an intermediary to calculate the bridge PPP, and all the bridge PPPs are geometrically averaged to obtain the PPP that meets the transitivity. From the above calculation process, it can be seen that the calculation of bridge PPP will traverse all the economies in the region by using the GEKS method. In global aggregate calculations, the calculations that bridge PPP traverse all economies.

The impact of the above calculation process on the comparison results is: when comparison is

done at the intra-regional level, the bridge PPP in the GEKS method only involves the economies in the region, so the intra-regional comparison results are only affected by the price data and expenditure data of the economies in the region. How the region is organized, that is, which economies are included in a particular region, will have a direct impact on the comparison results within the region. However, in the global GEKS method, bridge PPP involves all participating economies in the world, and the price data and expenditure data of all economies will have an impact on the final results. Therefore, from this point of view, the difference between the regional comparison results and the global GEKS results is mainly due to the difference in bridge PPP in the GEKS method and is affected by the regional grouping arrangements.

Further analysis shows when using the GEKS method for aggregation, the more similar the price level and expenditure structure of each economy in the region is, the more reliable the bridge PPP is. Therefore, the reliability of the results in the regional comparison is much better. When using the global GEKS method for aggregation, the comparison of PPP and real economic aggregates between any two economies in the region will be influenced by the price level and expenditure structure of all economies in the world. When calculating the PPP between economies with large difference in price level and expenditure structure, the statistical deviation is large (Deaton and Heston, 2010). For example, when using the global GEKS method for comparison between China and Hong Kong, the bridge PPPs that will be used are: $F_{\text{China-Saudi Arabia}} * F_{\text{Saudi Arabia-Hong Kong}}$,

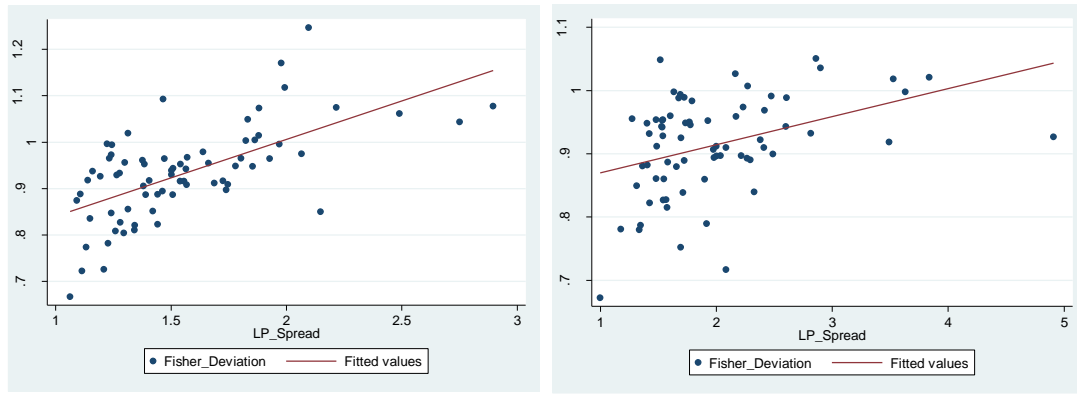
$F_{\text{China-Morocco}} * F_{\text{Morocco-Hong Kong}}$, $F_{\text{China-Egypt}} * F_{\text{Egypt-Hong Kong}}$ etc. The obvious fact is that many bridge PPPs in the global GEKS have low reliability for bridging purposes.

(3) Reasons for the Positive Correlation between Two Global Comparison Results

To further explore the reasons for the positive correlation in Figure 3, we selected Bangladesh and Myanmar, the least developed economies in the Asia-Pacific region, and the most developed economies, Macau and Singapore, for research. Considering that the global GKES results between any two economies are calculated by the geometric mean of the bridge PPP of all economies, we have separately calculated all bridged PPP between Bangladesh and Hong Kong, Myanmar and Hong Kong, Macau and Hong Kong, and Singapore and Hong Kong under the global GEKS method. Furth more we calculate the degree of deviation of these bridged PPP from the intra-regional PPP of the corresponding economy.

In order to analyze whether there are systematic characteristics on the bridge PPPs deviated from the regional comparison results, we also calculated the LP spread between Bangladesh, Myanmar, Macau and Singapore and all the other economies¹⁰. In general, the greater the LP spread between the two economies, the greater the difference in price levels and expenditure structure for these two economies. Figure 4 and Figure 5 show scatter plots of the degree of bridge PPP deviation and the LP spread.

¹⁰ Hill (1999) formally proposed the reliability of the bilateral comparison using the Laspeyres-Paasche (LP) distance when constructing the MST method. Since the Laspeyres index and the Paasche index are generally regarded as the two extreme values of the bilateral index, and the Fisher index is the geometric mean of the two indices. The longer the interval constructed by the Laspeyres index and the Paasche index, the higher the error of the bilateral comparison is generally considered.



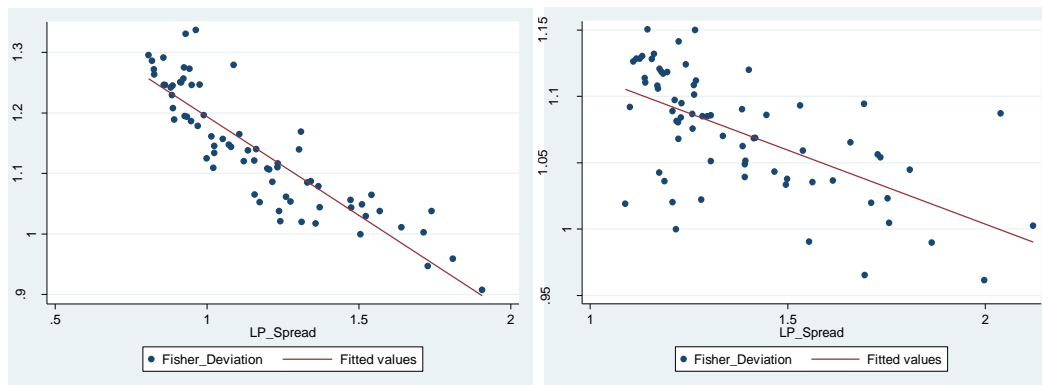
Bangladesh

Myanmar

Figure 4 Scatter plots of bridge PPP deviation and the LP spread

In figure 4 and figure 5, the Y-axis is the ratio of bridge PPP to its regional comparison counterpart; The X-axis is the LP spread, which measures the degree of difference in the price level and expenditure structure of a given economy and the bridge economy.

As can be seen from figure 4, when there are large gaps between the bridge countries and the least developed economies, it is much more likely to get a higher value of bridge PPP. Compared with the results from the regional comparison, the global GEKS has generally decreased the PPP of these least developed economies in the region and raised their real economic aggregates.



Macao

Singapore

Figure 5 Scatter plots of bridge PPP deviation and the LP spread

It can be seen from figure 5 that compared with the regional comparison results, the global GEKS aggregation have generally raised the PPP of these most developed economies in the region, which has lowered their real economic aggregates.

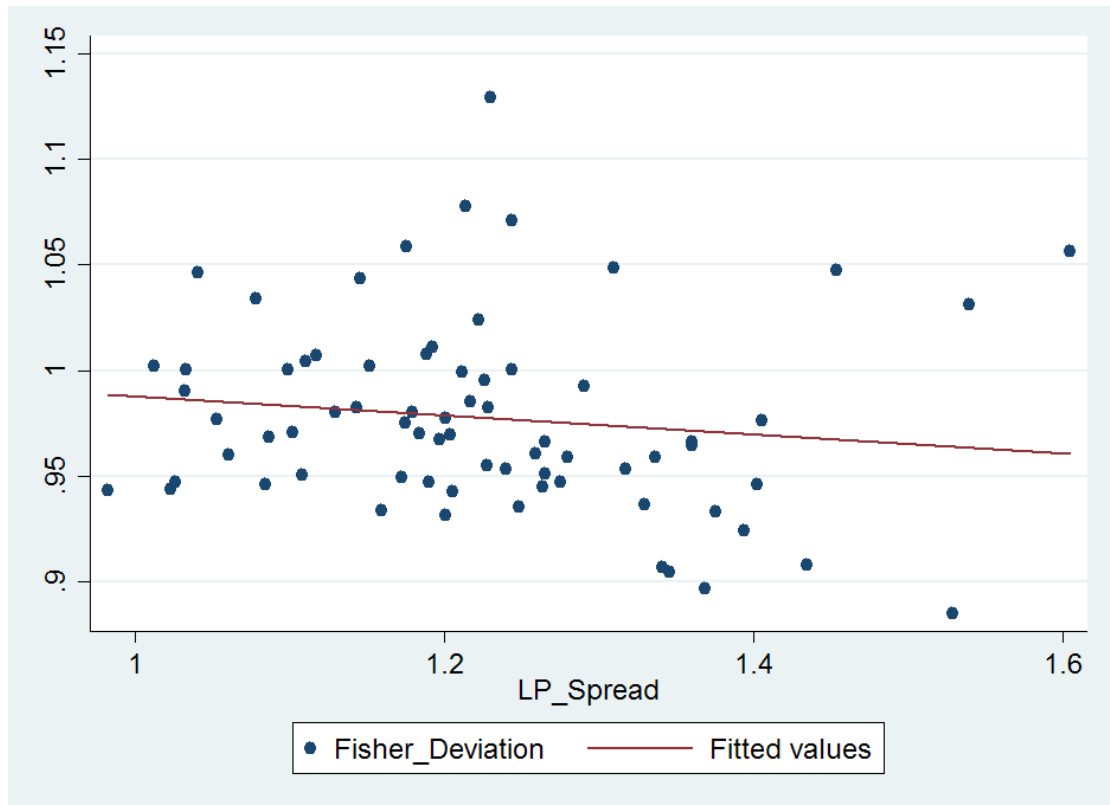


Figure 6 Scatter plot of the degree of bridge PPP deviation and the LP spread (China)

Figure 6 shows the scatter plot for China. It can be seen that if there are large differences in price level and expenditure structure between China and the bridge economies, there is a possibility of raising its PPP, and there is also the possibility of lowering its PPP, and the direction of influence is not consistent. However, on the whole, compared with the results from the regional comparison, the global GEKS has lowered China's PPP and raised the real economic aggregate.

According to the above analysis we can see that, for the Asia-Pacific region there is a significant positive correlation between per capita GDP and the ratio of PPP not subjected to fixity constraint to PPP subjected to fixity constraints. This correlation can be explained by the extent to which the bridge PPPs deviate from the regional comparison counterpart. Therefore, the use of different economies for bridge purpose will have an important impact on the results of PPP. In fact, the number of bridge countries in each region is directly determined by the regional grouping arrangement. This means that regional grouping arrangement will have an important impact on the CAR comparison results.

5 Simulation on regional grouping arrangements

This section will systematically study the impact of the adjustment of regional grouping arrangements on China's PPP and real economic aggregates. First, when using the CAR method as the regional linking method, we respectively calculate China's PPP and real GDP when China is located in the original Asia-Pacific region as well as when China is moved to the EU-OECD region, and then systematically compare the differences in the results; Secondly, when Japan and South Korea are moved to the Asia-Pacific region, the CAR method is still used as the regional linking

method to recalculate China's PPP and real economic size.

Table 8 Different regional division scenarios

Scenarios	Asia-Pacific	EU-OECD region	Four other regions
Original division	23 economies: Bangladesh, Bhutan, Brunei, Cambodia, China , Fiji, Hong Kong, China, India, Indonesia, Laos, Macau, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam	47 economies : Albania, Australia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Mexico, Montenegro, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States	Keep the economy grouped unchanged
China is located in the EU-OECD	22 economies: Bangladesh, Bhutan, Brunei, Cambodia, Fiji, Hong Kong, China, India, Indonesia, Laos, Macau, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam	48 economies : China , Albania, Australia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Mexico, Montenegro, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States	Keep the economy grouped unchanged
Japan and Korea are located in Asia-Pacific	25 economies: Japan, South Korea, Bangladesh, Bhutan, Brunei, Cambodia, China, Fiji, Hong Kong, China, India, Indonesia, Laos, Macau, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam	45 economies : Albania, Australia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Mexico, Montenegro, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States	Keep the economy grouped unchanged

Table 9 shows the results of the simulations under different scenarios. The simulation results show that the regional groupings will have certain influence on the final result when PPP at the GDP level is calculated using the CAR method. It can be seen that when China is located in the EU-OECD region, the GDP-level PPP is 3.535, which is 2.56% higher than that of PPP located in the Asia-Pacific region. When Japan and South Korea move back to the Asia-Pacific region, China's GDP-level PPP is 3.455. Compared with the GDP level PPP, the impact of regional grouping on China's household consumption PPP is smaller. When China is located in the EU-OECD region, household consumption PPP will increase by 0.8% compared with China is located in Asia-Pacific

region. When Japan and South Korea move back to the Asia-Pacific region, China's household consumption PPP will be reduced by 0.1%.

Table 9 PPP calculation results of GDP and household consumption under different regional division scenarios

Scenarios	PPP - GDP	PPP - Household consumption
Original division	3.446	3.686
China is located in the EU-OECD	3.535	3.715
Japan and Korea are located in Asia Pacific	3.455	3.682

From the perspective of China's real GDP and its proportion of the global total, regional grouping will also have an important impact on it. When China is located in the Asia-Pacific region, the real economic aggregate adjusted by PPP is 13.95 trillion US dollars, accounting for 15.13% of the global total. When China is moved to the EU-OECD region, the real GDP of China after PPP adjustment is reduced to 13.60 trillion US dollars, accounting for 14.81% of the global total; when Japan and South Korea are moved to the Asia-Pacific region, China's real GDP is 13.91 trillion US dollars, accounting for 15.09% of the global total.

Table 10 China's real GDP scale and proportion under different regional division scenarios

Scenarios	Real economic scale (\$ trillion)	Global share (%)
Original division	13.952	15.133
China is located in the EU-OECD	13.604	14.812
Japan and Korea are located in Asia-Pacific	13.917	15.094

The analysis suggests that, given the global data, a single regional grouping rearrangement of an economy will have a significant impact on its PPP and real GDP. The magnitude of the impact varies depending on the way of the rearrangement. This means that under the current methodological system, the global comparison results are not “neutral” for regional grouping, and the regional affiliation of an economy will have a great influence on the comparison results.

6. Research conclusions and enlightenment

Based on the systematic review of the ICP regionalization method, this paper uses the 2011 round of ICP researchers dataset provided by the World Bank to do in-depth analysis of the differences between the two global comparisons obtained in the CAR method adopted in the 2011 and 2017 rounds of ICP. The paper analyzes the direction and influence of the difference of regional grouping arrangements on China's PPP and real GDP. The main conclusions of this paper are:

First, for the Asia-Pacific region, the ratio of PPP obtained by the global GEKS method and CAR method has a significant positive correlation with per capita GDP. This correlation can be explained by the extent to which the bridge PPPs deviate from the regional comparison counterpart, which means that regional grouping arrangement will have an important impact on the GEKS based

comparison results.

Second, the simulation results show that the regional grouping arrangement will have an impact on the PPP and real GDP of China when using CAR method. When China is located in the EU-OECD region, PPP will increase by 2.56%, and the real GDP will be reduced by 2.49%. This shows that under the current methodological system, the global comparison results are not “neutral” for regional grouping. In the current theory and practice of ICP, there is still much room for improvements in PPP measurement and regional linking.

References:

- [1] Deaton, A. The ICP is 40! Many Happy Returns[DB/OL]. ICP Bulletin, 2008, 5(1): 14.
- [2] Deaton, A. and Heston, A. Understanding PPPs and PPP-based National Accounts[J]. *American Economic Journal: Macroeconomics*, 2010, 2 (4): 1-35.
- [3] Diewert, E. New Methodological Developments for the International Comparison Program[J]. *Review of Income and Wealth*, 2010, 56(s1): S11-S31.
- [4] Dikhanov, Y. and Vogel, F. Results and Empirical Analysis ICP 2005, Book Chapter in *Measuring the Real Size of the World Economy: The Framework, Methodology, and Results of the International Comparison Program*[M]. Washington, DC: World Bank, 2013.
- [5] Eurostat-OECD. Eurostat-OECD Methodological Manual on Purchasing Power Parities[M]. OECD Publishing, 2012.
- [6] Hill, R. J. Comparing Price Levels Across Countries Using Minimum-spanning Trees[J]. *Review of Economics and Statistics*, 1999, 81 (1): 135-142.
- [7] Hill, R.J. The Imposition of Within-Region Fixity in the International Comparison Program[R]. University of Graz, Working Paper, 2011.
- [8] Hill, R.J. A least squares approach to imposing within-region fixity in the International Comparisons Program[J]. *Journal of Econometrics*, 2016, 191 (2): 407–413.
- [9] Kravis, I. B., Heston, A. W., and Summers, R. *World Product and Income: International comparisons of real gross product*[M]. Baltimore, MD: Johns Hopkins Press, 1982.
- [10] Sergeev, S. The Evaluation of the Approaches Used for the Linking of the Regions in the ICP 2005[R]. Statistics Austria, 2009.
- [11] United Nations. Report of the consultant on the evaluation of the International Comparison Programme[R]. United Nations Statistical Commission Thirtieth Session, 1999.
- [12] United Nations and Eurostat. *World Comparisons of Purchasing Power and Real Product for 1980*[M]. United Nations publication, 1986.

- [13] World Bank. Global Purchasing Power Parities and Real Expenditures: 2005 international comparison program[M]. Washington, DC: World Bank, 2008.
- [14] World Bank. Measuring the Real Size of the World Economy: The Framework, Methodology, and Results of the International Comparison Program[M]. Washington, DC: World Bank, 2013.
- [15] World Bank. Operational Guidelines and Procedures for Measuring the Real Size of the World Economy: 2011 International Comparison Program[M]. Washington, DC: World Bank, 2015.
- [16] Yu F. D. Evaluation and recommendations for China's participation in international comparison program [J]. Statistical Research, 2017, 34(02): 23-32.