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Economic Efficiency and Its Influencing Factors on Urban Agglomeration—An Analysis Based on China's Top 10 Urban Agglomerations

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Abstract: Economic efficiency is the key issue of sustainable development in urban agglomerations. To date, more attention has been paid to the estimates of productivity gains from urban agglomerations. Differing from the previous studies, this paper focuses on the influencing factors and mechanisms of the economic efficiency of urban agglomerations, and check the effects of three different externalities (industrial specialization, industrial diversity and industrial competition) on the economic efficiency of urban agglomerations. The selected samples are multiple urban agglomerations, and the economic efficiency of urban agglomerations includes single factor productivity and total factor productivity. China's top 10 urban agglomerations are selected as the case study and their differences in economic efficiency are portrayed comparatively. Firstly, a theoretical analysis framework for three different externalities effect mechanisms on the economic efficiency of urban agglomerations is incorporated. Secondly, economic efficiency measurement index system composes of labor productivity, capital productivity, land productivity and total factor productivity, and the impact of various factors on the economic efficiency of urban agglomerations is tested. The results confirm some phenomena (MAR externality, Jacobs externality and Porter externality) discussed or mentioned in the literature and some new findings regarding the urban agglomerations, derive policy implications for improving economic efficiency and enhancing the sustainability of urban agglomerations, and suggest some potentials for improving the limitations of the research.

Keywords: urban agglomeration; economic efficiency; specialization; diversity; competition

1. Introduction

In the process of trade liberalization and economic globalization, urban agglomerations are increasingly becoming the center of modern economic growth and a new regional unit for the country to participate in global competition and international division. In today's economic globalization, "the world is not flat", half of the world's production activities are concentrated in 1.5% of the land area. If the total output per unit area is at an altitude, the world economic picture we see is a towering mountain peak formed by more than 10 metropolitan circles, a cluster of high and low hills composed of rural areas, a vast plain and a low-lying land formed by a depression [1]. More than 50% of the world population is now urban. With the annual increase of urban population by 1 million people its percentage will reach 67.2% by 2050 [2–4]. Urban concentration has been the subject of much attention in relation to economic development. Indeed, about the urbanization process that occurs with development [5]. Although the urban agglomeration process is not generally defined in the literature,

its core features are universally agreed on. Urban agglomeration is an ensemble of many relatively independent cities, the sum of all interurban relationships of those cities [6–9].

Under the "new normal", China's sustainable economic development urgently needs to accelerate the transformation of economic development mode. It is necessary to achieve efficiency-driven economic growth with the goal of improving quality and efficiency. The urban agglomeration will become the main form of China's urbanization and become the new power engine and core growth pole for the sustainable development of China's economy. Currently, a magnitude of socioeconomic factors, such as capital, labor, technology and information etc., are accelerating centralization in densely-populous and developed urban agglomerations, which results in a higher ability to aggregate factors in these regions [10–12]. At present, China's urban agglomerations shows higher economic efficiency overall, but the economic efficiency differences between different urban agglomerations are also very obvious. Therefore, economic efficiency of urban agglomerations is widely regarded as a way of identifying their sustainable development.

Regarding the reasons of economic efficiency differences among urban agglomerations, previous studies have paid more attention to the differences in regional historical conditions, geographic location, development policies, and factor inputs. In fact, differences in regional economic efficiency may also stem from inter-regional industrial structures. However, there is a big controversy about the mechanism and way of industrial structure on economic efficiency. It is concentrated in whether industrial specialization or industrial diversity is more conducive to economic growth in a given region. In addition, there is another debate about whether monopoly or competitive markets will promote regional economic growth. The issues discussed can be summarized as three effects of the agglomeration economics, namely MAR externality [13–15], Jacobs externality [16], and Porter externality [17]. The mechanism of MAR externality is that industrial specialization promotes regional economic growth through intra-industry competition, imitation, and rapid changes in resources. In contrast to MAR externality, Jacobs externality argues that the most important knowledge spillover comes from complementary industries, and that industrial diversity in geographical proximity can promote innovation and productivity more than industrial specialization. In addition, MAR externality theory argues that monopoly can promote technological innovation, while Jacobs argues that competition market and collaboration between complementary industries can promote productivity. Porter [17] argues that competition among firms within the same industry contributes to the creation and adoption of innovation, which later scholars referred to as Porter externality. What is the source of economic efficiency in urban agglomerations? Why are there significant differences in economic efficiency between urban agglomerations? Is it MAR externality, Jacobs externality or Porter externality contributes to the economic efficiency of urban agglomerations? How can we effectively improve the economic efficiency of urban agglomerations? These problems need further research from both theoretical mechanism analysis and empirical test.

In order to better explain the economic efficiency changes and differences of urban agglomerations, a theoretical framework and empirical test system for the analysis of economic efficiency of urban agglomerations is constructed. In terms of theoretical interpretation, three different externalities effect mechanisms on the economic efficiency of urban agglomerations is incorporated. According to the theoretical analysis framework system of economic efficiency of urban agglomeration, China's top 10 urban agglomerations are selected as the case study, the mechanism of industrial specialization (MAR externality), industrial diversity (Jacobs externality) and industrial competition (Porter externality) on the economic efficiency of urban agglomerations is examined. The reference and guidance are provided for improving the economic efficiency and sustainable development of urban agglomerations.

The next section of this five-section paper reviews the literature. The third section describes materials and empirical methods. The four section interprets the results and discussions. The final section summaries the major findings, contributions, followed by suggestions for future work.

2. Literature Review

The rapidly growing urban agglomeration can affect urban sustainability. Therefore, understanding causes behind policies leading to agglomeration is necessary for developing mitigation strategies. With the rapid development of urban agglomerations, more and more scholars pay attention to the phenomenon of urban agglomerations, and carry out theoretical and empirical research on the economic development of urban agglomerations. In the last decade, many studies focused on spatio-temporal patterns of urban agglomeration and its driving forces [18–27] categorized as bio-physical and human factors. Bio-physical factors are natural environmental processes, such as climate dynamics, topography, and geomorphologic processes [28,29]. Human factors include population growth, social and economic development, political and technological changes [18,20]. Political driving forces (laws, policy, regulations and their implementation) are distinguished from external driving forces (socioeconomical, technological, cultural and natural causes), which provide the context. Regulations and implementations include the development of urban management policies, agreements, and land-use plans which are results of decision making processes [30–33]. Previous studies have indicated that national city and land planning policies strongly affected urban patterns [33–35]. Moreover, the city planning law and the urban master plan are important tools for local governments to regulate urban development pattern. Evaluation of urban planning implementation has attracted much interest in recent years [36–38].

The theory of agglomeration economies proposes that firms enjoy positive externalities from the spatial concentration of economic activities. These benefits can arise from intra- and inter-industry clustering of economic activities, referred to as localization and urbanization economies in the agglomeration literature (see Fujita et al. [39]; Fujita and Thisse [40]). The localization economies is also called as Marshall-Arrow-Romer (MAR) externalities from a dynamic perspective. The urbanization economies or diversity effects are also called as Jacobs externalities in a dynamic context. Regarding whether monopoly or competitive markets will promote regional economic growth, Porter [17] believes that market competition is conducive to knowledge innovation and spillovers, and the externality mainly comes from within the same industry rather than between different industries, which is also known as Porter externalities. A Melitz-style model of monopolistic competition with heterogeneous firms is integrated into a simple new economic geography model to show that the standard assumption of identical firms is neither necessary nor innocuous [41]. The study finds that agglomeration on economic geography has a selection effect and sorting effect. By separating out the common shock and the individual shocks using a multi-level dynamic factor model, some scholars analyze the competitive and complementary relationship between regional economies [42,43]. To verify the role of MAR externality, Jacobs externality and Porter externality in economic growth, scholars have conducted a large number of empirical studies. The results of Glaeser et al. found that the intensity of competition (Porter externality) and the degree of industrial diversity (Jacobs externality) are conducive to industrial growth, while specialization (MAR externality) has a negative effect on industrial performance [44]. Henderson et al. found that for traditional industries, there is only MAR externality no Jacobs externality, and for high-tech industries there is both MAR externality and Jacobs externality (there is no introduction in the study to characterize Porter externality) [45]. Greenstone et al. discussed the relationship between the establishment of new factories in the new region and the productivity of local enterprises, who concluded that the newly established unions benefited from the similarity of local enterprises' technology and labor, and MAR externality was more significant [46]. Bishop et al. found that industrial diversity can promote employment growth in the UK. On the contrary, industrial specialization structures hinder regional employment growth [47]. Mameli et al. studied the role of regional diversity in the growth of employment in Italy, who distinguished the relevant and unrelated diversity of manufacturing and services. The research concluded that unrelated diversity in manufacturing promoted employment growth, and the related diversity in the service industry is conducive to employment growth [48]. Lucio et al. found evidence of dynamic effects due to specialization (MAR) based on data from the Spanish industry, but they did not find clear evidence on

the presence of diversity (Jacobs) and competition (Porter) externalities [49]. Simonen et al. studied the role of high-tech industrial structure in regional economic growth, and found that the marginal benefits of high-tech industry diversity decreased, and the benefits of high-tech industry specialization were confirmed [50]. By analyzing the phenomenon of regional industry aggregation in a long-term perspective, Kemeny and Storper found that the growth of absolute specialization is positively related to wages, and the change of relative concentration is not significantly related to wage changes [51]. Evangelista et al. explored the specialization of key technologies in the European Union region and its impact on regional development. The econometric estimates in the paper indicate that specialization in key technologies will affect the region economic growth, and this effect is stronger in the EU region where innovation is weak [52]. Empirical research generally finds positive productivity gains from urban agglomeration, but estimates vary greatly in magnitude. Although there are a number of previous comprehensive reviews of the empirical literature on agglomeration, there has been no attempt to quantify the differences in results reported across studies [53].

It can be seen that scholars pay attention to the differences between urban agglomeration characteristics and regional productivity, especially the characteristics of specialization and diversity agglomeration, characteristics of functional specialization and functional diversity, and the specialization and diversity of skill composition [54]. These kind of literatures mainly investigate the agglomeration characteristics of individual cities, but the "two-point method" of agglomeration features leads to the separation of different types of cities, and it is difficult to describe the urban structure and its dynamic evolution characteristics in the urban system [55]. And it is also difficult to reflect the reality and dynamic transformation process of specialization and diversity agglomeration characteristics [56]. According to the new economic geography literature, the division of functions of cities formed by the combination of "sorting effect" and "selection effect" has become the cause of higher productivity in large cities or urban efficiency differentiation [57–60]. Although these kind of literatures provide an excellent analytical framework for in-depth analysis of urban efficiency differentiation from the perspective of urban functional division, the existing empirical research lacks extensive support for this understanding, and the relationship between urban system functional division and urban efficiency differentiation also requires a large amount of empirical evidence to validate [55,61].

3. Materials and Methods

3.1. Study Area

China's "13th Five-Year Plan" issued by the National Development and Reform Commission of China [62], has been proposed to promote the sustainable development of some key urban agglomerations. With reference to the Chinese government's development plan for urban agglomerations and the consensus of most scholars and the current economic development of various urban agglomerations, this paper selects top 10 urban agglomerations as study samples, such as the Beijing-Tianjin-Hebei, the Yangtze River Delta, the Pearl River Delta, the Shandong Peninsula, West Coast of the Straits, Southern of Liaoning, Central Plains, Middle Yangtze River, Chengdu-Chongqing, and the Central Shaanxi Plain urban agglomerations (Figure 1 and Table 1), which include a total of 122 cities. In 2013, the 10 urban agglomerations had a population of 533 million and total GDP of 38.29 trillion CNY, accounting for 39.2% of total population and 67.3% of total GDP in China. These urban agglomerations are the most fundamental areas supporting China's land development and also play a vital role in China's participation in global competition. Geographically, these top 10 urban agglomerations involve three regions in the east, middle and west of China with gradient differences, and can better represent the economic development level and characteristics of the three regions in China.

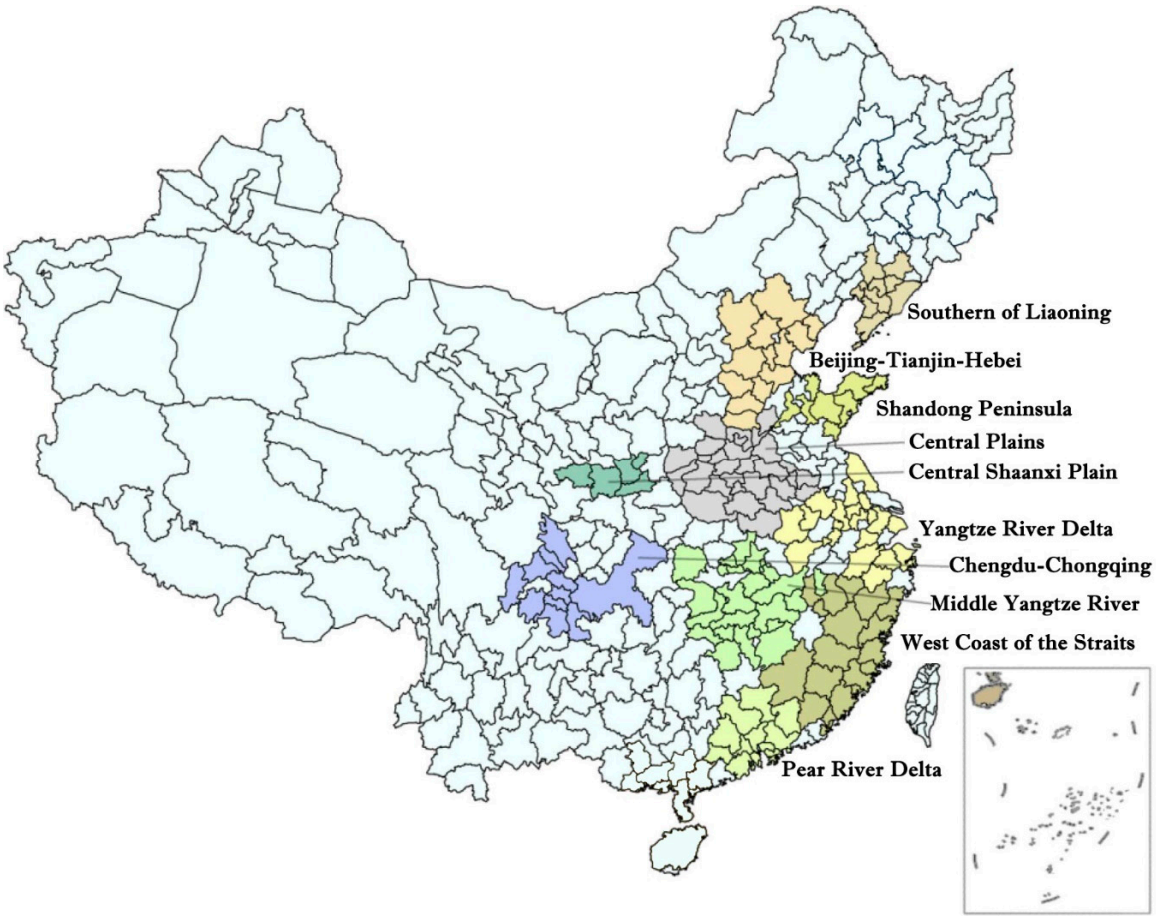


Figure 1. Location of 10 urban agglomerations in China.

Table 1. Definition of China's top 10 urban agglomerations.

Urban Agglomerations	Including Cities
Yangtze River Delta	Shanghai, Nanjing, Hangzhou, Suzhou, Wuxi, Changzhou, Zhenjiang, Yangzhou, Taizhou, Nantong, Jiaxing, Huzhou, Ningbo, Shaoxing, Zhoushan, Taizhou
Pearl River Delta	Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Zhaoqing, Jiangmen, Dongguan, Zhongshan
Beijing-Tianjin-Hebei	Beijing, Tianjin, Tangshan, Langfang, Baoding, Qinhuangdao, Shijiazhuang, Zhangjiakou, Chengde, Zhangzhou
Southern of Liaoning	Shenyang, Dalian, Anshan, Fushun, Benxi, Fuxin, Panjin, Dandong, Liaoyang, Tieling, Huludao, Yingkou, Jinzhou
Shandong Peninsula	Jinan, Qingdao, Yantai, Weihai, Rizhao, Dongying, Weifang, Zibo
West Coast of the Straits	Fuzhou, Xiamen, Zhangzhou, Quanzhou, Putian, Ningde
Central Plains	Zhengzhou, Luoyang, Kaifeng, Xinxiang, Jiaozuo, Xuchang, Jiyuan, Pingdingshan, Weihe
Middle Yangtze River	Wuhan, Changsha, Nanchang, Huangshi, Ezhou, Xiaogan, Huanggang, Xianning, Xiangyang, Yichang, Jingzhou, Jingmen, Zhuzhou, Xiangtan, Yueyang, Yiyang, Changde, Hengyang, Loudi, Jiujiang, Jingdezhen, Yingtan, Xinyu, Yichun, Pingxiang, Shangrao, Fuzhou
Central Shaanxi Plain	Xi'an, Xianyang, Tongchuan, Baoji, Weinan
Chengdu-Chongqing	Chengdu, Chongqing, Deyang, Mianyang, Yibin, Leshan, Zhangzhou, Nanchong, Zigong, Meishan, Neijiang, Suining, Guang'an, Ya'an, Ziyang, Dazhou

3.2. Data Sources

In the paper, the data of index system originated from two sources. Most statistical data were derived from the authoritative statistical yearbooks, including the 2002–2017 China Urban Statistical Yearbook, the 2002–2017 China Statistical Yearbook on Science and Technology, and the 2002–2017 China Statistical Yearbook. The institutional indicators of urban agglomerations are derived from the China Marketization Index Report published by Professor Fan Gang and Professor Wang Xiaolu [63–65].

3.3. Methods

The economic efficiency of urban agglomeration refers to the allocation efficiency, production efficiency, exchange efficiency and consumption efficiency which use the existing technology and various resources to organize production and the distribution, exchange and consumption of products in the region. That is, the input and output efficiency of urban agglomerations. The economic efficiency of urban agglomerations can be measured not only by single factor productivity such as labor productivity, capital productivity, land productivity, but also by total factor productivity. In essence, the economic efficiency of urban agglomerations is also achieved through a series of micro-mechanisms and approaches. A theoretical and empirical analysis framework for the three different externalities effect mechanisms (industrial specialization, industrial diversity and industrial competition) on the economic efficiency of urban agglomerations is incorporated and checked. In order to achieve this goal, a flow chart of the research framework is shown in Figure 2.

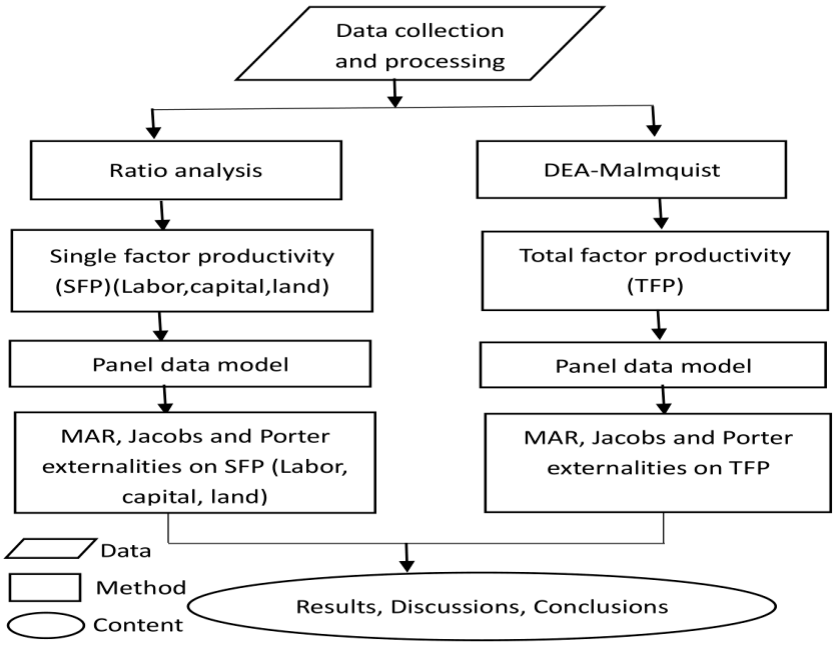


Figure 2. Flow chart of the research framework.

According to the theoretical and empirical analysis framework system of economic efficiency of urban agglomeration, this paper constructs the following panel data models:

$$\ln LGDP_{it} = \beta_0 + \beta_1 \ln RSI_{it} + \beta_2 \ln RDI_{it} + \beta_3 \ln IC_{it} + \beta_4 \ln P_{it} + \beta_5 \ln M_{it} + \beta_6 \ln TI_{it} + \varepsilon_{it} \quad (1)$$

$$\ln KGDP_{it} = \beta_0 + \beta_1 \ln RSI_{it} + \beta_2 \ln RDI_{it} + \beta_3 \ln IC_{it} + \beta_4 \ln P_{it} + \beta_5 \ln M_{it} + \beta_6 \ln TI_{it} + \varepsilon_{it} \quad (2)$$

$$\ln GGDP_{it} = \beta_0 + \beta_1 \ln RSI_{it} + \beta_2 \ln RDI_{it} + \beta_3 \ln IC_{it} + \beta_4 \ln P_{it} + \beta_5 \ln M_{it} + \beta_6 \ln TI_{it} + \varepsilon_{it} \quad (3)$$

$$\ln TFP_{it} = \beta_0 + \beta_1 \ln RSI_{it} + \beta_2 \ln RDI_{it} + \beta_3 \ln IC_{it} + \beta_4 \ln P_{it} + \beta_5 \ln M_{it} + \beta_6 \ln TI_{it} + \varepsilon_{it} \quad (4)$$

$$\varepsilon_{it} = \mu_i + \lambda_t + u_{it} \quad (5)$$

where $LGDP_{it}$ is the labor productivity of the i-th urban agglomeration in the t-th year, $KGDP_{it}$ is the capital productivity of the i-th urban agglomeration in the t-th year, $GGDP_{it}$ is the land productivity of the i-th urban agglomeration in the t-th year, and TFP_{it} is the total factor productivity of the i-th urban agglomeration in the t-th year; RSI_{it} is the industrial specialization division level of the i-th urban agglomeration in the t-th year (MAR externality), RDI_{it} is the industrial diversity division level of the i-th urban agglomeration in the t-th year (Jacobs externality),and IC_{it} is the industrial competitiom level of the i-th urban agglomeration in the t-th year (Porter externality). And P_{it} is the number of patent application for the unit land area of the i-th urban agglomeration in the t-th year, and M_{it} is the marketization index of the i-th urban agglomeration in the t-th year, and TI_{it} is the transportation infrastructure for the unit land area of the i-th urban agglomeration in the t-th year. Before the regression analysis, all the indicators were logarithmically processed. ε_{it} is the random error term, μ_i is the individual effect, λ_t is the time effect. i = 1, 2, ..., 10, representing 10 urban agglomerations; t = 1, 2, ..., 16, representing time 2001, 2002, ..., 2016. $E(\mu_i) = 0$, $E(\lambda_i) = 0$, $E(\mu_i u_{it}) = 0$, $E(\lambda_i u_{it}) = 0$. Calibrated variables in the panel data models are shown in Table 2.

Table 2. Calibrated variables.

Variables			Abbr.	Description
Explained variables	Single factor productivity	labor productivity	LGDP	the ratio of the sum of GDP to the total number of employed people
		capital productivity	KGDP	the ratio of the sum of GDP to the sum of capital stocks
		land productivity	GGDP	the ratio of the sum of GDP to the total land area
	Total factor productivity		TFP	input and output efficiency
Explanatory variables	Industrial specialization (MAR externality)		RSI	the industry's relative specialization index, measures the degree of difference in the industrial structure of urban agglomeration
	Industrial diversity (Jacobs externality)		RDI	the industry's relative diversity index, measures the degree of difference in the industrial structure of urban agglomeration
	Industrial competition (Porter externality)		IC	the ratio of number of businesses per 10,000 people in urban agglomeration to the national share
	Technological innovation		P	the ratio of the total number of patent applications to the total land area of the urban agglomeration
	Marketization institution		M	the marketization index of the urban agglomeration
	Transportation infrastructure		TI	the ratio of the total length of the road, railway and inland waterway to the total land area of the urban agglomeration

3.3.1. Estimation of Economic Efficiency

The economic efficiency measurement methods are generally divided into two categories: one is the single factor productivity measurement method. In the beginning, both academics and governments used single factor productivity as a measure of economic efficiency. Since 1926, the first US Bureau of Labor Statistics, which regulates the productivity of various industrial sectors, has adopted the method of measuring labor productivity. This method of measurement has been widely used in theory and practice, and has continued until now. According to this idea, many scholars later calculated the capital

productivity. Labor productivity and capital productivity become the most important representatives of single factor productivity. Many scholars use these indicators to reflect the economic efficiency of a company, industry, region or country. Single factor productivity is an absolute efficiency indicator, and its benefits are real, easy to understand, and easy to compare. The other type is the total factor productivity measurement method. The main measurement methods include growth kernel algorithm, frontier analysis and index method. As a frontier analysis method, Data Envelopment Analysis (DEA) uses the optimization method to determine the weight of various input factors endogenously, avoiding the specific expression of the relationship between input and output, and eliminating the interference of many subjective factors on the measurement method. It also has advantages such as no relationship with market price, and is especially suitable for economic efficiency evaluation of complex economies.

This paper uses both single factor productivity and total factor productivity methods, so as to more comprehensively measure the economic efficiency of urban agglomerations. Firstly, referring to the research of scholars such as Pain [66], the single factor productivity method is used to measure the economic efficiency of urban agglomerations, and three specific indicators are adopted: labor productivity (LGDP), capital productivity (KGDP), and land productivity (GGDP). Among them, Labor productivity (LGDP) is the ratio of the sum of GDP to the total number of employed people in urban agglomerations, and the capital productivity (KGDP) is the ratio of the sum of GDP to the total capital stocks of urban agglomerations, and land productivity (GGDP) is the ratio of the sum of GDP to the total land area of urban agglomerations. The capital stock is estimated using Goldsmith's Perpetual Inventory Method (PIM) [67]. The basic estimation formula is:

$$K_t = (1 - \delta_t)K_{t-1} + I_t \tag{6}$$

where K_t and K_{t-1} represent the regional capital stock of t and t − 1 period respectively, δ_t is the capital depreciation rate of period t, and I_t is the investment amount of period t.

Secondly, the total factor productivity method is used to measure the economic efficiency of urban agglomerations. This paper uses the DEA-Mamquist model to measure the total factor productivity of urban agglomerations. According to the classical Cobb-Douglas production function:

$$\mathrm{Q} = \mathrm{AL}^{\alpha}\mathrm{K}^{\beta} \tag{7}$$

where the two most important input factors in economic growth are labor L and capital K. In macroeconomic output, natural resources are also a key production factor, the most important of which is the land element. The output of efficiency is the macroeconomic output of the urban agglomeration. Therefore, the economic efficiency measurement model of the urban agglomeration includes three input indicators and one output indicator. The first input indicator is the input of labor factor, measured by the total number of employed people in the urban agglomeration. The second input indicator is the capital factor, measured by the total capital stock of the urban agglomeration in the current year, which is consistent with the capital stock estimate in the capital productivity. The third input indicator is the natural factor, which mainly refers to the input of the land elements of the urban agglomeration, measured by the total land area of the urban agglomeration. The DEA-Malmquist exponential model can be used to measure the change in total factor productivity of China's top 10 urban agglomerations from 2001 to 2016. The Malmquist index of total factor productivity changes from t to t + 1 is:

$$\mathrm{M}_{\mathrm{it}+1} = \left[\frac{D_i^t\left(X_i^{t+1}, Y_i^{t+1}\right)}{D_i^t\left(X_i^t, Y_i^t\right)} \times \frac{D_i^{t+1}\left(X_i^{t+1}, Y_i^{t+1}\right)}{D_i^{t+1}\left(X_i^t, Y_i^t\right)} \right]^{1/2} \tag{8}$$

where $X_i^t, Y_i^t, X_i^{t+1}, Y_i^{t+1}$ represent the input and output of the decision unit i in the t and t + 1 periods respectively, and $D_i^t\left(X_i^t, Y_i^t\right)$, $D_i^t\left(X_i^{t+1}, Y_i^{t+1}\right)$, $D_i^{t+1}\left(X_i^t, Y_i^t\right)$, $D_i^{t+1}\left(X_i^{t+1}, Y_i^{t+1}\right)$ represent the distance function.

It is worth noting that the Malmquist index measures only the change of total factor productivity.The total factor productivity (TFP) value of an urban agglomeration can be expressed as:

$$\mathrm{TFP_{it}} = \mathrm{TFP_{it-1}} \times \mathrm{TFPCH_{it}} \tag{9}$$

where $\mathrm{TFP_{it}}$ is the total factor productivity of the i-th urban agglomeration in the t-th year, and $\mathrm{TFPCH_{it}}$ is the change value of the total factor productivity of the i-th urban agglomeration in the t-th year, that is, the Malmquist index measured by the DEA model. This paper sets 2001 as the base period, that is, $\mathrm{TFP_{i2001}} = 1$. i = 1, 2, ..., 10, representing 10 urban agglomerations; t = 1, 2, ..., 16, representing time 2001, 2002, ..., 2016.

3.3.2. Eestimates of Industrial Specialization, Industrial Diversity and Industrial Competition

At present, there are three main ideas for the estimate of industrial specialization and diversity: Firstly, industry classification is used to measure specialization and diversity. The indicators of industrial specialization mainly include location quotient, Herfindahl-Hirschman index, Krugman specialization index. The main methods of measuring industrial diversity include: the proportion of the top five industries in terms of total employment [44], the lowest value of the location quotient [68], the reciprocal of the Gini coefficient, the relative diversity index [69]. The second idea is to use the "quotient" in the theory of dissipative structure to construct the measurement index of industrial specialization and diversity,which include concentration index, quotient diversity index, Gibbs-Martin diversifity index and relative quotient index, etc. The third way is using patent classification to measure the industrial specialization and diversity based on the technical links of economic activities.

Considering the comparability of calculation results, the practical explanation and the availability of the data, the relative specialization index (RSI) and relative diversity index (RDI) are used. Among them, the relative specialization index (RSI) is the maximum location quotient of various industries in the urban agglomeration. The calculation formula is:

$$\mathrm{RSI_i} = Max_j\left(\frac{S_{ij}}{S_j}\right) \tag{10}$$

where $\mathrm{RSI_i}$ is the relative specialization index of the i urban agglomeration, and S_{ij} indicates that the number of employees in the industry j of i urban agglomeration accounts for the total number of employees in all industries in the urban agglomeration, and S_j indicates that proportion of the total number of employees in the j industry accounts for the national. The relative specialization index (RSI) measures the specialization degree of the j industry in the i urban agglomeration relative to the national level. If this variable is positive, it indicates that industrial specialization (MAR externality) improves the economic efficiency of urban agglomerations.

The calculation formula of the relative diversity index (RDI) is:

$$\mathrm{RDI_i} = \frac{1}{\sum_j \left|S_{ij} - S_j\right|} \tag{11}$$

where $\mathrm{RDI_i}$ is the relative diversity index of the i urban agglomeration, the interpretation of S_{ij} and S_j is the same as in Equation (10). This indicator reflects the industrial diversity environment of the j industry in the i urban agglomeration. If the regression coefficient of the indicator is positive, it reflects that industrial diversity (Jacobs externality) promotes the economic efficiency of urban agglomerations.

For the measurement of the intensity of industrial competition (IC) in an urban agglomeration, which is shown as the ratio of the number of enterprises owned by the employees in j industry of i urban agglomeration to the average value of the national proportion in the country:

$$\mathrm{IC_{ij}} = \frac{E_{ij}/L_{ij}}{E_{nj}/L_{nj}} \tag{12}$$

where IC_{ij} is the industrial competition index of the industry j of i urban agglomeration, and E_{ij} indicates that the number of enterprises in the industry j of i urban agglomeration, L_{ij} indicates that the number of employees in the industry j of i urban agglomeration. E_{nj} indicates that the number of enterprises in the industry j in the country, L_{nj} indicates that the number of employees in the industry j in the country. Obviously, the larger the value of this indicator, the more companies there are in the region, and the more competitive the company faces. If the regression coefficient of the variable is positive, it indicates that the competition among enterprises in the same industry is conducive to promoting the economic efficiency of the urban agglomeration, that is, Porter externality exists.

4. Results and Discussion

4.1. Stationarity Test of Variables

Since many of the selected variables have a time trend, in order to prevent the phenomenon of pseudo-regression, it is necessary to first test the stability of each variable. In this paper, the four kinds of stationarity test methods of Levin-Lin-Chu panel unit root test (LLC), Im-Pesaran-Shin panel unit root test (IPS), Fisher-Augmented Dickey-Fuller test (ADF-Fisher) and Fisher-Phillips-Perron test (PP-Fisher) are used to ensure the accuracy of the test conclusion. Table 3 reflects the results of the stationarity test for each variable sequence.

Table 3. Results of stationarity test for each variable sequence.

Variable	LLC	IPS	ADF-Fisher	PP-Fisher
lnLgdp	−5.1648 *** (0.0000)	−5.17 *** (0.0000)	135.556 *** (0.0000)	228.0738 *** (0.0000)
lnKgdp	−3.9302 *** (0.0000)	−2.07349 ** (0.0191)	38.4213 ** (0.0079)	72.3303 *** (0.0000)
lnGgdp	−5.917 *** (0.0000)	−6.505 *** (0.0000)	146.29 *** (0.0000)	250.9028 *** (0.0000)
lnTFP	−11.2162 *** (0.0000)	−9.044 *** (0.0000)	116.2324 *** (0.0000)	48.9494 ** (0.0000)
lnRSI	−9.343 *** (0.0000)	−2.868 *** (0.0000)	64.4983 *** (0.0000)	149.9828 *** (0.0000)
lnRDI	−11.596 *** (0.0000)	−3.254 *** (0.0000)	96.278 *** (0.0000)	332.5217 *** (0.0000)
lnIC	−14.124 *** (0.0029)	−4.039 *** (0.0000)	78.8976 *** (0.0000)	632.8536 *** (0.0000)
lnP	−4.09543 *** (0.0000)	−5.133 *** (0.0000)	89.8465 *** (0.0000)	331.507 *** (0.0000)
lnM	−1.9418 ** (0.0261)	−0.632 * (0.064)	34.3275 ** (0.0240)	31.048 * (0.0546)
lnTI	−1.41704 * (0.0782)	−3.373 *** (0.0000)	40.4952 *** (0.0043)	113.2694 *** (0.0000)

Note: *, **, *** indicate that the variable is significant at 10%, 5% and 1% confidence levels respectively. The statistical values in the table are the result of the first-order difference of all variables.

According to the results of the four test statistic of each variable in Table 3, the original variable is not stable, but the first-order difference of all variables are stable, that is, obey the I(1) process. It can be seen that the variables are the same order. The co-integration test of the explained variables and explanatory variables can be performed before the regression analysis.

4.2. Cointegration Test between Variables

The Pedroni cointegration test method is the most commonly used co-integration test method, which can provide multiple test statistics at the same time, thus enhancing the scientificity of the test conclusion. The co-integration test results of the explained variable and the explanatory variable are shown in Table 4.

Table 4. Test results of the explained variable and the explanatory variable.

Test T	lnLgdp	lnGgdp	lnKgdp	lnTFP
Modified PP	3.946 *** (0.0000)	3.8996 *** (0.0000)	3.6658 *** (0.0001)	5.0669 *** (0.0000)
PP	−6.9775 *** (0.0000)	−6.2441 *** (0.0000)	−7.1565 *** (0.0000)	0.2568 * (0.0987)
ADF	−4.9587 *** (0.0000)	−4.354 *** (0.0000)	−5.4636 *** (0.0000)	−0.7563 ** (0.0247)

Note: *, **, *** indicate that the variable is significant at 10%, 5% and 1% confidence levels respectively.

From Table 4, it can be found that the Modified Phillips-Perron (Modified PP), Phillips-Perron(PP), and Augmented Dickey-Fuller (ADF) statistics test of lnLGDP, lnGGDP, lnKGDP, and lnTFP all reject the null hypothesis that "there is no co-integration relationship". Therefore, it can be concluded that there is a co-integration relationship between the explained variables and the explanatory variables. Therefore, this paper can select the variables and panel data model to analyze the influencing factors on economic efficiency of China's top 10 urban agglomerations.

4.3. Panel Data Model Results

4.3.1. Estimate Results of Single Factor Productivity of Urban Agglomerations

The estimate results of Equations (1)–(3) are shown in Table 5.

Based on the results of F test, LM test and Hausman test in Table 5, lnLGDP, lnGGDP, and lnKGDP are all fixed effect models as the optimal model. Analyze the estimate results of the model, some interesting findings are got.

Firstly, from the influencing factors on labor productivity (lnLGDP), the industrial specialization variable (lnRSI) statistical result is significant, and the coefficient is positive. This indicates that MAR externality exits, and the industrial specialization is conducive to the improvement of labor productivity of urban agglomerations. The coefficient of industrial diversity variable (lnRDI) is negative, but statistical result is not significant, which indicates that Jacobs externality is not supported. The industrial competition variable (lnIC) statistical result is significant, and the coefficient is positive. This indicates that Porter externality exits, and the industrial competition is conducive to the improvement of labor productivity of urban agglomerations. The technological innovation (lnP) and transportation infrastructure (lnTI) variables statistical results are significant, and the coefficient is positive, which indicates that the technological innovation and transportation infrastructure are conducive to the improvement of labor productivity of urban agglomerations. The marketization institution variable (lnM) statistical result is significant, and the coefficient is negative, which indicates that the marketization institution is not conducive to the improvement of labor productivity of urban agglomerations.

Table 5. The estimate results of Equations (1)–(3) (labor productivity, capital productivity, and land productivity).

Variable	lnLGDP			lnGGDP			lnKGDP		
	OLS	**FE**	**RE**	**OLS**	**FE**	**RE**	**OLS**	**FE**	**RE**
c	1.542 *** (0.293)	1.741 *** (0.168)	1.737 *** (0.191)	−2.272 *** (0.211)	−1.32 *** (0.174)	−1.669 *** (0.191)	−1.71 *** (0.22)	−0.53 *** (0.163)	−0.745 *** (0.18)
lnRSI	0.299 *** (0.105)	0.338 *** (0.077)	0.348 *** (0.076)	0.194 *** (0.076)	0.324 *** (0.08)	0.239 *** (0.077)	−0.095 (0.079)	−0.452 *** (0.074)	−0.381 *** (0.075)
lnRDI	0.057 (0.14)	−0.079 (0.079)	−0.089 (0.079)	0. 485 *** (0.101)	−0.041 (0.082)	0.11 (0.087)	−0.051 (0.105)	−0.189 ** (0.076)	−0.173 ** (0.082)
lnIC	0.186 *** (0.051)	0.083 *** (0.028)	0.091 *** (0.028)	0.157 *** (0.036)	0.08 *** (0.029)	0.132 *** (0.031)	0.019 (0.038)	0.055 ** (0.027)	0.061 ** (0.029)
lnP	0.62 *** (0.031)	0.564 *** (0.02)	0.571 *** (0.02)	0.667 *** (0.022)	0.596 *** (0.021)	0.635 *** (0.02)	0.095 *** (0.023)	0.152 *** (0.019)	0.128 *** (0.019)
lnM	−0.064 (0.134)	−0.194 *** (0.075)	−0.183 *** (0.075)	0.139 (0.096)	−0.177 ** (0.077)	−0.023 (0.084)	0.527 *** (0.1)	0.056 (0.073)	0.158 ** (0.078)
lnTI	−0.229 (0.056)	0.172 *** (0.054)	0.143 ** (0.052)	−0.091 ** (0.041)	0.178 *** (0.056)	0.038 (0.045)	−0.004 (0.042)	−0.005 (0.052)	−0.054 (0.047)
F Test		72.24 *** (0.000)			26.75 *** (0.000)			36.88 *** (0.000)	
LM Test			516.5 *** (0.000)			170.48 *** (0.000)			137.94 *** (0.000)
Hausman Test			p>chi2= 0.000		p>chi2= 0.000				p>chi2= 0.000
Numbers	160	160	160	160	160	160	160	160	160
R^2	0.9043	0.9709	0.9709	0.9616	0.9719	0.9691	0.5581	0.6618	0.6528

Note: ① *, **, *** indicate that the variable is significant at 10%, 5% and 1% confidence levels respectively; ② The values in parentheses below the coefficient of each variable are the corresponding standard deviations; ③ OLS, FE, and RE represent the Pooled Ordinary Least Squares Model, Fixed Effects Model, and Random Effects Model. ④ The selection of the model is mainly marked by F test, Lagrangian Multiplier(LM) test and Hausman test, and the corresponding statistical value and significance level are marked.

Secondly, from the influencing factors on land productivity (lnGGDP), the coefficient and statistical results of all variables are consistent with the estimates of labor productivity (lnLGDP).The results indicate that MAR externality and Porter externality exit,which show that the industrial specialization and the industrial competition are conducive to the improvement of land productivity of urban agglomerations. The Jacobs externality is also not supported in land productivity. The technological innovation and transportation infrastructure are conducive to the improvement of land productivity of urban agglomerations,while the marketization institution is opposite.

Thirdly, from the influencing factors on capital productivity (lnKGDP), the variables (lnRSI,lnRDI,lnIC) statistical results are significant. The coefficient of industrial specialization (lnRSI) and industrial diversity (lnRDI) variables is negative, which indicates that MAR externality and Jacobs externality do not exit. So the industrial specialization and industrial diversity are not conducive to the improvement of capital productivity of urban agglomerations. The coefficient of industrial competition variable (lnIC) is positive, which indicates that Porter externality exits.The industrial competition is conducive to the improvement of capital productivity of urban agglomerations. The technological innovation (lnP) variable statistical result is significant, and the coefficient is positive, which indicates that the technological innovation is conducive to the improvement of capital productivity of urban agglomerations. The marketization institution (lnM) and transportation infrastructure (lnTI) variables statistical results are not significant.

4.3.2. Estimate Results of Total Factor Productivity of Urban Agglomerations

The estimate results of Equation (4) are shown in Table 6.

Table 6. The estimate results of Equation (4) (total factor productivity).

Variable	lnTFP		
	OLS	**FE**	**RE**
c	0.836 *** (0.309)	1.709 *** (0.413)	0.836 *** (0.317)
lnRSI	−0.048 * (0.109)	−0.184 ** (0.186)	−0.048 * (0.111)
lnRDI	0.186 ** (0.144)	0.152 ** (0.186)	0.186 ** (0.148)
lnIC	0.003 * (0.051)	0.017 * (0.066)	0.003 * (0.053)
lnP	0.086 *** (0.032)	0.03 * (0.047)	0.086 *** (0.033)
lnM	−0.437 *** (0.143)	−0.868 *** (0.186)	−0.437 *** (0.147)
lnTI	−0.216 *** (0.059)	−0.121 (0.126)	−0.216 *** (0.061)
F Test		1.82 ** (0.0499)	
LM Test			0 (1.0000)
Hausman Test			P>chi2 = 0.0095
Numbers	160	160	160
R^2	0.5054	0.5983	0.5558

Note: the meaning of each variable, model and test representative in this table is consistent with Table 5.

It can be seen from the results of the F test, the LM test and the Hausman test in Table 6 that the fixed effect model is the optimal model. By analyzing the estimate results of the model, this paper can get some basic results.

From the influencing factors on total factor productivity (lnTFP) of urban agglomeration, the industrial specialization variable (lnRSI) statistical result is significant, and the coefficient is negative. This indicates that MAR externality does not exit, and the industrial specialization is not conducive to the improvement of total factor productivity of urban agglomerations. The coefficient of industrial diversity variable (lnRDI) is positive, and the statistical result is significant, which indicates that Jacobs externality exits. The industrial diversity is conducive to the improvement of total factor productivity of urban agglomerations. The industrial competition variable (lnIC) statistical result is significant, and the coefficient is positive. This indicates that Porter externality exits, and the industrial competition is conducive to the improvement of total factor productivity of urban agglomerations. The technological innovation (lnP) variable statistical result is significant, and the coefficient is positive, which indicates that the technological innovation is conducive to the improvement of total factor productivity of urban agglomerations. The marketization institution variable (lnM) statistical result is significant, and the coefficient is negative, which indicates that the marketization institution is not conducive to the improvement of total factor productivity of urban agglomerations. The transportation infrastructure (lnTI) variable statistical result is not significant.

4.4. Discussion

4.4.1. Specialization and Diversity

The industrial structure has an important impact on regional economic growth. However, there is a big controversy about the way the industrial structure affects regional economic growth. It is concentrated in the fact that whether industrial specialization or diversity in a given region is more conducive to economic growth (MAR externality or Jacobs externality). According to MAR externality theory, a certain enterprise can benefit from the economic activities of other enterprises in the same industry in a given region. And the Jacobs externality theory believes that companies mainly benefit from the economic activities of enterprises in different industries or complementary industries. The study in this paper finds that the results of the two externalities show differences when measuring economic efficiency with different indicators (Table 7).

Table 7. Test results of the MAR externality and Jacobs externality.

Externality	lnLgdp	lnGgdp	lnKgdp	lnTFP
MAR externality	positive, significant	positive, significant	negative, significant	negative, significant
Jacobs externality	negative, not significant	negative, not significant	negative, significant	positive, significant

From Table 7, MAR externality exists in labor productivity and land productivity, which is consistent with the findings of some scholars [45,46,49–52]. Jacobs externality exists in total factor productivity, which is consistent with the findings of some scholars [44,45,47,48]. MAR externality does not exist in capital productivity and total factor productivity, which may be related to the lock-in effect of the single industry and the industry life cycle. Jacobs externality does not exist in labor productivity, land productivity and capital productivity, which may be related to the macroeconomic situation and the impact of the external market environment.

4.4.2. Monopoly, Competition, Complementarity

The difference between MAR externality and Jacobs externality is not only reflected in the specialization or diversity which is conducive to regional economic growth, but also in whether monopoly or competitive market will promote regional economic growth. According to MAR externality theory, monopoly is more conducive to technological innovation and growth. Jacobs externality theory argues that a highly competitive market environment is conducive to accelerate the company's technological innovation and promote regional economic growth. However, Jacobs externality theory emphasizes competition and complementarity in different industries. Porter externality theory argues that market competition within the same industry rather than different industries is conducive to knowledge innovation and spillover. From the results of this study, the Porter externality exists regardless of the indicators of economic efficiency (labor productivity, capital productivity, land productivity, and total factor productivity). It can be seen that the competition of many enterprises within the same industry is conducive to the economic efficiency of urban agglomerations.

4.4.3. Economic Efficiency and Environmental Efficiency

Environment is a driving force of urban agglomeration which is also the undesirable output. Many scholars proposed extended DEA models to introduce environment as the undesirable output into the evaluation process of environmental efficiency. Urban agglomerations are also the sites at which contradictions between resource utilization, environmental pollution, and economic development are most apparent [70]. In recent years, urban environmental efficiency has received much attention from researchers. This paper discusses the land productivity, which reflects environmental efficiency from

one side. Among the factors affecting land productivity, industrial specialization (MAR externality), industrial competition (Porter externality), technological innovation, and transportation infrastructure have positive effects on land productivity. The marketization institution is not conducive to the improvement of land productivity, and the effect of industrial diversity (Jacobs externality) is not obvious. These researches have certain policy implications and can provide reference for policy makers to formulate policies. Land productivity has a certain correlation with environmental efficiency. Because the improvement of land productivity is conducive to the intensive use of land, and it is a necessary requirement to deal with the relationship between economic construction, resource utilization and environmental protection. The mixed land uses is one of the key indicators affecting the environmental changes efficiency [71]. Exploring the general distribution characteristics and evolution rule of urban land use efficiency is of great significance for the efficient integration between urban land use system and the external environment [72].

5. Conclusions

Urban agglomeration is an advanced stage of urbanization development, and the development of urban agglomeration has the characteristics of stage and dynamic. At different stages of development, the degree of maturity is different, and the economic efficiency will also be characterized by high and low. Different from previous research, this paper focuses on the influencing factors and mechanisms of economic efficiency of urban agglomerations, and check the effects of three different externalities (industrial specialization, industrial diversity and industrial competition) on the economic efficiency of urban agglomerations. The selected samples are multiple urban agglomerations, and the economic efficiency of urban agglomerations includes single factor productivity and total factor productivity. Taking China's top 10 urban agglomerations as an example, the economic efficiency of urban agglomerations is tested, which are composed of labor productivity, capital productivity, land productivity and total factor productivity. In summary, this paper draws the following main research conclusions.

Firstly, the urban agglomeration is not only a spatial region but also an economic region, and the economic characteristics and functions are more essential elements of the urban agglomerations. From the perspective of the spatial structure of the urban agglomeration, it has at least one or more core cities with international competitiveness. The urban distribution in the region reaches a high density, and the cities are open to each other and interconnected through developed infrastructure such as transportation and communication. From the perspective of the economic characteristics of urban agglomerations, it is an economic agglomeration composed of many urban units at the macro level. It is an industrial cluster at the meso level and a corporate cluster at the micro level.

Secondly, industrial specialization, industrial diversity and industrial competition effect (MAR externality, Jacobs externality and Porter externality) to economic efficiency of urban agglomerations show differences. MAR externality exists in labor productivity and land productivity, but it does not exist in capital productivity and total factor productivity. Jacobs externality exists in total factor productivity, but it does not exist in labor productivity, land productivity and capital productivity. Porter externality exists regardless of the indicators of economic efficiency (labor productivity, capital productivity, land productivity, and total factor productivity), which showes that the competition of many enterprises within the same industry is conducive to the economic efficiency of urban agglomerations.

Thirdly, there are orther key factors affecting economic efficiency of urban agglomerations, and show differences. The technological innovation is conducive to the improvement of both single factor productivity (labor productivity, land productivity and capital productivity) and total factor productivity of urban agglomerations. The marketization institution is not conducive to the improvement of labor productivity, land productivity and total factor productivity of urban agglomerations. The transportation infrastructure is conducive to the improvement of both labor productivity and land productivity of urban agglomerations.

Finally, in order to improve the economic efficiency of urban agglomerations, the overall principle should be to promote the coordinated development and sustainable development of urban agglomerations. Specific recommendations include: Firstly, the government should break the monopoly, especially reduce barriers to entry so as to promote the evolution of industrial innovation with the substitution of new enterprises, thus driving the economic efficiency of urban agglomerations. In addition, we must accelerate the pace of market integration, encourage competition among enterprises in different regions so as to promote economic growth. Secondly, the focus of industrial policy should be different. The policy focus should consider not only the differences between the MAR externality and Jacobs externality on the economic efficiency of urban agglomerations, but also their differences in the effects to single factor productivity and total factor productivity. Thirdly, improve the technological innovation level of urban agglomerations and synergistically promote the technological progress of urban agglomerations. Fourthly, the market institution is a double-edged sword. It is necessary to foster strengths and avoid weaknesses, and provide institutional guarantee for the coordinated development of urban agglomerations. At the same time, according to the calculation results of single factor productivity and total factor productivity, each urban agglomeration can make targeted improvements to weak links in industrial specialization, industrial diversity, industrial competition, technological innovation, or transportation infrastructure.

However, further research is needed as follows: Firstly, the scientific calculation of the total factor productivity of urban agglomerations. If the indicators, data, and methods are different, the measurement results of the total factor productivity of the urban agglomeration will show large differences. In the follow-up study, it is necessary to select more realistic indicators, and use different methods to measure and compare, and calculate more scientific and objective total factor productivity of urban agglomerations. The second is the study of the spatial effects of urban agglomerations. The spatial effects of urban agglomerations can be studied from three aspects: the spatial structure of urban agglomerations, the formation mechanism of spatial patterns of urban agglomerations, and the spatial spillover effects of urban agglomerations. The third is the study of the green economy efficiency of urban agglomerations. This paper believes that the process of improving the economic efficiency of urban agglomerations is actually to make the resources of each city more rationally allocated and efficiently utilized through industrial division and technological progress, which is conducive to resource conservation and reduction of pollution emissions. Therefore, the economic efficiency of urban agglomerations contains the concept of green development. Economic efficiency has a high correlation with green economy efficiency. However, the green economy efficiency will have more and more direct consideration of resources and environmental issues. Future research can consider more resources and environmental issues in the process of economic development of urban agglomerations, construct a scientific and rational evaluation index system for green economy efficiency, and incorporate environmental factors into the theoretical analysis framework of economic efficiency of urban agglomerations, exploring the role and mechanisms of industrial division, technological progress and institution to improve the environment of urban agglomerations.

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References

1. World Bank. *World Development Report 2009: Reshaping the World Economic Geography*; World Bank: Washington, DC, USA, 2008.
2. Lemelin, A.; Rubiera, M.F.; Gómez, L.A. Measuring urban agglomeration: A refoundation of the mean city-population size index. *Soc. Indic. Res.* **2016**, *125*, 589–612. [CrossRef]
3. United Nations. World Urbanization Prospects: The 2011 Revision. Available online: http://www.esa.un.org (accessed on 25 July 2012).
4. Li, X.M.; Zhou, W.Q.; Ouyang, Z.Y. Forty years of urban expansion in Beijing: What is the relative importance of physical, socioeconomic, and neighborhood factors? *Appl. Geogr.* **2013**, *38*, 1–10. [CrossRef]
5. Wu, J.G.; He, C.Y.; Huang, G.L.; Yu, D.Y. Urban landscape ecology: Past, present, and future. In *Landscape Ecology for Sustainable Environment and Culture*; Fu, B., Jones, B., Eds.; Springer: Dordrecht, The Netherlands, 2013; pp. 37–53.
6. Baigent, E. Patrick Geddes, Lewis Mumford and Jean Gottmann: Divisions over 'Megalopolis'. *Prog. Hum. Geogr.* **2004**, *28*, 687–700. [CrossRef]
7. Chen, Y. The Research on the Spatial Evolution and Maturation-Degree of Urban Agglomerations in China. Master's thesis, Peking University, Beijing, China, 2017. (In Chinese).
8. Fang, C.; Yu, D. Urban agglomeration: An evolving concept of an emerging phenomenon. *Landsc. Urban Plan.* **2017**, *162*, 126–136. [CrossRef]
9. Zhang, Z.; Wang, B.; Buyantuev, A.; He, X.; Gao, W.; Wang, Y.; Dawazhaxi; Yang, Z. Urban agglomeration of Kunming and Yuxi cities in Yunnan, China: The relative importance of government policy drivers and environmental constraints. *Landsc. Ecol.* **2019**, *34*, 663–679. [CrossRef]
10. Wheeler, C.H. Search, Sorting, and Urban Agglomeration. *J. Labor Econ.* **2001**, *19*, 879–899. [CrossRef]
11. Garcia-López, M.À.; Muñiz, I. Urban spatial structure, agglomeration economies, and economic growth in Barcelona: An intra-metropolitan perspective. *Pap. Reg. Sci.* **2013**, *92*, 515–534. [CrossRef]
12. Liu, C.; Wang, T.; Guo, Q. Factors Aggregating Ability and the Regional Differences among China's Urban Agglomerations. *Sustainability* **2018**, *10*, 4179. [CrossRef]
13. Marshall, A. *Principles of Economics*; Macmillan: London, UK, 1920; pp. 87–88.
14. Arrow, K.J. The economic implications of learning by doing. *Rev. Econ. Stud.* **1962**, *29*, 155–173. [CrossRef]
15. Romer, P.M. Increasing Returns and Long-Run Growth. *J. Polit. Econ.* **1986**, *94*, 1002–1037. [CrossRef]
16. Jacobs, J. *The Economy of Cities*; Vintage: New York, NY, USA, 1969.
17. Diebold, W.; Porter, M.E. The Competitive Advantage of Nations. *Foreign Aff.* **1990**, *69*, 180. [CrossRef]
18. Seto, K.C.; Fragkias, M.; Guneralp, B.; Reilly, M.K. A meta-analysis of global urban land expansion. *PLoS ONE* **2011**, *6*, e23777. [CrossRef] [PubMed]
19. Sexton, J.O.; Song, X.; Huang, C.; Channan, S.; Baker, M.E.; Townshend, J.R. Urban growth of the Washington, D.C.-Baltimore, MD metropolitan region from 1984 to 2010 by annual, Landsat-based estimates of imperious cover. *Remote Sens. Environ.* **2013**, *129*, 42–53. [CrossRef]
20. Li, G.; Sun, S.; Fang, C. The varying driving forces of urban expansion in China: Insights from a spatial-temporal analysis. *Landsc. Urban Plan.* **2018**, *174*, 63–77. [CrossRef]
21. Zhang, Z.; Su, S.; Xiao, R.; Jiang, D.; Wu, J. Identifying determinants of urban growth from a multi-scale perspective: A case study of the urban agglomeration around Hangzhou Bay, China. *Appl. Geogr.* **2013**, *45*, 193–202. [CrossRef]
22. Kuang, W.; Chi, W.; Lu, D.; Dou, Y. A comparative analysis of megacity expansions in China and the U.S.: Patterns, rates and driving forces. *Landsc. Urban Plan.* **2014**, *132*, 121–135. [CrossRef]
23. Wu, W.J.; Zhao, S.Q.; Zhu, C.; Jiang, J.L. A comparative study of urban expansion in Beijing, Tianjin and Shijiazhuang over the past three decades. *Landsc. Urban Plan.* **2015**, *134*, 93–106. [CrossRef]
24. Peng, J.; Zhao, M.; Guo, X.; Pan, Y.; Liu, Y. Spatial-temporal dynamics and associated driving forces of urban ecological land: A case study in Shenzhen City, China. *Habitat Int.* **2017**, *60*, 81–90. [CrossRef]
25. Wei, C.; Taubenböck, H.; Blaschke, T. Measuring urban agglomeration using a city-scale dasymetric population map: A study in the Pearl River Delta, China. *Habitat Int.* **2017**, *59*, 32–43. [CrossRef]
26. Dutta, I.; Das, A. Modeling dynamics of peri-urban interface based on principal component analysis (PCA) and cluster analysis (CA): A study of English Bazar Urban Agglomeration, West Bengal. *Model. Earth Syst. Environ.* **2018**, *5*, 613–626. [CrossRef]

27. Duta, I.; Das, A. Exploring the dynamics of spatial inequality through the development of sub-city typologies in English Bazar Urban Agglomeration and its peri urban areas. *GeoJournal* **2019**, *84*, 829–849. [CrossRef]
28. Pan, H.; Page, J.; Zhang, L.; Chen, S.; Cong, C.; Destouni, G.; Kalantari, Z.; Deal, B. Using comparative socio-ecological modeling to support Climate Action Planning (CAP). *J. Clean. Prod.* **2019**, *232*, 30–42. [CrossRef]
29. Pan, H.; Zhang, L.; Cong, C.; Deal, B.; Wang, Y. A dynamic and spatially explicit modeling approach to identify the ecosystem service implications of complex urban systems interactions. *Ecol. Indic.* **2019**, *102*, 426–436. [CrossRef]
30. Gennaio, M. Political Driving Forces of Urban Change in the Region Agglomeration Obersee. Ph.D. Thesis, Department of Geography, University of Zurich, Zürich, Switzerland, 2008.
31. Salem, M. Peri-urban dynamics and land-use planning for the Greater Cairo Region in Egypt. *Wit Trans. Built Environ.* **2015**, *168*, 109–119.
32. Garcia-Ayllon, S.; Miralles, J.L. New Strategies to Improve Governance in Territorial Management: Evolving from "Smart Cities" to "Smart Territories". *Procedia Eng.* **2015**, *118*, 3–11. [CrossRef]
33. Yu, W.; Zhou, W. Spatial pattern of urban change in two Chinese megaregions: Contrasting responses to national policy and economic mode. *Sci. Total Environ.* **2018**, *634*, 1362–1371. [CrossRef] [PubMed]
34. Feitelson, E.; Felsenstein, D.; Razin, E.; Stern, E. Assessing land use plan implementation: Bridging the performance-conformance divide. *Land Use Policy* **2017**, *61*, 251–264. [CrossRef]
35. Yu, J.; Zhou, K.; Yang, S. Land use efficiency and influencing factors of urban agglomerations in China. *Land Use Policy* **2019**, *88*, 1–12. [CrossRef]
36. Long, Y.; Gu, Y.; Han, H. Spatiotemporal heterogeneity of urban planning implementation effectiveness: Evidence from five urban master plans of Beijing. *Landsc. Urban Plan.* **2012**, *108*, 103–111. [CrossRef]
37. Tian, L.; Shen, T. Evaluation of plan implementation in the transitional China: A case of Guangzhou city master plan. *Cities* **2011**, *28*, 11–27. [CrossRef]
38. Wang, M.; Krstikj, A.; Koura, H. Effects of urban planning on urban expansion control in Yinchuan City, Western China. *Habitat Int.* **2017**, *64*, 85–97. [CrossRef]
39. Fujita, M.M.; Krugman, P.; Venables, A.J. *The Spatial Economy-Cities, Regions and International Trade*; The MIT Press: London, UK, 1999.
40. Fujita, M.M.; Thisse, J.F. *Economics of Agglomeration-Cities, Industrial Location and Regional Growth*; Cambridge University Press: Cambridge, UK, 2002.
41. Richard, E.B.; Toshihiro, O. Heterogeneous firms, agglomeration and economic geography: Spatial selection and sorting. *J. Econ. Geogr.* **2006**, *6*, 323–346.
42. Bai, J.; Wang, P. *Identification and Estimation of Dynamic Factor Models*; Discussion paper No. 1112-06; Department of Economics, Columbia University: New York, NY, USA, 2012.
43. Chung, S.; Hewings, G.J. Competitive and Complementary Relationship between Regional Economies: A Study of the Great Lake States. *Spat. Econ. Anal.* **2015**, *10*, 205–229. [CrossRef]
44. Glaeser, E.L.; Kallal, H.D.A.; Scheinkman, J.; Schleifer, A. Growth in cities. *J. Polit. Econ.* **1992**, *100*, 1126–1152. [CrossRef]
45. Henderson, J.V. Marshall's scale economics. *J. Urban Econ.* **2003**, *53*, 1–28. [CrossRef]
46. Greenstone, M.; Hornbeck, R.; Moretti, E. Identifying Agglomeration Spillovers: Evidence from Winners and Losers of Large Plant Openings. *J. Polit. Econ.* **2010**, *118*, 536–598. [CrossRef]
47. Bishop, P.; Gripaios, P. Spatial externalities, relatedness and sector employment growth in great Britain. *Reg. Stud.* **2010**, *44*, 443–454. [CrossRef]
48. Mameli, F.; Iammarino, S.; Boschma, R. Regional variety and employment growth in Italian labor market areas: Services versus manufacturing industries. *Pap. Evol. Econ. Geogr. (PEEG)* **2012**, *72*, 354–378.
49. Lucio, J.J.D.; José, A.H.; Goicolea, A. The effects of externalities on productivity growth in Spanish industry. *Reg. Sci. Urban Econ.* **2002**, *32*, 241–258. [CrossRef]
50. Simonen, J.; Svento, R.; Juutinen, A. Specialization and diversity as drivers of economic growth: Evidence from high-tech industries. *Pap. Reg. Sci.* **2015**, *94*, 229–247.
51. Kemeny, T.; Storper, M. Is specialization good for regional economic development? *Reg. Stud.* **2015**, *49*, 1003–1018. [CrossRef]
52. Evangelista, R.; Meliciani, V.; Vezzani, A. Specialization in key enabling technologies and regional growth in Europe. *Econ. Innov. New Technol.* **2017**, *27*, 273–273.

53. Melo, P.C.; Graham, D.J.; Noland, R.B. A meta-analysis of estimates of urban agglomeration economies. *Reg. Sci. Urban Econ.* **2009**, *39*, 332–342. [CrossRef]
54. Hendricks, L. The skill composition of US cities. *Int. Econ. Rev.* **2011**, *52*, 1–32. [CrossRef]
55. Behrens, K.; Robert-Nicoud, F. Agglomeration Theory with Heterogeneous Agents. *Handb. Reg. Urban Econ.* **2015**, *5*, 171–245.
56. Helsley, R.W.; Strange, W.C. Co agglomeration, clusters, and the scale and composition of cities. *J. Polit. Econ.* **2014**, *122*, 1064–1093. [CrossRef]
57. Ottaviano, G.I.P. 'New' new economic geography: Firm heterogeneity and agglomeration economies. *J. Econ. Geogr.* **2011**, *11*, 231–240. [CrossRef]
58. Combes, P.; Duranton, G.; Gobillon, L.; Puga, D.; Roux, S. The Productivity Advantages of Large Cities: Distinguishing Agglomeration from Firm Selection. *Econometrica* **2012**, *80*, 2543–2594.
59. Eeckhout, J.; Pinheiro, R.; Schmidheiny, K. Spatial Sorting. *J. Polit. Econ.* **2014**, *122*, 554–620. [CrossRef]
60. Behrens, K.; Duranton, G.; Robert-Nicoud, F. Productive Cities: Sorting, Selection, and Agglomeration. *J. Polit. Econ.* **2014**, *122*, 507–553. [CrossRef]
61. Desmet, K.; Henderson, J.V. The Geography of Development within Countries. In *Handbook of Regional and Urban Economics*; Duranton, G., Vernon Henderson, J., Strange, W.C., Eds.; Elsevier BV: Amsterdam, The Netherlands, 2015; Volume 5, pp. 1457–1517.
62. National Development and Reform Commission of China. Available online: http://www.ndrc.gov.cn/zcfb/zcfbghwb/ (accessed on 19 April 2016).
63. Fang, G.; Wang, X.L.; Zhu, H.P. *NERI Index of Marketization of China's Provinces 2011 Report*; Economic Science Press: Beijing, China, 2011.
64. Wang, X.L.; Fang, G.; Yu, J.W. *Marketization Index of China's Provinces: NERI Report 2016*; Social Science Literature Press: Beijing, China, 2017.
65. Wang, X.L.; Fang, G.; Yu, J.W. *Marketization Index of China's Provinces: NERI Report 2018*; Social Science Literature Press: Beijing, China, 2019.
66. Pain, K.; Van Hamme, G.; Vinciguerra, S.; David, Q. Global networks, cities and economic performance: Observations from an analysis of cities in Europe and the USA. *Urban Stud.* **2016**, *53*, 1137–1161. [CrossRef]
67. Shan, H.J. Re-estimation of China's capital stock K: 1952–2006. *Quant. Econ. Technol. Econ. Res.* **2008**, *10*, 17–31.
68. Fledman, M.P.; Audretsch, D.B. Innovation in cities: Science-based diversity, specialization and localized competition. *Eur. Econ. Rev.* **1999**, *43*, 409–429.
69. Duranton, G.; Puga, D. Diversity and specialization in cities: Why, where and when does it matter? *Urban Stud.* **2000**, *37*, 533–555. [CrossRef]
70. Lin, X.; Wang, Y. Measuring Resource, Environmental, and Economic Efficiency of China's Urban Agglomerations Based on Hybrid Directional Distance Function. *J. Urban Plan. Dev.* **2019**, *145*, 05019011. [CrossRef]
71. Kuo, H.-F.; Tsou, K.-W. Application of Environmental Change Efficiency to the Sustainability of Urban Development at the Neighborhood Level. *Sustainability* **2015**, *7*, 10479–10498. [CrossRef]
72. Lu, X.H.; Kuang, B.; Li, J. Regional difference decomposition and policy implications of China's urban land use efficiency under the environmental restriction. *Habitat Int.* **2018**, *77*, 32–39. [CrossRef]



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