Journal of Regional Economics

Homepage: https://anser.press/index.php/JRE

Research on The Intermediary Effect of Innovation Ability on The Internationalization and Competitiveness of Western Central-cities

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ABSTRACT

Based on the panel data of western central-cities from 2002 to 2021, this paper uses the intermediary effect model to analyze the relationship between urban internationalization, innovation ability and urban competitiveness. It is found that: (1) The internationalization of western central-cities has a positive and direct impact on the promotion of urban competitiveness, which has a significant impact on economic strength and infrastructure, and a weak impact on government efficiency and market efficiency The marginal growth effect of internationalization on urban scale will gradually decrease with the improvement of urban development level. (2) The continuous promotion of city internationalization can promote the innovation ability to enhance the competitiveness of the city. Compared with the internationalization of cities, the influence of innovation ability on the competitiveness of cities is small, and the innovation ability of western central-cities and each city is weak. The scale effect has become the main motivation to promote the competitiveness of cities. (3) In the process of internationalization of western central-cities, innovation ability has a part of intermediary effect on the improvement of urban competitiveness, and the effect on urban "hard environment" is significantly greater than that on urban "Soft-environment". The results of direct and indirect impact tests show that the impact of the process of internationalization of western central-cities on urban competitiveness is exogenous.

KEYWORDS

City internationalization; Innovation ability; Urban competitiveness; Mediation effect

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ISSN 2972-3434
doi: 10.58567/jre01010002

Received 25 November 2022; Accepted 24 December 2022; Available online 29 December 2022

1. Introduction

After China's economic development has entered a new normal, the economic zone represented by urban agglomerations has become an important engine of national economic growth. By the end of 2021, Beijing, Guangzhou, Shenzhen and Shanghai, the world's most cosmopolitan cities, will have made full use of their agglomeration and radiation effects, the GDP of the Beijing-Tianjin- Hebei , Pearl River Delta and Yangtze River Delta regions accounts for more than 40% of the country's total GDP, while the GDP of the Chengdu-Chongqing and Guanzhong-Tianshui economic zones in the same period only accounts for 6.2% and 4% of the country's total respectively, this reflects the core of the economic zone as a central city competitiveness has become the key to determine the development of urban agglomerations. In terms of development, according to international economic and social standards, 15 cities in China have a per capita GDP of more than twenty thousand dollars, reaching the level of primary developed countries (regions), with the exception of Wuhan and Changsha, which are in the middle of the country, the other 13 cities are all in the east, and the competitiveness gap between the western central-cities and the developed cities that's one way to look at it.

In view of the large gap between the eastern and western regions of China in terms of factor allocation, industrial system, infrastructure and so on, it is an inevitable choice for western central-cities to build international cities and an inevitable trend for them to catch up with and surpass the developed cities in the middle and eastern regions. In the meantime, the "Belt and Road City" initiative and the National Central City strategy also provide a good opportunity for the Guanzhong-Tianshui urban agglomeration with Xi'an as its center and the Chengdu-Chongqing urban agglomeration with Chengdu and Chongqing as its center to optimize the urban structure at a higher level and promote the international development of cities and the enhancement of urban competitiveness. In this regard, the study will take Chongqing, Chengdu, Xi'an three western central-cities as the object, from the perspective of urban internationalization to make a comparative analysis of the promotion of competitive advantage of western central-cities in China, on the one hand, on the basis of the comparison of the three cities' internationalization degree, this paper analyzes their respective competitive advantages, and on the other hand, probes into the mechanism of the effect of the internationalization of the western central-cities on the urban advantages, and then clarifies the direction and path of their internationalization, for the three cities of the international construction and urban competitiveness of the promotion of recommendations and reference. In the research method, the data of Chongqing, Chengdu and Xi'an are combined into the panel data of western central-cities, and the intermediary effect model is used to measure the process of urban internationalization from the whole and each city level, respectively, finally, Bootstrap method is used to test the significance of intermediary effect of innovation capability on urban competitiveness and sub-indicators.

The structure of the rest part: the second part is theoretical analysis and research hypothesis; the third part is model design and metrological test; the fourth part is conclusion and suggestion.

2. Literature Review

Porter(1990) believes that a country's competitive advantage mainly comes from the international competitiveness of its industry, and puts forward the famous "Diamond"model-competitive advantage model, but this kind of superiority obtains depends on the premise which the clear own city development localization. Therefore, the city internationalization needs to select and construct the city industrial system on the basis of its own factor endowment, so as to give full play to the advantages of production factors and cultivate and form the competitiveness superior to other cities, to achieve the advanced stage of urban evolution. As the basic force to support the competitiveness of cities, factors of production range from basic factors of labor and capital to advanced factors of production such as technology and system, driven by production factors, urban industrial system will

gradually complete the structural transformation from traditional industry to high-tech industry, and promote the formation and promotion of urban competitiveness in the process. Under the transformation of market demand, factors of production, as the driving factor of urban competitiveness, can be formed and put into the industrial system to maintain and promote the growth of urban industrial economy. It can be seen that the city as a factor and market "Bridge", on the one hand, constantly absorb market factors transformed by market demand conditions, expand urban production capacity; on the other hand, the scale effect, the learning effect and the spillover effect of industrial agglomeration enhance the market demand transformation ability. Finally, urban competitiveness is also affected by institutional factors, fiscal and tax system, property rights system and other incentives and security measures to promote the formation of a city and other cities of the system, enhance the attractiveness of the city.

Combing through the literature, the main research results on the intermediary effect between urban internationalization and urban competitiveness in academic circles are as follows: social network intermediary effect (Sarson et. al, 1993), trade intermediary effect (Jinzhen Shen and Yixing Zhou, 2003), industrial intermediary effect (Pengfei Ni, 2009), technology intermediary effect (Singh, 2010) and cultural intermediary effect (Florida, 2006; Lan Wang et al., 2012). These research results make us have a deep understanding of how the process of urban internationalization has a direct and indirect impact on urban competitiveness. However, as a synthesis system of many factors, the complexity of the impact of urban internationalization on urban competitiveness makes us need to look for more comprehensive impact of the intermediary factors. It is concluded that a series of innovative capabilities, such as trade innovation, technological innovation and cultural innovation, can enhance the efficiency of industrial absorption and factor transformation in the process of urban internationalization. In addition, the existing research results on the relationship between urban internationalization and urban competitiveness mainly focus on the developed countries and regions, and lack of research on the less developed countries and regions. Therefore, from the perspective of urban innovation capability, this study will explore the relationship between the internationalization level of the central-cities in western China and their urban competitiveness under the intermediary role of innovation capability, and then put forward relevant countermeasures and suggestions.

On the basis of analyzing the relationship among the factors of urban competitiveness model, we further elaborate the relationship among urban internationalization, innovation ability and urban competitiveness.

2.1. The relationship between urban internationalization and urban competitiveness

At present, urban internationalization has become an important symbol to measure the influence and competitiveness of cities, and there has been a great controversy on the relationship between urban internationalization and urban competitiveness, various theoretical models, such as u-type, inverted U-type and S-type, are used to explain the relationship between the two. Most scholars, such as Grosveld (2002), Weijin Gong (2019) and so on, agree that there is a U-shaped relationship between urban internationalization and urban competitiveness. In the early stage of urban internationalization, the ability of urban industry to absorb and transform elements is weak, and the low-level competition among cities in basic industries will aggravate the inefficient use of urban elements, due to the lack of industrial differentiation, it is difficult for cities to form competitiveness. At the stage of urban internationalization, cities have the ability of industrial absorption and factor transformation on the basis of industrial development and accumulation in the earlier period, under the effect of industrial structure adjustment, industrial differentiation begins to take shape, and cities gradually become more competitive than other cities, under the effect of industrial agglomeration, the advantages of urban industry can be fully displayed, the city can absorb the domestic and foreign industrial transfer and factor transfer, and promote the continuous optimization and adjustment of urban industrial structure to the advanced stage, finally, the formation of urban differentiation of industrial advantage, so that cities in the regional and even international scope with competitiveness. It can be seen that urban competitiveness will increase with the progress of urban

internationalization, so the study assumes that:

H_1: There is a positive correlation between urban internationalization and urban competitiveness.

2.2. The mediating effect of innovation capability on urban competitiveness in the process of urban internationalization

Urban internationalization has become an important symbol to measure the influence and competitiveness of cities. As an important goal of urban strategic positioning, urban internationalization is a high-quality development form of urban comprehensive functions. However, this abstract form of internationalization itself can not directly form urban competitiveness, it needs to promote urban competitiveness by means of industry, technology, culture, social network and other factors of production to play a fundamental role in economic growth. With the rapid growth of the contribution rate of high and new technology to the economy, innovation as a comprehensive reflection of urban industrial factor efficiency, it is an important quality index that can reflect the efficiency of industrial absorption and factor transformation in the process of urban internationalization. The WCI system proposed by the Robert Hodgins Association (2002) , which has a high degree of recognition in academic circles, The 3T system proposed by Florida (2003), as well as the ICPC system proposed by the National Commission for the Strategic Advancement of Innovation (2008), have also identified the critical role of innovation capacity for urban competitiveness. In view of the importance of innovation capability to urban competitiveness, the study considers that innovation capability has an intermediary effect on urban competitiveness in the process of urban internationalization:

H_2: Innovation ability plays an intermediary role in the relationship between urban internationalization and urban competitiveness.

2.3. Urban internationalization and urban innovation

The research on the relationship between urban internationalization and urban innovation ability mainly focuses on the impact of innovation ability on urban internationalization, but there are few research results on the impact of urban internationalization on innovation ability. The main reason lies in the fuzziness of the impact of internationalization on the formation and Operation Mechanism of the dynamic framework of knowledge spillover, the space economics school, represented by Krugman (1991), has turned its attention to the micro-mechanism of maintaining the continuous flow of innovation elements in space, and argues that in the process of urban internationalization, under the externalities of industrial linkages and industrial agglomeration, cities will accelerate the sustained inflow of external factors at higher levels and larger spatial scales. Under the influence of the scale effect of capital, technology and labor and the spillover effect of learning network, the innovation factors can spread rapidly between regions (Thisse, 2002) , which can improve the efficiency of regional innovation. From the reality of the situation, in its Global Urban Competitiveness Report 2019-2020, the joint Chinese Academy of Social Sciences and United Nations Human Settlements Programme (UN-HABITAT) Task Force evaluated the internationalization of Chinese cities , internationalization has a significant impact on urban innovation capacity, while the internationalization of Dalian and Tianjin has no significant impact on urban innovation capacity. It can be seen that the impact of urban internationalization on urban innovation capacity is complex. In order to analyze the relationship between the internationalization process of the western central-cities and the urban innovation capacity, the research hypothesizes:

H_3: There is a positive correlation between urban internationalization and innovation ability.

2.4. Urban innovation ability and urban competitiveness

Under the condition of knowledge-based economy, innovation ability has become an important "Engine" to promote the economic growth of a country or a region, Schumpeter (1912) innovation theory and Romer (1986) endogenous growth theory explicitly state that technological innovation plays an important role in national economic growth. According to the theory of urban innovation, Urban Enterprises continue to develop new technologies, new products, new methods and other innovative activities, which will result in horizontal and vertical transfer within and outside the industry under the effect of spillover effect, and eventually form the urban innovation system. The Perfection of urban innovation system can gradually form dynamic adjustment and development function in the process of innovation resource gathering and allocation, and then form and promote urban competitiveness. Therefore, urban innovation ability, as an important component of urban competitiveness, has become an important indicator for the evaluation of urban competitiveness in recent years. Singh (1999) identified innovation as a strategic element of urban competitiveness, and Shanshan Ye & Guofang Zhai (2010) used factor contribution ratios to analyze urban competitiveness in China and found that innovation can improve urban competitiveness more quickly. As a result of the combination of innovation factors and the innovation environment, one city can obtain sustained growth benefits better than other cities, the research assumes:

H_4: There is a positive correlation between urban innovation ability and urban competitiveness.

Based on the above theoretical analysis of the relationship between urban internationalization, urban innovation capability and urban competitiveness, we construct a model of the relationship between urban internationalization and urban competitiveness with urban innovation capability as the intermediary (Figure 1).

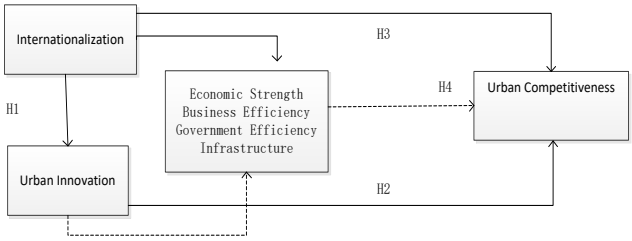

Figure 1. The relationship model between urban internationalization and urban competitiveness.

3. Methodology

In the study of variable selection, we insist on the principle of availability of data and credibility of indicators, adopt the variables used in academic circles as the basis of selection, and make adaptive adjustment according to the actual situation in western China.

3.1. Urban competitiveness

Urban competitiveness (CP) as an explanatory variable. The study draws on the internationally authoritative international competitiveness evaluation indicators established by the World Economic Forum (WEF) and the International Institute of Management (IMD) in Lausanne, to measure the city's competitive advantage from four aspects: government efficiency, economic strength, infrastructure and business efficienc (table 1).

Table 1. Evaluation Index of urban competitive advantage.

Interpreted variable	Index	Characteristic
CP	GDP Per Capita	Economic Strength
	Number of Listed Companies	Business Efficiency
	Fiscal Expenditure Per Capita	Government Efficiency

	Urban Public Transport Network	Infrastructure

Economic strength is reflected by regional economic output capacity, which is usually expressed by per capita GDP (Y), while government efficiency reflects the overall functional level of the government. Demei Sun et al. (2013) measured the difference in government efficiency from the perspective of public services, the study draws on and adopts per capita fiscal expenditure (FC) to express the government's public service efficiency, and business efficiency reflects the level of regional business development, Pengfei Ni (2009) and Yufen Liu (2010) both use the number of listed companies (PUB) as a measure , which is due to the joint effect of listed companies as operating efficiency and business environment in the region, it has a good evaluation effect on business efficiency, and the infrastructure is represented by the urban public transport network (PTN).

3.2. City internationalization

City internationalization (CI) as an explanatory variable . Based on the China Urban Internationalization Index(2017) compiled by "Xiao Kang" magazine and the China Institute of Standardization and the Center for development planning of Tsinghua University, the study divides the urbanization into four dimensions: economic internationalization, cultural internationalization, government internationalization and social internationalization. Economic internationalization uses the total import and export (EX); cultural internationalization uses the number of inbound tourists (FOR); government internationalization uses the international conference (Icon) ; and social internationalization uses the port cargo throughput (LOAD).

Table 2. The Evaluation Index System of urban internationalization.

Interpreted Variable	Index	Characteristic
CI	Total imports and exports	economy internationalization
	Number of inbound tourists received per year	culture, internationalization
	International conferences	government internationalization
	Port cargo throughput	society internationalization

We use the entropy method to measure the city internationalization and city competitiveness. Firstly, the four indicators of urban internationalization are treated dimensionless.

$$R_{ij} = \frac{X_{ij} - X_{min\ j}}{X_{max\ j} - X_{min\ j}} \times 10 \tag{1}$$

Next, we determine the eigenvalue λ_{ij} and the entropy value K_j:

$$\lambda_{ij} = \frac{R_{ij}}{\sum_{n=1}^{n} R_{ij}} \tag{2}$$

$$k_j = -\frac{1}{ln\ n} \sum_{i=1}^{\infty} \lambda_{ij}\ ln\ \lambda_{ij} \tag{3}$$

$$(i = 1,2 \ldots n; j = 1,2 \ldots n)$$

Finally, use k_j to get the difference value $D_j = 1 - k_j$, and calculate the entropy value of each index W_j:

$$W_j = \frac{D_j}{\sum_{n=1}^{n} D_j} \tag{4}$$

$$(j = 1,2 \ldots n, 0 < W_j < 1)$$

We can get the level of internationalization of each city $CI_i = \sum_{j=1}^{n} W_j\ \lambda_{ij}$,(i=1,2…n;j=1,2…n).

After calculating the internationalization level of Chongqing, Chengdu and Xi'an by the method of entropy, the paper obtains table 3.

Table 3. Internationalization level of western central-cities 2002-2021.

Region	Chongqing	Chengdu	Xi'an
2002	1.0845	1.1093	1.0289
2003	1.1794	1.0437	1.0570
2004	1.2641	1.1537	1.0618
2005	1.2793	1.1776	1.3019
2006	1.2800	2.0727	1.3325
2007	1.3031	2.2697	1.3522
2008	1.3175	2.4485	1.4110
2009	1.3623	2.4072	1.4395
2010	1.5417	2.4812	1.5437
2011	2.2778	2.5072	1.6051
2012	2.3905	2.5890	1.6844
2013	2.7208	2.5932	1.7104
2014	2.8127	2.6142	2.1937
2015	3.4086	2.6428	2.8133
2016	3.3676	3.0907	3.2014
2017	3.8560	3.1281	3.6868
2018	4.2094	3.8616	4.0127

Notes: Data are from business statistical yearbook, Chongqing Statistical Yearbook; Chengdu Statistical Yearbook; Xi'an Statistical Yearbook, 2002-2021.

From the comparative analysis of the urban internationalization level of the three cities from 2002 to 2021, we can see that the internationalization of Chengdu has always had a high level of development in the west, while the Internationalization of Chongqing and Xi'an has accelerated significantly since the "Belt and Road" initiative, the Internationalization of Chengdu has been relatively stable, particularly in the western part of the country, Xi'an has made a breakthrough in the process since 2015, and its level of internationalization has followed that of Chongqing.

3.3. Innovation ability

Innovation ability (IA) is the intermediary variable. Because of the complexity and uncertainty of the innovation system, the evaluation of the urban innovation ability has been controversial, Junsong Wang et al.(2017) used the number of three patents granted to analyze China's urban innovation capacity and innovation distribution trends; Xiaoguo Jiang (2019) used the number of patents owned by 1,000 people as a proxy for innovation capacity; As an intermediary variable, it measures the impact of innovation ability on industrial structure upgrading. Therefore, the study uses the number of three patents to indicate the innovation capability of the three cities.

3.4. Control variables

Because of the great development difference among Chongqing, Chengdu and Xi'an, we use city size, opening time and city location as the control variables. The size of the city is expressed by(PEOPLE), and the opening time (YEAR) is expressed by the number of years between the time when the State Council approves each city to be open to the outside world and the measured Krugman (1991) argues that location plays an important role in the efficiency of central-cities, and that the remoter a city is, the higher the cost per unit of freight transport, which has a negative impact on urban competitiveness, the opposite can have a positive effect, so the study uses the average distance (D) of the goods as a representation of geographic location, and the formula is: D = freight turnover/freight volume, and the smaller the D, the worse the geographical condition of the area, the reverse is stronger.

3.5. Virtual variables

Because of the difference of administrative levels among the three cities, the large difference in the state financial support and policy support among the administrative levels in China will lead to the large deviation of the

analysis results, in this study, administrative level (ADM) is regarded as a virtual variable. The direct municipality is 1, the non-direct municipality is 0.

4. Analysis

Based on the theoretical analysis of the relationship between urban internationalization, urban innovation capacity and urban competitiveness, we can get the relationship among the explanatory variables, the explained variables and the intermediary variables:

$$CP_{it} = \alpha_0 + \alpha_1 CI_{it} + \alpha_2 PEOPLE_{it} + \alpha_3 YEAR_{it} + \alpha_4 D + u_{1it} \quad (5)$$

$$IA_{it} = \beta_0 + \beta_1 CI_{it} + \beta_2 PEOPLE_{it} + \beta_3 YEAR_{it} + \beta_4 D + u_{2it} \quad (6)$$

$$CP_{it} = \gamma_0 + \gamma_1 IA_{it} + \gamma_2 PEOPLE_{it} + \gamma_3 YEAR_{it} + \gamma_4 D + u_{3it} \quad (7)$$

$$CP_{it} = \omega_0 + \omega_1 IA_{it} + \omega_2 CI_{it} + \omega_3 PEOPLE_{it} + \omega_4 YEAR_{it} + \omega_5 D + u_{4it} \quad (8)$$

In addition, as a continuous process, urban competitiveness will have a lasting impact on future competitiveness in the past, so it needs to consider its own lasting impact, in this paper, the lag period of urban competitiveness is introduced as a variable, and the model (4) is used to get:

$$CP_{it} = \omega_0 + \omega_1 IA_{it} + \omega_2 CI_{it} + \omega_3 PEOPLE_{it} + \omega_4 YEAR_{it} + \omega_5 D + \omega_6 CA_{it-1} + u_{5it} \quad (9)$$

As for data selection, China's entry into the WTO in 2002 quickens the pace of opening up to the outside world. Therefore, we select the relevant data of Chongqing, Chengdu and Xi'an from 2002 to 2021, data from the three cities in the corresponding year of the statistical yearbook, China Business Yearbook, China Industrial Yearbook.

4.1. Analysis of the relationship between the internationalization of western central-cities and urban competitiveness

Firstly, we analyze the relationship between the internationalization of western central-cities and urban competitiveness with the help of Model (1) , and obtain table 4.

Table 4. The relationship between the internationalization of western central-cities and urban competitiveness.

	CI	R-squared	F	VIF	Durbin-watson
The western	0.1718***	0.283	88.52	2.45	
Chongqing	0.2083*	0.8615	12.59	7.51	2.2322
Chengdu	0.2666***	0.8946	17.97	7.05	1.8414
Xi'an	0.2834**	0.9712	93.83	9.48	1.992

*Notes: ①()is the p value of coefficient test statistic, and * * *, * * and * represent the significance test under 1% , 5% and 10% conditions, respectively. ②VIF test is used to judge whether the model has multiple collinearity, the larger the difference expansion factor value is, the stronger the collinearity is. ③The zero hypothesis of Durbin-watson test is that there is no autocorrelation in the model.*

The regression results show that the coefficient α_1 of urban internationalization is positive and significant for both the western central cities as a whole and individual cities, indicating that there is a positive relationship between urban internationalization and urban competitiveness, this confirms the hypothesis that H1 holds true. The expansion factor VIF<10; shows that (1) there is no collinearity in the regression, the DW>F (Prob) accepts the original hypothesis, The perturbation term does not have autocorrelation, the model does not have heteroscedasticity problem, and the analysis results have good reliability.

4.2. The measurement of innovation intermediary effect between the internationalization of western central-cities and urban competitiveness

Based on the analysis of the relationship between urban internationalization and urban competitiveness, we

introduce innovation variable to evaluate its mediating effect on urban internationalization and urban competitiveness. In order to ensure the unbiased analysis results, the study carried out the first-order difference for each variable, and determined the selected fixed effects model by Hausman-test. Table 5 is obtained by using STATA16.0.

Table 5. The regression results of innovation intermediary effect in western central-cities.

	Model (2)	Model (3)	Model (4)	Model (5)	Model(5)※	2SLS	GMM
CI	0.5328***		0.809*	0.5549	0.5635	0.4874	0.4564
	(0.010)		(0.100)	(0.300)	(0.294)	(0.127)	(0.439)
AI		0.1908***	0.1686*	0.2465**	0.2487**	0.2246*	0.2521
		(0.002)	(0.051)	(0.017)	(0.017)	(0.080)	(0.330)
PEOPLE	0.4408**	0.0692	0.0711	0.0621	0.0627	0.0500***	0.0617
	(0.020)	(0.150)	(0.151)	(0.233)	(0.230)	(0.001)	(0.133)
D	0.1108	0.0485	0.0415	0.0517	0.0485	0.02439	0.0255
	(0.216)	(0.171)	(0.242)	(0.142)	(0.186)	(0.160)	(0.342)
YEAR	3.1454**	0.3567	0.3332	0.1149	0.1055	0.438***	0.4111*
	(0.015)	(0.173)	(0.225)	(0.165)	(0.785)	(0.005)	(0.089)
CPt-1				0.1351	0.1378*	0.0926	0.3731**
				(0.105)	(0.099)	(0.215)	(0.028)
ADM					0.150	0.0487**	0.0672***
					(0.728)	(0.023)	(0.001)
β0	2.9887	2.5702	2.3249	2.230	2.2841	2.0970	2.9801
	(0.028)	(0.000)	(0.000)	(0.001)	(0.001)	(0.063)	(0.411)
Wald chi2(2)						43.68	64.48
R-squared	0.6589	0.2125	0.3167	0.3392	0.3351		
F	79.36	203.55	70.78	38.45	57.58		
VIF	2.76	8.62	8.41	8.36	8.25		
Hausman						4.47	
						(0.027)	
sargan							2.90

*Notes: ①( ) is the P value of the coefficient test statistic, and * * *, * *, and * represent the significance tests under 1% , 5% , and 10% conditions, respectively. The null hypothesis of the ②The null hypothesis of Hausman test is that there is no systematic difference between the estimation coefficients of 2SLS and OLS, that is, the instrumental variables are exogenous; ③VIF test is used to judge whether the model has multiple collinearity, the larger the difference expansion factor value is, the stronger the collinearity is;④The null hypothesis of Argan test is that there is over-recognition of tool variables, and if the null hypothesis is accepted, the tool variables are reasonable.⑤(5)※ indicates the model (5) after the virtual variable is introduced.*

In the robustness test of (2)~(5) results, 2SLS and GMM are further used to solve the endogeneity and weak instrumental variables of the model. Due to the endogeneity of variables and the resulting problem of weak instrumental variables, the results of the analysis can be deviated, the recurrent approach is to use the lag period of urban competitiveness, which is related to urban competitiveness but not related to the error term, as the instrumental variable (IV), whereas the model (5) uses the lag period to indicate the continuous impact of urban competitiveness, here we use lagged two-stage as the instrumental variable and get a value of 4.47, P>5% by Hausman-test, which can not reject the original hypothesis, indicating that the instrumental variable has no endogenous problem. In the GMM test, the result of over-recognition test is 2.90, P>5%, the original hypothesis is accepted, and the model does not have over-recognition problem, which shows that the tool variables have strict exogenous and the model is reasonable. The results of 2SLS and GMM are in good agreement with those of OLS, which solves the problem of weak instrumental variables and verifies the robustness of the results.

The results show that the model (2) confirms the positive relationship between urban internationalization and urban innovation capability, and the hypothesis H4 is valid.Model (3) verifies that there is a positive relationship between urban innovation ability and urban competitiveness, and proves that hypothesis H3 is valid.From the model (4), it can be seen that the impact of internationalization on urban competitiveness is significantly enhanced, from 0.1718 to 0.809, and the goodness of fit from 0.2380 to 0.3167, it shows that urban innovation capability has mediating effect between urban internationalization and urban competitiveness, and proves that hypothesis H2 is valid. Model (5) after the lag of urban competitiveness was introduced, the effect of urban internationalization on urban competitiveness was offset by the persistence of urban competitiveness (down to 0.5549), but R-squared rose to 0.3392, and the effect of urban internationalization on urban competitiveness was reduced to 0.5549, it shows that in the long run, the intermediary effect of urban innovation ability on urban competitiveness has been strengthened. However, after introducing the virtual variables into the model (5), the corresponding variables have not changed significantly, indicating that the influence of regional administrative level on urban competitiveness is weak.

The results of comprehensive analysis show that opening to the outside world and urban internationalization have significant impacts on urban competitiveness, while population factor, geographical location factor and regional administrative level factor have no significant impacts, urban innovation ability has mediating effect on the promotion of urban competitiveness.

4.3. The measurement of innovation intermediary effect between the internationalization of western central-cities and the sub-index of urban competitiveness

Although we have concluded that urban innovation capacity has mediating effect on urban competitiveness in the process of urban internationalization, however, due to the complexity of urban competitiveness, the mediating effect of urban innovation ability on the factors of urban competitiveness may also be different. In this paper, urban competitiveness is divided into four indicators: economic strength (GDP), business efficiency (FC), government efficiency (PUB) and infrastructure (PTN), the mediating effect of innovation ability on each sub-index elements is reflected by means of models (1), (3) and (5).

Table 6. The regression results of innovation intermediary effect between the internationalization of western central-cities and the sub-index of urban competitiveness.

	Model (1)				Model (3)				Model (5)			
	GDP	FC	PUB	PTN	GDP	FC	PUB	PTN	GDP	FC	PUB	PTN
CI	0.9701**	0.3734*	0.2611	0.3780*					0.5557*	0.2560*	0.2128*	0.0826
AI					0.7670*	0.2424**	0.0616	0.4752***	0.6099**	0.1700	0.0860 *	0.4522**
F	4.19	2.64	2.75	1.95	4.38	2.72	2.80	4.39	4.37	2.28	2.30	3.75
R2	0.2676	0.1941	0.1891	0.2012	0.2984	0.1753	0.1842	0.3433	0.3239	0.1945	0.1914	0.3456
VIF	2.45				8.62				8.65			

*Notes: ①( ) is the p value of coefficient test statistic, and * * * , * * and * represent the significance test under 1% , 5% and 10% conditions, respectively;②VIF test is used to judge whether the model has multiple collinearity, and the larger the difference expansion factor value is, the stronger the collinearity.*

Table 6 shows that there is a positive correlation between urban internationalization and economic strength, government efficiency, business efficiency and infrastructure, the F-test results also confirm that urban competitiveness has a significant impact on economic strength, government efficiency, business efficiency, infrastructure. The Model (5) results show that the R-squared value of goodness of fit increases with the

introduction of urban innovation, with infrastructure (0.2012 up to 0.3456) showing the greatest improvement, economic Strength (0.2676 to 0.3239), market efficiency (0.1941 to 0.1945) and government efficiency (0.1891 to 0.1914) remained basically unchanged, it shows that innovation ability has significant mediating effect on economic strength and infrastructure, but not on market efficiency and government efficiency. In addition, the statistical value of the impact of internationalization on economic strength, government efficiency, market efficiency and infrastructure has declined, indicating that innovation capacity has a mediating effect in the relationship between urban internationalization and urban competitiveness, it also confirms the hypothesis that H2 holds true.

4.4. The measurement of innovation intermediary effect between the internationalization of three -cities and urban competitiveness

4.4.1. The innovation intermediary effect of three-city internationalization and urban competitiveness

From the above analysis, it is known that the innovation ability of western central-cities has mediating effect on urban competitiveness in the process of urban internationalization, but in each central city, whether there is intermediary effect in the relationship between urban internationalization and urban competitiveness needs to be deeply analyzed. By using the model (5) to regress the data of each city, we get table 7.

Table 7. Three cities internationalization and city competitiveness's innovation intermediary effect regression result.

	CI	AI	R-squared	F	VIF	Durbin-watson
Chongqing	0.1178**	0.1632***	0.9043	19.66	5.9	2.3578
Chengdu	0.1877*	0.0598*	0.9321	20.59	3.43	1.902
Xi'an	0.1937**	0.081	0.9784	99.1	8.05	2.2804

*Notes: ①( ) is the p value of coefficient test statistic, and * * *, * * and * represent the significance test under 1% , 5% and 10% conditions, respectively.②VIF test is used to judge whether the model has multiple collinearity, the larger the difference expansion factor value is, the stronger the collinearity is;③Durbin-watson test is that the model has no autocorrelation, and if the zero hypothesis is accepted, the model has no autocorrelation.*

The results show that the internationalization of Chongqing, Chengdu and Xi'an has a positive impact on urban competitiveness, which shows the importance of the impact of urban internationalization on urban competitiveness in western China, it also confirms the hypothesis that H1 holds true. Comparing with table 4, it can be seen that the influence coefficient of three-city internationalization on city competitiveness is weakened ($\omega_1<\alpha_1$) and the R-squared statistics of cities are increased after the factor of city innovation capacity is introduced, it shows that the innovation capability of the three cities has mediating effect between City internationalization and city competitiveness, and further confirms the hypothesis of H_2.

4.4.2. Three-city internationalization and innovation intermediary effect of city competitiveness sub-index

The intermediary effect of three cities' innovation capability on their own competitiveness in the process of internationalization makes it possible for us to further analyze the impact of the intermediary effect of innovation capability on the sub-index of three cities' competitiveness, in order to understand the more specific differential effects of city internationalization and innovation capability on city competitiveness, the mediating effects of innovation capability on the sub-index of three cities competitiveness were analyzed with the help of models (1) and (5) . The result of two regression shows that the impact of three-city internationalization on the sub-index of urban competitiveness is significant than the impact of innovation capacity. After introducing the variable of innovation capability, the effect of three cities internationalization on each sub-index decreased, and all kinds of goodness-of-fit values increased, indicating that innovation capability has intermediary effect on each sub-index of

three cities competitiveness. From the specific comparison of the three cities: Chongqing's internationalization has a strong impact on infrastructure and government efficiency; Chengdu's internationalization has a significant impact on economic strength; Xi'an's internationalization has a significant impact on economic strength and infrastructure. The ability to innovate has a strong impact on Chongqing's economic strength and infrastructure, while in Xi'an and Chengdu it is reflected in infrastructure.

4.5. Test of innovation intermediary effect between the internationalization of western central-cities and urban competitiveness

Mac Kinnon(2008), Fairchild et al.(2009) argued that the effect size values for mediating effects explained by the variance of R-squared in regression are not monotonic and difficult to understand. In this paper, Bootstrap method is used to examine the mediating effect between urban internationalization and urban competitiveness of the western central-cities and the three cities. After running with MPLS 7.0 software (table8).

Table 8. Test results of innovation intermediary effect between the internationalization of western central-cities and urban competitiveness.

Region	Inspection	Effect	BooSE.	BooLLCI	BooULCI
※The city internationalization to the city city competitiveness					
The western	DE	0.650	0.017	0.466	0.740
	IDE	0.427	0.252	0.219	0.563
Chongqing	DE	0.4137	0.0269	0.228	0.611
	IDE	0.2238	0.0478	0.014	0.230
Chengdu	DE	0.4791	0.083	0.270	0.773
	IDE	0.1108	0.064	0.2050	0.4478
Xi'an	DE	0.5042	0.090	0.3114	0.6779
	IDE	0.2006	0.062	0.2729	0.5365
※The chain-mediated effect test of urban innovation capacity					
The western	GDP(CI IA GDP)	0.277	0.051	0.284	0.598
	FC(CI IA FC)	0.149	0.185	-0.170	2.248
	PUB(CI IA PUB)	0.131	0.037	-0.062	3.151
	PTN(CI IA PTN)	0.215	0.078	0.206	0.688
Chongqing	GDP(CI IA GDP)	0.3714	0.048	0.2274	0.5881
	FC(CI IA FC)	0.1267	0.086	-0.1012	1.1468
	PUB(CI IA PUB)	0.0616	0.014	0.1226	0.324
	PTN(CI IA PTN)	0.1449	0.015	0.2607	0.589
Chengdu	GDP(CI IA GDP)	0.1701	0.055	0.2229	0.461
	FC(CI IA FC)	0.0298	0.006	-0.1117	0.261
	PUB(CI IA PUB)	0.0468	0.0102	-0.3238	0.874
	PTN(CI IA PTN)	0.1441	0.0221	0.1968	0.504
Xi'an	GDP(CI IA GDP)	0.2034	0.077	0.3776	0.8732
	FC(CI IA FC)	0.1892	0.0263	-1.5920	1.0476
	PUB(CI IA PUB)	0.0282	0.0036	-0.2560	0.8629
	PTN(CI IA PTN)	0.0297	0.0051	0.3315	0.846

Notes: Bootstrap=5000.

The test results of the impact of urban internationalization on urban competitiveness show that, at the whole level, the LLCI-ULCI values corresponding to the total effect values of western central-cities do not contain 0, it shows that the direct and indirect impacts of the internationalization of western central-cities on urban competitiveness are significant, and it also confirms that there is some mediating effect between urban internationalization and urban competitiveness, the H2 hypothesis is proved. In the chain-mediated effect test, the

sample size is 5000, the confidence interval is 95%. The results show that the impact of urban internationalization on economic strength and infrastructure does not contain 0, but LLCI-ULCI contains 0 for government efficiency and market efficiency, it shows that the urban innovation ability has a significant indirect effect on the urban economic strength and infrastructure, but not on the government efficiency and market efficiency.

At the city level, the test results of the impact of the internationalization of Chongqing, Chengdu and Xi'an on urban competitiveness show the existence of direct and indirect impacts, it is proved that the innovation ability of the three cities has some mediating effect on urban competitiveness. Among them, the direct impact of Xi'an Internationalization on urban competitiveness is the most significant (0.55), followed by Chengdu (0.48) and Chongqing (0.41).

The mediating effect of Chongqing's innovation ability on urban competitiveness was the most significant (0.22) , followed by Xi'an (0.20) and Chengdu (0.11) . The results show that the innovation ability has a significant mediating effect on Chongqing's internationalization and economic strength, government efficiency and infrastructure, but has no mediating effect on market efficiency Innovation ability has significant mediating effect on urban internationalization, economic strength and infrastructure of Chengdu and Xi'an, but has no mediating effect on government efficiency and market efficiency. The mediating effect of innovation capability on economic strength was the largest in Chongqing (0.37), followed by Xi'an (0.20) and Chengdu (0.17) The intermediary effect between the internationalization and infrastructure of Chongqing and Chengdu is equal, but the intermediary effect between the internationalization and infrastructure of Xi'an is small, which reflects the geographical advantages of Chongqing and Chengdu are equal and superior to Xi'an. It is worth noting that only Chongqing's innovation ability has a mediating effect on government efficiency in the process of urban internationalization, but the degree of the mediating effect is obviously lower than that of other factors, this reflects the innovation ability in the process of Chongqing's internationalization has promoted the improvement of government efficiency, but the impact is weak.

5. Conclusion

Based on the panel data of western central-cities from 2002 to 2021, this paper uses the intermediary effect model to study the relationship among the western central-cities and the three cities' urban internationalization, urban innovation ability and urban competitiveness:

Urban internationalization has a positive impact on urban competitiveness. Compared with the ability of innovation, the internationalization of western central-cities has a greater impact on urban competitiveness, and the internationalization of Xi'an City has the most significant impact on urban competitiveness, followed by Chengdu and Chongqing. Although the overall level of economic development in Xi'an is lower than that in Chongqing and Chengdu, the results of the analysis show that the urban competitiveness of the lower-level central-cities can be significantly improved in the process of urban internationalization. In addition, the impact on the sub-indicators of urban competitiveness, the city's economic strength, infrastructure, the impact on government efficiency and market efficiency is weak. Based on the study of the influence of the whole western central city and three-city internationalization on urban competitiveness and its sub-indexes, this paper concludes that the impact of urban internationalization on urban competitiveness is mainly in the aspect of scale economy, and with the continuous improvement of urban development level, the marginal growth effect of internationalization on urban size will gradually decline.

Innovation ability has positive influence on urban competitiveness. Compared with the internationalization of cities, the impact of innovation capability on the competitiveness of western central-cities and the competitiveness of the three cities is smaller, but from the comparison of the corresponding indicators of each city, the improvement of the city nationalization level can effectively promote the innovation ability to enhance the city competitiveness. On the impact of innovation ability on each sub-index of urban competitiveness, it only has a certain impact on the

economic strength and infrastructure of Chongqing, Chengdu and Xi'an, and has a weak impact on government efficiency and market efficiency. Thus reflects the western central city in the process of international construction, the high-tech industry-led structural adjustment is slow, the impact of innovation on urban competitiveness is weak, scale expansion has become the main driving force of urban competitiveness.

In the process of the internationalization of the western central-cities, the innovation ability has some mediating effect on the urban competitiveness. On the whole, due to the direct impact of urban internationalization on urban competitiveness, innovation ability has a partial intermediary effect on the competitiveness of western central-cities, and the intermediary effect is smaller than the direct effect. On the other hand, innovation capacity has a significant mediating effect on urban economic strength and infrastructure development, but not on government efficiency and market efficiency. As the Center City with the highest level of economic development in the west, Chongqing has the largest value of innovation intermediary effect and has a more comprehensive impact on urban competitiveness, the intermediary effect of innovation in Chengdu and Xi'an only has a certain impact on urban infrastructure and economic strength. It is worth noting that the level of economic development in Chengdu is higher than that in Xi'an, but its intermediary effect of innovation is lower than that in Xi'an, therefore, in the process of internationalization, the mediating effect of innovation capability on the improvement of urban competitiveness is complex.

The test results of the direct influence of city internationalization on urban competitiveness and innovation intermediary effect show that the promotion of urban competitiveness in the development of city internationalization in western central-cities of our country mainly focuses on the construction of "Hard-environment" represented by economic strength and infrastructure, but the "Soft-environment" which is mainly for government efficiency and market efficiency has weak promotion effect. Therefore, the process of internationalization of western central-cities has exogenous characteristics on the impact of urban competitiveness.

6. Discussion

Based on the above analysis and conclusion, this paper holds that the acceleration of the internationalization process of the western central-cities in our country, on the basis of maintaining the current level of economic expansion, should focus on promoting the impact of innovation ability on urban development, we will promote the growth of the connotation of urban competitiveness and the development of innovation. Specifically, in view of the current lack of innovation capacity in the western central-cities and the widespread inefficiency of the government and the market in promoting innovation capacity, it is necessary to continue and deepen the reform of urban management, it is the most important to improve the system and mechanism of cultivating innovative enterprises, and to optimize the business environment oriented by innovative economy. To promote the internationalization of the western central-cities in our country from the current expansion of the scale of development model, to the commercial efficiency and government efficiency to promote the connotation of high-quality development model. Finally, it forms an efficient and coordinated development mechanism driven by innovation ability, based on the platform of urban internationalization and aimed at improving the comprehensive competitiveness of the western central-cities.

Funding Statement

This research received no external funding.

Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

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