Asia Pacific Academy of Science Pte. Ltd.

City Diversity 2023, 4(1), 1949.
https://doi.org/10.54517/cd.v4i1.1949

Article

Dialect diversity, element agglomeration and city size—Empirical test based on satellite lighting data

Congming Ding*, Xueyang Huang, Min Zhou

School of Public Policy and Administration, Chongqing University, Chongqing 400044, China
*** Corresponding author:** Congming Ding, hayekting@126. com

CITATION

Ding C, Huang X, Zhou M. Dialect diversity, element agglomeration and city size——empirical test based on satellite lighting data. City Diversity. 2023; 4(1): 1949. https://doi.org/10.54517/cd.v4i1.1949

ARTICLE INFO

Received: 1 March 2023
Accepted: 22 March 2023
Available online: 18 April 2023

Abstract: Since the reform and opening up, China's urbanization has developed rapidly Behind the rapid urbanization is the imbalance and insufficiency of urban development From the perspective of social and cultural diversity, this paper explores the impact of the diversity of dialect types on urban scale The diversity of dialects leads to the division of trust, hinders the cross regional flow of factors, affects the agglomeration effect of factors, and then affects the expansion of urban scale Using the diversity index of regional dialect types and 2016 nppviirs urban night light index, this paper empirically studies the impact of dialect diversity on urban scale The measurement results show that: Dialect diversity has a significant negative impact on urban scale On average, the addition of one dialect category will lead to a 4.5% decline in the size of the city measured by the night light index 55%. A series of robustness tests and causal identification show that the estimation result in this paper is the causal relationship of robustnessfurther empirical research shows that dialect diversity mainly affects the expansion of urban scale by hindering the flow and agglomeration of labor, capital and technological factorsthe Enlightenment of this study: To build a diversified and inclusive modern city, we need to weigh the costs and benefits of cultural diversity and unity, break cultural barriers, eliminate cultural prejudices, improve social trust, and give full play to the complementary effects brought by multiculturalism.

Keywords: dialect diversity; city scale; night light index

1. Introduction

Since the reform and opening up, China's urbanization level has increased from 17.5% in 1978 9% steadily increased to 60.5% in 2019 60%. Overall, the level of urbanization has been significantly improved, but the quality of urbanization still needs to be improved As China's economy moves from a high-speed growth stage to a high-quality economic development stage, it is urgent to establish an "urban pattern with urban agglomeration as the main body and the coordinated development of large, medium and small cities and towns" in the spatial layout of cities The key to optimizing the spatial economic pattern is to understand the law behind the flow and agglomeration of economic factors in space, so as to make the best use of the situation to develop the factor agglomeration effect and economies of scale effect, which requires the theoretical circle to further explore the deep-seated influencing factors behind the urban scale and its distribution.

The expansion of urban scale is the product of the interaction of economic, social, cultural and other factors in the process of urban development. It is usually manifested in the increase of urban population, economic scale and the expansion of urban land scale. Therefore, urban scale has not only the attribute of "quantity" but also the attribute of "space" Academic research on the influencing factors of urban scale

development has yielded fruitful results, mainly exploring the influencing factors of urban scale from the perspectives of economy, politics, natural conditions and transportation [1,2,3]. It is true that the above factors do play an important role in the formation and development of urban scale, but there are few studies on the impact of cultural diversity on urban scale from the perspective of culture As a measure of China's vast territory, cultural diversity is more important Although China has a unified Chinese character as the writing language, the Chinese pronunciation has a southern accent and a northern accent, forming a quite diverse dialect system. The diversity of dialects will not only bring differences in communication costs, but also its identity recognition effect will lead to the division of trust among different dialect groups, which will affect labor mobility and technology diffusion, as well as the formation of integrated market [4,5,6]. There is no doubt that exploring the impact of dialect diversity on China's urban scale is of great significance for understanding the mechanism behind China's urbanization and the economic spatial layout of cities.

The theoretical circle has rich research on the diversity of culture and dialect. Xu Xianxiang et al. [7] found that dialect diversity hinders economic growth by hindering the dissemination of knowledge and technology. The research of Lin Jianhao and Zhao Zile [5] proves that dialect differences hinder the diffusion of technology from advanced areas to relatively backward areas Ruan. Jianqing and Wang Ling [8] proved that the greater the language difference, the greater the difference of regional market system. Ding Congming et al. [6] found that the diversity of dialects will increase the degree of regional market segmentation and hinder the formation of domestic market integration At the same time, the diversity of dialects also has an adverse impact on the degree of urban opening to the outside world [9]. Liu Yuyun et al. [4] proved that the flow of labor across dialect areas presents an "inverted U-shaped" mode Dai Yiyi et al. [10] proved that the dialect consistency between the board of directors and the management of the company is conducive to reducing the agency cost of the enterprise from a more micro level of the company In this study, the article mainly focuses on the impact of dialect diversity on urban scale Dialects will affect the formation of social trust [11]. Dialect differences will reduce the general level of social trust, which will have an adverse impact on technology diffusion and labor flow, lead to market segmentation and hinder the full play of factor spatial agglomeration effect. Obviously, the above literature suggests that dialect diversity may hinder the expansion of urban scale.

The marginal contribution of the article is mainly reflected in: From the perspective of culture and language, this paper studies the impact of dialect diversity on urban scale and the transmission mechanism behind it, which is a good supplement to the research of language economy and cultural economy Although the domestic research on urban scale has been very rich, the exploration of deeper cultural factors affecting factor agglomeration is still relatively weak The second part introduces the theoretical hypothesis and research design of this paper, and introduces the specific construction methods of relevant variables; The third part shows the regression results of the benchmark model and carries out a series of robustness tests; The fourth part is causal identification; The fifth part is the influence channel test; The sixth part is the conclusion and suggestion.

2. Theoretical hypothesis and research design

2.1. How does dialect diversity affect city size

As the carrier of information communication and exchange, language is the bridge between people However, the southern accent and northern accent of dialect pronunciation will bring obstacles to language communication and affect people's psychological distance Dialects affect the level of social trust through group identity and screening mechanism, affect the dissemination and diffusion of human, property and other elements and technologies, and then form invisible barriers Combined with the existing literature, this paper summarizes the theoretical channels of dialect influencing factor agglomeration and ultimately affecting the city scale as follows.

2.1.1. Dialects bring identity recognition, affect the level of social trust and form trust barriers

Dialect is the signal of identity and the symbol of group identity. People will recognize each other's identity according to different "accents" in communication, so as to give each other different levels of trust The use of each dialect has its specific regional scope, and the regional heterogeneity of dialects is an important dimension for dividing ethnic groups and identity recognition [12]. In the environment of dialect diversity, people who use the same dialect not only have the same geographical origin and similar cultural background, but also mean that they have more similar thinking patterns and more acceptable communication methods, which can often quickly eliminate the gap of trust Chen Z et al. [13] found in the study of Shanghai labor market that Shanghai dialect users mainly affect individual income level and job acquisition opportunities by strengthening the identity within the group rather than increasing the communication cost between strangers. When studying the influence of dialects on the entrepreneurship of floating population, Wei Xiahai et al. [14] found that mastering local dialect skills is conducive to improving the social identity of floating population in the place of immigration, reducing employment and entrepreneurship discrimination, so as to promote entrepreneurship.

2.1.2. The trust barrier brought by dialect diversity hinders the full flow and agglomeration of factors, thus affecting the expansion of urban scale

Cities are the concentrated embodiment of agglomeration effect, and the process of urban development is the process of human and property elements gathering in a region [15]. Combing the existing literature, the main mechanisms of dialect influencing factor flow include: (1) dialects affect the flow of labor factors, Li Qin and Meng Lingsheng [16] found that language communication barriers and common cultural background are important considerations for cross regional labor mobility. Considering that the diversity of dialects also has the effect of complementarity and identity, Liu Yuyun et al. [4] found that with the reduction of dialect distance, its impact on labor mobility changes from inhibition to promotion (2) Dialect affects the flow of technical elements Lin Jianhao and Zhao Zile [5] found that dialect differences will hinder technology diffusion by hindering institutional diffusion; Xu Xianxiang and others [7] also believe that dialect diversity hinders urban economic growth by hindering the dissemination of knowledge and technology To sum up, dialect diversity hinders the flow and agglomeration of labor and technical factors between cities, is a

hidden barrier to the spatial agglomeration of urban factors, and has an adverse impact on the development of urban scale Based on the above two analysis, this paper puts forward the following hypothesis.

Research hypothesis: Through the effect of identity and cultural identity, different dialects form a division of trust among different dialect groups, which hinders the full flow of urban labor, capital and technological elements and the full play of spatial agglomeration effect, and then hinders the expansion of urban scale.

2.2. Study design description

According to the above research hypothesis, this paper adopts the following linear model in the demonstration:

$$\ln psum_i = \alpha + \beta dia_i + \psi X_i + \varepsilon_i \quad (1)$$

Among them, the explained variable $\ln psum_i$ is the night light index, which represents the logarithmic average light brightness value of the ith urban circle. It is obtained by dividing the sum of the night light brightness values corresponding to the built-up areas of all cities in the urban circle by the number of cities in the urban circle and taking its natural logarithm; dia_i is the key explanatory variable of this paper, which represents the number of dialects in the ith urban circle; X_i refers to other control variables, covering the influencing factors of economy, transportation and politics, including market scale, geographical distance, highway density, whether it is a municipality directly under the central government, a provincial city or a provincial capital city, fiscal decentralization, fiscal expenditure, etc; ε_i is the error term, which is used to capture the influence of unmeasurable factors that have an impact on the city scale β. To measure the impact of dialect diversity on urban scale, this paper is expected to $\beta < 0$, that is, the richer the diversity of dialects, the smaller the urban scale of the urban circle.

The concept of "city circle" needs special explanation. This paper uses the municipal administrative region to construct the urban circle, mainly drawing on the methods of Lu Ming and Chen Zhao [17]. Each city can be regarded as the core city of the "city circle". The only criterion for whether to include other municipal administrative units in the city circle is "bordering on the core city". For example, Zhangjiakou, Baoding, Langfang, Tianjin and Chengde, which border Beijing, together with Beijing, constitute the "Beijing City Circle". All cities in the city circle have equal status without primary and secondary distinction. All variables in this paper take the urban circle as the basic measurement unit to construct data indicatorsthis paper excludes the cities in Hong Kong, Macao and Taiwan, Tibet and Hainan, including prefecture level cities, autonomous prefectures, municipalities directly under the central government and provincial cities.

This paper studies the impact of dialect diversity on urban scale. There are two reasons why the "city circle" is constructed as a measurement unit rather than a city in the traditional sense: First, the provincial data is not suitable to be used as the data related to the study of city scale. Due to the wide geographical area and large population scale of the province, the number of dialect types in each province will be close to that measured by the provincial administrative unit. If the provincial dialect

type data is used, the key explanatory variables will lack variation; second, the administrative level of a city is an important factor affecting the scale of the city. If a separate city is used as the basic measurement unit, the impact of the administrative level of the city on the scale of the city cannot be effectively controlled Based on the above situation, in order to build an effective dialect diversity index and control the influence of administrative zoning factors, this paper constructs a "virtual city", that is, a synthetic urban circle At the same time, this paper takes the "number of cities in the urban circle" as the control variable into the regression equation to control the impact of the difference in the number of cities in the urban circle on the urban scale.

2.3. Index description

(1) City scale index. The explanatory variable of this paper is city scaleit is reasonable to select the urban night light data to measure the urban scale: Urban night light area is a gathering area for people's production and life [18]. The more frequent economic activities, the more concentrated the population, and the brighter the light brightness [19]. The larger the light brightness value of an area, the more prosperous the economy of the area is [20]. Yang Mei et al. [21] quantitatively estimated the regional urbanization level by using night light data, which confirmed the reliability and universality of this method. Wu Jiansheng et al. [22] confirmed the feasibility and credibility of using night light data to measure the urban hierarchical structure and spatial structure. Levin and Zhang [23] found that the urban night lighting data of npp-viirs can highly fit the relevant conditions of urban GDP, population and built-up area. Yang Mengyu et al. [24] used night light data to build a city scale index, confirming that local government competition has an impact on the change of city scale.

The nighttime lighting data extraction method in this paper refers to the practice of Yang Renfei et al. [25]. Specifically, under the arcmap platform, the 2016 npp-viirs night light data is one-to-one corresponding to the Chinese urban administrative zoning map, and the grid area values above the gray values of pixels at all levels are counted. The gray value with the smallest error with the real urban built-up area is selected as the optimal light brightness extraction threshold. It is considered that the light spot area and shape under this threshold are the closest to the real urban built-up area; Finally, on the basis of this light brightness threshold, extract the sum of the corresponding night light brightness values of each city, that is, the sum of the light brightness of the built-up area The optimal light brightness extraction threshold calculated in this paper is 22, that is, it is considered that the light area when the brightness value is greater than or equal to 22 is the closest to the real urban built-up area. Based on this threshold, the night light brightness value of the built-up area in the urban circle is calculated, and then its natural logarithm is taken as the explanatory variable in this paper.

(2) Dialect diversity index Referring to the methods of Xu Xianxiang et al. [7], the dialect diversity indicators selected in this paper include both Chinese dialects and minority dialects Chinese dialect diversity data and minority dialect data are respectively from the Chinese Dialect Dictionary and the Chinese Language Atlas. Based on this, the urban dialect diversity data used in this study are sorted out, and absolute and relative indicators are constructed to measure dialect diversity.

Absolute indicators: That is, the number of dialects in the city, which can be divided into four categories according to their language level: Describe the "dialect category" of the language family to which the dialect belongs; Describe the dialect subclass of the language; Dialect blockbusters further subdivided on the basis of dialect subclasses; A small piece of minority dialect and sub dialect In the benchmark regression, the article uses the number of common dialect sub categories to measure the diversity of dialects In the later research, we also provide the empirical results of dialect categories, large dialects and small dialects to prove the robustness of the results of this paper.

Relative indicators: Considering that only the number of dialect types is used to measure the diversity of dialects, it is slightly monotonous, and the dialect difference is closely related to the number of users and the similarity of dialectsbased on the methods of Xu Xianxiang et al. [7] and Liu Yuyun et al. [4], this paper constructs the "dialect distance" index to measure the degree of dialect difference in urban circle. Therefore, the following calculation formula is $div\_s_t = \sum_{j=1}^{J}\sum_{k=1}^{K} S_{ji} \times S_{ki} \times d_{jk}$ designed, in which div_s is the dialect distance index. S_{ji} and S_{ki} respectively represent the proportion of the population using dialect sub category *j* and dialect sub category *k* in urban circle *i*, and d_{jk} represents the dialect distance between *j* and *k*. The index is constructed as follows: If *j* and *k* belong to the same dialect category, the distance is 0; If it is different dialect subclasses under the same dialect category, it is assigned as 1; if it is different dialect subclasses under different dialect categories, it is assigned as 2. The greater the value of div_s, the greater the relative difference of dialects in the urban circle, that is, the higher the dialect diversity using the relative index scale.

Table 1. Control variables and their construction methods.

Control variable	Construction method
Market size	Population per square kilometer × Per capita GDP The denser the population and the higher the income level of an area, the larger the market scale will be formed, and then it will gather into large-scale cities. Therefore, it is necessary to control the impact of market scale
Geographical distance	Calculation method of geographical distance between cities: search the mileage (kilometers) of the most convenient traffic route between the two cities in Baidu map, and then calculate the average mileage between other cities in the circle and core cities
Highway density	Highway mileage of urban circle (km)/administrative area of urban circle (km^2) This variable measures the traffic development degree of the urban circle
Urban administrative level	Virtual variable to measure "whether there are municipalities directly under the central government, provincial capital cities and provincial cities in the city circle". If there are cities of any of the above levels, it will be assigned as 1, and if there is no city, it will be assigned as 0
Fiscal Decentralization	Fiscal expenditure within the per capita budget of the urban circle/fiscal expenditure within the national per capita budget This variable is used to control the degree of fiscal decentralization of the city circle, that is, the impact of the financial autonomy of the city circle government on the city scale of the city circle
Number of surrounding cities	The number of cities constituting the urban circle. Controlling this variable is to control the "inflation" effect caused by the excessive number of cities constituting the urban circle
Expenditure	The total financial expenditure of the city circle is taken as the natural logarithm Controlling this variable can more directly control the impact of government behavior and policies on urban scale

Number of ethnic minorities	The number of ethnic minorities with more than 10,000 people in the urban circle

(3) Other control variables Based on the existing literature, this paper further controls the following variables that may affect the city scale. Duan Ruijun [2] believes that market scale and public financial expenditure will have a significant impact on the change of urban scale; The research results of Li Wan et al. [26] proved that urban administrative level, traffic accessibility and other factors will have a significant impact on the formation and evolution of cities; Chen Liangwen et al. [1] found that urban growth will be significantly affected by urban market potential and whether the city is coastal or not; Sun Bindong et al. [3] found that policy intervention, information and transportation costs between cities will affect the differences in the size of citiesthe city circle with more administrative divisions may have smaller city scale. In order to control the above impact, the number of tier cities in the circle is included in the control variable in this paper See **Table 1** for the construction method of each control variable. The relevant statistical data of each city are from the urban statistical yearbook of each province in 2016.

Table 2. Benchmark regression results.

	Night light index			Urban built-up area	Resident population	GDP
	(1)	(2)	(3)	(4)	(5)	(6)
Dialect subclass	−0.071*** (0.018)	−0.054*** (0.018)	−0.113*** (0.025)	−0.0824*** (0.013)	−0.0137* (0.007)	−0.0525*** (0.014)
Market size		0.000176*** (0.000)	0.000134*** (0.000)	0.0000835*** (0.000)	0.0000269*** (0.000)	0.000100*** (0.000)
Geographical distance		0.269** (0.106)	0.219** (0.110)	0.0232 (0.060)	−0.0378 (0.033)	0.0628 (0.061)
Highway density		−0.231 (0.176)	−0.212 (0.187)	0.270*** (0.102)	0.649*** (0.057)	0.633*** (0.104)
Urban administrative level			0.0421 (0.165)	0.0719 (0.090)	0.0231 (0.050)	0.100 (0.091)
Fiscal Decentralization			−0.00179 (0.075)	−0.0110 (0.041)	0.0172 (0.023)	−0.0101 (0.041)
Number of surrounding cities			−0.0419 (0.037)	−0.0273 (0.020)	−0.0909*** (0.011)	−0.0410** (0.021)
Expenditure			0.147 (0.124)	0.346*** (0.068)	0.637*** (0.038)	0.404*** (0.069)
Number of ethnic minorities			0.0741*** (0.019)	0.0332*** (0.011)	0.00858 (0.006)	0.0188* (0.011)
N	300	300	300	300	300	300
R2	0.047	0.275	0.324	0.569	0.806	0.651

Note: ***, ** and * respectively indicate that the estimation coefficient is significant at the level of 1%, 5% and 10%, and the standard error of robustness is in parentheses. The same below.

3. Analysis of empirical results

3.1. Benchmark model

Table 2 shows the benchmark regression results of this paper. The estimation results in column (1) show that: It is estimated that the light index of each dialect category will increase significantly by 7.0% at night 1%. In column (2), economic factors and traffic factors affecting urban scale are added, and the regression result is still significantly negative at the level of 1%. The coefficients of other control variables are basically consistent with the existing research. The expansion of market scale and the improvement of traffic accessibility will have a positive impact on the expansion of urban scale Column (3) adds political factors and the number of ethnic minorities on the basis of column (2). The regression coefficient of the key explanatory variable dialect category is still significantly negative at the level of 1%, and the absolute value of the estimated coefficient rises to 11.5% 3%, that is, for each dialect sub category added in the urban circle, the night light index will drop by 11 3%. The estimation results show that the city circle with more dialect diversity has lower urban lighting index and smaller urban scale in the city circle.

In order to more intuitively verify the above conclusions, columns (4)–(6) of **Table 2** replace the night light index with the area of urban built-up area per city in the urban circle, the resident population per city and the GDP per city after taking the natural logarithm as the explanatory variable to participate in the regression The regression coefficient of the key explanatory variables in columns (4)–(6) Dialect subclass is still significantly negative. Each additional dialect subclass will reduce the urban built-up area, permanent resident population and GDP by 8.5% respectively 24%, 1.37% and 5.25%, and the estimated results once again show that there is a negative correlation between dialect diversity and city sizee Based on the results of each column in **Table 2**, the basic assumptions of this paper are preliminarily verified: The more diverse the dialects, the smaller the city size.

3.2. Robustness test

Based on the above, we conduct a series of robustness tests.

(1) Language level. The classification of language has a certain degree of subjectivity. Different types of attribution need to compare the language characteristics such as vocabulary, pronunciation and intonation. The quantitative research of dialects should be classified quantitatively according to the similarity of these language characteristics. Therefore, they will be classified into different language levels according to the difference of "degree", that is, dialect categories, dialect sub categories, dialect large areas and dialect small areasin the benchmark regression in this paper, only the dialect category is used as the index to measure the diversity of dialects. In order to test the robustness of the benchmark regression results, columns (1)–(3) of panel a in **Table 3** are the robustness test results by further using the indicators of "dialect category", "dialect large area" and "dialect small area" instead of the "dialect small category" in the benchmark regression, The key explanatory variable in column (4) is replaced by the relative index of dialect diversity "dialect distance" The regression results again show that no matter what kind of dialect

diversity measurement method is adopted, language diversity has a significant negative impact on the city scale.

(2) The amount of light index at night. The night light index of the city circle used in columns (1)–(3) of **Table 2** is the arithmetic mean of the sum of the brightness values of all cities in the city circle. Considering the possible impact of different light index measurement methods on the results, this paper further uses GDP, administrative area and permanent resident population to weighted average the light brightness values of all cities in the city circlethe regression results are shown in columns (1)–(3) of panel B in **Table 3**. The regression coefficient of key explanatory variables is still significantly negative, and the regression coefficient is 11.5% higher than that of dialect categories in column (3) of **Table 2** Compared with 3%, it is basically close, indicating that the difference of lighting index measurement methods does not affect the basic conclusion of this paper.

Table 3. Robustness test: Different measurement methods based on dialect and night light index.

Panela	**Night light index**			
	(1)	**(2)**	**(3)**	**(4)**
Dialect categories	−0.246*** (0.062)			
Dialect blockbuster		−0.0892*** (0.017)		
Dialect fragment			−0.0442*** (0.015)	
Dialect distance				−0.416** (0.189)
Control variable	Yes	Yes	Yes	Yes
N	300	300	300	300
R2	0.312	0.341	0.297	0.287
Panelb	Explained variable: night light index under different measurement methods			
	GDP weighting	Area weighting	Population weighting	Night light index
Dialect subclass	−0.132*** (0.030)	−0.132*** (0.025)	−0.131*** (0.028)	−0.0988*** (0.018)
Control variable	Yes	Yes	Yes	Yes
N	300	300	300	300
R2	0.273	0.334	0.312	0.428

Since the shape, distribution, area and other characteristics of the built-up area of the city can be highly fitted by using the night light data [23], the night light data used as the explanatory variable in the benchmark regression in this paper is essentially extracted on the basis of the real built-up area of each city Using the extraction method of night light data provided in the second part of this paper, the similarity between the fitting area of the grid with brightness value greater than or equal to 22 and the area of the real urban built-up area has reached 85%, which shows that there is still a certain degree of measurement error in fitting the urban scale with night light data In column (4) of panel B in **Table 3**, the article further uses the night light data extracted based

on the principle of "optimal fitting degree" to replace the original data in the benchmark regression for regression The goodness of fit between the fitting area under the "optimal fit" method and the real urban built-up area has reached 90%, which reduces the data bias caused by the fitting problem to a certain extent, and the regression results again prove the robustness of the benchmark regression results.

4. Causal identification

This paper will further discuss the possible estimation errors with the help of more control variables and instrumental variables.

4.1. Missing variables

In order to more clearly identify the impact of dialect diversity on the city scale, the article further increases six factors: the potential characteristics of the city circle, other cultural factors, the degree of government intervention, the degree of opening to the outside world, the city scale distribution of the city circle and the level of industrial structure, so as to avoid possible missing variables.

a)Impact of potential characteristics of urban circle. The potential characteristics of urban circle refer to some inherent factors that will not change with time in a certain period of time. These factors may also affect the urban scale of the urban circle Combined with the research background, this paper divides the potential characteristics of the urban circle to be controlled into the following two categories The first category is geographical factors, including whether the urban circle is coastal and the average slope of the urban circle The second category is administrative division factors. On the basis of benchmark regression, the administrative area of urban circle is added to further control the influence of administrative division factors The regression results are reported in column (1) of **Table 4** It can be seen that after further considering the geographical factors and administrative division factors, the basic conclusion of this paper is still stable.

b) Other cultural factors Dialect is the carrier of regional culture. The influence of dialect on urban scale may actually be due to the influence of other cultural factors rather than the dialect itself In order to eliminate this possibility, this paper controls the "number of cross-cultural areas in the urban circle" as a measurement variable of other cultural factors, so as to distinguish whether the dialect itself or other cultural factors have an impact on the urban scale. The division and distribution of cultural areas come from Wu Bihu [27] Column (2) of **Table 4** shows the results of controlling other cultural factors The regression coefficient of the variable "number of cross-cultural areas in the city circle" is not significant, and the regression coefficient of the key explanatory variable dialect category is significantly negative, indicating that dialect rather than other cultural factors is the factor affecting the city scale.

c) Degree of government intervention Cities are the concentrated embodiment of agglomeration effect, and the optimal development of urban scale is also closely related to agglomeration effect Considering that the degree of government intervention may have a certain impact on the size of the city, we take the ratio of government expenditure of the city circle to the GDP of the city circle as the index to measure the "degree of government intervention of the city circle" and add it into the regression

equation as the control variable. The regression results are shown in column (3) of **Table 4** Compared with the regression results in the first two columns of **Table 4**, the absolute value of the regression coefficient of the key explanatory variable dialect category decreased by about 2%, but it is still significantly negative.

d) Degree of opening to the outside world Li Guangqin et al. [9] found that dialect diversity has a significant negative impact on the degree of urban opening-up. Fan Yi [28] showed that the improvement of the degree of opening-up will promote the development of the city In this paper, the opening degree of the urban circle is measured by the ratio of the total import and export volume of the urban circle to the GDP of the urban circle. The results of controlling this variable are shown in column (4) of **Table 4**. The regression results show that the opening degree has a significant positive impact on the city scale. At the same time, the regression coefficient of the key explanatory variable dialect diversity is still significantly negative, and the estimated coefficient is 7.99%. Considering the openness of urban economy, the negative impact of dialect diversity on urban scale has not been disturbed.

e) City size distribution There are two situations of urban scale distribution: centralized and decentralized. When the urban scale distribution of an urban circle presents the characteristics of centralization, it shows that the human and property elements of the urban circle are more concentrated in one or a few cities, which has the characteristics of first distribution; On the contrary, when the human and property elements of the urban circle are scattered in various cities, it is considered that the urban scale distribution of the urban circle has the characteristics of decentralization Population concentration and economic concentration are respectively used to measure the urban scale distribution. The larger the concentration index, the more concentrated the urban scale distribution of the urban circle, and vice versa After controlling the distribution of city size, the regression coefficient of key explanatory variables is still significantly negative (see column (5) of **Table 4**).

f) Industrial structure level Referring to the practices of Zhao Ranran and Shen Chunmiao [29], we build an industrial structure upgrading index(β) , To measure the industrial development of the city circle, the specific construction method is as follows: where Yi represents the proportion of $\beta = \sum_{i=1}^{3} y_i \times i$ the output value of the I industry in GDP, and the value range of the industrial structure upgrading index is $1 \le \beta \le 3$, β The closer it is to 1, the lower the industrial structure level of the city. The closer it is to 3, the higher the industrial structure level of the city Upgrading the industrial structure index β The regression results in column (6) of **Table 4** show that after controlling the development of industrial structure in the urban circle, dialect diversity still has a significant negative impact on the city scale.

Column (7) of **Table 4** shows the regression results after adding all the above missing variables. The regression coefficient of dialect diversity is still significantly negative Compared with the benchmark regression, adding one more dialect subclass will lead to the reduction of city size from 11.3% to 4.55%, indicating that after considering the influence of possible missing variables, the estimation results in this paper are more “clean”.

4.2. Estimation of instrumental variables

The tests of many methods above have confirmed the robustness of the estimation results in this paper. In theory, the following simultaneous problems cannot be excluded: Is the diversity of dialects hindering the expansion of urban scale, or the diversity of dialects brought about by the scattered distribution of cities in history? For this question, this paper further analyzes it with the help of instrumental variables. Referring to Ding Congming et al. [6], this paper uses the types of local operas as the instrumental variable of dialect diversity Generally speaking, local operas in a region are sung by local dialects, and the audience is mainly local residents. The diversity of local operas is mainly caused by the diversity of dialects [30]. Therefore, the relevance of opera types as instrumental variables of dialect diversity can be better metin this paper, we count the number of local operas in each city circle according to the distribution of local operas in the manual of Chinese operas.

Table 4. Missing variables.

	Night light index						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Dialect subclass	−0.0867***(0.025)	−0.0883*** (0.025)	−0.0667*** (0.023)	−0.0799*** (0.024)	−0.0763*** (0.025)	−0.0701*** (0.023)	−0.0455** (0.022)
Average slope	−0.108*** (0.036)						−0.0834** (0.033)
Coastal or not	0.437** (0.170)						0.120 (0.150)
District area	0.132 (0.243)						0.301 (0.216)
Number of cross-cultural areas	0.0258 (0.066)						0.00307 (0.057)
Degree of government intervention				−4.644*** (0.654)			−3.746*** (0.623)
Degree of opening to the outside world				1.424*** (0.362)			0.921*** (0.329)
Population concentration					0.154*** (0.050)		0.121*** (0.045)
Economic concentration					0.0456 (0.048)		0.133*** (0.042)
Industrial structure level						4.424*** (0.671)	3.827*** (0.632)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of samples	300	300	300	300	300	300	300
R2	0.473	0.359	0.455	0.392	0.382	0.444	0.554

In terms of exogeneity, on the one hand, it is really difficult for us to have a priori reason to believe that the types of operas have an impact on the scale of cities Of course, theoretically, there may be some other factors that affect the types of operas and the size of the city The greatest possibility is that the cultural diversity other than dialects affects not only the types of operas, but also the expansion of urban scale In order to eliminate the above possibility, the number of cultural areas in the urban circle is controlled in the empirical regression in **Table 5**, and the specific control variables

are consistent with column (2) of **Table 4**. On the other hand, based on the empirical framework of IV estimation by Conley et al. [31] under the condition of relaxing the exogenous of instrumental variables, we retest the robustness of the IV estimation results in this paper. Conley et al. [31] assumed that the instrumental variables were close to the approximate exogenous, so as to investigate the change trend of IV estimation results under different degrees of exogenous approximation This paper tests the robustness of the two-stage estimation results of instrumental variable local opera types under the condition of approximate exogenous. The results are shown in columns (5)–(7) of **Table 5**.

Table 5. Estimation of instrumental variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	**Two stage estimation results**			**Approximate exogenous of instrumental variables: ltz method**		
	Full sample	Full sample	Exclude samples including municipalities directly under the central government	Eliminate minority language areas	Full sample	Exclude samples including municipalities directly under the central government	Eliminate minority language areas
Dialect subclass	−0.0530** (0.023)	−0.238* (0.138)	−0.260** (0.123)	−0.241* (0.135)	−0.239* (0.134)	−0.259** (0.123)	−0.240* (0.132)
Types of local operas	−0.0130 (0.009)						
Number of cross-cultural areas	0.0483 (0.060)	0.118 (0.085)	0.128 (0.080)	0.101 (0.083)			
Control variable	Control	Control	Control	Control	Control	Control	Control
Number of samples	300	300	277	278	300	277	278
		Phase I estimation results					
		Explained variable: number of dialect sub categories in urban circle					
Types of local operas		0.0702*** (0.022)	0.0863*** (0.025)	0.0729*** (0.025)			
Control variable	Control	Control	Control	Control			
Number of samples	300	300	277	278			
R2	0.499	0.655	0.644	0.632			
F statistic	—	25.12	25.3	21.89			

Table 5 reports the regression results of instrumental variables In column (1), in order to simply show the exogenous nature of instrumental variables, we also include instrumental variables into the regression equation. The results show that the estimation coefficient of local opera types is not significant, which indirectly proves that instrumental variables do not have a direct impact on urban scale Columns (2)–(4) report the estimation results using the two-stage least squares method The regression results of the first stage are significantly positive at the level of 1%, which proves that there is a high correlation between the types of local operas and the

diversity of dialects. The F statistics are greater than 10. The assumption of weak instrumental variables is rejected based on experience In the second stage, the estimated coefficient was negative and passed the significance test at the level of 10%. On the whole, the estimated coefficient met the expectation The two-stage estimation coefficient is about 5 times larger than the OLS regression coefficient (4.55%) The coefficient expansion may come from the local average processing effect mainly captured by the instrumental variable estimation, while the OLS estimation results mainly capture the global average processing effect, resulting in the expansion of the estimation coefficient Columns (3) and (4) exclude the samples including municipalities directly under the central government and the samples excluding ethnic minority language areas respectively. The estimated coefficient is not different from column (2) The empirical results of using the local to zero approach (ltz) are shown in columns (5)–(7) of **Table 5** In general, under the local approximate zero method (ltz), the estimation coefficient of endogenous variables (dialect categories) is still significantly negative, which supports the robustness of the estimation results of instrumental variables in this paper Of course, considering the expansibility of the estimation coefficient of instrumental variables, the estimation results in column (7) of **Table 4** are still used for interpretation in this paper.

5. Influence channels

The second part of the article points out that the possible influence channel of dialect diversity on urban scale is that dialect forms the division of trust between different dialect groups through the effect of identity and cultural identity, hinders the flow of urban labor, capital and technological elements and the full play of spatial agglomeration effect, and then hinders the expansion of urban scale This paper will test the above transmission mechanism and construct the following variables to measure the flow and agglomeration of labor, capital and technological factors(1) labor mobility variables The construction of the variable is based on the practice of Shao Yihang et al. [32] and Xu Yan [33], and the ratio of the urban resident population to the registered residence population (*Lflow*) is used to measure the city labor mobility. When the ratio is greater than 1, it is indicated that the city is the labor force inflow area. When the ratio is less than 1, it indicates that this place is the place of labor outflow (2) capital variables Referring to the practice of Wang Linhui and Zhao Xing [34], the capital stock is measured by the amount of fixed asset investment (*InFA*) of each city (3) technical variables The construction of technical variables refers to the method of Xu Xianxiang et al. [7] and considers the neoclassical economic growth model under steady-state economy, i.e. $Y = K^{\alpha}(ALh)^{1-\alpha}$, Among them, *Y*, *K*, *L* and *h* are respectively substituted by the GDP, fixed asset investment, permanent resident population and logarithmic average employee salary of each city. Simplify the value of α as 1/3 [7], and after substituting the above data into the neoclassical economic growth model, the corresponding technological development level (A) of each city can be obtained. In order to better measure the flow and agglomeration of the three elements, the above variables are dealt with as follows.

Table 6. Description of indicators.

Labor variables	Loop lflow	The total resident population in city circle / total registered residence population: It is used to measure the overall labor flow in the urban circle. The larger the value, the more labor flows into the place, and the better the agglomeration effect on labor factors. On the contrary, the worse the agglomeration effect of labor in the place
	STD-Lflow	Standard deviation of lflow in cities around the city circle: It is used to measure the difference of labor mobility among member cities in the urban circle. The larger the value, the higher the labor mobility among cities in the urban circle and the better the labor agglomeration effect; On the contrary, it shows that the lower the labor mobility, the worse the labor agglomeration effect
Capital variable	Ring InFA	Total fixed asset investment in the urban circle (logarithm): it measures the overall capital stock of the urban circle. The larger the value, the more the capital stock of the urban circle
	STD-InFA	Differences in fixed asset investment among cities within the urban circle: It is used to measure the difference of capital stock among cities within the urban circle. The larger the value, the greater the difference, which means that the capital within the urban circle gathers to a few cities, and the stronger the spatial agglomeration effect of capital
Technical variables	Circle A	Technical level within the city circle: The total GDP, total investment in fixed assets, total resident population and average wages of several employees of the urban circle are substituted into the neoclassical economic growth model to represent the overall scientific and technological level of the urban circle. The larger the value, the higher the scientific and technological level
	STD-A	Standard deviation of technical level a of each city in the urban circle: It indicates the difference of scientific and technological level between cities within the urban circle. The greater the value, the greater the difference of scientific and technological level and the stronger the agglomeration effect of scientific and technological elements

Table 7 shows the results of regression using the above indicators. The analysis of panel a in **Table 7** uses labor, capital and technical factors to regress the types of dialects. The results show that: In terms of labor mobility, the increase of dialect diversity in urban circle will have an adverse impact on Labor Inflow (circle *Lflow*) in urban circle, and has no significant impact on labor agglomeration effect (*STD-Lflow*) in urban circle; In terms of capital flow, the increase of dialect diversity in urban circles will only significantly worsen the spatial agglomeration effect of capital (*STD-InFA*) within urban circles, and has no significant impact on the capital stock flow between urban circles (*INFA*); At the level of technology flow, the increase of dialect diversity in the urban circle will not only hinder the overall scientific and technological level of the urban circle (circle A), hinder the free flow of scientific and technological elements between the urban circles, but also hinder the exertion of the spatial agglomeration effect of science and Technology (*STD-A*) within the urban circle Further, in **Table 7** panel B, this paper uses the night light index to measure the city scale to regress the indicators of factor flow and factor agglomeration. The results show that labor inflow (column (1) of **Table 7** panel B), capital flow and agglomeration (columns (3) and (4) of **Table 7** panel B) and technological factor flow and agglomeration (columns (5) and (6) of **Table 7** panel B) have a significant positive correlation with the expansion of city scale.

Table 7. Transmission mechanism test.

Panela	Labor mobility		Capital flows		Technology flow	
	(1)	(2)	(3)	(4)	(5)	(6)
	Loop Lflow	STD-Lflow	Ring InFA	STD-InFA	Circle A	STD-A
Dialect subclass	−0.00895*** (0.002)	−0.00313 (0.003)	−0.0117 (0.012)	−0.0538*** (0.019)	−0.0821*** (0.015)	−0.0369*** (0.013)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
N	300	300	300	300	300	300
R2	0.842	0.678	0.702	0.394	0.644	0.305
Panel B	Explained variable: night light index					
Loop Lflow	2.687*** (0.649)					
STD-Lflow		-0.644 (0.513)				
Ring InFA			1.034*** (0.105)			
STD-InFA				0.642*** (0.069)		
Circle A					0.711*** (0.086)	
STD-A						0.656*** (0.110)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
N	300	300	300	300	300	300
R2	0.315	0.279	0.441	0.440	0.414	0.354

Source: The statistical data of capital, technology and labor force in 2016 are from the statistical yearbook of China.

Based on the regression results in **Table 7**, it is not difficult to confirm the transmission mechanism of dialect diversity affecting urban scale: The increase of dialect diversity is not conducive to the flow and agglomeration of labor and scientific and technological elements. The spatial agglomeration effect of capital within the urban circle is significantly worse, while the poor mobility of labor, capital and scientific and technological elements between the urban circles and the weakening of the agglomeration effect within the urban circle will have an adverse impact on the urban scale The deep-seated factors affecting the establishment of the above transmission mechanism mainly come from the flow barriers brought by cultural diversity: The more diverse the dialects, the more serious the division of trust caused by the identification effect of dialects, and the lower the general level of social trust, the more people tend to distrust strangers and choose to trust more familiar people and things with similar culture and origin backgroundthis will undoubtedly affect people's employment choice, investment decision-making and technical cooperation. This "group warming" behavior based on dialect cultural background will hinder the flow of labor, capital and technical factors among different groups, form flow barriers, and then hinder the full flow and agglomeration of various elements of the city, affect the exertion of urban spatial agglomeration effect, and ultimately have an adverse impact on the scale of the city.

6. Concluding remarks

This paper examines the impact of dialect diversity on urban scale from the perspective of cultural economy Since the reform and opening up, China's urbanization level has been greatly improved. The continuous improvement of urbanization rate and the continuous expansion of urban scale have resulted in the unbalanced and insufficient development of urban space There is a huge gap between the eastern and central and western regions, coastal and inland citiesthe academic circles have conducted extensive and in-depth discussions on the reasons for the differences in urban scale in China. Based on the existing literature, this paper further explores the reasons for the differences in urban scale development from a cultural perspective China has a vast territory and diverse cultures. The cultural area with dialect as the carrier naturally forms the plate structure foundation of regional economy Dialects form trust segmentation among different dialect groups through identity recognition effect, which affects the general level of social trust, the flow of factors between cities and the agglomeration within cities, and then has an adverse impact on the scale of cities In the empirical study, in order to eliminate the interference of administrative division factors on dialect and urban scale, this paper divides the virtual urban circle as the basic measurement unit based on the standard of bordering on the core city In order to comprehensively measure the quantity and spatial attributes of urban scale, this paper uses night light data as a proxy variable to measure urban scale The empirical regression estimation results of this paper show that: Dialect diversity has a significant negative effect on city scale. A series of robustness test results show that the empirical results of this paper are robust As far as the dialect category is concerned, every increase in the dialect category will lead to a decrease of 4.5% in the size of the city measured by the urban night light index 55%. In order to test the causality of the above relationship, this paper uses "local opera types" as the instrumental variable of dialect diversity. The estimation results of two-stage least square method and ltz method support the causal effect of dialect diversity on urban scale Through further transmission mechanism analysis, it is found that dialect diversity mainly affects the flow and agglomeration of labor, capital and technological factors, and then affects the urban scale.

The research of this paper shows that under the background of transition period and new urbanization construction, the urban scale is affected by a series of economic and policy factors such as geographical endowment, regional economic development level and traffic accessibility. At the same time, cultural diversity and dialect diversity formed on this basis are also deep-seated factors affecting the difference of urban scale While protecting cultural diversity and linguistic diversity, the policy focuses on improving the level of social trust, reducing the negative impact of trust segmentation caused by the identity and screening mechanism of dialects, eliminating cultural barriers, and giving full play to the complementary effect brought by multiculturalism, so as to build a more diversified and inclusive modern city.

Author contributions: Conceptualization, CD and XH; methodology, MZ; software, MZ; validation, CD, XH and MZ; formal analysis, CD; investigation, CD; resources, MZ; data curation, XH; writing—original draft preparation, CD; writing—review and

editing, XH; visualization, MZ; supervision, MZ; project administration, CD; funding acquisition, XH. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

References

1. Chen L, Yang K, Wu J. Empirical Research on the evolution of China's urban system. Jiangsu Social Sciences. 2007; 1.
2. Duan R. Research on China's urban scale and its influencing factors -- Empirical Evidence from 284 prefecture level and above cities. financial research. 2013; 9.
3. Sun B, Jin X, Lin J. China's new urbanization pattern towards coordinated development of large, medium and small cities -- Evolution and influencing factors of China's urban scale distribution since 1952. Geographical research. 2019; 1.
4. Liu Y, Xu X, Xiao Z. Inverted U-shaped model of labor force flow across dialects. Economic research. 2015; 10.
5. Lin J, Zhao Z. Invisible barriers to balanced development: dialects, institutions and technology diffusion. Economic research. 2017; 9.
6. Ding C, Ji Z, Lei Y, Liang Z. Dialect diversity and market integration: from the perspective of urban circle. Economic research. 2018; 11.
7. Xu X, Liu Y, Xiao Z. Dialects and economic growth. Journal of economics. 2015; 2.
8. Ruan J, Wang L. Language differences and market system development. Management world. 2017; 4.
9. Li G, Cao J, Shao S. Language diversity and regional differences in China's opening up. world economy. 2017; 3.
10. Dai Y, Xiao J, Pan Y. Can "local accent" reduce the agency cost of the company? -- Research from the perspective of dialect. Economic research. 2016; 12.
11. Huang J, Liu C. Dialect and social trust. financial research. 2017; 7.
12. Pendakur K, Pendakur R. Language as Both Human Capital and Ethnicity. International Migration Review. 2002; 36(1): 147-177. doi: 10.1111/j.1747-7379.2002.tb00075.x
13. Chen Z, Lu M, Xu L. Returns to dialect. China Economic Review. 2014; 30: 27-43. doi: 10.1016/j.chieco.2014.05.006
14. Wei X, Chen S, Li J. Dialect skills and entrepreneurial choices of floating population. China Population Science. 2016; 6.
15. Chen J, Huang J. China's industry, city and region from the perspective of Agglomeration -- a summary of the latest progress of domestic spatial economics. Journal of Zhejiang University. 2008; 4.
16. Li Q, Meng L. Dialects, Putonghua and regional mobility of Chinese labor force. Journal of economics. 2014; 4.
17. Lu M, Chen Z. Market integration and industrial agglomeration in China's regional economic development. Shanghai People's publishing house; 2006.
18. Doll CNH, Muller JP, Morley JG. Mapping regional economic activity from night-time light satellite imagery. Ecological Economics. 2006; 57(1): 75-92. doi: 10.1016/j.ecolecon.2005.03.007
19. Elvidge CD, Cinzano P, Pettit DR, et al. The Nightsat mission concept. International Journal of Remote Sensing. 2007; 28(12): 2645-2670. doi: 10.1080/01431160600981525
20. Chen X, Nordhaus WD. Using luminosity data as a proxy for economic statistics. Proceedings of the National Academy of Sciences. 2011; 108(21): 8589-8594. doi: 10.1073/pnas.1017031108
21. Yang M, Wang S, Zhou Y, Wang L. Remote sensing estimation method of urbanization level based on DMSP / OLS image. Remote sensing information. 2011; 4.
22. Wu J, Liu H, Peng J, Ma L. The hierarchical structure and spatial pattern of China's urban system -- An Empirical Study Based on DMSP/OLS night light data. Journal of geography. 2014; 6.
23. Levin N, Zhang Q. A global analysis of factors controlling VIIRS nighttime light levels from densely populated areas. Remote Sensing of Environment. 2017; 190: 366-382. doi: 10.1016/j.rse.2017.01.006
24. Yang M, Cai Z, Zhang K. The measurement of China's urban scale and the source of its spatial competition -- a study based on global night light data. Finance and trade economics. 2017; 3.
25. Yang R, Luo H, Zhou S, et al. Reconstruction and analysis of spatial formation process of Chengdu Chongqing urban agglomeration driven by night light data. Journal of Earth Information Science. 2017; 5.

26. Li W, Sun B, Liu Q, Zhang T. Characteristics and influencing factors of China's urban spatial structure. Geographical Sciences. 2018; 6.
27. Wu B. Formation and division of Chinese cultural areas. Academic monthly. 1996; 3.
28. Fan Y. Inflection point and transformation of China's urban development: from the perspective of dynamic mechanism. Economic aspect. 2019; 8.
29. Zhao R, Shen C. Capital flow, industrial agglomeration and Industrial Structure Upgrading -- Empirical Analysis Based on panel data of 16 central cities in the Yangtze River Delta. Exploration of economic problems. 2019; 6.
30. You R, Zhou Z. Dialects and Chinese culture. Fudan Journal. 1985; 3.
31. Conley TG, Hansen CB, Rossi PE. Plausibly Exogenous. The Review of Economics and Statistics. 2012; 94(1): 260-272. doi: 10.1162/REST_a_00139
32. Chen J, Huang J. China's industry, city and region from the perspective of Agglomeration -- a summary of the latest progress of domestic spatial economics. Journal of Zhejiang University. 2008; 4.
33. Xu Y, Yin X, Yin X. Labor mobility and wage changes of Chinese urban residents. population and economy. 2019; 4.
34. Lu M, Chen Z. Market integration and industrial agglomeration in China's regional economic development. Shanghai People's publishing house; 2006.