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A Study on the Mechanism of the Impact of Urban Functional Mixing on Community Social Inclusion from a Big Data Perspective

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Abstract Modern urban planning has gradually shifted from functional zoning to functional mixing, and functional mixing has become a consensus of urban planning. This study explores the mechanism of the influence of urban functional mixing degree on neighborhood and social inclusiveness, adopts the EBM-GML index to measure the total factor productivity of neighborhood and social inclusiveness, and constructs two-way fixed effects and panel threshold models to analyze the relationship between the two. Taking the panel data of City A from 2014 to 2024 as a sample, the study finds that the degree of urban functional mixing is significantly and positively correlated with neighborhood and social inclusiveness, and social inclusiveness grows by 0.099 percentage points for every 1 percentage point increase in the degree of urban functional mixing. The analysis of regional heterogeneity shows that the degree of urban functional mixing contributes most significantly to social inclusion in the western region, with a regression coefficient of 0.169. The dimensional analysis shows that land use is a key factor influencing social inclusion with a regression coefficient of 0.075. The analysis of the threshold effect shows that when the functional mix of the city exceeds the threshold of 221.6352, its facilitating effect is enhanced from 0.092 to 0.111 percentage points. The results of the study have important guiding significance for optimizing urban spatial layout and promoting harmonious urban development, and it is suggested that urban planning should pay attention to functional mixing, optimize the land use structure, and enhance the infrastructure interconnection between different regions, so as to enhance social inclusiveness.

Index Terms urban functional mixing, neighborhood, social inclusion, multiple regression analysis, panel threshold model, spatial heterogeneity

I. Introduction

From Goggio's “industrial city” to Corbusier's “centralized city” and later the Athens Charter, the idea of “functional zoning” originated from modern rationalism was gradually formed and established as an important principle guiding modern urban planning and construction. The idea of “functional zoning”, which originated from modern rationalism, was gradually formed and established, and became an important principle guiding modern urban planning and construction. However, the over-emphasis on pure function and rationalism in the Athens Charter has led to many social problems, especially the lack of urban vitality and inclusiveness [1], [2]. 1977 Machu Picchu Charter puts forward the idea of mixed-function zones, aiming to create an integrated, multi-functional environment, which has gradually become the consensus of urban planners and city managers [3].

During the rapid urbanization process over the past few decades, a large number of urban areas with relatively single and scattered functions have been built. The single functional zoning has created numerous "sleeping towns" and "ghost towns", which not only intensified the pressure on urban traffic but also reduced the usage frequency and vitality of communities, resulting in the waste of urban space and the decline in the quality of the community environment [4]-[7]. An increase in the degree of mixing of urban functional districts can promote resource sharing and utilization efficiency between different functional districts. For example, an increase in the mixing degree of commercial and residential districts can reduce the commuting time of residents, increase the utilization rate of commercial facilities, and promote social interaction and innovation, and a higher mixing degree of urban functional districts can help to promote communication and interaction between different groups, and promote innovation and knowledge transfer [8]-[10]. The mixing of different functional areas can create more crossover opportunities and innovative environments and enhance urban sustainability. By reducing the commuting distance and reducing the dependence on private cars, traffic congestion and environmental pollution can be reduced, the ecological efficiency of the city can be improved, and the urban spatial layout can be optimized, and the study of the degree of mixing of urban functional districts can provide a scientific basis for urban governance and urban planning and spatial layout [11]-[14]. Therefore, advocating the principle of moderate functional mixing and deeply exploring the relationship between urban functional mixing and urban vitality is of great significance in guiding urban planning and construction practice and promoting sustainable urban development.

With the continuous acceleration of urbanization, how to achieve social inclusiveness has become a crucial issue. Social inclusiveness means that in the process of urbanization, every participant, regardless of his or her origin, wealth, geography, occupation and other factors, can enjoy the opportunities and benefits brought by urbanization in a fair way, find his or her own position and sense of belonging in the towns, realize friendly relations with neighbors, and realize his or her own values and dreams, which is not only the requirement of social fairness and justice, but also the guarantee of sustainable development of urbanization [15]-[17]. And social inclusiveness in the urban functional area planning of urbanization, its public services and public space present fairness and diversity, and the probability of neighborhood social interaction presents different [18]. Then what role different types of urban functional mixing degree plays in neighborhood and social inclusion is worth pondering.

From Goggio's "industrial city" to Corbusier's "centralized city" and later the Athens Charter, the idea of "functional zoning" originating from modern rationalism has gradually been formed and established as an important principle guiding the planning and construction of modern cities. However, the over-emphasis on pure functionality and rationalism in the Athens Charter led to many social problems, especially the lack of urban vitality and inclusiveness, and in 1977 the Machu Picchu Charter put forward the idea of mixed-functional zones, aiming to create an integrated and multi-functional environment, which gradually became the consensus of urban planners and city managers. In the past decades of rapid urbanization, a large number of relatively single-function, scattered urban areas have been built, and single-function zoning has shaped a large number of "sleepy towns" and "ghost towns", which not only exacerbate the pressure of urban traffic, but also reduce the frequency of use and vitality of the community, resulting in a waste of urban space and a reduction in the quality of community environment. Increasing the degree of mixing of urban functional areas can promote the sharing of resources between different functional areas and improve the efficiency of utilization. For example, an increase in the mix of commercial and residential areas can reduce residents' commuting time, increase the utilization rate of commercial facilities, and promote social interaction and innovation, and a higher degree of mixing of urban functional areas can help to promote communication and interaction between different groups, and promote innovation and knowledge transfer. The mixing of different functional areas can create more crossover opportunities and innovative environments and enhance urban sustainability. By reducing the commuting distance and the dependence on private cars, it can reduce traffic congestion and environmental pollution, improve the ecological efficiency of the city, and optimize the spatial layout of the city. The study of the mixing degree of urban functional zones can provide a scientific basis for urban governance and urban planning and spatial layout. Therefore, it is of great significance to advocate the principle of moderate functional mixing and to deeply explore the relationship between urban functional mixing and urban vitality, in order to guide the practice of urban planning and construction and to promote the sustainable development of cities.

As the urbanization process continues to accelerate, how to achieve social inclusiveness has become a crucial issue. Social inclusiveness means that in the process of urbanization, every participant, regardless of his/her origin, wealth, geography, occupation and other factors, can enjoy the opportunities and benefits brought by urbanization in a fair way, find his/her own position and sense of belonging in the towns, realize the friendly relationship with the neighbors, and realize his/her own values and dreams, which is not only the requirement of social fairness and justice, but also the guarantee of the sustainable development of urbanization. And social inclusiveness in the urban functional area planning of urbanization, its public services and public space present fairness and diversity, and the probability of neighborhood social interaction presents different.

This study explores the relationship between urban functional mixing degree and neighborhood social inclusion from three perspectives: economic, social and environmental. Firstly, a two-way fixed-effects model is constructed to verify the correlation between the two; secondly, the moderating effects of Internet penetration and urbanization level on this relationship are analyzed; thirdly, the panel threshold model is used to identify the turning points in the nonlinear relationship; and finally, an in-depth analysis is carried out in terms of both regional heterogeneity and dimensional heterogeneity. The study will provide empirical evidence for urban planning and promote the coordinated development of functional mixing and social inclusion, thus improving the quality of life of urban residents and promoting social harmony and progress.

II. Theoretical analysis and research design

II. A. Theoretical analysis

II. A. 1) Direct impact of the degree of urban functional mix on neighborhoods and social inclusion

Neighborhood and social inclusion emphasizes the inclusiveness and greening of economic growth, so the impact of the mix of urban functions on neighborhood and social inclusion is explored from three aspects: economic, social and environmental.

(1) Impact on economic growth. The degree of urban functional mixing mainly promotes economic growth through economies of scale, economies of scope, and the long-tail effect. (a) Economies of scale. The development of mixed urban functions can push enterprises to expand their production scale, thus generating economies of scale and promoting economic growth. (b) Economies of scope. With the improvement of digital infrastructure, the scale of Internet users continues to expand, and the massive number of network users lays the foundation for enterprises to expand their business scope. Moreover, relying on the network platform, digital enterprises can enrich product categories at lower operating costs, thus generating economies of scope and promoting economic growth. (c) Long tail effect. Digital enterprises can quickly capture the personalized needs of the market with the help of information technology, and according to the long-tail effect, enterprises are also conducive to the formation of economies of scale and economies of scope in the process of cultivating niche markets, thus promoting economic development.

(2) Impact on social inclusion. The degree of mixing of urban functions exerts an enabling effect at the micro, meso and macro levels, promoting social inclusion and sharing of outcomes. (a) Micro-level. In the era of mixed urban functionality, the deep integration of traditional enterprises and digital technology significantly improves the information accessibility of enterprises and effectively breaks down the “data barriers” and “information silos” of small and medium-sized enterprises (SMEs). Moreover, the degree of urban functional mix can raise the income level of rural residents through broadening product sales channels and upgrading employment skills, thus promoting the sharing of the fruits of development. (b) Meso level. Compared with the traditional economy, the development of mixed degree of urban function constantly weakens the boundary of economic activities between industries, significantly enhances the communication and cooperation within and between industries, and gradually realizes the common construction and sharing of information and technology between industries, which is conducive to the integrated development of industries and the improvement of the overall level [19]. (c) Macro level. The mixed degree of urban functions has the attributes of integration, association and innovation, which can guide the flow of information, capital, technology and other resource elements to rural areas, thus stimulating the vitality of rural consumer market, capital market and resource market and narrowing the development gap between urban and rural areas. Moreover, the development of mixed urban functions can strengthen the radiation-driven role of developed regions, guide the flow of digital technology to the whole country, and continuously narrow the regional development gap.3. Impact on green ecology. The mixed degree of urban function mainly realizes green development by improving the efficiency of government environmental supervision, promoting the green transformation of enterprise production, and promoting the low-carbon transformation of residents' life. In terms of government supervision, with the help of big data, cloud computing and other digital technologies, the government can significantly improve the efficiency of environmental supervision, reduce the cost of environmental supervision, and guide the green development of the market economy. In terms of enterprise production, the development of mixed urban functions can promote the sharing of resources such as sewage equipment, green technology and low-carbon transformation talents among enterprises, thus reducing the cost of enterprise green transformation and improving the effectiveness of enterprise emission reduction and carbon reduction. In terms of residents' life, the hybrid city function utilizes the network platform to effectively guide the public to practice low-carbon concepts and participate in social environmental protection undertakings. In addition, the application of digital technology in areas such as online office and online medical care can promote green consumption by residents and reduce pollution emissions and energy consumption.

II. A. 2) Non-linear relationship between the impact of the functional mix of the city on neighborhoods and social inclusion

(1) Internet penetration. As an important infrastructure for the development of mixed urban functionality, the Internet plays an important role in the process of promoting neighborhood and social inclusion in mixed urban functionality. When Internet penetration is low, digital infrastructure construction is insufficient, and there are significant differences in the development of urban function mixing between regions and between urban and rural areas, the “digital divide” problem seriously restricts the empowering effect of urban function mixing. However, it can be seen from Metcalfe's Law that the more users participate in the Internet, the higher the value of network data. With the increase of Internet penetration and the continuous improvement of digital infrastructure, the efficiency of communication and interaction between regions, industries and enterprises has been significantly improved, and the scale and scope effects of

urban functional mixing degree can be fully realized, at which time the promotion effect of urban functional mixing degree on neighborhood and social inclusion is more obvious [20].

(2) Level of urbanization. The empowering effect of urban functional mix on neighborhood and social inclusion is affected by many factors, and the empowering effect may have non-linear characteristics under different levels of urbanization. At the early stage of urbanization, there are big differences in the city scale and population density of each region, the radiation-driven ability of big cities is very limited, and the level of digital infrastructure is low and the Internet penetration is not high, so at this time, it is difficult to release the development dividend of the mixed degree of urban function completely. After the level of urbanization breaks through a certain threshold, cities become the gathering place of innovative talents, information technology and high-tech industries, the scale and agglomeration effects of urbanization are fully released, and the digital infrastructure is becoming more and more perfect, and at this time the mixed degree of urban functions can give full play to the empowering effect, promote the inclusive growth of neighborhoods and societies and accelerate the pace of green transformation of industries.

II. B. Study design

II. B. 1) Modeling

(1) Baseline panel model

Based on the research hypotheses, a two-way fixed effects model is constructed in order to verify whether there is some association between the degree of urban functional mix and neighborhood and socially inclusive growth [21]:

$$\begin{aligned} TFP_{it} &= \alpha_0 + \alpha_1 DIFI_{it} + \alpha_2 FIN_{it} + \alpha_3 LAN_{it} + \alpha_4 POP_{it} + \alpha_5 INC_{it} \\ &+ \alpha_6 INT_{it} + \alpha_7 SCI_{it} + \alpha_8 EDU_{it} + \alpha_9 OPE_{it} + \mu_i + \nu_t + \varepsilon_{it} \end{aligned} \tag{1}$$

where i and t denote city and year, respectively. TFP is an explanatory variable representing neighborhood and social inclusion. DIFI is a core explanatory variable representing the degree of functional mixing in the city. $FIN, LAN, POP, INC, INT, SCI, EDU$ and OPE denote the level of financial development, land resources, population development, government public budget, Internet development, scientific development, regional education and openness to the outside world, respectively. α_0 is a constant term. $\alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8$ and α_9 denote the regression coefficients for the respective regression coefficients of the control variables. μ_i are individual fixed effects. v_t is the time fixed effect. ε_{it} is the random disturbance term.

(2) Panel threshold model

Considering that there may be a nonlinear relationship between the degree of urban functional mixing and neighborhood and social inclusive growth with some variables as threshold factors, this paper takes the level of economic development, urbanization rate and infrastructure construction level as threshold variables respectively, and uses the panel threshold model to identify the shift in the impact of the degree of urban functional mixing on neighborhood and social inclusive growth before and after the threshold value, and establishes the following panel threshold model:

$$\begin{aligned} &TFP_{it} = \alpha_0 + \alpha_1 DIFI_{it} \times I(q \leq \lambda_1) \\ &+ \alpha_2 DIFI_{it} \times I(q > \lambda_1) \\ &+ \cdots \\ &+ \alpha_n DIFI_{it} \times I(q \leq \lambda_n) \\ &+ \alpha_n DIFI_{it} \times I(q > \lambda_n) \\ &+ \alpha_c X_{it} + \mu_i + \nu_t + \varepsilon_{it} \end{aligned} \tag{2}$$

where X_{it} is the control variable. q is the threshold variable, which is the level of economic development, the urbanization rate and the level of infrastructure construction, respectively. λ is the threshold to be estimated, which can divide the data into a number of intervals and examine the effect of different intervals. $I(\cdot)$ is the indicative function, which takes the value of 1 when the condition in parentheses is met, and 0 when the opposite is true.

II. B. 2) Variables and data sources

(1) Explanatory variables

The explanatory variable of this paper is the development level of urban functional mixing degree (DIFI). It can be divided into land use, transportation and infrastructure, economic and industrial structure and policy and planning.

(2) Explained Variables

The explanatory variables are neighborhood and socially inclusive growth (TFP). In order to measure neighborhood and social inclusive growth in a more scientific and reasonable way, the EBM-GML index is used to measure the neighborhood and social inclusive total factor productivity index, and the neighborhood and social inclusive total factor productivity index is multiplied to get the value of urban neighborhood and social inclusive total factor productivity in each year, and this represents the level of neighborhood and social inclusive growth.

The accurate selection of input and output indicators is the key to measuring neighborhood and social inclusive total factor productivity, and the specific input and output indicators in this paper are explained and treated as follows:

(a) Input indicators. Input indicators include labor input, capital input and energy input. Labor input is expressed as the number of employees in urban units in each city. Capital input is expressed by the capital stock of each city.

(b) Output indicators. Output indicators include desired output and non-desired output. Desired output is expressed by deflating the GDP price index of each city to get the constant price GDP of each city. The non-desired output includes the income gap indicator and the environmental pollution index, and the income gap is expressed by the ratio of disposable income per capita of urban residents to disposable income per capita of rural residents. The environmental pollution index is calculated by the entropy method from urban industrial wastewater emissions, industrial sulfur dioxide emissions and industrial smoke and dust emissions.

(3) Threshold variables

(a) Level of economic development (PGDP). This paper adopts per capita GDP to measure the regional economic development level.

(b) Urbanization rate (UBR). This paper uses urban population divided by total population to measure urbanization rate.

(c) Infrastructure development (INF). This paper adopts urban road area per capita to measure infrastructure development.

(4) Control variables

(a) Financial development level (FIN), which adopts the ratio of the loan balance of local financial institutions to regional GDP to measure the level of financial development.

(b) Land resources (LAN), using the logarithmic value of the land area of the regional administrative area to measure land resources.

(c) Population Development Level (POP), which measures the level of population development using the logarithm of regional population density.

(d) Local Government Revenue (INC), which measures local government revenue using the ratio of local general public budget revenue to GDP.

(e) Internet development level (INT), using the ratio of the number of fixed Internet users to the household population to measure the level of Internet development.

(f) The level of scientific development (SCI), using the ratio of scientific expenditure to GDP to measure the level of scientific development.

(g) Regional education level (EDU), using the ratio of education expenditure to GDP to measure the regional education level.

(h) Openness to the outside world (OPE), using the ratio of total import and export trade to GDP to measure the level of openness to the outside world.

(5) Data source

The data for the above indicators come from the China Statistical Yearbook, China Urban Statistical Yearbook, EPS database, Wind database, statistical yearbooks of prefectural cities and statistical bulletins of prefectural cities in the past years. Due to the availability of data, City A is selected as the research sample in this paper. Panel data for a total of 10 years from 2014-2024 are selected for the study.

III. Analysis of empirical results

III. A. Characterization of the mix of urban functions

III. A. 1) Statistical characterization of the functional mix of cities

Based on the previous method, the functional mixing density of all land parcels in a city was calculated. From the calculation results, the spatial distribution characteristics of functional mixing in the city show an obvious structure of “one main and many secondary”, which indicates that this result is reasonable. The statistical distribution of functional mixed density is shown in Figure 1. From the figure, it can be seen that there are different degrees of functional mixing in most areas. Most of the single-function sites are parks, cultural and historical sites, medical facilities, etc., while almost all of the sites with the main functions of residence, commercial services, recreation and sports are functionally mixed.

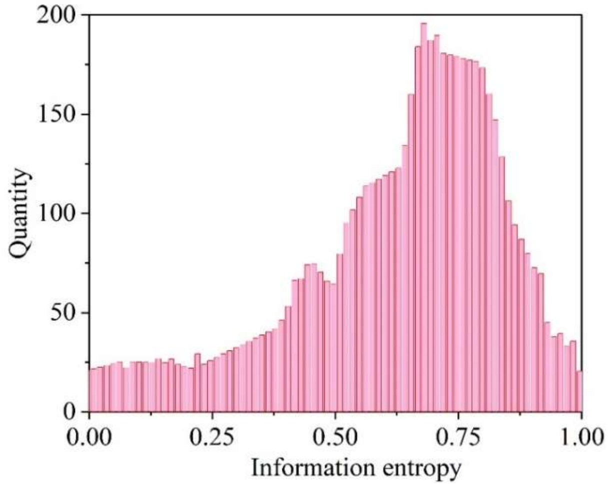

Figure 1: Statistical distribution of functional mixing density

III. A. 2) Spatial characterization of the mix of urban functions

In terms of overall spatial distribution, the polycentric character of functional mixing in City A is remarkable. Within the Second Ring Road and around the Second Ring Road, the density of functional mixing is very high, reflecting the fact that City A has formed a highly complex and stable functional layout after long years of renewal and development. Between the Second and Fourth Ring Roads, the urban land use as a whole maintains a high functional mixed density, indicating the maturing development of the area. Between the 4th and 5th Ring Roads, the density of mixed functions decreases and the number of single-function sites increases, partly due to the large number of sites still under construction and partly due to the large number of ecological open spaces in the area. Outside the Fifth Ring Road, the overall mixed density is further reduced, but in sub-centers such as Yizhuang Development Zone, Tongzhou New Town, and Shunyi Airport New Zone, the density of mixed functions has increased. The relationship between functional mixed density and spatial location is shown in Figure 2, where the closer the distance to the main city center, the higher the land use mixing degree is, for example, at a distance of 10km from the main city center, the mixing degree reaches -2.6.

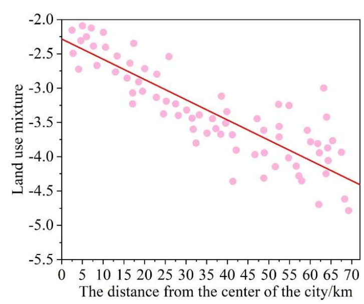

Figure 2: The relationship between functional mixing density and spatial location

III. B. Analysis of empirical results

III. B. 1) Benchmark regression results

Under the fixed effects model, this paper uses stepwise regression to add control variables sequentially. The results of the benchmark regression are shown in Table 1 (***, **, and * denote 1%, 5%, and 10% significance levels, respectively; numbers in parentheses are robust standard errors). The table presents the regression results of model (1). Column (1) shows the regression results with only urban functional mix as an explanatory variable, controlling for area fixed effects and year fixed effects, and the regression coefficients are significantly positive. In order to exclude the interference of other factors, columns (2) to (5) are the regression results after adding control variables sequentially. It can be seen that the regression coefficients of the degree of urban functional mixing affecting neighborhood and socially inclusive growth do not fluctuate significantly, the regression results do not change with the addition of control variables, and all of them pass the 1% significance level test. It shows that the degree of urban functional mix affects neighborhood and social inclusive growth has a very significant promotion effect in the examination period.

Table 1: Benchmark regression

Variable	Neighborhood and social inclusion								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Urban function mix	0.059**(2.78)	0.116***(2.81)	0.105***(2.52)	0.089***(2.81)	0.092***(2.75)	0.095***(2.62)	0.098***(2.76)	0.098***(2.43)	0.099***(2.2)
Financial development level (FIN)		0.127***(6.38)	0.125***(6.13)	0.142***(6.24)	0.149***(6.05)	0.153***(6.36)	0.155***(6.35)	0.162***(6.41)	0.165***(6.43)
Land resources (LAN)			0.025***(2.77)	0.018***(3.11)	0.018***(3.18)	0.012***(2.75)	0.010***(3.1)	0.010***(2.84)	0.009***(3.11)
Population development level (POP)				0.005***(2.44)	0.006***(2.33)	0.008***(1.56)	0.008***(1.96)	0.009***(2.46)	0.009***(1.53)
Local government income (INC)					0.002***(2.52)	0.003***(2.38)	0.003***(2.04)	0.005***(2.64)	0.006***(2.47)
Internet development level (INT)						-0.002**(2.88)	-0.001**(1.32)	-0.001**(1.29)	-0.001**(1.3)
Scientific development level (SCI)							-0.002**(-2.68)	-0.001**(-2.61)	-0.001**(-2.68)
Regional education (EDU)								-0.001**(-2.13)	-0.001**(-2.39)
Open level (OPE)									0.000(0.75)
Constant term_cons	0.410***(21.95)	0.362***(18.58)	0.360***(18.65)	0.439***(17.98)	0.392***(17.65)	0.431***(16.32)	0.425***(15.59)	0.415***(14.32)	0.365***(14.05)
Year FE/Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observed Obs	360	360	360	360	360	360	360	360	360
Quasi congruent R2	0.901	0.911	0.926	0.932	0.933	0.941	0.945	0.955	0.956

III. B. 2) Heterogeneity analysis

The above empirical results indicate that there is a close link between the degree of urban functional mix and neighborhood and social inclusion. Further, this paper analyzes the relationship between the degree of urban functional mixing and the growth of neighborhood and social inclusion in terms of regional heterogeneity and urban functional mixing dimension heterogeneity respectively, and the results of the heterogeneity analysis are shown in Table 2.

(1) Regional heterogeneity

This section uses panel data from the eastern, central, and western regions of City A to test the differences in the impact of the degree of urban functional mix on neighborhood and socially inclusive growth under different regional institutional environments. By comparing Table Column (1) to Column (3), it can be found that the degree of urban functional mixing in the eastern, central, and western regions has a promoting effect on neighborhood and social inclusion, but only the western region is significant at the 5% significance level, with a regression coefficient of 0.169. It can be seen that the positive effect of the degree of urban functional mixing is significant on tourism neighborhood and social inclusion in the western region of City A.

Table 2: Heterogeneity analysis results

Variables	(1) Eastern region	(2) Central region	(3) Western region	(4) Land use	(5) Traffic and infrastructure	(6) Economic and industrial structure	(7) Policy and planning
Urban function mix	0.066(1.23)	0.075(0.85)	0.169**(1.98)				
Land use				0.075*(1.85)			
Traffic and infrastructure					0.015***(2.95)		
Economic and industrial structure						0.052*(1.05)	
Policy and planning							0.036*(0.96)
Constant term_cons	0.422***(13.85)	0.291***(6.85)	0.206***(4.57)	0.405***(19.85)	0.415***(25.87)	0.428***(23.69)	0.432***(24.57)
Control variable	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Year FE/Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample number obs	135	80	145	360	360	360	360
Quasi congruent R2	0.966	0.904	0.8305	0.883	0.892	0.923	0.922
F	76.37	33.02	21.74	72.13	70.16	71.14	72.65

(2) Heterogeneity of urban functional mix dimensions

In order to explore the deep-seated reasons for the role of urban functional mixing degree, this paper conducts regression analyses on land use, transportation and infrastructure, economic and industrial structure, and policy and planning affecting neighborhood and social inclusiveness respectively to identify their specific impact effects and the degree of impact. The results of columns (4) to (7) show that the regression coefficients of the degree of urban functional mixture affecting the growth of tourism neighborhood and social inclusiveness are 0.075, 0.015, 0.052, and 0.036, respectively, and all of them pass the test of significance level of at least 10%. It can be seen that land use is the key dimension influencing neighborhood and socially inclusive growth during the study period. The reason for this is that, from the underlying logic of the formation of the urban functional mixing degree, the urban functional mixing degree firstly emphasizes the rational land use. In modern society, land use is the foundation and core of market operation, which can capture more market opportunities to realize value appreciation. The formation of industrial agglomeration relies on land use, which can work effectively through the "strong links" between individuals in the region and the "weak links" between individuals within and outside the region.

III. C. Nonlinearity of Impacts - Threshold Effects Analysis

In order to explore the number of threshold values in the threshold effect model, it is first necessary to test the existence of threshold values, and the threshold effect existence test is shown in Table 3. It can be seen that the F-values of the three threshold tests are 65.99, 17.85, and 7.69 respectively, while only the P-value of the single-threshold effect model is less than 0.01, i.e., it is significant at the 1% significance level, while the results of the remaining two threshold tests are insignificant, so the single-threshold model is selected for estimation.

Table 3: Threshold effect existence test

Hypothesize	MSE	F value	P value	Number of BS	10%	5%	1%
Single threshold	17.295	65.99	0.0000	400	27.2708	30.9693	46.486
Double threshold	16.3944	17.85	0.1226	400	17.7393	23.5554	33.7427
Triple threshold	15.3717	7.69	0.7562	400	19.6106	22.6611	33.087

The threshold values and confidence intervals for the single threshold effect model are shown in Table 4. From the table, the threshold value and the confidence interval at the 95% level for the single threshold effect model can be obtained.

Table 4: Threshold effect model threshold and confidence interval

Hypothesize	Threshold value	Confidence interval of 95%
Single threshold	216.9572	(216.5213, 218.6591)

Before applying the single-threshold effect model for regression, it is also necessary to test the consistency of the threshold value by using the Bootstrap method, which can be done by constructing the LR likelihood statistic. The graph of the threshold value and likelihood ratio function of the single threshold effect model is shown in Figure 3, from which it can be seen that the threshold value is true and reliable.

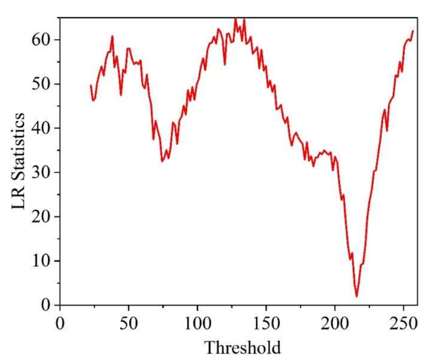

Figure 3: The threshold value and the likelihood ratio function diagram

The results of the single-threshold regression are shown in Table 5, from which it can be seen that City A was divided into two groups bounded by the threshold value of urban functional mix, i.e., those with a lower degree of urban functional mix (DIFI < 221.6352) and those with a higher degree of urban functional mix (DIFI ≧ 221.6352). In terms of significance, the effects on neighborhood and social inclusion are all significant at the 1% significance level, indicating that regardless of the degree of urban functional mix, increasing the degree of urban functional mix can improve local neighborhood and social inclusion. Looking specifically at the coefficients of the two groups of urban functional mixing degrees, it can be seen that for every percentage point increase in the urban functional mixing degree of regions with higher urban functional mixing degrees, their neighborhood and social inclusion degree increases by 0.1112 percentage points, which is significantly higher than that of the regions with lower urban functional mixing degrees, 0.09225 percentage points, which indicates that the promotion effect of the degree of urban functional mixing degree (DIFI) on the degree of neighborhood and social inclusion degree in higher degree of urban functional mix is more significant. This might be because a certain "economic foundation" is needed for the urban functional mix degree to fully play its role. At the same time, it can also be concluded that: There is a single threshold effect between urban functional mix degree (DIFI) and neighborhood and social inclusion degree, and this promoting effect is strengthened as the level of urban functional mix degree crosses the threshold value (DIFI ≧ 221.6352).

Table 5: Single gate sill regression results

Variable	COPR
DIFI<221.6352	0.09225***(0.0035)
DIFI≧221.6352	0.1112***(0.00321)
FIN	0.0009(0.05)
LAN	0.00152(0.16)
POP	0.00036(0.23)
INC	0.00025(0.12)
INT	0.00005(0.02)
SCI	0.00198(0.16)
EDU	0.00044(1.56)
OPE	-0.00325**(-2.12)
Intercept term	59.5987***(89.65)
R2	0.749

IV. Conclusion

This study empirically analyzes the relationship between the degree of urban functional mix and neighborhood and social inclusiveness through multiple regression and panel threshold model, and draws the following conclusions:

The degree of urban functional mixing has a significant promoting effect on neighborhood and social inclusion, with a regression coefficient of 0.099, indicating that increasing the degree of urban functional mixing does help to enhance neighborhood and social inclusion. The analysis of regional heterogeneity shows that the degree of urban functional mixing has the most significant promotion effect on the western region, with a regression coefficient of 0.169, much higher than that of 0.066 in the eastern region and 0.075 in the central region, suggesting that in the western region, which is relatively insufficient in terms of resources and infrastructures, the reasonable layout of functional mixing is more effective in enhancing social inclusiveness.

From the perspective of dimensional heterogeneity, the four dimensions of land use, transportation and infrastructure, economic and industrial structure, and policy and planning all have a positive impact on neighborhood and social inclusiveness, with land use having the most significant effect, with a regression coefficient of 0.075, which suggests that reasonable land use is the foundation and core of market functioning, and is a key path to realizing the mixing of urban functions.

The analysis of the threshold effect reveals that there is a non-linear relationship between the degree of urban functional mixing and neighborhood and social inclusiveness, and when the degree of urban functional mixing exceeds the threshold value of 221.6352, its facilitating effect is enhanced from 0.092 to 0.111, which indicates that the degree of urban functional mixing needs to reach a certain level in order to give full play to its advantages.

In summary, urban planning should pay attention to functional mixing, optimize the land use structure, strengthen the infrastructure interconnection between different regions, and pay special attention to the differentiated development strategies in the western region, so as to promote the overall enhancement of urban neighborhoods and social inclusiveness.

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