Spatiotemporal Evolution and Influencing Factors of Urban-Rural Income Gap at the Municipal Level in China: Postprint

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Abstract

Common prosperity is an essential requirement of socialism with Chinese characteristics, and narrowing the urban-rural income gap is an unavoidable practical issue in the process of achieving common prosperity and integrated urban-rural development. Based on data of the urban-rural income ratio for 366 municipal-level research units from 2012 to 2021, this study comprehensively employs research methods such as kernel density estimation and exploratory spatial data analysis to examine the spatio-temporal evolution characteristics of China's urban-rural income gap, and further utilizes a geographically weighted regression model to explore the spatial differentiation characteristics of the influence degree of various factors on the urban-rural income gap in different regions of China. The results indicate that: (1) From 2012 to 2021, China's urban-rural income gap exhibited a gradually narrowing trend, while the relative differences in the urban-rural income gap among various municipal-level units were also continuously diminishing. (2) The low-value areas of China's urban-rural income gap are mainly distributed in the southeastern coastal regions and a few cities in Heilongjiang Province and the Xinjiang Uygur Autonomous Region, whereas the high-value areas are primarily located in the Yunnan-Guizhou mountainous areas, the Tibet Autonomous Region, and some cities in the middle and upper reaches of the Yellow River. From a global trend perspective, China's urban-rural income gap presents a spatial distribution pattern characterized by high in the west and low in the east, high in the south and low in the north, and high in the middle and low on both sides. (3) At the municipal scale, China's urban-rural income gap demonstrates significant positive spatial autocorrelation, with municipal units having large urban-rural income gaps and those having small urban-rural income gaps both tending to cluster. (4) The influencing factors exhibit regional heterogeneity; therefore, each region should implement locally adapted policies in the process of narrowing the urban-rural income gap and coordinating urban-rural development.

Full Text

Spatiotemporal Evolution and Influencing Factors of Urban-Rural Income Gap at the City-Level Scale in China

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Abstract

Common prosperity is a fundamental requirement of socialism with Chinese characteristics, and narrowing the urban-rural income gap is an unavoidable practical challenge in achieving common prosperity and integrated urban-rural development. Based on urban-rural income ratio data from 366 city-level research units between 2012 and 2021, this study comprehensively employs kernel density estimation and exploratory spatial data analysis to examine the spatiotemporal evolution characteristics of China's urban-rural income gap. A geographically weighted regression model is then used to explore the spatial differentiation of various influencing factors on the urban-rural income gap across different regions of China. The results show that: (1) From 2012 to 2021, China's urban-rural income gap exhibited a gradually narrowing trend, with the relative differences in urban-rural income gaps among cities also continuously decreasing. (2) Low-value areas of the urban-rural income gap are mainly distributed in the southeast coastal regions and a few cities in Heilongjiang Province and Xinjiang Uygur Autonomous Region, while high-value areas are primarily concentrated in the Yunnan-Guizhou mountainous areas, Tibet Autonomous Region, and some cities in the middle and upper reaches of the Yellow River. Overall, China's urban-rural income gap displays a spatial distribution pattern characterized by high in the west and low in the east, high in the north and low in the south, and high in the middle and low at both ends. (3) At the city-level scale, China's urban-rural income gap demonstrates significant spatial positive correlation, with cities having large urban-rural income gaps and those having small gaps tending to cluster. (4) Influencing factors exhibit regional heterogeneity, emphasizing the need for region-specific policies in narrowing the urban-rural income gap and promoting coordinated urban-rural development.

Keywords: urban-rural income gap; common prosperity; spatial distribution pattern; spatiotemporal evolution; influencing factors

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1 Data and Methods

1.1 Study Area

This study focuses on China's prefecture-level administrative divisions (prefecture-level cities, prefectures, autonomous prefectures, and leagues)

and municipalities directly under the central government from 2012 to 2021, excluding Taiwan Province, Hong Kong Special Administrative Region, and Macao Special Administrative Region. To maintain spatial completeness and facilitate analysis, 13 county-level administrative units directly under provincial jurisdiction were also included in the research scope: Tianmen, Xiantao, Qianjiang, and Shennongjia Forest District in Hubei Province; Jiyuan City in Henan Province; Alar, Beitun, Huyanghe, Kokdala, Kunyu, Shihezi, Shuanghe, Tiemenguan, Tumshuq, Wujiaqu, and Xinxing City in Xinjiang Uygur Autonomous Region; and Wuzhishan, Wenchang, Qionghai, Wanning, Ding'an, Tunchang, Chengmai, Lingao, Dongfang, Ledong Li Autonomous County, Qiongzhong Li and Miao Autonomous County, Baoting Li and Miao Autonomous County, Lingshui Li Autonomous County, Baisha Li Autonomous County, and Changjiang Li Autonomous County in Hainan Province. Since Shenzhen and Sansha had urbanization rates of 99.82% and 100% respectively in 2021, essentially having no rural population, these two prefecture-level cities were excluded from the study to ensure accuracy and scientific rigor. Accordingly, 366 prefecture-level administrative units (including municipalities directly under the central government and counties directly under provincial jurisdiction) were included in the analysis.

1.2 Data Sources

The urban-rural disposable income ratio is the most commonly used indicator for measuring the urban-rural income gap. This study also uses the urban-rural disposable income ratio to measure China's urban-rural income gap at the city-level scale. Data were obtained from the 2013-2022 China Statistical Yearbooks and the China City Statistical Yearbooks.

1.3 Methods

1.3.1 Kernel Density Estimation Kernel density estimation is an important non-parametric estimation method with weak model dependency and strong robustness, making it a popular approach for studying uneven distributions. Kernel density estimation can represent the distribution pattern of random variables using continuous density curves, and comparing kernel density curves across different years can reveal the temporal evolution characteristics and trends of random variables. The formula is:

$$f(y) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{y - y_i}{h}\right)$$

where $f(y)$ is the density function of random variable y; n is the number of cities; y_i is the urban-rural income ratio of city i; y is the mean of urban-rural income ratios across all city units; h is the bandwidth; and $K(\cdot)$ is the kernel function. This study uses the default bandwidth and kernel function in Eviews software.

1.3.2 Exploratory Spatial Data Analysis Three-dimensional Trend Analysis. Three-dimensional trend analysis is a trend analysis method based on the ArcGIS platform that can convert the data values of research objects into spatial heights based on their spatial locations, and form projection scatter plots of the data values in the X-Z and Y-Z planes. Through these scatter plots, an optimal curve can be fitted to reflect the overall trend of the research object in a specific direction and reveal its overall spatial distribution pattern.

Spatial Autocorrelation. Spatial autocorrelation models can measure the correlation of the same variable at different spatial locations, including global autocorrelation and local autocorrelation. Global autocorrelation is expressed through the global Moran's I index, which can depict the overall spatial clustering degree of the urban-rural income gap at the city-level scale. Local autocorrelation is expressed through the local Moran's I index (Ii), which can reflect the spatial location of clustering centers. The formulas are:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

$$I_i = \frac{(y_i - \bar{y})}{S^2}\sum_{j=1}^{n} w_{ij}(y_j - \bar{y})$$

where n is the number of cities; w_{ij} is the spatial weight matrix, with an adjacency matrix used in this study (when cities i and j share a common boundary, $w_{ij} = 1$, otherwise $w_{ij} = 0$); y_i and y_j are the urban-rural income ratios of cities i and j respectively; and $\bar{y}$ is the mean of urban-rural income ratios. The global Moran's I index ranges from $[-1, 1]$, indicating positive spatial correlation, negative spatial correlation, and no spatial correlation respectively. If I is significant at a certain level, it indicates the existence of spatial correlation. For the local Moran's I index (I_i), when $I_i > 0$, it indicates similar spatial clustering (high-high or low-low) around city i; when $I_i < 0$, it indicates dissimilar spatial clustering (high-low or low-high).

1.3.3 Geographically Weighted Regression Model Compared with traditional linear regression models, the geographically weighted regression (GWR) model incorporates spatial location information into the regression equation, effectively reflecting the spatial non-stationarity of regression relationships and possessing advantages in handling spatial heterogeneity. The formula is:

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^{p} \beta_k(u_i, v_i)x_{ik} + \varepsilon_i$$

where y_i is the urban-rural income ratio of city i; (u_i, v_i) are the geographic coordinates of city i; $\beta_k(u_i, v_i)$ is the regression coefficient of the kth explanatory

variable for city i; x_{ik} is the value of the kth explanatory variable for city i; β_0 and β_k are parameters; and ε_i is the random error term.

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2 Results

2.1 Temporal Evolution Characteristics of Urban-Rural Income Gap

Since the reform and opening up, the evolution trend of China's urban-rural income gap aligns with Kuznets' hypothesis that income disparity first increases and then decreases with economic development. China's urban-rural income gap peaked in 2009 (with an urban-rural income ratio of 3.33), after which it began to gradually decline, indicating that since 2010, China's urban-rural income gap has generally entered the right side of the "inverted U-shaped" curve. From 2012 to 2021, China's urban-rural income gap at different research scales showed a gradually narrowing trend [Figure 1: see original paper], with the city-level urban-rural income gap significantly lower than that at the provincial and national scales. In terms of the magnitude of change, the city-level urban-rural income ratio decreased from 2.69 in 2012 to 2.19 in 2021, a decline of approximately 18.59%, higher than the decline at the national scale (12.90%) and provincial scale (12.21%). A common feature across all research scales is that the urban-rural income ratio declined rapidly before 2015, entered a period of stable decline after 2015, and then began to decline at an accelerated pace after 2018. This may be related to changes in the statistical 口径 of rural residents' income in most provinces and cities around 2013 and 2014. The accelerated decline after 2018 benefited from China's rural revitalization strategy proposed in 2017, which promoted rural economic development, increased rural residents' income levels, and accelerated the reduction of the urban-rural income gap.

Using non-parametric kernel density estimation can further reveal the evolution characteristics of China's urban-rural income gap at the city-level scale and differences among cities. For illustration, kernel density distribution maps were plotted using data from 2012, 2015, 2018, and 2021 [Figure 2: see original paper]. Overall, the kernel density curves for all four years are unimodal, with peaks gradually increasing and curves narrowing over time, reflecting that the relative differences in urban-rural income gaps among cities continuously decreased during the study period.

Based on the status quo of China's urban-rural income gap during the study period and existing research experience, this paper classifies the urban-rural income gaps of each city-level research unit into four categories: low urban-rural income gap (urban-rural income ratio < 1.5), medium urban-rural income gap (1.5–2.5), high urban-rural income gap (2.5–3.5), and extremely high urban-rural income gap (> 3.5). In terms of spatial distribution patterns and changes , cities with extremely high urban-rural income gaps decreased from 44 in 2012 to 12 in 2021, accounting for 12.02% of the total, mainly distributed in the Yunnan-Guizhou mountainous areas and parts of Gansu, Qinghai, and Shanxi

provinces. Cities with high urban-rural income gaps are primarily distributed in southwestern and northwestern China, with a few scattered in central and eastern cities. Cities with medium urban-rural income gaps are mainly contiguously distributed in northeastern, northwestern, and southeastern China. No cities had low urban-rural income gaps in 2012, but this number increased to 3 in 2021, distributed in Beitun, Huyanghe, and Shihezi in Xinjiang; Jixi, Hegang, and Yichun in Heilongjiang; and Zhongshan, Dongguan, and Chaozhou in Guangdong.

2.2 Spatial Distribution Pattern

2.2.1 Spatial Distribution Characteristics Using the natural breaks classification method in ArcGIS 10.8 software, the per capita disposable income of urban and rural residents in each city from 2012 to 2021 was clustered into five groups: low-income, lower-middle income, middle income, upper-middle income, and high-income groups. In terms of spatial distribution of rural residents' per capita disposable income, the high-income group in 2012 was mainly concentrated in the Yangtze River Delta and Pearl River Delta urban agglomerations, with Beijing, Changsha, and Karamay added in 2021. The upper-middle income group in 2012 was mainly distributed in the Liaodong Bay, Beijing-Tianjin-Hebei, Shandong Peninsula, Yangtze River Delta, and Pearl River Delta urban agglomerations, as well as some provincial capitals in central and western China and parts of Xinjiang. The low-income group was mainly distributed in the Qinghai-Tibet Plateau, Yunnan-Guizhou Plateau, Loess Plateau, eastern Inner Mongolia Plateau, and eastern Henan Province—areas with poor transportation or backward economies. Regarding urban residents' per capita disposable income, the high-income group was concentrated in the Yangtze River Delta and Pearl River Delta urban agglomerations, as well as Beijing and Xiamen. The low-income group was mainly distributed in northern Heilongjiang, western and northern Xinjiang, eastern Henan, western Hunan, and the Hexi Corridor region. The spatial distribution of rural residents' per capita disposable income changed more dramatically than that of urban residents, with many cities in central and western regions such as Sichuan, Tibet, Guangxi, Henan, and Anhui transitioning from low-income to lower-middle or middle-income groups.

2.2.2 Three-Dimensional Macro Trend Three-dimensional trend surfaces were further employed to reflect the macro trend characteristics of China's urban-rural income gap and disposable income [Figure 3: see original paper]. The Z-axis represents the urban-rural income ratio or per capita disposable income of each city, the X-axis represents the overall east-west trend, and the Y-axis represents the overall north-south trend. The projection trend lines for all four time points show that China's urban-rural income gap exhibits a west-high-east-low and middle-high-both-ends-low pattern in the east-west direction, and a south-high-north-low and middle-high-both-ends-low pattern in the north-south direction. Urban residents' per capita disposable income shows an east-high-west-low pattern in the east-west direction and a south-high-north-low, middle-

high-both-ends-low pattern in the north-south direction. Rural residents' per capita disposable income shows an east-high-west-low, both-ends-high-middle-low pattern in the east-west direction and a north-high-south-low pattern in the north-south direction.

2.2.3 Spatial Correlation Tobler's First Law of Geography states that everything is related to everything else, but near things are more related than distant things. Using formula (2), the global Moran's I index for China's urban-rural income ratio at the city-level scale was calculated and tested for significance . The results show that the global Moran's I index fluctuated between 0.4 and 0.5 during the study period, with Z-values far exceeding the critical values at corresponding confidence levels, indicating that China's urban-rural income gap exhibits extremely significant spatial positive correlation. Cities with large urban-rural income gaps and those with small gaps tend to cluster.

To further explore local spatial association types, LISA cluster maps were generated for 2012 and 2021 [Figure 4: see original paper]. Low-low clusters are mainly distributed in Xinjiang Uygur Autonomous Region, northeastern China, and the eastern coastal areas. High-high clusters are contiguously distributed in Guangxi Zhuang Autonomous Region, the Yunnan-Guizhou Plateau, and the middle and upper reaches of the Yellow River, forming vast continuous regions. The number of low-low cluster cities increased from 31 in 2012 to 48 in 2021, while high-high cluster cities decreased from 44 to 42, indicating that the spatial clustering of cities with low urban-rural income gaps weakened slightly, while that of cities with high gaps remained largely unchanged.

2.3 Influencing Factors of Urban-Rural Income Gap

The formation and influencing factors of the urban-rural income gap are complex, involving natural factors such as geographic location, altitude, resource endowment, and ecological environment, as well as socioeconomic factors including economic development level, urban-rural development policies, urbanization level, and regional development strategies. Drawing on existing research, this paper uses the urban-rural income ratio of 366 city-level research units as the dependent variable and per capita GDP (logarithmic), urbanization rate (ratio of urban population to permanent population), industrial structure upgrading (ratio of tertiary industry value-added to secondary industry value-added), and financial development level (ratio of year-end deposit and loan balances of financial institutions to GDP) as explanatory variables for geographically weighted regression. The regression coefficients of each influencing factor were spatially visualized [Figure 5: see original paper].

Economic Development Level. As shown in [Figure 5a: see original paper], most Chinese cities are on the right side of the Kuznets curve, where economic development negatively correlates with the urban-rural income gap. However, most cities in Hainan Province and northeastern China remain on the left side of the curve, where economic development widens the urban-rural income gap.

Possible reasons include: (1) Hainan's economy is tourism-dominated, while northeastern China has heavy industries, both concentrated in urban areas with high-income positions mostly accessible to urban residents; (2) As these regions develop, resources (education, healthcare, etc.) may concentrate in cities while rural areas face shortages; (3) In tourism hotspot cities in Hainan and major cities in northeastern China, housing prices may rise rapidly with economic development, increasing urban residents' wealth while rural residents cannot benefit from real estate appreciation.

Urbanization Rate. As shown in [Figure 5b: see original paper], urbanization rate negatively correlates with the urban-rural income gap for most Chinese cities. However, for Beijing, northern Hebei, western Inner Mongolia, southern Heilongjiang, Jilin, and Liaoning, urbanization expansion widens the urban-rural income gap. Possible reasons include: (1) During rapid urbanization, especially in large cities like Beijing, rising housing prices increase urban residents' wealth while rural residents cannot benefit; (2) Northeastern regions (Liaoning, Jilin, Heilongjiang) have historical industrial structure issues with more severe disconnect between urban and rural economic development; (3) As urbanization progresses, more public resources, high-paying jobs, and services concentrate in cities, widening the gap.

Industrial Structure Upgrading. As shown in [Figure 5c: see original paper], industrial structure upgrading negatively affects the urban-rural income gap in northern Xinjiang, Shanxi, northwestern Henan, northern Hebei, and northeastern China—mostly industrial "resource-based" cities where industrial upgrading can narrow the gap. However, industrial structure upgrading positively affects most other regions, particularly cities in the upper and middle reaches of the Yangtze River (Qinghai, Sichuan, Guizhou, Chongqing, western Hunan, northeastern Guangxi). This may be because developing tertiary industry requires good infrastructure (communication, transportation) that is inadequate in rural areas of these regions, limiting rural development. Additionally, tertiary industry often requires higher education and professional skills, which rural residents may lack due to scarce educational resources and opportunities.

Financial Development Level. As shown in [Figure 5d: see original paper], improving financial development level narrows the urban-rural income gap in northern Xinjiang, northeastern China, Shanxi, Henan, Hubei, Anhui, Hunan, Jiangxi, and Tibet. This is mainly because enhanced financial development increases financial service supply in rural areas, providing more funding support for industrial investment and employment opportunities, thereby raising rural residents' income. For other regions, financial development level positively correlates with the urban-rural income gap, with particularly strong effects in western Xinjiang, Sichuan, and Yunnan.

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3 Conclusions and Recommendations

3.1 Conclusions

(1) From 2012 to 2021, China's urban-rural income gap showed a gradually narrowing trend, generally entering the right side of the Kuznets curve. The relative differences in urban-rural income gaps among cities also continuously decreased during the study period.

(2) Cities with large urban-rural income gaps were mainly distributed in southwestern China, with a few in the middle and upper reaches of the Yellow River. Cities with small gaps were primarily distributed in eastern coastal areas and parts of Xinjiang and Heilongjiang. Overall, the urban-rural income gap exhibits a west-high-east-low, middle-high-both-ends-low pattern in the east-west direction and a south-high-north-low, middle-high-both-ends-low pattern in the north-south direction.

(3) At the city-level scale, China's urban-rural income gap demonstrates significant spatial positive correlation, with cities having large gaps and those having small gaps tending to cluster. Low-low clusters are mainly distributed in Xinjiang, northeastern China, and the eastern coastal areas, while high-high clusters are contiguously distributed in Guangxi, the Yunnan-Guizhou Plateau, and the middle and upper reaches of the Yellow River, forming vast continuous regions.

(4) Economic development level and urbanization rate negatively affect the urban-rural income gap in most regions but positively affect some cities in northeastern China. Industrial structure upgrading negatively affects the urban-rural income gap in northern Xinjiang, Shanxi, northwestern Henan, northern Hebei, and northeastern China—mostly industrial "resource-based" cities—but positively affects most other regions. Financial development level negatively affects the urban-rural income gap in northern Xinjiang, northeastern China, Shanxi, Henan, Hubei, Anhui, Hunan, Jiangxi, and Tibet, while positively affecting other regions. Influencing factors exhibit regional heterogeneity, requiring tailored policies for different regions.

3.2 Recommendations

(1) Cities with large urban-rural income gaps are mainly distributed in southwestern China, with a few in the middle and upper reaches of the Yellow River (Longnan, Tianshui, Qingyang in Gansu, and Xinzhou in Shanxi). Economic development level and urbanization rate negatively affect the urban-rural income gap in southwestern China. Southwestern regions can develop eco-tourism, characteristic agriculture, and traditional cultural industries to provide more employment opportunities and income sources for farmers, promote farmer income growth, and improve infrastructure (roads, bridges, electricity, communication) and poverty relocation to pro-

mote integrated urban-rural development and gradually narrow the gap.

(2) Economic development level and urbanization rate negatively affect the urban-rural income gap in cities of the middle and upper Yellow River region (Tianshui, Qingyang, Longnan, and Xinzhou). Industrial structure upgrading and financial development level also negatively affect Xinzhou's urban-rural income gap. Tianshui, Qingyang, and Longnan can develop rural e-commerce to boost production and sales of regional characteristic agricultural products, increasing farmer income and employment opportunities. Improving urbanization levels can also help narrow the gap through housing subsidies, improved living environments, diversified job opportunities, and skills training. Xinzhou can additionally narrow its urban-rural income gap by optimizing industrial structure, deepening industrial chains, upgrading traditional industries, encouraging emerging industries, expanding financial service coverage, strengthening financial education, and encouraging fintech development.

(3) The urban-rural income gap among Chinese cities exhibits significant spatial positive correlation. Regional economic construction planning can leverage the radiation effect of "cold spots" (low-low clusters) in economic belts and urban agglomerations on reducing surrounding cities' urban-rural income gaps. However, changes in the urban-rural income gap have certain phased and stable characteristics, and narrowing the gap requires sustained, long-term efforts.

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Note: Figure translations are in progress. See original paper for figures.