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Industrial Agglomeration Externalities, City Size, and Regional Economic Development: Empirical Research Based on Dynamic Panel Data of 283 Cities and GMM Method

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Abstract: Local governments have long been ardently pursuing the industrial specialization effect (MAR externalities) and industrial diversification effect (Jacobs externalities). Such a pursuit has resulted in severe distortion of resource allocation and negative effect on sustainability of local economic development. Regarding the effect from both MAR and Jacobs externalities on local economic development existing literature records notable disputes. Therefore, for local economic development, one important issue is which externality (MAR or Jacobs) can better bring the effect into play. By studying a panel data of 283 Chinese cities from 2003 to 2012 and applying dynamic plane data GMM method, this paper conducted a regression analysis of the relationship among industrial agglomeration externalities, city size, and regional economic development. The result indicates that with regard to the whole nation, MAR externalities are conducive to regional economy development whereas Jacobs externalities will, to an extent, restrain regional economic development. As regards eastern, middle, and western regions, MAR externalities are conducive only to the economic development of the eastern region; their effects on middle and western regions are insignificant. Moreover, the interaction item between MAR externalities and city size has a significant negative synergistic effect on national economic development and a certain acceleration effect on eastern region as well as a strong negative synergistic effect on the middle region and an insignificant effect on the western region. The interaction item between Jacobs externalities and city size has a positive synergistic effect on only the middle region and has an insignificant synergistic effect on both eastern and western regions. Capital stock and labor input have significant accelerating effects on GDP growth per capita of Chinese cities, whereas material capital and labor input remain primary driving forces for Chinese local economic development. Furthermore, human capital contributes to accelerating urban economic development, whereas government intervention restrains urban economic development.

Keywords: MAR externalities; Jacobs externalities; city size; regional economic development

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1 Introduction

Industrial agglomeration externalities primarily include MAR externalities and Jacobs externalities. According to Marshall (1920), geographical agglomeration of enterprises from one industry can generate overflow of knowledge and technologies and generate a share of intermediate input products and labor markets. Hence, such a dynamic intra-industrial agglomeration economy is also known as MAR externalities. Conversely, cross-industrial agglomeration economy is referred to as Jacobs externalities (Jacobs, 1969) and its connotation

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includes the benefits of regional economy diversification and economic aggregate. Hoover (1937) distinguished the two types of externalities in industrial agglomeration. One formed via intra-industrial enterprises clustering for organizing production (localization economy); the other is formed by interests related to general economic development level of certain regions or industrial diversification (urbanization economy). In the literature, localization and urbanization economies are generally called static externalities; these economies correspond to the dynamic MAR externalities and Jacobs externalities, respectively. Their static state emphasizes their effect on the industrial pattern whereas their dynamic state involves the influence on the industrial growth in a certain region or city. Different industrial externalities have different effects on regions and constant exploration should be used in developing the economy. Chinese local governments have long been ardently pursuing industrial specialization or diversification; such a thrust has resulted in ineffective labor division and lack of cooperation among regions. Meanwhile, heedless expansion of city areas and inadequate industry-city integration directly threaten the healthy and sustainable development of the regional economy. Therefore, whether industrial agglomeration externalities (MAR and Jacobs) can improve regional productivity and facilitate regional economic development is a focal point for economists and is a crucial real-world issue.

Relevant literature indicates that some scholars support either MAR externalities or Jacobs externalities. Henderson (1986) studied the regional cross sectional data of double-digit manufacturing industries in the United States and Brazil as research samples and found that industrial specialization has a significant effect in regional economic clusters of medium and small scales whereas industrial diversification had insignificant effect. Later, Henderson *et al.* (1995) used panel data from five capital-intensive industries in the United States as samples to conduct an empirical survey of the relationship between externalities and industrial development. The result reveals the existence of strong MAR externalities (localization) and weak Jacobs externalities (urbanization). Mukkala (2004) studied the relationship between agglomeration economy and regional productivity via production function method based on data from three manufacturing sub-departments in 83 inland subregions of Finland from 1995 to 1999. He concluded that the primary externalities in the manufacturing department are MAR externalities (localization economy) instead of Jacobs externalities and the localization economy facilitates development of small enterprises. Martin *et al*. (2008) analyzed the effect from spatial cluster activities on enterprise productivity using data of individual enterprises in France from 1996 to 2004. The result shows that the existence of MAR externalities generates a positive effect in French enterprises but had neither Jacobs externalities or Porter externalities. By using data from three county-level high-tech industries in China from 1998 to 2007, Fan *et al*. (2014) found that a specialization economy can significantly improve the growth rate of TFP while diversification economy has an insignificant effect. Other scholars support Jacobs externalities instead of MAR externalities. Contrary to Marshall (1920), Jacobs (1969) argued that the higher the degree of industrial diversification, the more assistance for the functioning of an agglomeration economy and knowledge overflow effect and the more likely the improvement of regional productivity. Ellison and Glaeser (1997) examined the manufacturing industry of the United States using the EG index and established a conclusion that supports Jacobs externalities. Batisse (2002) studied the effect of externalities on regional economy growth using panel data of 30 manufacturing industries in 29 Chinese provinces from 1988 to 1997 and discovered that diversity of external industrial environment (or Jacobs externalities) and intra-industrial competition are favorable to industrial growth whereas industrial specialization (or MAR externalities) produce significant negative effect on industrial economic growth. Cheng and Yu (2014) investigated the spatial spillover effect of the effect from industrial agglomeration on the regional salary level. Their research indicates that industrial diversification positively affects the improvement of China’s regional salary levels, whereas industrial specialization has an obvious inhibiting function. Furthermore, several scholars examined the effect of industrial agglomeration pattern on innovation. For example, Feldman and Audretsch (1999) investigated the effect of industrial specialization and diversification on new products from the United States. They found that a diversified industrial structure is more likely to facilitate innovation. In addition to the above studies, some other scholars support both MAR and Jacobs externalities. Forni and Paba (2002) empirically analyzed the effects of industrial specialization and diversification on Italy's manufacturing department growth via the employment data of three-digit industries. The result indicates that industrial agglomeration effect is vital in regional industrial growth and that industrial specialization and diversification have a significant facilitating function for most manufacturing industries. Peng and Jiang (2011) conducted an empirical research of the effect from intra-regional knowledge externalities and enterprise competition on industrial innovation of Chinese manufacturing industries via panel data from21 industries in 30 Chinese regions from 1999 to 2007. The result shows that for regional industrial innovation in China, both MAR and Jacobs externalities have apparent positive effects (although the degrees vary). Within regions, enterprise competition typically negatively affects innovation. Wang and Zhao (2014) established a double-region, double-industry model from the perspective of regional openness, considering that MAR, Jacobs, and Porter externalities co-exist in regional industrial upgrading.

Using data from18 industries in 283 Chinese cities, this paper examined: 1) the effect of industrial agglomeration externalities on regional economic development; 2) the synergistic effect of MAR externalities and city size; and 3) the synergistic effect of Jacobs externalities and city size on regional economic development using dynamic panel data GMM method as well as MAR and Jacobs externalities. Moreover, this paper presents an analysis of the features and mechanisms attempting to address deficiencies of current research literature in China, and provides more practical theoretical bases and supports for the transformation and development of Chinese regional economy.

2 Materials and Methods

2.1 Setting of measurement model

As a dynamic evolution process, regional economic development is affected not only by current factors but also by preliminary factors. To investigate the impact mechanism of industrial externalities and city size, this paper will establish the following dynamic panel data model based on the classical theory framework:

$$\ln y_{it} = \beta_0 + \rho \ln y_{i(t-1)} + \beta_1 MAR_{it} + \beta_2 Jacobs_{it} + \beta_3 \ln K_{it} + \beta_4 \ln L_{it} + \lambda X_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

where y_{it} is the economic development level of city i in year t and $y_{i(t-1)}$ is the first-order lag item of the explained variable for describing possible dynamic features in the process of city economic development. MAR_{it} refers to MAR externality level of a city; $Jacobs_{it}$ is the Jacobs externality level of a city; K_{it} is the capital stock; and L_{it} is the labor input; X_{it} refers to a group of other control variables including city size (*sca*), foreign direct investment level (*fdi*), transport infrastructure (*inf*), government intervention degree (*gov*), human capital level (*hum*), and so on; β_i, ρ and λ are the coefficients of the independent variables; μ_i refers to unobservable entity fixed effect and ε_{it} is the random error item. To eliminate the effect of heteroscedasticity, this paper applied the form of natural logarithm for relevant variables.

Existing literature suggests that the effect of MAR and Jacobs externalities on a city economy varies greatly depending on the city size (Su and Zhao, 2011; Sun and Zhou, 2013). However, most of such research conducted grouping studies of city sizes based year-end population and non-agricultural population; hence, they are unable to reveal the possible synergistic effect among MAR externalities, Jacobs externalities, and city size, and neither can they observe the influence of the synergistic effect on regional economic development. To further uncover the influence of synergistic effect among MAR externalities, Jacobs externalities, and city size on economic development, this paper introduced an interaction item among MAR externalities, Jacobs externalities, and city size respectively based on Equation (1).

$$\ln y_{it} = \beta_0 + \rho \ln y_{i(t-1)} + \beta_1 MAR_{it} + \beta_2 Jacobs_{it} + \beta_3 \ln K_{it} + \beta_4 \ln L_{it} + \lambda_1 \ln sca_{it} + \lambda_2 fdi_{it} + \lambda_3 inf_{it} + \lambda_4 gov_{it} + \lambda_5 \ln hum_{it} + \varphi MAR_{it} \times \ln sca_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

$$\ln y_{it} = \beta_0 + \rho \ln y_{i(t-1)} + \beta_1 MAR_{it} + \beta_2 Jacobs_{it} + \beta_3 \ln K_{it} + \beta_4 \ln L_{it} + \lambda_1 \ln sca_{it} + \lambda_2 fdi_{it} + \lambda_3 inf_{it} + \lambda_4 gov_{it} + \lambda_5 \ln hum_{it} + \varphi Jacobs_{it} \times \ln sca_{it} + \mu_i + \varepsilon_{it} \quad (3)$$

where $MAR \times \ln sca$ is the interaction item between MAR externalities and city size while $Jacobs \times \ln sca$ is the interaction item between Jacobs externalities and city size, λ_i refers to the coefficient of the independent variable.

2.2 Variable declaration

2.2.1 Explained variable

A common practice in available literature is the use of actual gross regional domestic product per capita to represent the economic development level. This paper follows suit by measuring with actual GDP per capita for the municipal districts of all cities. Meanwhile, 2003 is taken as the base period and regional gross production value deflators of all provinces (cities and autonomous regions) were applied for smooth adjustments to gross regional production values of all cities in order to convert it to actual value with 2003 as base period. Subsequently, year-end total populations of all municipal districts were divided. Gross regional production value deflators of every province (city or autonomous region) were attained through calculating with gross regional production value of every province (city or autonomous region).

2.2.2 Explaining variables

After referring to measurement methods used by scholars such as Yu and Jin (2014), Zhang (2014) and other scholars, this paper applied industrial specialization indexes and industrial diversification indexes for measuring MAR externalities and Jacobs externalities.

(1) MAR externalities (*MAR*)

In general, industrial specialization indexes (for measuring MAR externality level) can be classified into absolute measurement indexes and relative measurement indexes. Considering the research purpose of this paper and in order to present the industrial specialization degree between different cities in a more accurate way and to objectively compare MAR externality levels of different regions, relative measurement indexes were applied. The calculation formula is:

$$MAR_i = \max_j (s_{ij} / s_j) \quad (4)$$

where s_{ij} refers to proportion of employment figure in industry j in the ith city in the total employment figure of the city and s_j refers to the proportion of employment figure in all industries j in the total city employment figure.

(2) Jacobs externalities (*Jacobs*)

To be consistent with MAR externality level, this paper applied relatively diversified indexes for measuring. The specific calculation formula is:

$$Jacobs_i = 1 / \sum_j | s_{ij} - s_j | \quad (5)$$

The definitions of s_{ij} and s_j are the same as Formula (4).

Notably, the relative specialization indexes and relative diversification indexes present relationships between city industrial structure and other cities. Specialization and diversification attained via Formulas (4) and (5) are not complete opposites; rather, industrial diversification does not indicate a lack of professions: one region can have not only diversified industrial structure but also a professionalized industry.

(3) Capital stock (*K*)

Currently, most scholars in China use the ‘Perpetual Inventory Method (PIM)’ for estimating capital stock. The specific calculation formula is as follows:

$$K_{it} = (1 - \delta) K_{i(t-1)} + E_{it} / d_{it} \quad (6)$$

K_{it} refers to actual capital stock of city i in year t, $K_{i(t-1)}$ the actual capital stock of city i in year (t–1), E_{it} is the fixed capital investment of city i in year t, d_{it} the fixed capital investment price index in city i in year t, and δ the depreciation rate. After consulting relevant literature, this paper set the depreciation rate of capital stock at 9.6% (Zhang *et al*., 2004). The fixed capital investment price indexes of all cities have never been officially publicized; hence, this paper used fixed capital investment price indexes of provinces (cities and autonomous regions) of the cities from 2003 to 2012 and assumed 2003 as the base period. After referring to the research of Young (2000), this paper divided 10% with fixed capital investment scales of all cities in the base period 2003 as capital stocks of all regions during the base period.

(4) Labor input (*L*)

The scientific measurement index of labor input is labor quality where labor time multiplies by average per unit time. Thus far, however, data are unavailable. Therefore, this paper applied a method used by most literature, that is, taking ‘number of on-post staff’as an alternative index.

(5) City size (*sca*)

The effect of industrial specialization and diversification on economic development level vary depending on city size. Generally, big cities have diversified industrial features, whereas small cities tend to specialize. On the one hand, specialized cluster in small cities is conducive to the formation of externality effect of industrial spillover regarding knowledge, technology, and information. Big cities are able to provide diversified intermediate input products featured with increasing returns to scale and bring inter-industrial spillover externality effect of knowledge and technology into play (Glaeser *et al.*, 1992). On the other hand, when a city size exceeds a certain range, problems like increased labor cost, increase inland rent, traffic congestion, and environmental degradation will occur. Consequently, a the diseconomies of agglomeration can be caused, thereby indicating the close relationship among MAR externalities, Jacobs externalities and city size. Following the consistency of available literature, this paper measured with year-end population of the city.

2.2.3 Control variables

In order to reduce endogeneity biases caused by missing variables, the following control variables were chosen based on available literature and by considering actual economic development conditions of China:

(1) Foreign direct investment (*fdi)*: based on availability of data and following consistency of literature, this paper measured with proportion of annual actual used foreign investment in GDP; annual actual used foreign direct investment is computed with annual average rage (middle rate) of CNY to the US dollar, and smooth adjustment is made according to GDP indexes (2003 as base period).

(2) Transport infrastructure (*inf*): by referring to the practice of Yu Binbin (2014), this paper applied road occupation area per capita as proxy variable of regional/city transport infrastructure.

(3) Government intervention degree (*gov*): factors of local governments like fiscal expenditure, tax policy, and promotion of government officials will certainly affect regional economic development. This paper applied proportion of fiscal expenditure in GDP for presenting government intervention degree.

(4) Human capital level (*hum*): human capital presented labor quality and education degrees of the workforce. This paper measured the number of students in higher education institutions per ten thousand people.

2.3 Explanation of data and methods

Based on the availability of statistical data, this paper chose a panel data of 283 prefecture-level and above cities of 30 provinces (municipalities and autonomous regions) in China (except for Hong Kong, Macao, Taiwan and Tibet) from 2003 to 2012 as regional research samples. Research samples of this paper cover all prefecture-level cities and higher in China and better present basic conditions of China in recent years in areas such as industrial development and economic development.

Data are sourced from the China City Statistical Yearbook (National Bureau of Statistics of China, 2004–2013), the China Statistical Yearbook (National Bureau of Statistics of China, 2004–2013) and 'provincial annual databases' from the state website on statistics. Meanwhile, smooth handling is done for data absent for certain cities and some years. In addition, changes were made to administrative levels and district division of some cities during the sample period. First, Longnan (Gansu) and Zhongwei (Ningxia) were not established in 2003. Second, the state council upgraded Bijie City and Tongren City in Guizhou to prefecture-level cities and established Sansha City in Hainan Province while canceling Caohu City in Anhui Province from 2011 to 2012. To promote completeness of data and consistency in statement, this paper eliminated such cities and chose data of the rest of the 283 prefecture-level cities and higher as research samples.

The National Bureau of Statistics released an update of the National Economic Industry Classification and Codes in 2002. The document indicates that the original 15 industries were adjusted to 19. Every statistical index in the China City Statistical Yearbook listed city observation value and city jurisdiction area observation value. To remain consistent with relevant literature, this paper applied city jurisdiction data of all cities and excluded data of counties under the cities. Moreover, this paper considered the low proportion of first industry (agriculture, forestry, animal husbandry, and fishery industry) in the city jurisdiction area and therefore eliminated the first industry, that is, the other 18 industries were used as objects of observation for calculating industrial externalities.

This paper solves the possible endogeneity problem in explaining variables and control variables with DIF-GMM proposed by Arellano and Bond (1991). DIF-GMM estimation can be divided into first-step estimation and second-step estimation. With limited samples, standard error of the second-step estimation will generate downward bias. Therefore, this paper applied the more reliable first-step DIF-GMM estimation for regression analysis of the empirical model. Furthermore, standard errors of parameter estimated values are robust standard errors of heteroscedasticity.

3 Analysis of Empirical Results

3.1 Descriptive statistics of variables

Table 1 shows the mean values of national MAR externalities and Jacobs externalities from 2003 to 2012 arranged by the authors.

With regard to the entire country, mean values of MAR externalities are on the rise from 2003 to 2012 in general and reach the peak (3.939) in 2010; in 2011, it began to decline but subsequently followed a rising trend again. Mean values of Jacobs externalities declined from 2003 to 2010; in 2010, a declining trend occurred and the mean value reached its lowest value (1.718); after that, it began to rise to 2.198 although a slight decline was observed in 2012.

By taking advantage of the visualization technology of the GIS platform, the space pattern of mean value of MAR externalities, Jacobs externalities, and actual GDP per capita of the 283 cities from 2003 to 2012 are presented as Fig. 1. The figure indicates that high MAR externality values are concentrated in the middle and western regions where high Jacobs externality values are relatively disperse. However, high GDP per capital values concentrate in the eastern region and the spatial correlation among the three is not obvious. Therefore, we discuss its in-depth action mechanism via panel regression model, especially by separate research of the eastern, middle, and western regions. The inherent development correlation between industrial agglomeration externalities of different regions and regional economic development can be further illustrated and refined.

Table 1 Mean values of MAR externalities and Jacobs externalities

Year	Mean values of MAR externalities	Mean values of Jacobs externalities
2003	3.155	2.496
2004	3.141	2.436
2005	3.208	2.358
2006	3.259	2.339
2007	3.300	2.340
2008	3.383	2.287
2009	3.524	2.206
2010	3.939	1.718
2011	3.486	2.198
2012	3.614	2.165

3.2 Regression analysis of national total samples

Table 2 presents the result of regression analysis of national total samples. In the first-step DIF-GMM estimation, Hansen inspections of all models accept the original hypotheses, thereby indicating that the setting of tool variables is effective; Arellano-Bond inspection value refuses the original hypothesis in AR(1) and accepts the original hypothesis in AR(2), thereby indicating that no significant second-order autocorrelation issue occurs in random errors of the model. By estimating the measurement model of this paper with OLS and FE, estimated first-order coefficient values of all explained variables of first-step DIF-GMM estimation lie between the two approaches (Due to limited length, Table 2 does not display other OLS (ordinary least square) and FE (Fixed Effects) estimation results. Those who are interested can ask the authors for them, as well as for the other tables). The above inspection indicates that the result of first-step DIF-GMM estimation here is valid.

In OLS and FE estimation of columns (1) and (2), estimation coefficient of MAR externalities is positive (0.0009) but insignificant. The estimated hypothesis is that MAR externalities are exogenous variables; this hypothesis obviously inconsistent with theories and reality and underestimates the effect of MAR externalities on actual GDP per capita and result in downward bias. In column (5), this hypothesis is loosened and MAR externalities were viewed as endogenous. The estimated coefficient of DIF-GMM approach is 0.0104 and its effect is not only much more than that from OLS and FE estimations but also significant at least under the level of 5%. Similarly, the estimated coefficients of Jacobs externalities is negative in OLS and FE estimations and has upward bias, thereby indicating that the effect of Jacobs externalities on actual GDP per capita is underestimated and its effect is much more than that from OLS and FE estimations and significant at least under the level of 10% under DIF-GMM approach. The regression result in column (5) indicates that when other conditions are kept unchanged, the effect of MAR externalities on actual GDP per capita is less than that of Jacobs externalities. Furthermore, cities in which MAR externalities are increased by one unit will facilitate actual GDP per capita to increase by roughly 1.04%, whereas Jacobs externality will make actual GDP per capita decrease by approximately 1.49%. Meanwhile, this indicates that MAR externalities constitute the primary

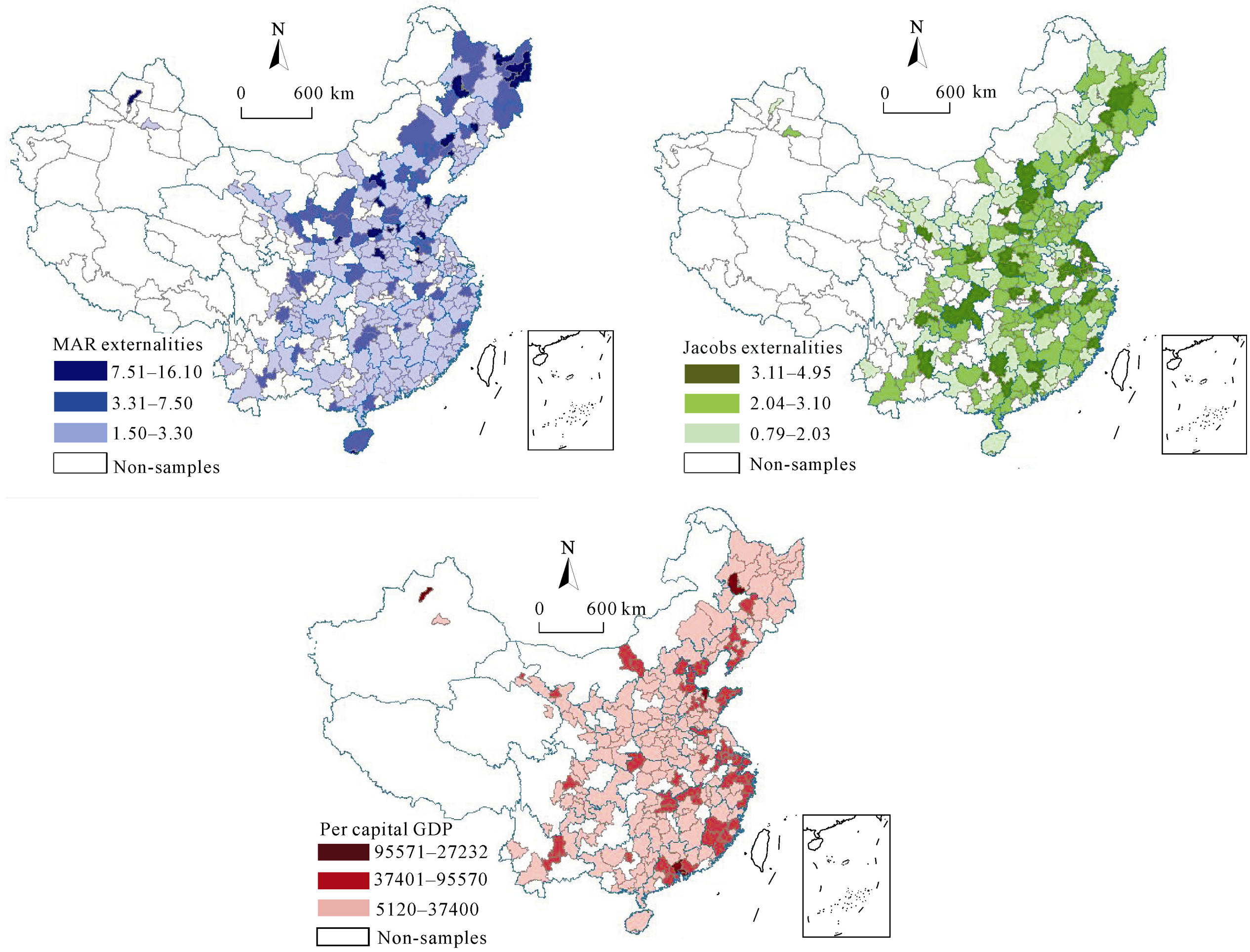

Fig. 1 MAR externalities, Jacobs externalities, and state of regional economic development

source for actual GDP per capita in cities. MAR externalities can bring for enterprises laborers with specialized skills, low-cost intermediate input products, specialized knowledge spillover effect, and facilitate the growth of GDP per capita for cities.

The regression result of column (5) shows that parameter estimates of both capital stock and labor input are positive and significant at least under the level of 1%, thereby indicating that material capital investment and labor input remain important driving forces for economic development in Chinese cities. When capital stock increases by one percent, GDP per capita will increase by roughly 0.128 percent; when labor input increases by one percent, GDP per capita will increase by approximately 0.169 percent. Moreover, variable city size has a significant negative effect on the performance of GDP per capita. However, when the authors replaced the dependent variables with actual GDP output, city size shows significant positive value. The possible reason is related the year-end population being used for measuring city size in this paper. Furthermore, foreign direct investment has a positive effect on the growth of GDP per capita although it is insignificant. The authors assume that such a condition is because the negative competition effect resulted from foreign enterprises entering various areas of China has to a certain extent offset the spillover effect of their technology, knowledge, and management experience. Additionally, the estimated coefficient of transport infrastructure is insignificant, thereby indicating that the effect of road occupation area per capita on GDP per capita of the cities requires further observation and study. Elasticity of GDP per capita to human capital is about 0.0042 and passes the inspection of 5% significance level; thus, capital has certain positive effects on city economic development. Furthermore, government intervention has significant negative effect on GDP growth per capita of the cities under the level of 1%, thereby proving that government intervention has significant negative effect on the development and improvement of city economic development in China and that is consistent with the conclusion of most literature.

In column (5) of Table 2, we further introduced the interaction item among MAR externalities, Jacobs externalities, and city size, that is, they correspond to Formulas (2) and (3). The regression estimate result reports are shown as columns (6) and (7). After the interaction item between MAR externalities and city size is introduced, the report in column (6) shows that the interaction coefficients of MAR externalities and city size are negative and significant under the level of 5% and the synergistic effect of MAR externalities and city size is negative. Therefore, a certain substitutional relationship occurs between city size and specialized cluster. The economic definition is that regions with highly specialized cluster level pursuing higher-level agglomeration economy through expanding city populations will obtain the opposite result of decreased growth of GDP per capita. After the interaction item between Jacobs externalities and city size is introduced, the report in column (7) shows that the interaction coefficients of Jacobs externalities and city size are positive and significant under the level of 5%, thereby indicating that a significant positive synergistic effect occurs between Jacobs externalities and city size. Therefore, certain complementary relationships occur between city size and diversified cluster level. The implied economic definition is that the appropriate expansion of city population and improvement of diversified cluster level is conducive to the growth of regional GDP per capita and city economic development. Finally, estimation results of regression coefficients of interaction items are featured with strong policy implications. The functioning of MAR externalities and Jacobs externalities should fit city size; otherwise, the efficiency of resource allocation will be reduced to the disadvantage of city economic development.

3.3 Regression analysis of regional samples of eastern, middle, and western regions

3.3.1 Regression result of the eastern region

Since its form and 'opening-up', China has practiced gradient development strategy and established three major geographical regions including eastern, middle, and western regions (Eastern region includes Beijing, Shanghai, Guangdong, Jiangsu, Zhejiang, Shandong, Fujian, Tianjin, Hebei and Hainan; middle region includes Henan, Anhui, Hubei, Hunan, Jiangxi, Shanxi, Liaoning, Heilongjiang and Jilin; western region includes Sichuan, Chongqing, Shanxi, Yunnan, Guizhou, Inner Mongolia, Gansu, Guangxi, Ningxia, Xinjiang and Qinghai). However, the three regions vary from each other in many areas including economic development level, 'opening-up', resource endowment, and market completion degree. Here, separate regression estimations of samples from the three regions will be made for observing differences among the three regions regarding the effect of MAR externalities and Jacobs externalities on GDP per capita.

Table 3 is the regression result report of the eastern region. As displayed in column (3) in Table 3, when other conditions are kept unchanged, the estimation coefficient of MAR externalities is insignificant whereas the estimation coefficient of Jacobs externalities is negative and passes significant test under level of 5%. Thus, the effect of MAR externalities in the eastern region is insignificant and Jacobs externalities are disadvantageous to the improvement of GDP per capita in the cities. The estimation coefficient of variable transport infrastructure is positive under the significant level of 5%, thereby indicating that conditions of transport infrastructure can facilitate the growth of GDP per capita in the eastern region.When road occupation area per capita in the cities increases by one square meter, the GDP per capita in those cities will increase by 0.56%. As an unpaid production element, transport infrastructure can affect city economic activities by sharing infrastructure, reducing transaction costs, and promoting the playing of agglomeration economy.

As with the performance of interaction items in the eastern region, reports in columns (4) and (5) of Table 3 indicate that the interaction coefficient of MAR externalities and city size is positive under the level of 5%, thereby indicating that the synergistic effect between MAR externalities and city size in the eastern region has a facilitating function on the growth of GDP per capita. However, the interaction coefficient between Jacobs externalities and city size is insignificant and the effectof diversified agglomeration economy and city size on GDP per capita in the eastern region requires further

Table 2 Regression estimation results of national total samples

	(1) OLS	(2) FE	(3) DIF-GMM	(4) DIF-GMM	(5) DIF-GMM	(6) DIF-GMM	(7) DIF-GMM
ln*y* (–1)	0.9042***	0.6997***	0.8743***	0.8777***	0.8678***	0.8669***	0.8679***
	(0.0120)	(0.0342)	(0.0601)	(0.0628)	(0.0607)	(0.0604)	(0.0611)
MAR	0.0009	0.0009	0.0132**		0.0104**	0.0130**	0.0107**
	(0.0009)	(0.0023)	(0.0054)		(0.0050)	(0.0055)	(0.0051)
Jacobs	–0.0037	–0.0012		–0.0210**	–0.0149*	–0.0167**	–0.0219***
	(0.0023)	(0.0048)		(0.0086)	(0.0084)	(0.0082)	(0.0084)
ln*K*	0.0797***	0.2697***	0.1271***	0.1190***	0.1280***	0.1287***	0.1292***
	(0.0096)	(0.0333)	(0.0432)	(0.0437)	(0.0425)	(0.0430)	(0.0426)
ln*L*	0.0055	0.0747***	0.1664***	0.1792***	0.1686***	0.1706***	0.1687***
	(0.0063)	(0.0178)	(0.0451)	(0.0513)	(0.0460)	(0.0466)	(0.0465)
ln*sca*	–0.0816***	–0.3514***	–0.5502***	–0.5557***	–0.5516***	–0.5612***	–0.5755***
	(0.0120)	(0.0553)	(0.0536)	(0.0524)	(0.0544)	(0.0577)	(0.0552)
fdi	0.0003	–0.0034**	0.0023	0.0030	0.0022	0.0026	0.0022
	(0.0008)	(0.0017)	(0.0030)	(0.0031)	(0.0030)	(0.0030)	(0.0029)
inf	0.0012	0.0017	0.0038	0.0037	0.0036	0.0037	0.0035
	(0.0007)	(0.0015)	(0.0029)	(0.0029)	(0.0028)	(0.0029)	(0.0028)
gov	–0.2197***	–0.3083***	–0.4694***	–0.4502***	–0.4630***	–0.4745***	–0.4627***
	(0.0620)	(0.1099)	(0.1534)	(0.1527)	(0.1532)	(0.1537)	(0.1532)
ln*hum*	–0.0004	0.0080***	0.0042**	0.0043**	0.0042**	0.0041**	0.0043**
	(0.0019)	(0.0019)	(0.0019)	(0.0020)	(0.0019)	(0.0019)	(0.0019)
ln*sca*×*MAR*						–0.1946**	
						(0.0786)	
lnsca×*Jacobs*							0.2112**
							(0.0854)
_cons	0.1792***	0.2232					
	(0.0624)	(0.2457)					
AR(1)			[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
AR(2)			[0.2279]	[0.1838]	[0.1918]	[0.2158]	[0.2375]
Hansen			[0.5479]	[0.2596]	[0.6778]	[0.7054]	[0.7073]
N	2465	2465	2182	2182	2182	2182	2182

Notes: lny(–1) refers to the first-order lag item of the explained variable; The data inside parentheses are robust standard errors of heteroscedasticity and those inside brackets are significance level of corresponding test statistics; ***,** and * represents being able to pass statistical test under levels of 1%, 5% and 10% respectively; AR(1) and AR(2) represent test statistics of Arellano-Bond for testing whether first-order and second-order autocorrelation exist in the first difference residual sequence or not, and its original hypothesis is no autocorrelation; original hypothesis of Hansen test is that all tool variables are valid, which is the same hypothesis as the following tables.

Table 3 Regression result of the eastern region

	(1) OLS	(2) FE	(3) DIF-GMM	(4) DIF-GMM	(5) DIF-GMM
ln*y*(–1)	0.893***	0.655***	0.690***	0.698***	0.692***
	(0.026)	(0.093)	(0.124)	(0.113)	(0.123)
MAR	0.000	–0.012***	–0.010	–0.042***	–0.010
	(0.002)	(0.004)	(0.011)	(0.015)	(0.011)
Jacobs	–0.007**	–0.009	–0.022**	–0.024**	–0.021*
	(0.003)	(0.006)	(0.011)	(0.011)	(0.011)
ln*K*	0.080***	0.321***	0.268***	0.276***	0.267***
	(0.019)	(0.082)	(0.089)	(0.079)	(0.089)
ln*L*	0.018	0.120***	0.196***	0.195***	0.195***
	(0.016)	(0.041)	(0.071)	(0.074)	(0.071)
ln*sca*	–0.088***	–0.429***	–0.635***	–0.585***	–0.636***
	(0.026)	(0.116)	(0.111)	(0.091)	(0.110)
fdi	0.002*	–0.003	–0.008	–0.008	–0.008
	(0.001)	(0.003)	(0.006)	(0.006)	(0.006)
inf	0.001	0.004**	0.006**	0.004**	0.006**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
gov	–0.232***	–0.431**	–0.585*	–0.610*	–0.590*
	(0.083)	(0.193)	(0.328)	(0.333)	(0.329)
ln*hum*	–0.002	0.007***	0.005**	0.005**	0.005**
	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
ln*sca*×*MAR*				0.464**	
				(0.232)	
ln*sca*×*Jacobs*					–0.051
					(0.099)
_cons	0.298**	0.120			
	(0.121)	(0.390)			
AR(1)			[0.000]	[0.000]	[0.000]
AR(2)			[0.351]	[0.545]	[0.343]
Hansen			[1.000]	[1.000]	[1.000]
N	775	775	687	687	687

research. Parameter estimations of other variables are generally consistent with the research conclusion of national samples and are not explained here.

3.3.2 Regression result of the middle region

Table 4 presents the regression result report of the middle region. Column (3) of Table 4 shows that when other conditions are kept unchanged, MAR externality coefficient is positive under the significant level of 10% whereas Jacobs externality coefficient is insignificant, thereby indicating that MAR externalities have a certain facilitating effecton growth of GDP per capita in the middle region. When MAR externality increases by one unit, GDP per capita will increase by 1.35%, but the effect of Jacobs externalities on the growth of GDP per capita is insignificant. Meanwhile, the regression results of material capital accumulation and labor input of the middle region are lower than those of the eastern region, but the negative effect of government intervention on the growth of GDP per capita in this region is higher than that in the eastern region, meaning improper government expenditure scale will naturally distort the allocation efficiency of production factors and work against the growth of GDP per capita in the middle region.

As with the interaction items, report columns (4) and (5) of Table 4 shows that the interaction item between MAR externalities and city size has significant negative effect and passes the extreme significant test under the level of 1%, proving that the synergistic effect between MAR externalities and city size has a significant negative effect on the growth of GDP per capita in the middle region. Therefore, a strong substitutional relation occurs between city size and specialization cluster in the middle region. The interaction estimation coefficient between Jacobs externalities and city size is positive and passes the significant test under the level of 10%, thereby indicating that diversified agglomeration economy and city size in the middle region have positive effecton the growth of GDP per capita. With the promotion of national strategies such as ‘middle rising up’, the middle region has assumed much of the industrial transfer from the coastal region; the transfer has constantly enriched and optimized the industrial agglomeration level of the middle region. Consequently, the agglomeration economy effect begins to show and form interactive coordinated development with population scale of this region.

3.3.3 Regression result of the western region

Table 5 presents the regression result report of the western region. Column (3) of Table 5 indicates that when other conditions are kept unchanged, the regression estimation coefficients of MAR externalities and Jacobs externalities are positive but insignificant, meaning specialization cluster and diversified cluster do not have obvious effects on the growth of GDP per capita in the western region and the effect of their economic development of the western region should be further enhanced. Meanwhile, the estimation coefficients of capital stock and labor input in the western region are positive, but the facilitating function of capital stock on the growth of GDP per capita is lower than that in the eastern region. Moreover, the effect of labor input is similar to that in the eastern region. Furthermore, the result of foreign direct investment on the growth of GDP per capita in the western region passes the significant test under level of 10%, possibly because the investment of foreign-funded enterprises in primary industries (such as the processing of farm and pasture products) in the western region has, to a certain degree, driven the local economy. Finally, parameter estimations of other variables of the western region are insignificant.

As with the interaction items, reports of columns (4) and (5) in Table 5 shows that although the interaction estimation coefficient between MAR externalities and city size and that between Jacobs externalities and city size are positive, they are insignificant, thereby indicating that no significant synergistic effect occurs from the specialization cluster, diversification cluster, and city size on the growth of GDP per capita. Such a condition may occur because of the low levels of population scale, city grade, industrial scale development, and other aspects in the western region, thereby resulting in the absence of the agglomeration economy effect.

4 Research Conclusions and Policy Suggestions

By using a sample data of 283 Chinese cities from 2003 to 2012 and applying a dynamic panel data model and DIF-GMM method, this paper attempts to analyze the impact mechanism of industrial agglomeration externalities and city size on economic development. Unlike available literature, this paper not only studied the effect of MAR externalities and Jacobs externalities on GDP

Table 4 Regression result of the middle region

	(1) OLS	(2) FE	(3) DIF-GMM	(4) DIF-GMM	(5) DIF-GMM
ln*y*(–1)	0.908***	0.651***	0.792***	0.798***	0.712***
	(0.017)	(0.039)	(0.071)	(0.073)	(0.069)
MAR	0.002*	0.004	0.013*	0.015*	0.012*
	(0.001)	(0.003)	(0.007)	(0.008)	(0.006)
Jacobs	0.001	0.000	–0.003	–0.006	–0.010
	(0.004)	(0.008)	(0.013)	(0.012)	(0.012)
ln*K*	0.081***	0.321***	0.244***	0.237***	0.310***
	(0.015)	(0.040)	(0.075)	(0.078)	(0.067)
ln*L*	–0.004	0.013	0.073**	0.066*	0.039
	(0.008)	(0.020)	(0.037)	(0.037)	(0.035)
ln*sca*	–0.080***	–0.312***	–0.486***	–0.506***	–0.443***
	(0.018)	(0.041)	(0.047)	(0.049)	(0.052)
fdi	–0.002*	–0.005	0.006	0.006	0.005
	(0.001)	(0.003)	(0.005)	(0.005)	(0.004)
inf	0.001	0.001	0.002	0.002	0.001
	(0.001)	(0.002)	(0.004)	(0.004)	(0.003)
gov	–0.311***	–0.524***	–0.774***	–0.781***	–0.700***
	(0.101)	(0.118)	(0.172)	(0.171)	(0.176)
ln*hum*	0.003	0.011***	0.006*	0.007**	0.007**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
ln*sca*×*MAR*				–0.294***	
				(0.113)	
ln*sca*×*Jacobs*					0.182*
					(0.095)
_cons	0.126	–0.115			
	(0.089)	(0.286)			
AR(1)			[0.000]	[0.000]	[0.000]
AR(2)			[0.455]	[0.492]	[0.449]
Hansen			[0.987]	[0.986]	[1.000]
N	1009	1009	893	893	893

Table 5 Regression result of the western region

	(1) OLS	(2) FE	(3) DIF-GMM	(4) DIF-GMM	(5) DIF-GMM
ln*y*(–1)	0.916***	0.784***	0.857***	0.840***	0.853***
	(0.017)	(0.045)	(0.061)	(0.063)	(0.063)
MAR	–0.002	–0.012	0.003	–0.007	0.003
	(0.003)	(0.007)	(0.009)	(0.008)	(0.009)
Jacobs	–0.001	0.003	0.007	0.011	0.003
	(0.006)	(0.009)	(0.014)	(0.014)	(0.016)
ln*K*	0.075***	0.187***	0.175***	0.216***	0.175**
	(0.018)	(0.050)	(0.067)	(0.074)	(0.071)
ln*L*	0.006	0.125***	0.191***	0.096	0.191***
	(0.012)	(0.026)	(0.067)	(0.070)	(0.068)
ln*sca*	–0.082***	–0.276***	–0.541***	–0.534***	–0.527***
	(0.020)	(0.061)	(0.087)	(0.095)	(0.093)
fdi	0.001	–0.002	0.010*	0.002	0.008
	(0.002)	(0.004)	(0.005)	(0.006)	(0.006)
inf	0.001**	0.001	0.001	–0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
gov	–0.060	0.040	–0.134	–0.072	–0.131
	(0.060)	(0.078)	(0.110)	(0.108)	(0.111)
ln*hum*	–0.003	0.002	–0.001	–0.001	–0.001
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
ln*sca*×*MAR*				0.031	
				(0.229)	
ln*sca*×*Jacobs*					0.175
					(0.142)
_cons	0.123	0.263			
	(0.123)	(0.373)			
AR(1)			[0.000]	[0.000]	[0.000]
AR(2)			[0.106]	[0.113]	[0.112]
Hansen			[0.995]	[0.999]	[1.000]
N	681	681	602	602	602

per capita but also introduced an interaction item among MAR externalities, Jacobs externalities, and city size. The empirical result indicates the following:

(1) With regard to the entire country, MAR externalities are conducive to the growth of GDP per capita of the cities whereas Jacobs externalities are, to a certain extent, restraining the growth of GDP per capita of the cities. MAR externalities and city size have significant negative synergistic effect on the growth of GDP per capita of the cities and a certain substitutional relation is present. Conversely, the synergistic effect of Jacobs externalities and city size is positive and a certain complementary relationship exists.

(2) When the eastern, middle and western regions are observed separately, MAR externalities are conducive only to the growth of GDP per capita in the middle region and their effects on the eastern and western regions are insignificant. However, Jacobs externalities restrains only growth of GDP per capita in the eastern region and its effect on the middle and western regions is insignificant. Meanwhile, the interaction item between MAR externalities and city size has a certain facilitating function on the growth of GDP per capita in the eastern cities while exhibiting strong negative synergistic function on the middle region, and an insignificant effect on the western region. In addition, the interaction item between Jacobs externalities and city size has a positive function only in the middle region while having an insignificant synergistic effect on the eastern and western regions.

(3) Capital stock and labor input have significant facilitating effect on the growth of GDP per capita of Chinese cities, but material capital investment and labor input remain primary driving forces for the development of China's local economy. Furthermore, human capital has certain positive effect on city economic development but government intervention restrained city economic development and enriched the conclusions of relevant literature.

Through stating the functioning mechanism of industrial externalities on regional economic development, this paper has drawn a series of conclusions with theoretical and practical significance. At the stage in which Chinese economic development has entered a 'new normal', the conclusion of this paper carries the following important policy implications:

(1) Effective industrial agglomeration and close inter-regional development differences are attained. Industrial externalities are vital in regional economic development. China has long relied on industrial agglomeration to drive economic growth, which is a highly effective approach but also results in problems including glow economic efficiency. At the stage of its 'new normal', Chinese cities should apply differentiated cluster ways based on local features to increase utilization rates of production elements and resources, improve technical efficiency, and drive technological progress. Under the current macro trend of industrial transfer, the middle and western regions should apply effective industrial undertaking and industrial agglomeration methods in order to close the gap with the eastern region in terms of economic development.

(2) Government intervention is reduced and free competitionis facilitated. Minimize government intervention and fully utilize the advantages of the market in resource allocation. Meanwhile, implement laws and regulations to fully guarantee fair competition among economic agents in the market. According to Jacobs theory, competition can facilitate exchanges of inter-industrial technologies, knowledge, innovation, and information and improve technological innovation ability and industrial productivity of enterprises. The eastern region should maximize external economic advantages from industrial diversification to promote the inter-enterprise competition effect while attracting and aggregating more human capital. As with middle and western regions, the government should create an environment of fair and reasonable competition according to local scale features to provide a good market environment for industrial development and create a precondition for bringing innovation effect into play.

(3) When improving local economic growth with agglomeration economy, local governments should consider factors such as regional scale, infrastructure, and 'opening-up'. For the eastern region, they should continue to expand 'opening-up', encourage the localization of foreign-funded enterprises' research, development, and innovation and further establish a supporting environment and enact policies that allow foreign-funded enterprises to establish research and development institutions in China. Moreover, they should establish relatively reasonable and complete city systems in certain areas while taking local resource endowment advantages and local scale features into account. Similar to the middle and western regions, they should proactively

complete their market system and reasonably introduce foreign-funded enterprises to invest while increasing investment in research and human capital and improving the ability to absorb the technological spillover effect from foreign-funded enterprises. Meanwhile, they should improve local infrastructure conditions, reasonably allocate resources, promote inter-regional exchange of innovative ideas, and fully engage the knowledge spillover effect.

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