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Research on the Efficiency Calculation and Influencing Factors of New Urbanization in China

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Abstract: Scientific and systematic evaluation of the efficiency of new urbanization is an important basis to realize the high-quality development of new urbanization. Starting from the connotation of new urbanization, this paper takes population, economic, spatial, social indicators and environmental pollution indicators as expected outputs or unexpected outputs to construct an input-output model and calculates the efficiency of new urbanization in 239 prefecture-level cities in China from 2014 to 2019 by directional distance function (DDF) and Global Malmquist-Luenberger (GML) index. And it examines the main factors influencing the efficiency of new urbanization under environmental constraints by using a two-way fixed effect model. The results show that: with full consideration of environmental constraints, the efficiency of China's new urbanization shows a v-shaped growth trend and regional heterogeneity from 2014 to 2019. Especially, the effect of the national new urbanization strategy is more significant after 2017, which significantly improves the overall efficiency level of cities and towns. Population, FDI and savings level are the most important factors affecting the efficiency of new urbanization.

Keywords: China's urbanization; urbanization efficiency; direction distance function

JEL Classification: R00; R15; R42

1. Introduction

In the past four decades, China's unprecedented rapid urbanization has become an important engine driving economic growth and eliminating rural poverty. However, the long-term rapid urbanization process has also brought with it the aggravation of environmental pollution and the deterioration of urban governance, the expansion of urban-rural inequality, and the lag of population urbanization. The root cause lies in the tendency of blindly pursuing rapid growth in quantity in the past urbanization. The vigorous "city-building movement" and have resulted in a great waste of land and other factor resources, thus dragging down the efficiency and quality of urbanization. Efficiency is the core issue to be solved in the process of Urbanization in China. In 2013, the China Urbanization Conference put forwards the new urbanization strategy of "promoting people's urbanization as the core and improving quality as the guidance", marking that China has entered the new urbanization stage. Compared with traditional urbanization, new urbanization emphasizes the core role of human, highlights the transformation of the development way with high pollution and high energy consumption, pursues green, low-carbon, intelligent and sustainable high-quality development. Therefore, this paper tries to include the core index of human urbanization into the calculation of the new urbanization efficiency, and analyzes the influencing factors of new urbanization efficiency under the constraints of environmental protection, which represents the requirements of sustainability.

Most of the existing literatures used non-parametric methods to calculate China's urbanization efficiency, especially data Envelopment analysis (DEA) and Malmquist index model (ML). The general conclusion is that China's urbanization efficiency is chronically low and growth is slow (Huang, 2015). A few literatures use stochastic frontier function (SFA) to study regional urbanization efficiency and the influence of various factors under specific applicable conditions (Dai, 2012). The core of DEA model is to use linear programming to project the decision unit (DMU) onto the DEA frontier and judge its validity by comparing its deviation from the optimal frontier. Therefore, the selection of the direction distance function is the key to measure the scientific nature of measurement. To solve this problem, the traditional radial DEA model is widely used in existing literatures (Nie & Jia, 2011), but this model is difficult to solve the measurement error caused by ignoring relaxation variables (Wei, 2014). In a small number of literatures that choose non-radial DEA model, the selected distance function is not suitable for research purposes (Wan, 2015). In our paper, we use DDF and GML index models to measure the efficiency of new urbanization, which can effectively avoid the above problems.

The follows of the paper is: Section 2 introduces the research methods and data description; Section 3 calculates the efficiency of new urbanization; Section 4 analyzes the influencing factors; Section 5 gives the concluding comments and suggestions.

2. Methodology and Data

2.1. Calculation Model

We use DDF-GML model to Calculation of the efficiency of new urbanization. DDF-GML is an important method in the field of efficiency measurement. Among them, DDF is essentially a general expression of the radial DEA model (Chung, 1997). GML index is constructed by Oh (2010). Due to the limitation of the length of the article, the mathematical derivation of the model is shown in the appendix.

2.2. Data Description and Index Selection

Based on the above Calculation model, this paper calculates the new urbanization efficiency of 239 prefecture-level cities in China from four dimensions of population, economy, space and society. The original data of relevant indicators come from "China Urban Statistical Yearbook", "China Urban and Rural Construction Statistical Yearbook", provincial and municipal statistical yearbook, CEIC database and Wind database, and interpolation method is used to supplement some missing data. In Table 1 and Table 2 (see below), there is a detailed description of input-output variable selection and data adoption.

3. Efficiency Measurement Results of China's New Urbanization

According to the above measurement method of directional distance function and GML productivity index, we calculate the new urbanization efficiency of 239 prefecture-level cities in China. In order to facilitate in-depth analysis of the changes of production frontier boundary of China's new urbanization efficiency and further explore its dynamic evolution trend, we decompose the total factor productivity of new urbanization into two parts: technical efficiency change (EC) and technological progress change (TC) by using the Global Malmquist-Luenberger (GML).

Table 1. Selection of input-output indicators of new urbanization efficiency

Intension	Variable means	Specific calculation method
Input index	Non-agricultural labor	Non-agricultural industrial employees/ten thousand
	Capital investment	Actual fixed assets investment / 100 million yuan
	Land input	Built-up area/km2
	Energy resources	The city's electricity consumption/ten thousand kWh
Expected output	Population Urbanization	(permanent urban population/total resident population)×100
	Economic Urbanization	Actual per capita GDP/ yuan
	Spatial Urbanization	(built-up area/land area of municipal district)×100
	Social Urbanization	(per capita disposable income of urban residents/rural income)
Unexpected output	Waste water pollution	Waste water discharge/ten thousand tons
	Exhaust pollution	Sulfur dioxide emissions/ton
	Smoke (powder) dust pollution	Powder (smoke) dust emissions/ton

Table 2. Descriptive statistics of input-output indicators of new urbanization efficiency

Input-output indicators		Maximum	Minimum	Mean	Standard Deviation
Input index	Non-agricultural labor	420.72	1.38	29.28	43.52
	Capital investment	7,739.60	21.65	1,225.72	1,129.48
	Land input	1,249.00	13.00	116.68	127.93
	Energy resources	8,235,701.43	9,754.00	810,254.20	1,060,220.00
Expected output	Population Urbanization	94.95	21.4	52.60	14.05
	Economic Urbanization	22.89	0.58	4.21	2.74
	Spatial Urbanization	94.85	0.30	9.20	10.46
	Social Urbanization	4.63	0	2.50	0.52
Unexpected output	Waste water pollution	86,804.00	7.00	7,089.42	7,886.88
	Exhaust pollution	496,377.00	2.00	52,933.62	46,797.19
	Smoke (powder) dust pollution	5,168,812.00	34.00	41,151.19	182,881.80

3.1. Efficiency Trend of China's New Urbanization at the National Level

Table 3 shows the dynamic change trend and decomposition results of new urbanization efficiency at the national level from 2014 to 2019. It is not difficult to see that, with full consideration of undesired output, the efficiency of new urbanization at the national level from 2014 to 2019 presents a v-shaped growth trend and significant stage characteristics. On the whole, the annual growth rate of new urbanization efficiency reached 2.88%. In terms of stages, it can be divided into two stages with completely different characteristics and obvious differences in situation.

Table 3. Efficiency and decomposition of China's new urbanization from 2014 to 2019

Year	GML	EC	TC
2014	1.0320	0.9927	1.0593
2015	0.9890	1.0782	0.9317
2016	1.0149	1.0573	0.9660
2017	1.0388	1.0150	1.0405
2018	1.0305	0.9730	1.0746
2019	1.0675	1.0402	1.0441
2014-2016	1.0120	1.0427	0.9857
2017-2019	1.0456	1.0093	1.0531
Overall Average	1.0288	1.0260	1.0194

3.2. Efficiency Differences of China's New Urbanization at City Levels

In order to further analysis due to the individual heterogeneity between different cities new urbanization efficiency difference, we divide cities into different type by population size.

Table 4 shows the efficiency and decomposition results of new urbanization of Different Cities in China from 2014 to 2019. On the whole, the four types of cities in China show a trend of improving the efficiency of new urbanization, with their annual growth rate (from large to small) reaching 1.81%, 3.26%, 4.37% and 1.23% respectively. On the other hand, the efficiency of new urbanization in large cities and medium-sized cities is 2.88%, which is higher than the average level of the whole city, and significantly higher than megacities and small cities. To be specific, the efficiency improvement of big cities mainly comes from technological progress, with an average annual growth rate of 3.94%. The high quality of urbanization in medium-sized cities benefits from the technical efficiency. This shows that the current effect of promoting the new urbanization process in large and medium-sized cities is good. On the other hand, the efficiency of new urbanization in megacities and small cities lags behind the national average. The low efficiency of small cities is mainly rooted in the weak foundation of their own economic development, which is difficult to rely on the improvement of economic level and promote spontaneously, thus resulting in the phenomenon of extensive expansion led by administration. However, megacities are basically regional central cities, and the level of public service facilities at the present stage cannot meet the needs of rapid urbanization development, which leads to a series of "urban diseases", resulting in low urbanization efficiency.

Table 4. New urbanization efficiency and its decomposition by city from 2014-2019

Year	Megalopolis			Big city			Medium city			Small city		
	GML	EC	TC	GML	EC	TC	GML	EC	TC	GML	EC	TC
2014	1.025	0.982	1.044	1.060	0.966	1.133	1.020	0.992	1.046	1.022	1.014	1.018
2015	1.016	1.019	0.999	0.998	1.065	0.951	1.016	1.140	0.909	0.953	1.034	0.932
2016	1.007	1.023	0.985	1.008	1.047	0.972	1.050	1.094	0.967	0.986	1.032	0.959
2017	1.047	0.998	1.050	1.025	0.967	1.080	1.043	1.023	1.044	1.044	1.044	1.006
2018	0.993	0.986	1.007	1.035	0.978	1.076	1.052	0.981	1.093	1.008	0.960	1.061
2019	1.019	1.002	1.017	1.067	1.076	1.023	1.080	1.046	1.047	1.060	1.011	1.059
2014-2016	1.016	1.008	1.009	1.022	1.026	1.019	1.029	1.075	0.974	0.987	1.027	0.970
2017-2019	1.020	0.995	1.025	1.043	1.006	1.060	1.058	1.017	1.061	1.038	1.005	1.042
Total	1.018	1.001	1.017	1.033	1.017	1.039	1.043	1.046	1.018	1.012	1.016	1.006

4. The Influencing Factors of China's New Urbanization Efficiency

4.1. Selection of Influencing Factors of New Urbanization Efficiency

Based on the above new urbanization GML index calculation results, we mainly select the following influencing factors to explore their impact on the efficiency of new urbanization:

(1) Government role. In the process of China's economic development, the government plays a crucial role (Lin, 2002). (2) Industrial structure. The industrial structure reflects the mode of urban economic growth and division of labor between cities. The jobs brought by urban industries are the fundamental driving force of urbanization (Lu, 2011). (3) Demographic factors. Population agglomeration is an important driving force for urban development and realization of scale economy. (4) Degree of opening-up. The ability of a city to attract foreign direct investment not only reflects the level of openness and internationalization of a city, but also represents the attraction of attracting all kinds of talents and capital. (5) Savings level. Urbanization process is an important factor affecting the savings rate of urban and rural residents. Urbanization can bring about the decline of the national savings rate through economic growth and economic structure. (6) Infrastructure level. Infrastructure modernization is an important symbol of urban development, and its allocation level directly affects the capacity of a city to attract foreign capital, population, technology and other factors. Table 5 below shows the specific forms of variables.

Based on the practices of Jin (2016), this paper constructs a two-way fixed effect model using panel data to test the effects of various influencing factors on the efficiency of new urbanization.

$$Y_{it} = \beta_0 + \beta_i X_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (1)$$

Y_{it} is the explained variable, and the logarithm value of the cumulative GML index of new urbanization measured above is selected to measure the influence of all influencing factors on the efficiency of new urbanization. Subscripts *I* and *T* respectively represent the *I* city and *t* year, γ_t represents the time-fixed effect, μ_i represents the individual fixed effect of prefecture-level cities, and X_{it} is the above influencing factors. Including the role of government, industrial structure, demographic factors, degree of openness, savings level and infrastructure level. In the above model, we focus on the estimated value of the coefficient β_i, which measures the net impact of each influencing factor on the efficiency of new urbanization.

Table 5. New urbanization efficiency and its decomposition by city from 2014-2019

Influence factor	Variables Represent	Specific calculation method
Role of government	Gov	(government expenditure/regional GDP) x 100
Industrial structure	Na-Industry	(Output value of regional secondary and tertiary industries/Regional GDP)×100
Demographic factors	POP	The population density of pop municipal districts is logarithmi
Degree of Openness	FDI	regional actual utilization of foreign direct investment/Regional GDP)×100
Savings level	Save	(total savings of urban and rural residents/Regional GDP)×100
Level of infrastructure	Infra	Per capita paved road area is logarithmic

Table 6. Estimated results of influencing factors of regional new urbanization efficiency by region

Variables	All region	Eastern region	Central region	Western region
	(1)	(2)	(3)	(4)
gov	0.0022	0.0072*	0.0040	-0.0009
	(0.9876)	(1.9609)	(0.4712)	(-0.3339)
Na-industry	-0.000042	0.000469	0.000930	-0.001159
	(-0.0636)	(0.6119)	(0.5471)	(-0.8715)
pop	0.1801***	0.1980***	0.1679***	0.2229***
	(8.4948)	(6.2995)	(5.0571)	(3.7845)
fdi	0.0201***	0.0332***	0.0263	-0.0213
	(2.6787)	(4.2043)	(1.4765)	(-1.1964)
save	-0.0022***	0.0004	-0.0041***	-0.0002
	(-2.9251)	(0.2941)	(-2.7530)	(-0.1810)
infra	0.0112	0.0020	0.0995***	-0.0359
	(0.6937)	(0.0952)	(2.6587)	(-1.2031)
Year FE	YES	YES	YES	YES
Region FE	YES	YES	YES	YES
Observations	1,422	583	413	426
$R-\text{squared}$	0.132	0.283	0.127	0.165

Note: The values in brackets are T-values; *, ** and ** are significant at the significance level of 10%, 5% and 1%, respectively.

4.2. Results of Influencing Factors of New Urbanization Efficiency

Table 6 shows the regression results of influencing factors of regional new urbanization efficiency. Column (1) shows the influence of various factors on the efficiency of new urbanization in all cities. Columns (2) to (4) show results in the samples of three regions. By observing the characteristics of the influence of various factors on urbanization efficiency, the following conclusions can be drawn:

(1) From a comprehensive perspective, population factors, the level of opening and the level of savings are the most important factors affecting the efficiency of new urbanization. Among them, no matter in the analysis of the whole sample or by region, the population factor plays a huge role in promoting the efficiency of new towns, which is significantly positive at 1%. The degree of opening-up is also an important variable to improve the efficiency of new urbanization, especially in the eastern coastal cities where foreign capital is most widely utilized. Savings level has a negative effect on the city's urbanization efficiency.

(2) The government plays a positive role in the efficiency of new urbanization. The government-led urbanization promotion mode is the fundamental difference between Chinese urbanization and that of European and American countries (Wang & Zhang, 2014). Although the coefficient result of the empirical whole is not significant, it is obviously positive, and in the sample of the eastern region, its coefficient result is significant and higher than the overall coefficient. This shows that, the prefecture-level cities in the east have greater motivation to promote the new urbanization process more effectively by relying on their rich financial resources.

(3) The developed level of urban infrastructure promotes the improvement of urbanization efficiency, and its influence is very significant in the central region. Although industrial structure factors play a significant role in the efficiency of new urbanization in theory, the empirical results are not significant.

Table 7. Estimated results of influencing factors of regional new urbanization efficiency by city

Variables	**Megalopolis**	**Big city**	**Medium city**	**Small city**
	(1)	(2)	(3)	(4)
gov	0.0185	0.0042	0.0025	0.0028
	(1.0837)	(0.6144)	(0.3458)	(1.1775)
Na-industry	0.000803	-0.000399	0.000135	-0.000603
	(0.4965)	(-0.3937)	(0.1113)	(-0.5528)
pop	0.1279	0.4071***	0.2015***	-0.0649*
	(1.7021)	(14.7220)	(4.6294)	(-1.7124)
fdi	0.0104	0.0234**	0.0431***	0.0069
	(0.7677)	(2.0002)	(2.8035)	(0.5422)
save	-0.0018	-0.0007	-0.0022	-0.0017
	(-0.8894)	(-0.5230)	(-1.4370)	(-1.5318)
infra	0.0538	0.0034	-0.0158	0.0290
	(1.0525)	(0.1004)	(-0.4589)	(1.2251)
Year FE	YES	YES	YES	YES
Region FE	YES	YES	YES	YES
Observations	39	380	494	503
R-squared	0.547	0.463	0.205	0.079

Note: The values in brackets are T-values; *, ** and ** are significant at the significance level of 10%, 5% and 1%, respectively.

Table 7 implies the regression results of influencing factors of urban new urbanization efficiency. Columns (1) to (4) correspond to the effects of influencing factors on new urbanization efficiency under the different samples. The results show that the population factor and the degree of opening to the outside play a significant role in promoting cities of different sizes.

5. Conclusions

This paper estimates the efficiency of new urbanization in 236 China's cities, and analyzes its influencing factors. The results imply that the efficiency of China's new urbanization shows a v-shaped growth trend and significant spatial and regional differences when fully considering the undesired output. Although the efficiency growth rate in the eastern region is not as high as that in other regions, the eastern regional cities can promote the new urbanization process more stably by relying on their strong local financial resources and market resources advantages. And analysis of influencing factors tells us that Population, FDI and savings level are the most important factors affecting the efficiency of new urbanization.These research conclusions will provide a very important empirical evidence for China to better promote new urbanization.

Conflict of interest: none

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Appendix

The Introduction of Directional distance function (DDF) and Global Malmquist-Luenberger index (GML)

1. Directional distance function (DDF)

Directional distance function (DDF) is essentially a generalized expression of radial DEA model. Its advantage lies in that the direction of the projection of the evaluated DMU in the production front can be customized by the researcher, so that the desired industry and undesired output can be effectively treated differently. Therefore, DDF is introduced into the calculation of new urbanization efficiency. We defined $\vec{g} = (\vec{g}_x, \vec{g}_y, \vec{g}_b)$as the directional vectors of various input and output variables, then the corresponding directional distance function of the t period is in the form of:

$$\vec{D}^t(x^t, y^t, b^t, \vec{g}) = max\{\beta|(x^t - \beta\vec{g}_x, y^t + \beta\vec{g}_y, b^t - \beta\vec{g}_b) \in P(x)\}$$

x^t, y^t, b^t respectively represent factor input vector, expected output vector and unexpected output vector of t period; Is the vector of the inefficient term, and represents the directional distance function value of the maximum expected output and minimum unexpected output in the t period. According to the directional vector $\vec{D}^t(x^t, y^t, b^t, \vec{g})$, we can clearly judge the effectiveness of input-output. $\vec{D}^t(x^t, y^t, b^t, \vec{g}) = 0$ Indicates that the input-output efficiency of DMU has reached the optimal under the given conditions of input factors. At that time, $\vec{D}^t(x^t, y^t, b^t, \vec{g}) > 0$ indicates that the input-output efficiency still has potential room for improvement, and the higher its value is, the lower the efficiency is and the greater the room for improvement is. Therefore, based on the specific direction distance function, we can build a new urbanization efficiency model based on non-expected output and expected output.

2. Global Malmquist- Luenberger index

GML index is constructed by Oh (2010) by combining the Global Malmquist productivity concept and malmquist-Luenberger index method. Its purpose is to solve the defects of DDF-ML index constructed by Chung (1997) in measuring productivity. This paper uses it as an effective method to measure the efficiency of new urbanization. According to the GML index constructed by Oh (2010), the GML productivity index between the t period and the $t+1$ period is defined as:

$$GML^{t,t+1}(x^t, y^t, b^t, x^{t+1}, y^{t+1}, b^{t+1}) = \frac{1 + D^G(x^t, y^t, b^t)}{1 + D^G(x^{t+1}, y^{t+1}, b^{t+1})}$$

$D^G(x, y, b) = max\ \{\beta|(y + \beta y, b - \beta b) \in P^G(x)\}$ is the global directional distance function; $P^G(x)$is the global production possibility set, which is the union of all current production possibility sets; $GML^{t,t+1}$is the total factor productivity from period t to period $t+1$, when $GML^{t,t+1} > 0$, it means that the total factor productivity increases; when $GML^{t,t+1} < 0$,it means that the total factor productivity decreases; when $GML^{t,t+1} = 0$,it means that the total factor productivity remains unchanged. Further, similar to ML index, the index can be divided into two parts: change in technical efficiency (EC) and technological progress (BPC or TC):

$$GML^{t,t+1}(x^t, y^t, b^t, x^{t+1}, y^{t+1}, b^{t+1}) = \frac{1 + D^G(x^t, y^t, b^t)}{1 + D^G(x^{t+1}, y^{t+1}, b^{t+1})}$$

$$= \frac{1 + D^t(x^t, y^t, b^t)}{1 + D^{t+1}(x^{t+1}, y^{t+1}, b^{t+1})} \times \left[\frac{1 + D^G(x^t, y^t, b^t)}{1 + D^G(x^{t+1}, y^{t+1}, b^{t+1})} \times \frac{1 + D^{t+1}(x^{t+1}, y^{t+1}, b^{t+1})}{1 + D^G(x^t, y^t, b^t)}\right]$$

$$= \frac{TE^{t+1}}{TE^t} \times \frac{BPG_{t+1}^{t,t+1}}{BPG_t^{t,t+1}} = EC^{t,t+1} \times BPC^{t,t+1}$$

$EC^{t,t+1}$ represents the change of technical efficiency from the t period to the $t+1$ period. Its plus and minus respectively represent the improvement and deterioration of technical efficiency. $BPC^{t,t+1}$ is the ratio of the closeness of the frontier in phase t to the global frontier and the closeness of the frontier in phase $t+1$ to the global frontier, and represents the technological progress in two periods. Its plus and minus signs respectively represent technological progress and regression.