Study on Sub-regional Cooperation in the Central Region
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Abstract. The development of the central region plays an important role in the pattern of regional
development in China. Taking 8 typical sub-regions in the central region as the research object, this
paper studies the sub-regional cooperation conditions in the central region. Through the
measurement and comprehensive scoring of sub-regional cooperation conditions, this paper makes
an evaluation of sub-regional cooperation conditions in order to contribute to sub-regional
cooperation and development in the central region.

Introduction
The central region, including Shanxi, Henan, Anhui, Hubei, Jiangxi and Hunan six provinces,
linking the east to the west, connecting the south to the north, is an important part of The Belt and
Road economy. It is a key area of strategic implementation in the central region and plays an
important role in the pattern of regional development in China.

Through the implementation of Promote the Central Region, the central region has developed
rapidly, and has become an important area for China to undertake industrial transfer in the eastern
coastal area. With the implementation of the National New-type Urbanization Plan, the new-type
urbanization has accelerated the economic development of the central region. However, the social
economic resources are too concentrated in the central cities of the central region, and sub-regions
often become a forgotten corner. In the development plan of the urban agglomeration of the middle
reaches of Yangtze River, the National Development and Reform Commission clearly stated
"encourage and support the sub-regional cooperation demonstration area of Tongcheng, Pingjiang
and Xiushui" [1]. How can we strengthen the sub-regional cooperation? This paper is to explore the
sub-regional cooperation conditions in the central region, in order to promote the development of
regional integration in the central region.

Compared with previous researches, the possible contributions are:(1) the study is beneficial to
speed up the cooperation of urban agglomeration, which supports the strategy of the rise of the
central region [2]; (2) the study will help to speed up the construction of new-type urbanization,
which plays an important exemplary role in improving the urban system construction in the central
and western regions; (3) the study will help to break the traditional barriers, form an integrated
structure model and establish a long-term and effective cooperative mechanism for development
and cooperation.

Literature review and theoretical basis
Sub-region and sub-regional cooperation. Sub-region, Li Tieli(2005) thinks that it is a relative
concept of the region [3], and Yang Aiping(2007) thinks sub-region is a smaller area under macro
scale area [4]. In this paper, sub-region is a region which is formed by geographical location,
administrative division, resource conditions, industrial structure and other reasons, and it has a
certain homogeneity and common boundary, which is a specific geographical space smaller than the
"region".

Sub-regional cooperation, Hu Zhiding (2010) believes that sub-regional cooperation refers to the
cooperation between the border provinces of the neighboring countries, which are carefully defined
and within a small cross border area, to develop the needs of economic development and social
stability [5]. In this paper, sub-regional cooperation is a comprehensive cooperation for the needs of
stability and development in many countries or regions in a small "region" with a certain homogeneity and common boundary, involving economic, political, cultural, environmental and security fields.

**Sub-regional Cooperation Model in the Central Region.** Sub-regional cooperation can present many different models and types [6]. From the perspective of the subject of cooperation, it can be divided into government led model and enterprise led model. From the perspective of the comparative relationship between the economic development level of the two parties, it can be divided into strong and strong cooperation mode, strong and weak cooperation mode and weak and weak cooperation mode.

**The Restrictive Factors of sub-regional Cooperation in the Central Region.** Combined with the division of sub-regional cooperation mode in the central region, we can extract the restrictive factors of sub-regional cooperation. (1) Subject factors. Sub-regional administrative division involved in the planning scope is complex [7], which increases its difficulty, while non-governmental organizations fail to provide sufficient support. (2) Dynamic factors. The interest community in the sub-region hasn't really formed yet, and national support level isn't enough. (3) Operating factors. The level of urbanization in the sub-region isn't high, the competitiveness of the core cities isn't strong, the degree of integration isn't enough, the industrial structure is highly converging, and administrative barriers and market segmentations are serious. (4) Security factors. The cooperative security mechanism is imperfect, and there isn't effective incentive and restraint mechanism. Interest sharing and compensation mechanism hasn’t been established yet [8].

**Data and Methodology**
Combining the different sub-regional cooperation modes and the restrictive factors of cooperation in the central region, we study the measure and comprehensive score of sub-regional cooperation conditions from subject mechanism, internal dynamic mechanism, external dynamic mechanism and security mechanism, and evaluate the sub-regional cooperation conditions [9].

In Table 1, the object of this study is 8 typical sub-regions in the central region, including 24 prefecture-level cities, 6 counties and 1 county-level forest area. In order to make the statistics of the panel data consistent, the data of the county level unit are treated as follows: the six counties of Chongqing is considered as a region, assuming it is the East Chongqing area; Shennongjia forest region is a county, and it's close to Yichang, so they are regarded as the area of Yishen. This paper divides the research objects into two spatial dimensions, one is 8 sub-regions, the other is 25 regions.

This paper selects 2011-2015 years as the research time of empirical analysis. Urban data mainly originates from "China's urban statistical yearbook 2012-2015", the statistical yearbook of Shaanxi, Shanxi, Henan, Anhui, Hubei, Hunan, Chongqing and Jiangxi, as well as the annual report and statistical bulletin of the related cities. Sub-regional data is accumulated by regional data. The regional sample data is 1500 and the sub-regional sample data is 140.
Table 1 Division of Sub-regional Cooperation in the Central Region

<table>
<thead>
<tr>
<th>Typical sub-region in central region(8)</th>
<th>Region(25)</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Yuncheng-Lинфen-Sanmenxia-Weinan&quot;</td>
<td>Yuncheng</td>
<td>-</td>
</tr>
<tr>
<td>Golden Triangle Sub-region of the Yellow River</td>
<td>Linfen</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Sanmenxia</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Weinan</td>
<td>-</td>
</tr>
<tr>
<td>&quot;Xinyang-Fuyang-Huainan-Bengbu&quot; Sub-region of the Middle Reaches of Huaihe</td>
<td>Xinyang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Fuyang</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Huainan</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Bengbu</td>
<td>-</td>
</tr>
<tr>
<td>&quot;Xinyang-Huanggang-Anqing-Lu'an&quot; Sub-region of the Ring Dabie Mountains</td>
<td>Xinyang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Huanggang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Anqing(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Lu'an</td>
<td>-</td>
</tr>
<tr>
<td>Sub-region of Ecological Economic Cooperation of the Three Gorges</td>
<td>the East Chongqing area</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>the area of Yishen</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Shennongjia forest region</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Jingzhou(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Jingmen</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Enshi</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Zhangjiajie</td>
<td>-</td>
</tr>
<tr>
<td>&quot;Xianning-Yueyang-Jiujiang&quot; Small Triangle Sub-region</td>
<td>Xianning</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Yueyang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Jiujiang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td>&quot;Jiujiang-Huanggang-Huangshi&quot; Cross River Sub-region</td>
<td>Jiujiang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Huanggang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Huangshi</td>
<td>-</td>
</tr>
<tr>
<td>&quot;Jingzhou-Yueyang-Changde-Yiyang&quot; Ecological Economic Sub-region of Dongting Lake</td>
<td>Jingzhou(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Yueyang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Changde</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Yiyang</td>
<td>-</td>
</tr>
<tr>
<td>&quot;Jiujiang-Anqing-Chizhou-Jingdezhen&quot; Sub-region</td>
<td>Jiujiang(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Anqing(Intersecting area)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Chizhou</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Jingdezhen</td>
<td>-</td>
</tr>
</tbody>
</table>

The variables selected in this article are shown in Table 2. The sub-regional cooperation conditions in the central region include subject mechanism (Sub), internal dynamic mechanism (Int), external dynamic mechanism (Ext) and security mechanism (Sec) 4 two level indexes and 15 three grade indexes, and the comprehensive scores are:

$$Z_{i,t}=f(Sub_{i,t}, Int_{i,t}, Ext_{i,t}, Sec_{i,t})(1)$$

In order to avoid multicollinearity, this paper uses the SPSS17 statistical analysis software to measure the level of cooperation conditions in different years by using the time series global principal component analysis method. Based on the original observation data, the global variables are processed dimensionless, and then the validity analysis is carried out. It can be tested by KMO test and Bartlett sphere test, 3 principal components are extracted, and variance accounts for 88.593% of the total variance, which is suitable for factor analysis.
Table 2  The Variables of Sub-regional Cooperation Conditions in the Central Region

<table>
<thead>
<tr>
<th>Variable</th>
<th>Symbol</th>
<th>Variable measure</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject mechanism</td>
<td>Sub</td>
<td>Financial Expenditure /GDP</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Value added for industrial enterprises above scale</td>
<td>Hundreds of millions Yuan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R&amp;D personnel</td>
<td>person</td>
</tr>
<tr>
<td>Internal dynamic mechanism</td>
<td>Int</td>
<td>Total industrial output value for domestic enterprises above scale</td>
<td>Hundreds of millions Yuan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total retail sales of consumer goods</td>
<td>Hundreds of millions Yuan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total import</td>
<td>Hundreds of millions dollars</td>
</tr>
<tr>
<td>External dynamic mechanism</td>
<td>Ext</td>
<td>Actually utilized foreign capital</td>
<td>Hundreds of millions dollars</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total export</td>
<td></td>
</tr>
<tr>
<td>Security mechanism</td>
<td>Sec</td>
<td>Broadband Internet access number of 100 people</td>
<td>Households / 100 people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The number of students in Colleges and Universities</td>
<td>Person</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accepting an application for a patent for invention</td>
<td>Piece</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Domestic tourist reception income</td>
<td>Hundreds of millions Yuan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy consumption in unit industry</td>
<td>Tons of standard coal / 10000 yuan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Every 10000 people have green space</td>
<td>Hectare / 10000 people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Road mileage / Area</td>
<td>Km / sq km</td>
</tr>
</tbody>
</table>

Results

The detailed results are shown in Table 3 and Table 4, it can be seen that the sub regional cooperation conditions in the central region have shown an obvious upward trend in the two levels of sub-region and region, but the annual and spatial differences are obvious.

From Table 3, at the sub-region level, the mean value of sub-regional cooperation in the central region increases year by year in 2011-2015, from 1.00 in 2011 to 1.44 in 2015, with an increase of 0.44. The sub-regional cooperation conditions show a polarization trend. The Sub-region of the Three Gorges Ecological Economic Cooperation and the Ecological Economic Sub-region of the Dongting Lake belong to the first echelon, the other 6 sub-regions belong to the second echelon, and the spatial differences of the two echelons increase year by year. This shows that the gap in the development level of the sub-region is mainly manifested in the gap between the two echelons.

Table 3  Comprehensive Scores of the Cooperation Conditions at the Sub-region level

<table>
<thead>
<tr>
<th>Sub-region</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden Triangle Sub-region of the Yellow River</td>
<td>0.989</td>
<td>1.083</td>
<td>1.146</td>
<td>1.192</td>
<td>1.180</td>
</tr>
<tr>
<td>Sub-region of the Middle Reaches of Huaihe</td>
<td>0.843</td>
<td>0.942</td>
<td>1.042</td>
<td>1.119</td>
<td>1.204</td>
</tr>
<tr>
<td>Sub-region of the Ring Dabie Mountains</td>
<td>1.016</td>
<td>1.137</td>
<td>1.245</td>
<td>1.367</td>
<td>1.450</td>
</tr>
<tr>
<td>Sub-region of Ecological Economic Cooperation of Three Gorges</td>
<td>1.405</td>
<td>1.611</td>
<td>1.795</td>
<td>1.989</td>
<td>2.145</td>
</tr>
<tr>
<td>&quot;Xiaoning-Yueyang-Jiujiang&quot; Small Triangle Sub-region</td>
<td>0.887</td>
<td>1.021</td>
<td>1.143</td>
<td>1.261</td>
<td>1.356</td>
</tr>
<tr>
<td>&quot;Jiujiang-Huanggang-Huangshi&quot; Cross River Sub-region</td>
<td>0.752</td>
<td>0.851</td>
<td>0.950</td>
<td>1.043</td>
<td>1.100</td>
</tr>
<tr>
<td>&quot;Jiujiang-Anqing-Chizhou-Jingdezhen&quot; Sub-region</td>
<td>0.794</td>
<td>0.891</td>
<td>0.970</td>
<td>1.064</td>
<td>1.126</td>
</tr>
<tr>
<td>Ecological Economic Sub-region of Dongting Lake</td>
<td>1.314</td>
<td>1.504</td>
<td>1.667</td>
<td>1.845</td>
<td>1.990</td>
</tr>
</tbody>
</table>

From Table 4, at the region level, the gradient pattern of sub-regional cooperation conditions is basically stable in the central region in 2011-2015. The highest comprehensive score was the area of "Yishen", the lowest was Zhangjiajie; The top three of the increase were "Yishen" (1.24), Yueyang (0.97) and Changde (0.89), and the last two were Huainan (0.06) and Linfen (0.03).

The comprehensive score threshold of cooperative conditions is defined as 1.2. The area with a comprehensive score greater than 1.2 is defined as strong cooperative condition (S), the area with a comprehensive score less than or equal to 1.2 is defined as weak cooperative condition (W). From Table 4, at the region level, the timing and spatial differences of the cooperation conditions are...
more significant in 2011-2015. Yuncheng, Huainan, Lu'an, Enshi, Zhangjiajie, Xianning, Chizhou and Jingdezhen are always weak cooperative condition, while Xinyang, the area of "Yishen", Yueyang, Jiujiang and Changde are strong cooperative condition. There are 12 areas of strong and weak type change, of which 11 areas from weak to strong, only Linfen from strong to weak.

Table 4  Comprehensive Scores and Types of the Cooperation Conditions at the Region level

<table>
<thead>
<tr>
<th>Region</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yuncheng</td>
<td>1.003</td>
<td>W</td>
<td>1.054</td>
<td>W</td>
<td>1.125</td>
</tr>
<tr>
<td>Linfen</td>
<td>1.120</td>
<td>W</td>
<td>1.204</td>
<td>S</td>
<td>1.207</td>
</tr>
<tr>
<td>Sanmenxia</td>
<td>1.049</td>
<td>W</td>
<td>1.133</td>
<td>W</td>
<td>1.189</td>
</tr>
<tr>
<td>Weinan</td>
<td>1.015</td>
<td>W</td>
<td>1.196</td>
<td>W</td>
<td>1.331</td>
</tr>
<tr>
<td>Xinyang</td>
<td>1.260</td>
<td>S</td>
<td>1.390</td>
<td>S</td>
<td>1.560</td>
</tr>
<tr>
<td>Fuyang</td>
<td>0.842</td>
<td>W</td>
<td>0.950</td>
<td>W</td>
<td>1.048</td>
</tr>
<tr>
<td>Huangnan</td>
<td>0.700</td>
<td>W</td>
<td>0.771</td>
<td>W</td>
<td>0.808</td>
</tr>
<tr>
<td>Bengbu</td>
<td>0.770</td>
<td>W</td>
<td>0.878</td>
<td>W</td>
<td>0.994</td>
</tr>
<tr>
<td>Huanggang</td>
<td>1.031</td>
<td>W</td>
<td>1.177</td>
<td>W</td>
<td>1.315</td>
</tr>
<tr>
<td>Anqing</td>
<td>1.199</td>
<td>W</td>
<td>1.341</td>
<td>S</td>
<td>1.399</td>
</tr>
<tr>
<td>Lu'an</td>
<td>0.810</td>
<td>W</td>
<td>0.906</td>
<td>W</td>
<td>0.997</td>
</tr>
<tr>
<td>the East Chongqing area</td>
<td>1.155</td>
<td>W</td>
<td>1.270</td>
<td>S</td>
<td>1.394</td>
</tr>
<tr>
<td>the area of Yishen</td>
<td>2.126</td>
<td>S</td>
<td>2.492</td>
<td>S</td>
<td>2.797</td>
</tr>
<tr>
<td>Jingzhou</td>
<td>1.029</td>
<td>W</td>
<td>1.180</td>
<td>W</td>
<td>1.317</td>
</tr>
<tr>
<td>Jingmen</td>
<td>0.930</td>
<td>W</td>
<td>1.071</td>
<td>W</td>
<td>1.187</td>
</tr>
<tr>
<td>Enshi</td>
<td>0.413</td>
<td>W</td>
<td>0.476</td>
<td>W</td>
<td>0.545</td>
</tr>
<tr>
<td>Zhangjiajie</td>
<td>0.294</td>
<td>W</td>
<td>0.334</td>
<td>W</td>
<td>0.361</td>
</tr>
<tr>
<td>Yueyang</td>
<td>1.874</td>
<td>W</td>
<td>2.170</td>
<td>W</td>
<td>2.398</td>
</tr>
<tr>
<td>Jiujiang</td>
<td>1.240</td>
<td>S</td>
<td>1.401</td>
<td>S</td>
<td>1.580</td>
</tr>
<tr>
<td>Huangshi</td>
<td>0.914</td>
<td>S</td>
<td>1.026</td>
<td>S</td>
<td>1.129</td>
</tr>
<tr>
<td>Chizhou</td>
<td>0.368</td>
<td>W</td>
<td>0.412</td>
<td>W</td>
<td>0.456</td>
</tr>
<tr>
<td>Jingdezhen</td>
<td>0.557</td>
<td>W</td>
<td>0.620</td>
<td>W</td>
<td>0.671</td>
</tr>
<tr>
<td>Xianning</td>
<td>0.643</td>
<td>W</td>
<td>0.751</td>
<td>W</td>
<td>0.860</td>
</tr>
<tr>
<td>Changde</td>
<td>1.787</td>
<td>S</td>
<td>2.011</td>
<td>S</td>
<td>2.235</td>
</tr>
<tr>
<td>Yiyang</td>
<td>0.872</td>
<td>W</td>
<td>1.007</td>
<td>W</td>
<td>1.108</td>
</tr>
</tbody>
</table>

Conclusions

Through the measurement and comprehensive scoring of sub-regional cooperation conditions, this paper studies the sub-regional cooperation conditions in the central region. In order to contribute to sub-regional cooperation in the central region, firstly, the government can set up specialized agencies to coordinate sub-regional development [10], and play the main role of non-governmental organizations. Secondly, the government should uphold top-level design, plan ahead and institutional innovation, and support and create sub-regional cooperation zones [11]. Thirdly, the government should promote the new urbanization, strengthen the industrial integration and promote the coordinated development of sub-regions. Finally, we should perfect the cooperation security mechanism, establish an effective incentive and restraint mechanism, and establish the benefit sharing and compensation mechanism.

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