Urban Construction Land Deployment Based on Ecological Efficiency Malmquist Index

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Abstract
Rational allocation of the urban construction land is an important task of urbanization in China. This paper, based on Malmquist index model, studies the allocation scheme of construction land of China during urbanization with the carbon emissions caused by the urban land use change as constraints. The major finding of this study is that the ecological efficiency of urban construction land in eastern China is the highest, followed by the middle region, and the efficiency in western China is the lowest. Therefore, the eastern region of China should be allocated with more construction land and the weatern region should be

allocated with more agricultural land.

Key words: ECOLOGICAL EFFICIENCY, URBANIZATION, CARBON EMISSION, CONSTRUCTION LAND, MALMQUIST INDEX.

1. Introduction

Since the 1970s, people began to pay close attention to researches on global carbon cycle, especially on the human activities which lead to the rise of global warming and carbon emissions, such as the influence of the burning of fossil fuels and land use activities on carbon emissions[1]. The change of the land use mode is one of the human driving factors which impact the carbon cycle of terrestrial ecosystem greatly. It has the second largest effect on the increase of atmospheric CO_2 concentration while the largest influencing factor is the burning of fossil fuels[2]. The change of land use mainly has two impacts on soil : one is the direct impact on the distribution and content of soil organic carbon; the other is the indirect influence on it by influencing factors associated with the formation and transformation of soil audience.[3] Unscientific land use leads to the release of carbon into the atmosphere and the increase of atmospheric CO_2 concentration which will has further influence on the global warming and climate change.[4] Therefore, the mechanism and effect of carbon emission caused by the change of land use is a widely researched topic nowadays.

The change of cultivated land to construction land is the major reason for the reducing number of carbon in vegetation. However, different regions have different influence on carbon in vegetation and land use mode.[5] The change of the agricultural land and unused land to construction land will also affect soil carbon pool. The process of more land converted as habitations leads to the development and expansion of cities and towns, causing the mechanical disturbance of the soil, which will further lead to phenomena such as the burying or collecting of soil and influence the soil carbon pool eventually. In recent years, for example, the contribution rate of construction land on carbon emissions in Jiangsu province remained a very high level. The highest one has reached more than 96%. The carbon emission of construction land in Jiangsu province reaches 0.109 PgC per year [6].

In recent years, many scholars have done multi-scale research from multiple perspectives on the relationship between land use and the mechanism of the morphological change of the carbon, such as the research on the effect of land-use change to the emissions of greenhouse gases in America by Searchinger T, and other scholars [7]. Krankinad researches on the carbon stores, sinks, and sources in forests of northwestern Russia based on statistics and remote sensing data [8]. Zhou Tao analyses the indirect influence of land-use change on the soil carbon stocks [9]. Wang Shaoqiang calculated and did spatial analysis of the soil carbon stocks of northeast China [10]. Li Hu combined sample experiment method and the DNDC model as a way to analyze and predict farmland soil carbon emission of China on which the wheat and cotton are mainly cultivated [11]. Shang Jie optimized the land use mode of Tongyu, Jilin province based on the calculation of carbon stocks of different land use modes [12].

From the researches listed above, two conclusions can be received. One is that most studies are mainly concentrated on a single angle or on national scale, or only on the data analysis, thus failing to analyze the regional carbon balance and the adjustment of land use mode on quantitate level as well as on spatial layout; the other is that the analyses of carbon emissions of land use are based on total factor ecological efficiency rather than on a single factor ecological efficiency. These two conclusions show that the calculation results of ecology efficiency of urban construction land might not be so accurate, leading to an unscientific allocation scheme of construction land.

2. Methodology and Model Building

2.1 Eco-environmental Technology

The production process of economic system is accompanied by the input of various resources. Some products are desirable (known as good output) while some are undesirable (known as bad output). Assuming that the combination of three traditional inputs — capital (*K*), labor force (*L*), territory (*T*) can produce an expected output, gross domestic product (*Y*) and a non-expected output, CO_2 (*C*), the production process is expressed in the Formula $P(x)=\{(Y,C):(K,L,T,Y,C)\in T\}$, among which T refers to the technical relation in the production process and $P(K,L,T)$ refers to the output set. This Formula conforms to traits of closed, bounded and convexity namely limited input cannot get an unlimited output. If two groups of outputs can be obtained, then the random weighted average of these outputs can also be obtained. The $P(x)$ quality is according to Cui Wei (2012) [13].

The theory above combines expected output and unexpected output effectively and deeply analyzes the production technology of eco-environment. However, it lacks applicability and can not be applied to empirical study. Only the combination of this theory with DEA technology can applicability be obtained (Chung, *Färe* and Grosskopf,1997) [14]. According to the DEA by Zhou, Ang and Poh (2008) [15], assuming the number of decision-making unit (DMU) is I, the input-output of region i is (K,L,T,Y,C), the Formula (1) of productive process under the condition of constant returns to scale can be expressed as

$$\begin{aligned}
&P(K,L,T)=\{(K,L,T,Y,C)\}\\
&\sum_{i=1}^{I}\lambda_i K_i \le K;\sum_{i=1}^{I}\lambda_i L_i \le L;\sum_{i=1}^{I}\lambda_i T_i \le T\\
&\sum_{i=1}^{I}\lambda_i Y_i \ge Y\\
&\sum_{i=1}^{I}\lambda_i C_i = C\\
&\lambda_i \ge 0, i=1,2,\cdots,I
\end{aligned} \tag{1}$$

Among which, λ_i is the evaluation unit DMU$_i$ of unit i of the newly constructed group DMU comparing to DMU$_{0.}$ The Formula, $\lambda_i \ge 0$, means that production technology is the constant returns to scale. The inequality constraint in Formula (1) indicates that factor inputs and expected outputs have strong disposability while the equality constraint indicates the weak disposability of unexpected output and the null-jointers of the two kinds of outputs.

2.2 Malmquist Ecological Efficiency Index

Malmquist index can be obtained with the help of distance function. Cui Wei (2013) [16] presents detailed processing method. In Formula (2), according to Malmquist TFP index, the dynamic ecological efficiency of Malmquist index can be assumed as *MEI*, since MEI can use the technology of t period as well as t+1 period as reference. To avoid the differences of the results caused by different period chosen, the geometrical averages of period t and t+1 are used to measure the changes of CO$_2$ output of the two periods. Detailed explanations are presented in Formula (3).

$$MEI(t,t+1)=\left[\frac{D^{t}(K^{t},L^{t},T^{t},Y^{t},C^{t})\cdot D^{t+1}(K^{t},L^{t},T^{t},Y^{t},C^{t})}{D^{t}(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})\cdot D^{t+1}(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})}\right]^{\frac{1}{2}} \tag{2}$$

Set $(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})$ and set $(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})$ represent the input output quantity of period t and period t+1 respectively. D^{t} and D^{t+1} represent the distance function of ecological efficiency of period t and period t+1respectively with technology *T* (*t*) and technology *T*(*t*+1) as reference. Under the condition of constant returns to scale, Formula (3) can be presented as follows.

$$MEI(t,t+1)=\frac{D^{t+1}(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})}{D^{t}(K^{t},L^{t},T^{t},Y^{t},C^{t})}\left[\frac{D^{t}(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})\cdot D^{t}(K^{t},L^{t},T^{t},Y^{t},C^{t})}{D^{t+1}(K^{t},L^{t},T^{t},Y^{t},C^{t})\cdot D^{t+1}(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})}\right]^{\frac{1}{2}} \tag{3}$$

The specific values inside and outside the square brackets of the Formula's right side reflect technological progress index (*TECH*) and technical efficiency index (*EFFCH*) of period t and period t+1respectively, which are shown in Formula (4) and Formula (5). Formula (4) measures the investigated regions' degree of pursuing productive frontiers while Formula (5) measures the technical change situation from period t to period t+1. If *TECH* or *EFFCH* is larger than 1, they can be regarded as the source of the rise in ecological efficiency of unban non-agricultural land, or vice versa. If *MEI* is larger than 1, the ecological efficiency of unban non-agricultural land will rise, or vise versa.

$$TECH=\left[\frac{D^{t}(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})\cdot D^{t}(K^{t},L^{t},T^{t},Y^{t},C^{t})}{D^{t+1}(K^{t},L^{t},T^{t},Y^{t},C^{t})\cdot D^{t+1}(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})}\right]^{\frac{1}{2}} \tag{4}$$

$$EFFCH=\frac{D^{t+1}(K^{t+1},L^{t+1},T^{t+1},Y^{t+1},C^{t+1})}{D^{t}(K^{t},L^{t},T^{t},Y^{t},C^{t})} \tag{5}$$

If the dynamic Malmquist ecological efficiency index is wanted, the four distance functions of four periods' techniques are needed to be regarded as reference, and linear programming method needs to be applied. The single factor ecological efficiency index can be presented as Formula (6), among which, p and q are the periods and $p,q\in(t,t+1)$.

$$\begin{aligned}
&\left[D^{P}(K_i^{q},L_i^{q},T_i^{q},Y_i^{q},C_i^{q})\right]^{-1}=\min\rho\\
&s.t.\sum_{i=1}^{I}\lambda_i K_i^{p}\le K_i^{q};\sum_{i=1}^{I}\lambda_i L_i^{p}\le L_i^{q};\sum_{i=1}^{I}\lambda_i T_i^{p}\le \rho T_i^{q};\sum_{i=1}^{I}\lambda_i Y_i^{p}\ge Y_i^{q};\sum_{i=1}^{I}\lambda_i C_i^{p}=\rho C_i^{q}\\
&\lambda_i\ge 0, i=1,2,\cdots,I
\end{aligned} \tag{6}$$

3. Data Specification and Empirical Analysis

3.1 Data Sources and Specification

To make this research more scientific, this paper select the capital, labor force, territory of 28 provincial level administrative units of China from 2004-2013 as input, GDP as expected output and CO_2 as unexpected output. Data selection, processing methods and assumptions refer to Cui Wei (2013) [17]. Some data are from China Compendium of Statistics 1949-2008, China Statistical Yearbook, China City Statistical Yearbook, and China Statistical Yearbook on Environment. Some data specifications are shown in Table 1.

Table 1. Statistical Description of Different Regions' Input-output Index in 2004-2013

Index	Unit	Maximum Value	Minimum Value	Mid-value	Mean Value	Standard Deviation
Capital Stock(K)	A hundred million	23721.61	96.5	2356.05	3463.47	3544.14
Labor Force (L)	Ten thousand	4293.62	113.84	1098.62	1393.45	1002.16
Territory (T)	Hectare	646412.19	1017.72	33441.48	39848.62	42463.92
GDP(Y)	A hundred million	279.79	38.82	70.20	85.42	56.44
CO_2(C)	Ton	6806718.36	10709.01	352133.73	419605.98	447145.04

Data sources: statistical yearbook.

3.2 Empirical Analysis

Formula (3) and Formula (6) are used to calculate the ecological efficiency index (MI) of 28 provincial level administrative units' non-agricultural land under the condition of CO_2 emissions constraints. The results are shown in Table 2. Due to the limited space, 2004 in Table 2 means 2003-2004 and this method also goes to other time expression in Table 2, 3 and 4. Formula (4), together with Formula (6) and Formula (5), together with Formula (6) are used to calculate the changes in technical efficiency (EI) and technical progress (TI) of 28 provincial level administrative units' non-agricultural land. The results are shown in Table 3 and Table 4.

Table 2. MI of Different Regions' Non-agricultural Land

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Beijing	0.9349	1.0876	1.0214	1.0219	0.8041	1.0328	1.0908	0.7335	1.0160	1.0070
Tianjin	0.9454	0.7356	0.6796	0.9261	1.0370	1.0515	1.0954	1.2728	1.5770	0.6733
Hebei	1.1438	1.4274	0.9132	1.2280	0.9680	0.9272	0.9613	0.9816	0.7247	1.0000
Shanxi	0.9523	0.9405	0.8560	1.1148	0.9436	0.9487	0.8571	0.9660	0.9565	1.1667
Neimenggu	0.9193	0.9224	1.0083	1.0542	0.9411	0.9519	0.9547	0.9220	1.0854	1.0060
Liaoning	1.1325	1.2198	1.2385	0.7236	1.0105	0.8215	0.9179	1.3403	0.9012	1.5238
Jilin	1.1378	0.9524	1.0730	0.8128	0.9888	1.0029	0.9758	0.9731	0.9523	1.0889
Heilongjiang	0.9450	1.0076	0.9925	0.9458	0.9974	1.0051	0.9721	0.9455	0.8939	0.9524
Shanghai	0.9155	0.7207	1.3608	1.4382	0.9402	0.9413	0.9363	0.7604	1.0052	2.3611
Jiangsu	0.8421	1.5483	1.2319	0.9421	1.3483	1.4829	0.9493	1.2089	1.1262	0.7385
Zhejiang	0.7427	1.1624	1.1727	0.8667	0.9035	0.9703	0.8924	1.0558	1.0058	1.1667

Anhui	0.9813	1.0139	1.0180	1.4025	1.2821	0.7125	1.2121	1.0011	0.9464	1.5833
Fujian	1.3864	0.9249	1.0735	0.9241	0.7632	0.9999	1.0042	1.1556	0.8716	1.0833
Jiangxi	1.0092	1.2646	1.1894	1.2433	1.0654	0.9178	0.9329	0.7213	0.8836	0.7419
Shandong	0.9821	0.9210	0.9357	0.9032	0.7990	1.0014	0.9241	1.1841	0.6221	0.9231
Henan	1.0057	0.7749	1.0472	0.8970	0.9409	0.8901	0.9582	0.7444	0.6857	1.4795
Hubei	1.0692	1.0769	1.0192	0.8619	1.0025	0.9511	1.0380	0.8784	1.1645	1.3333
Hunan	1.1231	0.9902	0.9380	1.0900	1.1422	0.9731	1.2277	0.9689	0.8157	1.1111
Guangdong	0.8483	1.2197	0.9581	0.7987	1.0941	1.0097	0.9934	1.2249	1.0696	0.6000
Guangxi	1.0377	0.9278	0.7886	1.0063	1.1135	0.9854	0.8977	1.2054	0.9055	1.5625
Sichuan	1.1007	0.9629	0.6986	0.9832	1.0627	0.9539	0.8178	1.2579	0.8539	1.0353
Guizhou	0.8665	1.0274	0.8779	1.0251	1.7846	1.5395	0.9330	1.0932	0.9295	0.4800
Yunnan	0.9009	1.1448	1.3022	1.1826	0.9393	0.9561	0.9707	0.9792	1.0402	1.0000
Shaanxi	1.3328	1.0507	0.7983	1.2694	0.8298	0.9493	1.0271	1.0023	0.8770	0.9286
Gansu	1.1806	1.0046	0.9731	0.9864	0.9135	1.0116	1.0043	0.9982	0.9570	1.0833
Qinghai	1.2686	1.3659	0.9616	0.9724	0.8953	0.9636	0.9239	1.0012	1.0273	1.0000
Ningxia	0.8918	1.0106	0.9954	1.0194	0.9586	1.0171	0.7857	0.9825	1.0126	1.0000
Xinjiang	1.2235	1.0535	0.9075	0.8184	1.0798	0.9401	0.9415	0.8467	0.9004	1.2500
AVEC	0.9874	1.0967	1.0586	0.9773	0.9668	1.0239	0.9765	1.0918	0.9919	1.1077
AVCC	1.0279	1.0026	1.0167	1.0460	1.0454	0.9252	1.0217	0.8998	0.9123	1.1821
AVWC	1.0722	1.0470	0.9311	1.0317	1.0518	1.0269	0.9256	1.0289	0.9589	1.0346
AVWN	1.0293	1.0521	1.0011	1.0164	1.0196	0.9967	0.9713	1.0145	0.9574	1.1028

Data sources: calculation. (AVEC: Average value of the Eastern China; AVCC: Average value of the Central China; AVWC: Average value of the Western China; AVWN: Average value of the Whole Nation)

Table 3. EI of Different Regions' Non-agricultural Land

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Beijing	1.2000	1.1163	0.8194	0.9153	1.3519	0.8082	0.9746	1.3043	0.8000	1.0833
Tianjin	1.1577	1.1494	1.1300	0.8850	1.0000	1.0000	1.0000	0.7350	0.6871	1.4851
Hebei	0.7892	0.8224	1.2960	0.7654	1.3710	1.1176	0.8316	0.8861	1.3571	0.6842
Shanxi	1.0448	0.8722	1.3190	0.8105	1.2742	0.9937	1.1019	0.8092	1.0000	0.8571
Neimenggu	0.9879	1.1754	0.9925	1.0376	0.9638	1.0301	1.0219	0.9571	0.9701	0.9231
Liaoning	1.0398	0.8961	0.8043	1.5045	0.9401	1.1656	1.0601	0.6598	1.2500	0.7500
Jilin	0.7250	1.1488	0.9137	1.3307	0.9112	1.0584	1.0184	0.9458	0.8917	0.8571
Heilongjiang	1.0793	0.9850	1.0152	1.0000	1.0000	0.9950	1.0050	1.0000	1.0000	1.0000
Shanghai	1.0000	1.0000	0.6750	1.4296	1.0363	1.0000	1.0000	1.0000	0.8500	0.7059
Jiangsu	0.9715	0.8308	1.1976	1.0000	0.9700	0.9433	1.1585	0.7075	0.8000	1.2500
Zhejiang	1.3082	0.7603	1.0360	0.9826	1.5841	0.8156	1.2055	0.9432	0.8434	1.3571
Anhui	1.0840	1.0000	0.9650	0.8135	1.1465	1.6667	0.5267	1.0063	1.1950	0.6316
Fujian	0.6814	1.0342	0.9587	1.0259	1.3529	0.9814	0.8924	0.9078	1.0156	0.9231
Jiangxi	0.9600	0.9271	0.9438	0.9107	1.2157	1.0753	1.0000	1.0000	1.0000	1.0000

Shandong	0.8428	0.7718	1.1913	1.1825	0.9383	1.0855	1.1636	0.6667	2.0313	1.0000
Henan	0.7496	0.9130	0.9048	1.2105	1.2754	1.1250	0.8283	1.2866	1.4692	0.6452
Hubei	0.9211	1.0317	1.1231	1.1027	1.0435	1.0238	0.8779	1.1060	0.9581	0.7500
Hunan	0.8944	1.0407	1.1788	0.9479	1.0000	1.3650	0.8535	0.8584	1.0000	0.9000
Guangdong	0.9984	0.6935	0.9845	1.4252	1.0442	0.7566	1.2378	0.8079	0.8392	1.3333
Guangxi	0.8957	0.8857	1.2823	0.9811	1.0064	1.0510	0.9636	0.7736	1.2195	0.8000
Sichuan	0.7110	1.1193	1.0246	0.9360	1.4615	0.9357	1.3563	0.6820	1.4865	0.9091
GUIzhou	1.0977	1.0000	1.0000	1.0000	0.8200	1.0366	1.0059	0.8421	1.2500	1.1111
Yunnan	0.9452	0.8068	0.8662	0.9512	1.3077	1.0000	0.9477	0.9241	0.8955	1.0000
Shaanxi	0.6890	1.0952	1.5826	0.6319	1.3913	1.0000	0.9063	0.9103	0.9848	1.0769
Gansu	0.7412	0.9909	1.0183	1.0090	1.1875	0.9699	0.9690	0.9200	1.1304	0.8462
Qinghai	0.8817	0.7181	0.9907	1.0377	1.2364	0.9853	0.9627	0.9380	0.9091	1.0000
Ningxia	0.9442	0.7803	1.0291	0.9717	1.0777	1.0090	1.0089	0.9735	1.0000	1.0000
Xinjiang	0.9903	0.8271	1.1545	1.2205	0.8323	1.1628	0.9733	1.0479	0.9804	0.8000
AVEC	0.9989	0.9075	1.0093	1.1116	1.1589	0.9674	1.0524	0.8618	1.0474	1.0572
AVCC	0.8821	0.9223	1.0285	1.1381	1.1771	1.0466	0.9847	0.9252	1.2270	0.8708
AVWC	0.8884	0.9399	1.0941	0.9777	1.1285	1.0180	1.0116	0.8969	1.0826	0.9466
AVWN	0.9404	0.9426	1.0499	1.0364	1.1336	1.0413	0.9947	0.9143	1.0648	0.9528

Data sources: calculation.

Table 4. TI of Different Regions' Non-agricultural Land

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Beijing	0.7791	0.9743	1.2464	1.1165	0.5948	1.2778	1.1193	0.5624	1.2700	0.9295
Tianjin	0.8166	0.6399	0.6014	1.0464	1.0370	1.0515	1.0954	1.7317	2.2953	0.4534
Hebei	1.4494	1.7357	0.7047	1.6044	0.7060	0.8296	1.1560	1.1078	0.5340	1.4615
Shanxi	0.9115	1.0783	0.6490	1.3755	0.7405	0.9548	0.7778	1.1937	0.9565	1.3611
Neimenggu	0.9306	0.7847	1.0159	1.0160	0.9764	0.9241	0.9343	0.9633	1.1188	1.0898
Liaoning	1.0891	1.3612	1.5398	0.4809	1.0749	0.7048	0.8659	2.0313	0.7210	2.0317
Jilin	1.5694	0.8291	1.1743	0.6108	1.0851	0.9475	0.9582	1.0289	1.0679	1.2704
Heilongjiang	0.8755	1.0229	0.9776	0.9458	0.9974	1.0102	0.9673	0.9455	0.8939	0.9524
Shanghai	0.9155	0.7207	2.0160	1.0060	0.9073	0.9413	0.9363	0.7604	1.1826	3.3449
Jiangsu	0.8668	1.8635	1.0286	0.9421	1.3900	1.5720	0.8194	1.7085	1.4077	0.5908
Zhejiang	0.5677	1.5290	1.1319	0.8820	0.5704	1.1896	0.7403	1.1194	1.1926	0.8596
Anhui	0.9052	1.0139	1.0549	1.7240	1.1183	0.4275	2.3014	0.9948	0.7920	2.5069
Fujian	2.0346	0.8943	1.1198	0.9008	0.5641	1.0189	1.1253	1.2730	0.8582	1.1736
Jiangxi	1.0513	1.3640	1.2602	1.3652	0.8764	0.8536	0.9329	0.7213	0.8836	0.7419
Shandong	1.1654	1.1933	0.7855	0.7638	0.8515	0.9225	0.7942	1.7761	0.3063	0.9231
Henan	1.3416	0.8487	1.1575	0.7410	0.7377	0.7912	1.1569	0.5786	0.4667	2.2933
Hubei	1.1609	1.0437	0.9075	0.7816	0.9608	0.9290	1.1824	0.7943	1.2154	1.7778

Hunan	1.2557	0.9514	0.7957	1.1500	1.1422	0.7129	1.4384	1.1288	0.8157	1.2346
Guangdong	0.8496	1.7586	0.9732	0.5604	1.0478	1.3346	0.8026	1.5161	1.2746	0.4500
Guangxi	1.1585	1.0475	0.6150	1.0257	1.1064	0.9376	0.9316	1.5583	0.7425	1.9531
Sichuan	1.5481	0.8603	0.6818	1.0504	0.7271	1.0195	0.6030	1.8443	0.5744	1.1388
GUIzhou	0.7894	1.0274	0.8779	1.0251	2.1764	1.4851	0.9276	1.2981	0.7436	0.4320
Yunnan	0.9531	1.4189	1.5033	1.2433	0.7183	0.9561	1.0243	1.0596	1.1616	1.0000
Shaanxi	1.9344	0.9593	0.5044	2.0090	0.5964	0.9493	1.1333	1.1010	0.8904	0.8622
Gansu	1.5928	1.0138	0.9556	0.9775	0.7693	1.0430	1.0364	1.0850	0.8466	1.2803
Qinghai	1.4388	1.9021	0.9706	0.9371	0.7242	0.9780	0.9597	1.0674	1.1300	1.0000
Ningxia	0.9445	1.2951	0.9672	1.0491	0.8896	1.0080	0.7788	1.0093	1.0126	1.0000
Xinjiang	1.2354	1.2738	0.7860	0.6706	1.2974	0.8085	0.9673	0.8080	0.9184	1.5625
AVEC	1.0534	1.2670	1.1147	0.9303	0.8744	1.0843	0.9455	1.3587	1.1042	1.2218
AVCC	1.2973	1.1794	1.0651	0.8457	0.8188	0.9166	0.9974	1.2137	0.7953	1.4739
AVWC	1.2526	1.1583	0.8878	1.1004	0.9981	1.0109	0.9296	1.1794	0.9139	1.1319
AVWN	1.1475	1.1573	1.0001	1.0357	0.9423	0.9849	1.0166	1.1702	0.9740	1.2741

Data sources: calculation.

The changes of ecological efficiency of different regions' non-agricultural land can be looked up in Table 2. The cause of these changes, whether it is technical efficiency or technical progress, can be inferred from comparison Table 3 and 4. Figure 1 below shows the changes of ecological efficiency of three regions' non-agricultural land. Through comparison, it can be concluded that only in the period 2004-2005, western China has the highest numerical value, while eastern China has the highest numerical value in the period 2005-2007 and 2009-2012, and central China, in the period 2009-2010 and 2012-2013. The numerical value of central and western China reaches the extreme in the period 2007-2008 simultaneously while the numerical value of eastern and western China reaches the extreme in the period 2008-2009 simultaneously. It can be concluded from Figure 1 that on the whole, the ecological efficiency of non-agricultural land of the eastern part of China is highest, while the central, the medium and the western, the lowest.

Figure 2 shows the trends and motivations of eco-efficiency changes of urban non-agricultural land. According to Figure 2, the lines drop in the 2008-2010 and 2011-2012. The motivation of this change is the relative decline of technology. The lines in Figure 2 show a tendency of rising in other years, but the motivations for this tendency are different from year to year, detailed explanation of which can be seen in Figure 2.

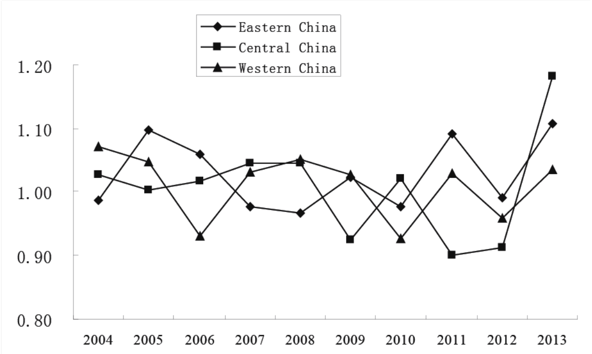

Figure 1. MI of Three Regions' Non-agricultural Land

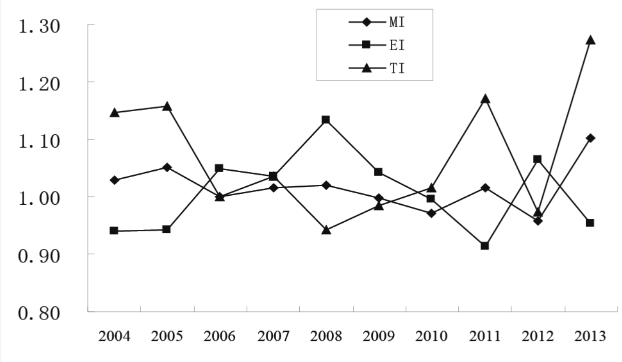

Figure 2. Trends and Motivations of Eco-efficiency Changes of Urban Non-agricultural Land

4. Conclusions

During the process of urbanization, to increase the utilization efficiency, intensive use of construction land is necessary. This paper constructed a dynamic ecological efficiency Formula to measure urban construction land, with CO2 emission taken into consideration, and calculated the ecological efficiency of 28 provincial-level administrative region's non-agricultural land. The analysis is mainly from two aspects, technical progress and technical efficiency. The major finding of this paper is that whether regarding a certain area, the eastern, central, western China, or the whole country's non-agricultural land as the research object, the ecological efficiency is changing from year to year. The causes of the changes are technical efficiency and technical progress. Therefore, to realize intensive utilization of land, two things need to be done: on the one hand, the innovation achievement transformation and regional development need to be sped up, so that the innovation achievement can be transformed into actual productivity as soon as possible and technical progress can be promoted; on the other hand, incentives measures should be taken so that the land can be used more efficiently, improving the technical efficiency.

The allocation scheme of construction land can be obtained from the research results in this paper. According to Table 1, the ecological efficiency of construction land of the eastern China is highest, while the central, the medium and the western, the lowest. Therefore, eastern China is suggested to be allocated with the largest proportion of construction land, central China, the second largest, and the weatern China should retain more agricultural land. Only when both the technical progress and technical efficiency index were increased can the non-agricultural land ecological efficiency be ensured, and waste land situation be stopped.

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Cooperative Development on Higher Education and Economic Development

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Abstract

Economy and education are two basses for the development of modern society; the higher education has transformed from elite education to mass education and received a good development. Reasonable planning and scientific development at all levels of high education is the only way for social progress and economic development. But it is not harmonious between higher education and economic development because of regional difference and imbalance of higher education's investment. So we use the methods of cluster analysis and the panel data