Study on the Urban Economic Development and Pollutants Emission

Yanzhen Yang[*]

School of Transportation and Civil Engineering, Shandong Jiaotong University, Jinan, 250357, China

*Corresponding author e-mail: sdust_soden@126.com

Abstract. In the process of urban economic development, pollutants emission is paid more and more attention. GDP can reflect the economic development level. So studying the relationship between the pollutants emission and GDP is very important to the environment of urban economic development. In the paper, based on the data of the pollutants emission and GDP of 17 cities, Shandong province in 2016, by using SPSS and GIS, some analysis are carried out. Some comprehensive evaluations of the economic development environment of these cities are obtained. The analysis results can provide some references for promoting the sustainable development of urban economic environment.

1. Introduction

With the rapid development of the industrialization of the human society, the increase of the population and the accelerating urbanization, the development of the urban economy is different in degree. The important indicator GDP (Gross Domestic Product), which measures the urban economic situation and development level, has close connection with the urban resources consumption and environmental pollution. Therefore, it is especially important to study the relationship between the urban economic development and the emission of various pollutants, to predicate the health degree of the urban economic development, and to explore the pathway for the sustainable development of urban economy and environment.

In the paper, based on the data of the economic development and pollutant emission of 17 cities, Shandong province in 2016, the relevant data analysis is carried out by using GIS (Geographic Information System) technology and SPSS. The economic development and environmental conditions of these cities are reflected. So some references are provided for the effective management of the urban environmental protection and the gradually realizing energy conservation and emission reduction.

2. Data Sources

The data of the paper are derived from "the Statistical Yearbook of Shandong (2017)". The types of data are obtained, such as the GDP, the industrial water waste emissions, the COD (Chemical Oxygen Demand) emissions, the ammonia nitrogen emissions, the SO_2 emissions, the smoke dust emissions, the industrial solid waste emissions and industrial structure of 17 cities, Shandong Province in 2016.

According to these data, the relationship is studied between the urban economic development and pollutant emission. The detail data are shown in table 1.

Table 1. All kinds of Data of 17 Cities, Shandong Province in 2016

city	IWW (10kt)	COD (t)	A.N. (t)	SO$_2$ (t)	SD (t)	ISW (10kt)	GDP (100m RMB)	Industrial structure		
								PI (%)	SI (%)	TI (%)
Jinan	34530	30202	4306	44403	64253	935.7	6536.12	4.90	36.20	58.90
Qingdao	51536	29095	3539	23320	24387	762.3	10011.29	3.70	41.60	54.70
Zibo	35329	32027	5359	171735	90670	1690.3	4412.01	3.40	52.50	44.10
Zaozhuang	20251	20204	3294	46821	25935	597.2	2142.63	7.60	51.20	41.20
Dongying	19139	15216	1845	44858	6513	346.6	3479.60	3.50	62.20	34.30
Yantai	25915	34077	4164	69112	39644	2697.7	6925.66	6.70	50.00	43.30
Weifang	53917	59800	6619	68452	56588	1355.5	5522.68	8.60	46.40	45.00
Jining	42425	36418	6151	79865	56693	1844.0	4301.82	11.20	45.30	43.50
Taian	19992	38629	5596	32895	25160	1017.1	3316.79	8.50	44.80	46.70
Weihai	18280	11241	2842	35722	19207	265.9	3212.20	7.10	45.60	47.30
Rizhao	14078	13942	2358	37796	97968	799.4	1802.49	8.10	47.30	44.60
Laiwu	5837	9269	1565	36718	124639	1905.3	702.76	7.80	50.20	42.00
Linyi	46315	55384	9847	75430	83160	1572.4	4026.75	8.90	43.10	48.00
Dezhou	28249	38074	4647	61708	39423	1312.2	2932.99	10.10	47.80	42.10
Liaocheng	29216	22193	3726	62985	17258	1350.4	2859.18	11.80	49.50	38.70
Binzhou	32230	32695	3534	171392	60924	4771.9	2470.10	9.40	46.30	44.30
Heze	30350	51984	8583	71313	41408	474.5	2560.24	11.00	51.30	37.80

* IWW: industrial water waste emissions   A.N.: ammonia nitrogen emissions
SD: smoke dust emissions   ISW: Industrial solid waste emissions
PI: primary industry   SI: secondary industry   TI: tertiary industry

3. GPI and data process by using SPSS

The development of urban economy is mainly measured by GDP. However, it inevitably brings a series of environmental pollution problems in the process of GDP growth. The management of pollutants increases GDP conversely. So the GDP is closely related to the emission of pollutants. In order to study the relationship between them, one method of data process used based on the pollutant emission indicator (GPI) per unit of GDP proposed in reference in the paper. This method can reasonably reflect the coordinated development of economic growth and environment. GPI [1] is shown as below.

$$GPI = \frac{pollutant\ emission}{GDP} \tag{1}$$

If GPI value is low, it shows the good economic development environment. If GPI value is high, it suggests that the economic development environment is poor. Because the unit of the data used in the paper is not consistent, so they need to be standardized. By using SPSS, the processed data are shown in table 2.
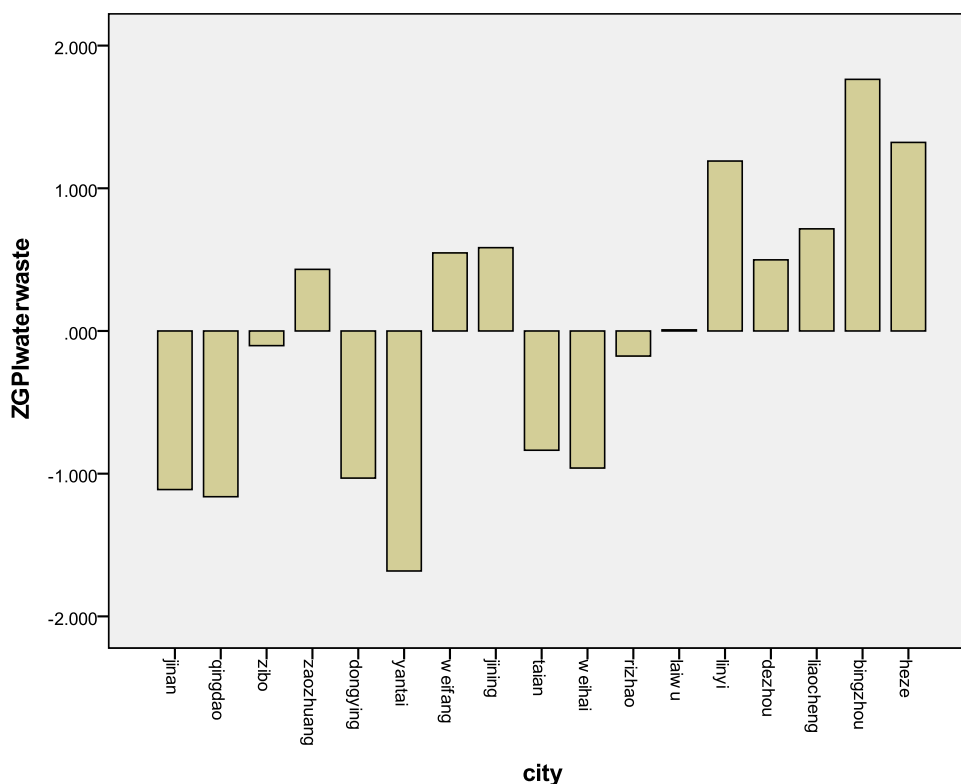
Z_{GPI} of above six kinds of pollutant emission of 17 cities of Shandong province are shown from figure 1 to figure 6.
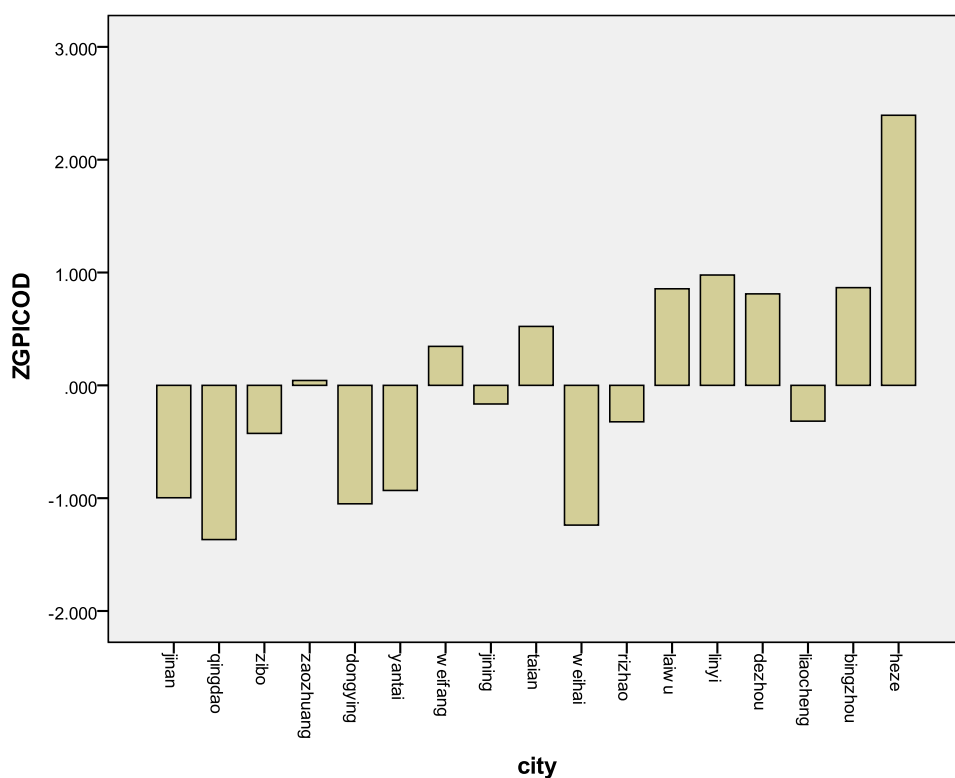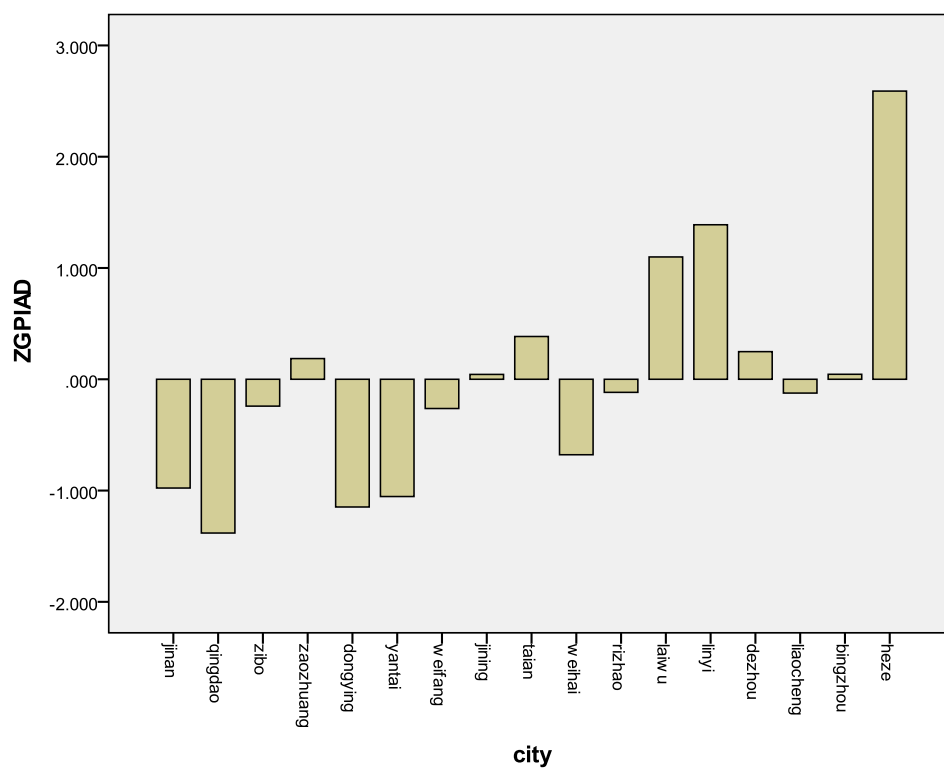
From figure 1, it is observed that Z_{GPI} of water waste of some cities is at lower level, such as Yantai, Jinan, Qingdao. But Z_{GPI} of water waste of some cities is at higher level, such as Binzhou, Heze, Linyi.
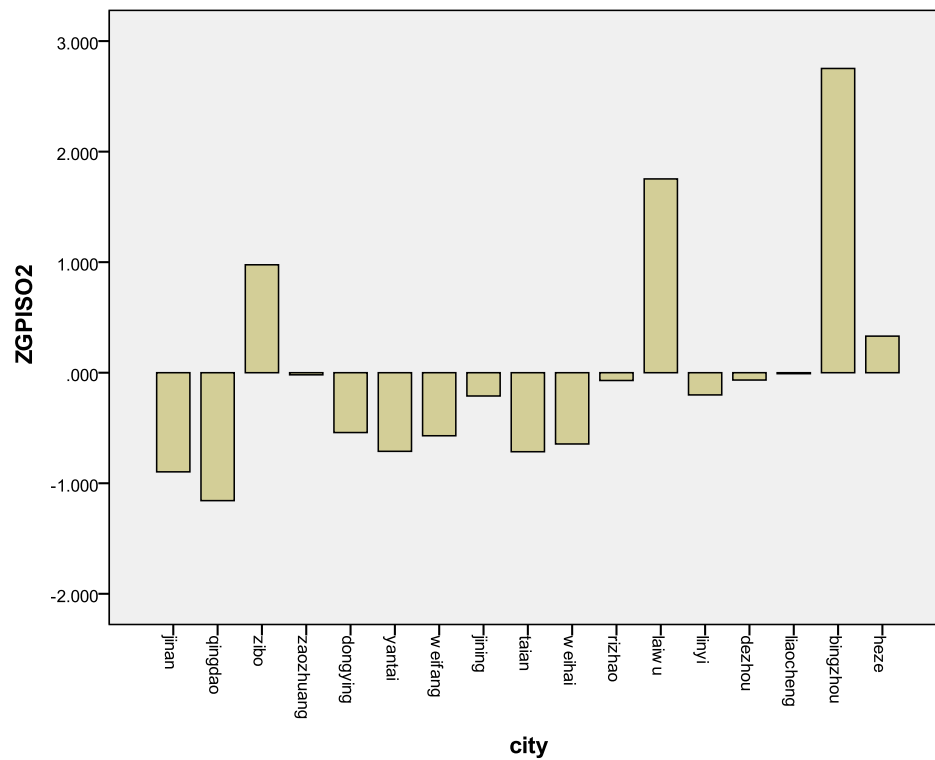
Form figure 2, it is observed that the Z_{GPI} of COD of Heze city is at a fairly high level. But for Jinan, Qingdao, Weihai, Dongying etc., the Z_{GPI} of COD is at lower level.
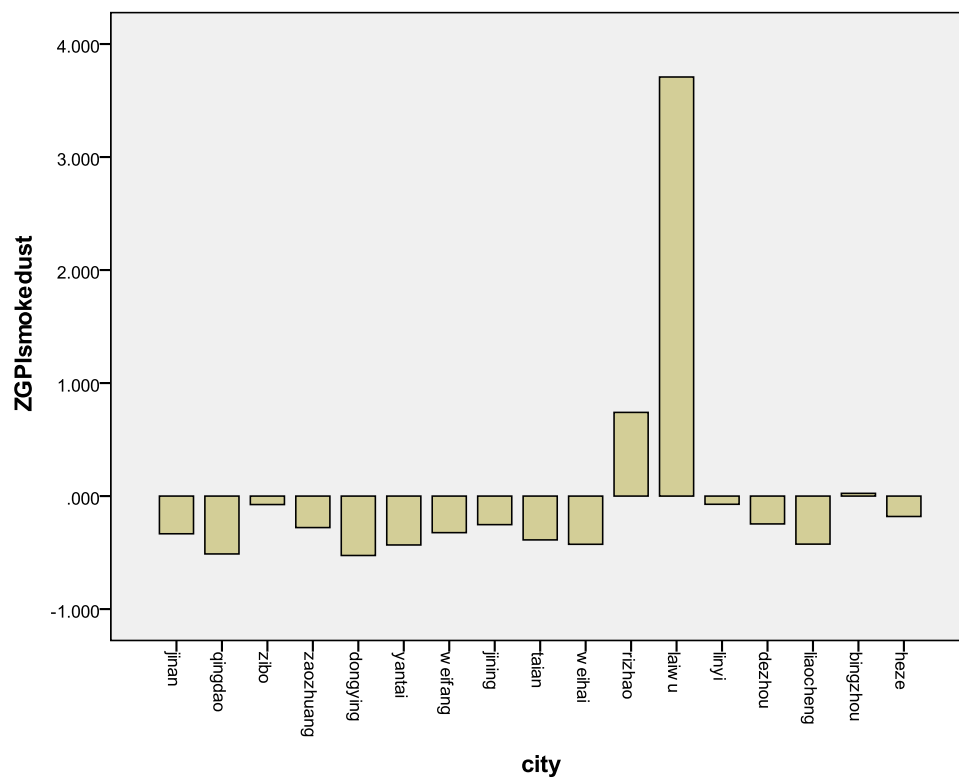
Table 2. Standardized GPI

city	Z_{GPI} water waste	Z_{GPI} COD	Z_{GPI} A.N.	Z_{GPI} SO_2	Z_{GPI} smoke dust	Z_{GPI} solid waste
Jinan	-1.111	-0.996	-0.977	-0.897	-0.334	-0.552
Qingdao	-1.161	-1.367	-1.382	-1.157	-0.512	-0.648
Zibo	-0.103	-0.426	-0.241	0.976	-0.075	-0.210
Zaozhuang	0.432	0.043	0.186	-0.019	-0.279	-0.359
Dongying	-1.031	-1.050	-1.148	-0.541	-0.526	-0.614
Yantai	-1.682	-0.932	-1.054	-0.711	-0.433	-0.201
Weifang	0.547	0.345	-0.263	-0.570	-0.324	-0.406
Jining	0.584	-0.165	0.044	-0.211	-0.253	-0.145
Taian	-0.836	0.522	0.384	-0.715	-0.388	-0.319
Weihai	-0.960	-1.239	-0.678	-0.645	-0.427	-0.638
Rizhao	-0.176	-0.323	-0.117	-0.071	0.741	-0.124
Laiwu	0.008	0.856	1.099	1.753	3.708	3.110
Linyi	1.191	0.978	1.389	-0.201	-0.073	-0.199
Dezhou	0.498	0.811	0.248	-0.066	-0.246	-0.118
Liaocheng	0.716	-0.317	-0.124	-0.009	-0.425	-0.083
Binzhou	1.763	0.866	0.045	2.752	0.024	1.999
Heze	1.321	2.394	2.590	0.331	-0.181	-0.492

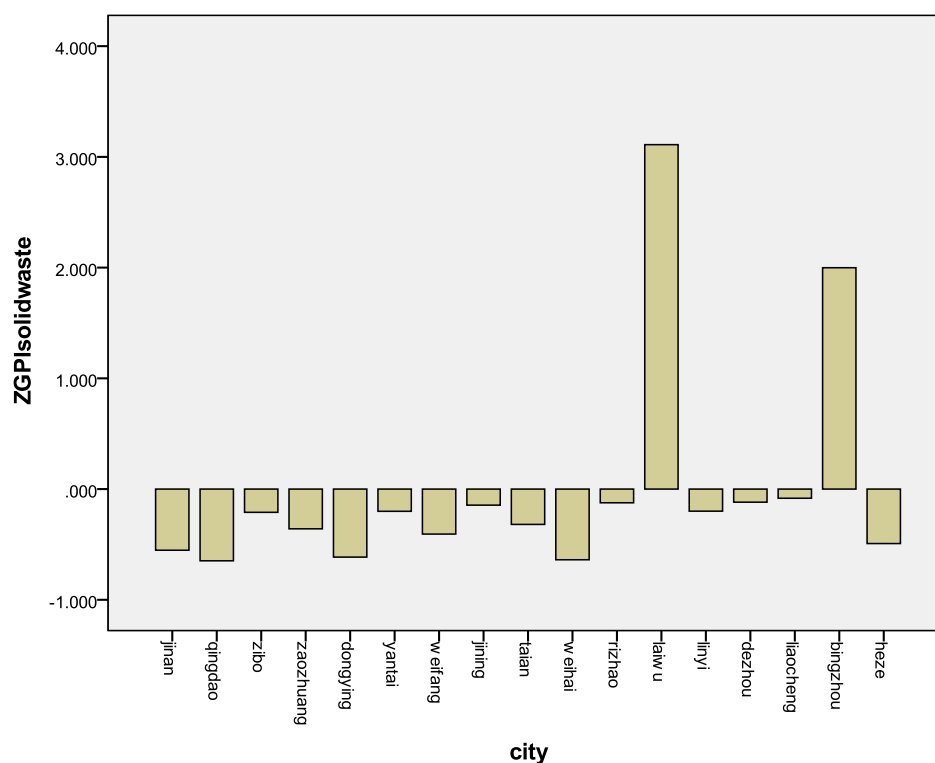**Figure 1.** Z_{GPI} of Water Waste of 17 Cities

Figure 2. Z_{GPI} of COD of 17 Cities

Figure 3. Z_{GPI} of Ammonia Nitrogen of 17 Cities

Figure 4. Z_{GPI} of SO_2 of 17 Cities

Figure 5. Z_{GPI} of Smoke Dust of 17 Cities

Figure 6. Z_{GPI} of Solid Waste of 17 Cities

From figure 3, it is observed that the Z_{GPI} of ammonia nitrogen is at higher level, such as Heze, Laiwu, Linyi. But for Jinan, Dongying, Qingdao, Yantai, the Z_{GPI} of ammonia nitrogen is at lower level.

From figure 4, it is observed that the Z_{GPI} level of SO_2 is lower, such as Jinan, Qingdao. But for Binzhou, Laiwu, Zibo, the Z_{GPI} of SO_2 level is higher.

From figure 5, the Z_{GPI} level of smoke dust for Laiwu is much higher than other cities.

From figure 6, the Z_{GPI} level of solid waste is very high, such as Laiwu, Binzhou. But for Weihai, Qingdao, the Z_{GPI} level of solid waste is at lower level.
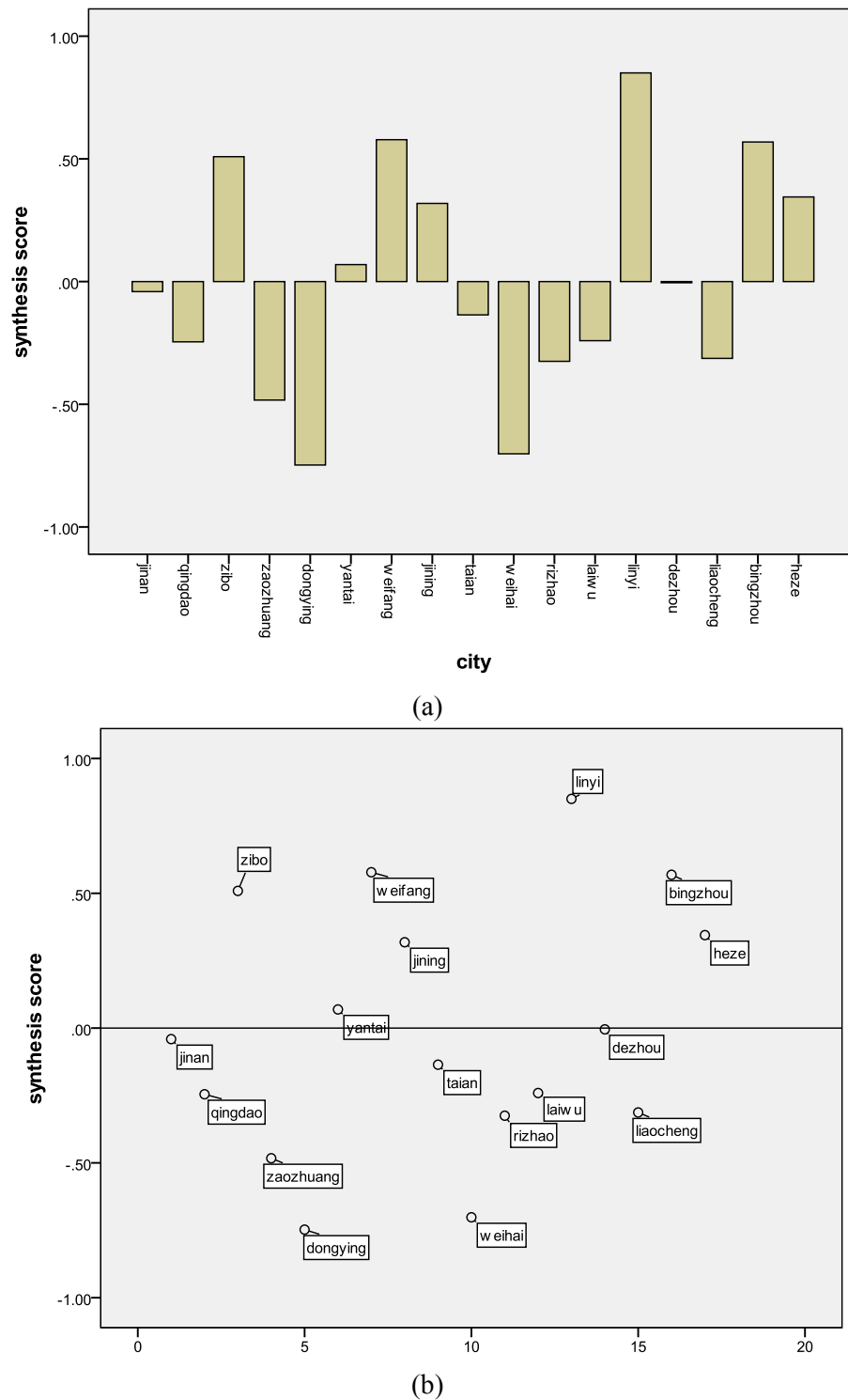
The above analysis is based on single indicator. If considering these six various opinions factor together, by using factor analysis in SPSS soft, the weight is calculated for every factor. According to the weight, the composite score is calculated. The results are shown in table 3.
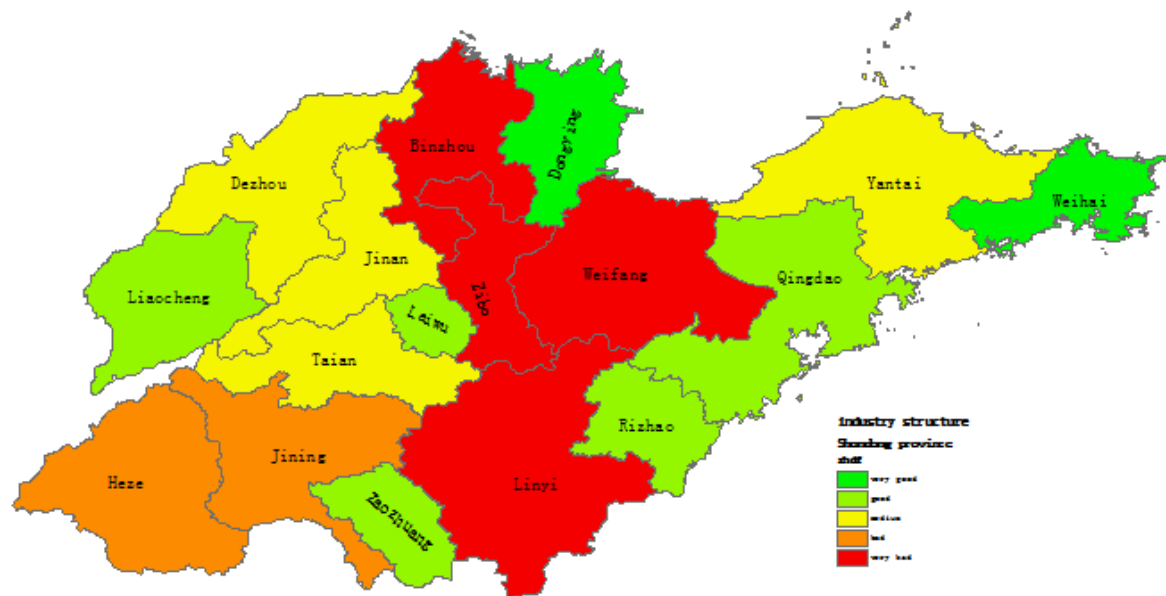
Table 3. Composite Score

No.	city	score	No.	city	score
1	Dongying	-0.75	10	Dezhou	0.00
2	Weihai	-0.70	11	Yantai	0.07
3	Zaozhuang	-0.48	12	Jining	0.32
4	Rizhao	-0.32	13	Heze	0.34
5	Liaocheng	-0.31	14	Zibo	0.51
6	Qingdao	-0.25	15	Binzhou	0.57
7	Laiwu	-0.24	16	Weifang	0.58
8	Taian	-0.14	17	Linyi	0.85
9	Jinan	-0.04			

The high composite score shows that the pollutant emission of per unit of GDP is high. On the contrary, the low score observes the low pollutant emission of per unit of GDP and the better environmental conditions of economic development.
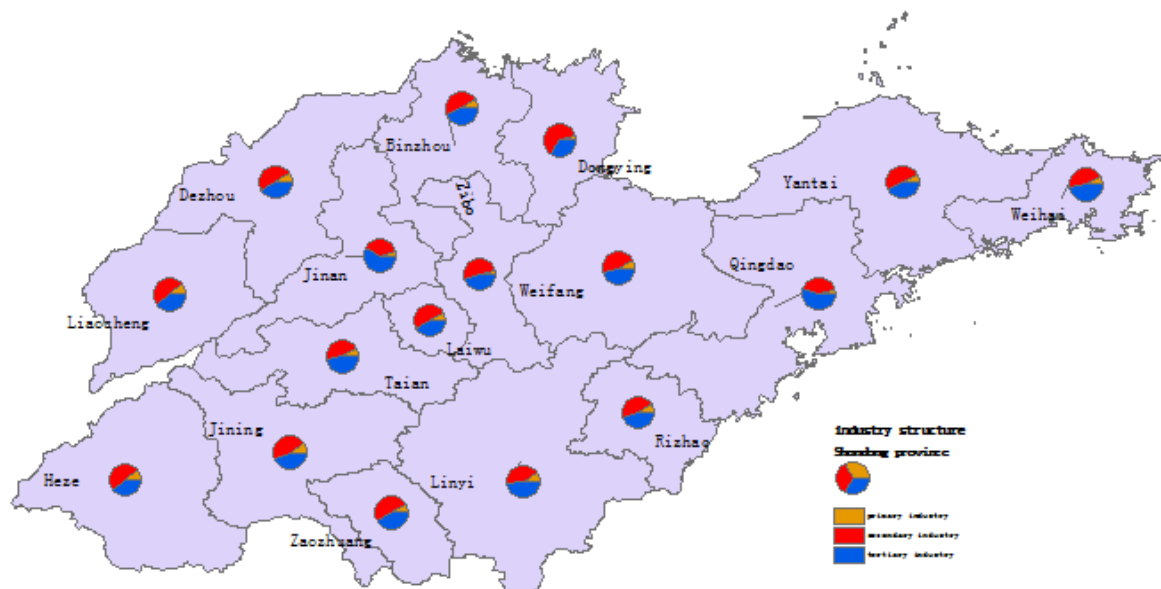
4. Conclusion

(a)

(b)

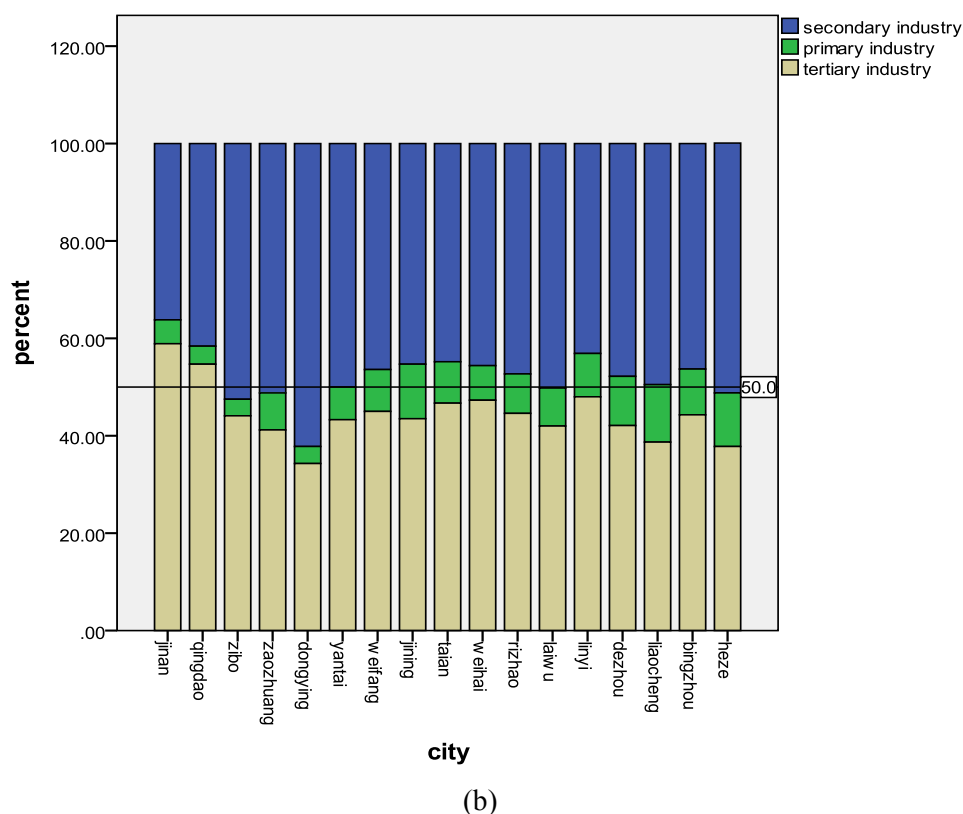**Figure 7.** Synthesis Score of 17 Cities, Shandong Province, 2016

Figure 8. Environmental Condition of Economic Development of 17 Cities, Shandong Province, 2016

In order to express analysis result more intuitive, composite score of each city can be represented by using GIS. GIS is a science and technology which is supported by computer hardware and software, and can analysis and represent all kinds of spatial data. All data related to the spatial location can be combined with GIS. This method can express the result of data analysis more intuitively and visually.

Here, the paper uses two methods to show the analysis result, by using SPSS and GIS, figure7 and figure 8.

(a)

(b)

Figure 9. Industrial Structure of 17 Cities, Shandong Province, 2016

Compared with figure 7, figure 8 and figure 9, seven cities have better economic development environment, such as Qingdao, Weihai, Dongying etc. (below line in figure 7 and green color in figure 8).But four cities have worse economic development environment, such as Binzhou, Zibo, Linyi, Weifang (above line in figure 7 and red color in figure 8).To analyze the reasons, a large part reason of this situation is related to the industrial structure of the 17 cities in Shandong province. This can be supported through figure 9. From figure 9, it can be found that the tertiary industry is occupy larger proportion of the city whose pollutant emission of per GDP is lower than other cities, such as Jinan, Qingdao etc..On the contrary, the second industry is occupy larger proportion of the city whose pollutant emission of per GDP is higher than other cities, such as Zibo, Laiwu etc.. There are exceptions, although the second industry occupies larger proportion of the city, but its pollutant emission of per GDP is at lower level, such as Dongying. It shows that the management of pollutant emission is well for this city.

Therefore, from the point of GPI, these cities should continue to control pollutant emission, which have lower pollutant emission level per GDP, such as Qingdao, Weihai, Dongying etc.. And for generating higher pollutant emission level per GDP of those cities, especially Zibo, Binzhou, Weifang, Linyi, should pay more attention to the conditions of economic development environment. These cities should increase govern and enterprise input to handle the pollutant emission, continuously improve industrial production, conserve energy, reduce emission, raise the environmental level of economic development, avoid environment further deterioration, etc., in order to promote sustainable development of urban economic environment.

References

[1]   M. Y. Yang, X.L. Dong, Environ. Sci. Manage. 38, 41-46 (2013). (in Chinese)
[2]   J. Liu, S.Y. Ye, H.M. Yuan, etal., Environ. Sci. Pollut. Res. 1-16 (2017).
[3]   F. J. Hidemichi, M. Shunsuke, Environ. Sci. Pollut. Res. 23, 2802–2812 (2016).
[4]   C. Schröder, N. Reimer, & P. Jochmann, Ambio 46, 400–409 (2017).
[5]   J. Mendes Campolina, , C. São Leandro Sigrist, J.M. Faulstich de Paiva, etal, Int. J. Life. Cycle. Assess. 22, 1957–1968 (2017).
[6]   S. Hishe, J. Lyimo & W. Bewket, Environ. Syst. Res. 6-26 (2017).
[7]   C.H. Zhou, C.Q. Liu, J.H. Liang, S.H. Wang, Environ. Sci. Pollut. Res. 1-11 (2017).