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Research on the Spillover Effect of Environmental Pollution Loss Based on Data Mining BIRCH Algorithm

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Abstract

In the era of big data, data mining is the most critical and most valuable work. In this paper, the author analyzes the spillover effect of environmental pollution loss based on data mining BIRCH algorithm. The calculation of environmental pollution losses has great reference value and practical significance for the development and adjustment of environmental policy and the coordinated development of economy and environment. Based on the research by the world bank in 2011, we calculated the Hangzhou 2002-2012 pollution losses in trajectory, then from the influence of labor productivity and spatial spillover affect two aspects to test the spillover effect of the loss of environmental pollution in Hangzhou. According to the analysis results, author puts forward the countermeasures and suggestions for the treatment of environmental pollution, mainly from the aspects as adjustment of industrial structure, optimize energy consumption, promote technological progress and build green environmental pollution joint prevention control platform.

Keywords: *Data Mining, BIRCH Algorithm, Environmental pollution losses, Spillover effect, Green technology progress*

1. Introduction

Hangzhou's rapid economic development in the past 30 years, the problem of environmental pollution is worrying. According to the Hangzhou municipal environmental situation bulletin, the water pollution, air pollution situation is grim in Hangzhou [1]. The loss of environmental pollution mainly refers to air pollution, water pollution, solid waste pollution damage to human health, natural resource damage, loss and pollution of factory production downtime and increase the cost of agricultural economic losses. According to the world bank's data, in 2008 China's economic losses caused by pollution and environmental degradation is about 10.51% of the total national income. Annual economic losses caused by air pollution in China, based on the cost of disease is equivalent to 1.2% of GDP, based on the willingness to pay is estimated as high as 3.8%. From the perspective of the economic development of the developed countries, there is an inverted U relationship between environmental quality and income, namely environmental quality began to deteriorate with increasing income, income level rises to a certain extent with the increase in income and improve. 2013 Hangzhou per capita GDP based on the resident population reached $15220, is roughly at the critical level in the upper world countries and rich countries, at the same time it also faces frequent fog and haze and other serious environmental pollution situation of PM2.5 exceed the standard. Under this background, the government and the academic circles have been concerned about the problem of how to lose the environmental pollution in Hangzhou, whether it has the spillover effect and how to manage the problem.

At present, domestic and foreign scholars have been on the loss of environmental pollution to a certain degree of research, mainly involves the following aspects: (1) the

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study of pollution loss estimate environment: non monetary evaluation and monetary evaluation of two modes of environmental pollution loss measurement. Non monetary evaluation mode mainly through establishing an index system of multi-dimensional and multi-level evaluation of resources and environment condition, representative results such as China science and sustainable development strategy research group [2] in environment and resources comprehensive performance index is proposed. In the monetary evaluation model of environmental pollution losses, the calculation methods are: pollution loss method, opportunity cost method, cost control method. (2) study on the causes of environmental pollution losses: Xiao Shien [3] believes that economic growth is the fundamental causes of environmental pollution in China is high, the consumption structure of China's economy to the high energy consumption and high pollution industry, the excessive dependence, dominated by coal and the comparatively backward technology structure is caused by the structural causes of the environmental pollution. Cui Riming [4] believes that for a long time, Chinese export growth is fast but inefficient, ecological deficit behind the huge trade surplus is increasing, outstanding performance for the Embodied Carbon, the energy content of the net foreign output, and led directly to the ecological resources of the barren. (3) to study the effect of environmental pollution losses: Yang [5] from the impact of pollution on the production and payment decision effects on labor two channels is discussed the impact of pollution on labor productivity; Shu [6] analysis of the provinces of China's per capita environmental pollution loss of resources and regional distribution characteristics and examines the spillover effects of the size.

From the object of study, the existing research mainly focus on the regulation of the macro environment, the specialized research on the loss of environmental pollution and its spillover effect is relatively small, accurate assessment of the loss of environmental pollution and its spillover effect is of great importance for improving the ecological environment quality, are worthy of research and detailed deep. From the research content, the research on the loss of environmental pollution has been pay more attention to the status quo, problems and suggestions, still remain at the macro level data description and discussion, not system on environmental pollution causes and spillover effect on the theoretical analysis, this is helpful to the construction of ecological civilization for effective analysis. From the perspective of research area, the research has been mainly focused on the national environmental pollution losses or economic and social effects, and the lack of environmental pollution losses in Hangzhou and its spillover effect of the system.

2. Data Mining Algorithm

2.1. Data mining

The so-called data mining, with no strict distinction between the case is also called knowledge discovery in database, is from the practical application of data to extract the implicit, unknown, but potentially useful patterns of advanced treatment process. Data mining is a combination of statistics, artificial intelligence, database, visualization technology and other fields. And sequential data mining is an important research area of data mining. TDM by the time the introduction of data mining technology, not only provides a detailed observation form for the event at the time of the order, it can be found that the causal relationship between mining neglected in other data technology. In a time sequence database, it is not a time point to save data, but a large number of time points on the data. The information contained in each tuple is the current information that is stored in a sequence from the date in which it is stored to the date of the next tuple.

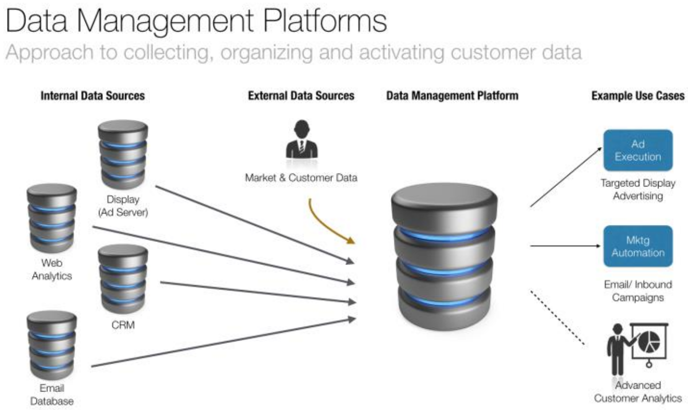

Figure 1. Data management platform

- Database: is one or a group of databases, data warehouses or other types of information database, it can be data cleaning and integration.
- Server: according to the user's data mining request, the database or data warehouse server is responsible for the extraction of relevant data. Knowledge base: is the domain knowledge, used to guide the search, or to assess the results of the model of interest.
- Data mining engine: it is the basic part of the data mining system, which is composed of a function module, which is used for characteristic, correlation, classification, cluster analysis, evolution and deviation analysis.
- Pattern evaluation module: usually it makes the interest measure and interacts with the data mining module in order to focus the search on the interesting patterns.
- User interface layer: the decision makers to submit relevant operating orders according to the need to obtain feedback results.

At the same time, these enterprises purchase information will be recorded in the temporal database, database data is the original data. Because the original data may contain a number of noise and other interference information, directly on the raw data mining may result in wrong, therefore, need to use some data to the original data screening tool for screening, the screening data mining meets the requirements before.

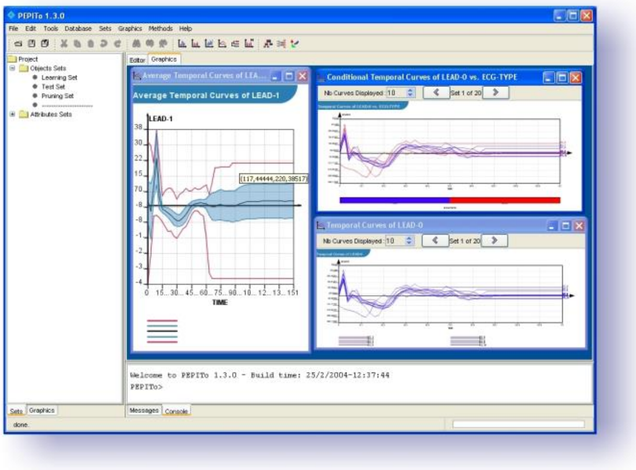

Figure 2. Temporal Data Mining

2.2. BIRCH algorithm

Implementation of sequential data mining process second steps using data warehouse technology. A data warehouse contains data acquisition, data storage, data access of 3 key components, is characterized by subject oriented, integrated, stable and time-varying, decision support system is a structured environment and online analysis application of the data source. Third steps to implement sequential data mining is to use visual tools. Visualization tools can be used in the dynamic interaction between user and database, for example, the classification model can be visualized and implemented a new representation method. The visual association rules based on genetic algorithm for undirected graph drawing and puts forward some improved method, using multi view mode to realize the association rules of various forms of display, using Open-GL pickup and feedback mechanism to solve the problem of dynamic interaction with the user. Cluster analysis visualization uses the parallel coordinate technology based on the scan line algorithm to achieve clustering recognition process. The CF tree definition is as follows:

$$CF = (n, LS, SS)$$

$$LS = \sum_{i=1}^{n} x_i$$

$$SS = \sum_{i=1}^{n} x_i^2$$

So that, cluster centroid X_0, radius R will be:

$$x_0 = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{LS}{n}$$

$$R = \sqrt{\frac{\sum_{i=1}^{n} (x_i - x_0)^2}{n}} = \sqrt{\frac{nSS - 2LS^2 + nLS}{n^2}}$$

$$d = \sqrt{\frac{\sum_{i=1}^{n} \sum_{j=1}^{n} (x_i - x_j)^2}{n(n-1)}} = \sqrt{\frac{2nSS - 2LS^2}{n(n-1)}}$$

Then, we can get that:

$$d^* = \sqrt{\frac{SS_1}{N_1} + \frac{SS_2}{N_2} - \frac{2LS_1 LS_2}{N_1 N_2}}$$

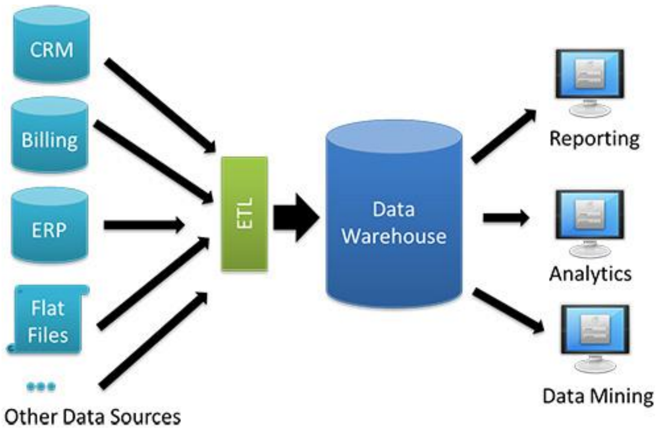

Figure 3. Data warehouse

Finally, a new knowledge model, which is the result of data mining, can be obtained by using the time sequence mining algorithm to mine the data which is selected and extracted. Temporal data mining itself contains a lot of conventional data mining methods, but also because of the complexity of the timing and type of query and become more complex; and do not usually accept similar sequence database and traditional database snapshot update and query, only allows correction and form changes, so when the database is updated, the selection criteria become timing is quite complicated.

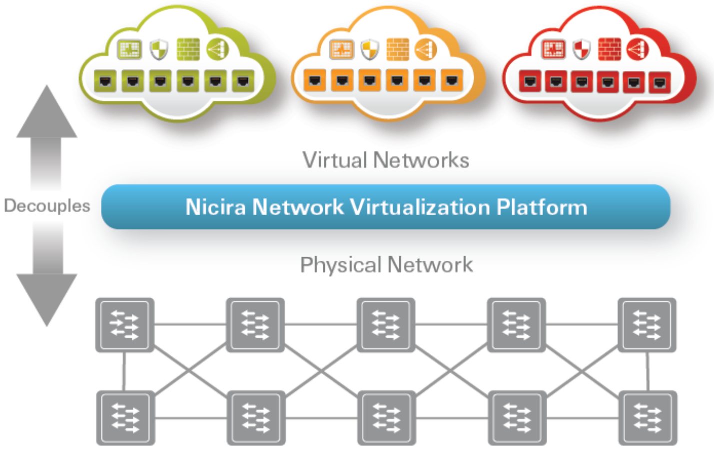

Figure 4. Visual data platform

3. Measurement of Environmental Pollution losses in Hangzhou and Comparison with Other Cities in Yangtze River Delta

3.1. Calculation method of environmental pollution loss

Based on the reference of Hamilton, Clemens[7] and Shu Yuan, Huang Liangxiong [6]on the basis of the way of thinking is mainly from the World Bank estimates 2011 of environmental pollution resources to the extent of the loss, the loss of environmental pollution as CO_2 emission from destruction and governance of environmental damage into two parts, the specific formula is:

$$DAM = \sum CD + GE \quad (1)$$

Among them, DAM is the loss of environmental pollution, CD is the destruction caused by CO_2 emissions, GE is the government investment in environmental damage. Compared with other evaluation systems, this method is more operable and applicable, and can be easily extended to the city level. Considering the city carbon emissions mainly by the industrial sector of raw coal, washed coal, coke, gasoline, kerosene, diesel oil, fuel oil, liquefied petroleum gas, natural gas and other traditional energy generation, set the formula for carbon emissions:

$$E_{city} = \sum C_i \bullet EF_i \qquad (2)$$

Among them, E_{city} is the main energy consumption of the urban industrial CO_2 emissions, C, EF indicating that the different types of energy consumption and CO_2 emission factor. The CO_2 emission factor of the main energy source is calculated according to the method recommended by IPPC. The specific results are shown in Table 1. Formula (2) in the energy consumption data from the statistical yearbook of the city.

The damage to the environment of governance input GE is equal to the operating costs, sewage treatment facilities sewage treatment operation cost, operation cost and exhaust emission and treatment of industrial pollution control project investment of the four and the four main sources of data in each period Chinese Environment Yearbook. Limited to the availability of data, this paper chooses Shanghai, Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Zhenjiang, Hangzhou, Ningbo, Jiaxing, Huzhou, Shaoxing, Zhoushan 13 Yangtze River Delta city were analyzed, index data of individual city individual year loss, we used the interpolation approximation obtained the use of specific estimates, the data in 2000 as the base year, using the GDP deflator for processing deflator.

Table 1. Main energy class CO_2 emission coefficient

Energy class	Raw coal	Washed coal	coke	gasoline	kerosene	diesel	fuel oil	LPG	Natural gas
Carbon content coefficient (kg/GJ)	25.8	25.8	29.2	20.2	19.5	20.2	21.1	17.2	15.3
Rate of carbon oxide	1	1	1	1	1	1	1	1	1
Net calorific value (TJ/Gg or Kg/m^3)	20.9	26.3	28.2	43	44.1	43	40.4	47.3	38931
CO2 emission coefficient (t/t or t/10^4m^3)	1.98	2.49	3.02	3.18	3.15	3.18	3.13	2.98	21.84

Note: the data is calculated by the author according to the method recommended by IPCC.

In the total amount of environmental pollution losses, Nanjing and Hangzhou roughly equivalent, far below the three cities of Suzhou, Ningbo, Shanghai. 2002-2012 annual environmental pollution losses of 3.955 billion yuan in Hangzhou, since 2005 to reach the highest point of loss of 4.599 billion yuan, in recent years has been in a slow decline in the channel. Hangzhou environmental pollution losses in the period of 2002-2012 decreased by 27.87%, while the industrial output value of the same period has achieved a double growth performance. 2002 Hangzhou environmental pollution loss was 4 billion 156 million yuan, ranked fifth in the 13 city in the Yangtze River Delta, after the row in front of the Ningbo (10.73 billion yuan), Shanghai (6.64 billion yuan), Suzhou (5.2 billion yuan), Wuxi (4.54 billion yuan), higher than row in the sixth Jiangsu provincial capital city of Nanjing is about 108 million yuan. In 6 cities in Zhejiang Province, Hangzhou, Ningbo, the total environmental pollution losses after, much higher than Shaoxing (2.6 billion yuan), Jiaxing (1.88 billion yuan), Huzhou (1.69 billion yuan), Zhoushan (302 million yuan). 2012 Hangzhou environmental pollution losses of about 2 billion 996 million yuan, 13 in the Yangtze River Delta city ranked sixth in Suzhou (11.63 billion yuan), Ningbo (10.18 billion yuan), Shanghai (4.97 billion yuan), Wuxi (4.8 billion yuan), Nanjing (4.26 billion yuan) after. Although in the province of Zhejiang city in the ranking has not changed, but the total losses of environmental pollution in Hangzhou has been with Jiaxing (2.55 billion yuan), Shaoxing (1.8 billion yuan) two is close to the city. From the composition of environmental pollution losses, industrial carbon emissions caused by the loss of industrial carbon emissions accounted for 75% of the environmental pollution loss in the same period, 25% of the pollution damage to industrial pollution equivalent to of the loss of environmental pollution. From the trend point of view, although in recent years, industrial emissions accounted for the loss decreased, decreased from 84.1% in 2002 to 62.8% in 2012, the pollution damage investment has increased, rising from 15.94% in 2002 to 2012 in 37.2%, but the industrial pollution losses caused by environmental pollution remains a major cause of the loss of Hangzhou.

Judging from the loss of environmental pollution per capita, the environmental quality of Hangzhou is gradually improved. 2002-2012 annual per capita environmental pollution losses of 587 yuan in Hangzhou, since 2005 reached the highest value of 701 yuan, gradually showing a downward trend. 2002 Hangzhou per capita environmental pollution loss was 657 yuan, seventh in the 13 city in Yangtze River Delta, the pollution loss came in before the Hangzhou city followed by Ningbo (1849 yuan), Zhenjiang (1147 yuan), Wuxi (1039 yuan), Suzhou (893 yuan), Nanjing (713 yuan), Huzhou (658 yuan). In 6 cities in Zhejiang Province, Hangzhou per capita environmental pollution losses in Ningbo, Huzhou, higher than Shaoxing (605 yuan), Jiaxing (568 yuan), Zhoushan (308 yuan). 2012 per capita environmental pollution losses of 342 yuan in Hangzhou, 13 cities in the Yangtze River Delta ranked twelfth, only higher than Shanghai (210 yuan). Hangzhou city in Zhejiang Province, 6 in the per capita environmental pollution loss is minimized, according to the amount of loss in ascending order, in addition to Hangzhou, followed by Shaoxing (409 yuan), Huzhou (479 yuan), Zhoushan (580 yuan), Jiaxing (744 yuan), Ningbo (1765 yuan). Although the environmental quality of Hangzhou has improved in recent years, Hangzhou's per capita environmental pollution losses are still far higher than in Shanghai, in most years after 2006 is higher than in Nanjing. This also highlights the current implementation of energy-saving emission reduction and environmental pollution control tasks and the urgency of the task.

3.2. The change of environmental pollution loss in Hangzhou and the comparison with other cities in Yangtze River Delta

In this paper, the environmental pollution losses of Hangzhou 2002-2012 were calculated and compared with other cities in Yangtze River Delta. Calculation results show as table 2. In order to compare the regional distribution of the Yangtze River Delta city per capita loss of environmental pollution, we have less than 400 yuan, 400-800 yuan, mote than 800 yuan as the standard per capita loss of environmental pollution, the 13 Yangtze River Delta city is divided into three groups. In Table 2, in 2002, is located in the first group of city of Shanghai City, Nantong city and Zhoushan city (per capita environmental pollution loss is less than 400 yuan), in the second group of the city of Nanjing City, Changzhou City, Hangzhou City, Jiaxing City, Huzhou city and Shaoxing city (per capita environmental pollution loss between 400-800 yuan in the third group), the city of Wuxi City, Suzhou City, Zhenjiang city and Ningbo city (per capita environmental pollution loss of more than 800 yuan) in 2012, compared with 2002, the group changed less among the city, especially the original in second, the group of three city basically no change, only in Hangzhou city by 2002 second group up to 2012, the first group of Wuxi city increased from third in 2002 to second in 2012 the group, at the same time, Zhoushan City, the first group decreased from 2002 to second in 2012 Group. Such regional distribution has strong correlation with urban factor endowment and industrial structure. Taking Shanghai as an example, its industrial structure presents industrial growth speed, stabilization of "service economy situation, automobile, tobacco and other high value-added industries grew rapidly, iron and steel, building materials and other high energy consuming industries continued to decline, petrochemical, nonferrous metals and other industry growth is slowing down, the industrial structure toward low energy consumption, low pollution and low emission" the direction of further optimization, which is why Shanghai city per capita loss of environmental pollution has been ranked first in the group. As for the Zhenjiang city and Ningbo City, because of oil refining, chemical, electric power, steel, metallurgy and other industries for the manufacturing industry structure in a large proportion, and the industrial structure of the "high energy consumption, high pollution and high emissions" in the short term is difficult to completely change, resulting in two of the per capita loss of environmental pollution has been at the high level. The per capita environmental pollution loss in Suzhou is high, mainly due to the rapid development of heavy industry, the prominent degree of economic development and consumption of a large number of fossil fuels. The city of Hangzhou and the reason from the per capita environmental pollution loss in second group in the first group, in Hangzhou city industrial structure adjustment and energy saving and emission reduction measures and achieved initial success.

Table 2. 2002-2012 annual per capita environmental pollution in Yangtze River Delta (Unit: Yuan)

year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Shanghai	393	359	349	344	320	291	259	246	217	241	210
Nanjing	713	706	736	709	688	573	434	391	497	593	524
Wuxi	1039	1198	1327	1436	1305	1393	976	879	820	807	749
Changzhou	613	696	838	751	848	873	649	630	582	597	562
Suzhou	893	1007	1347	1457	1835	1961	1225	1205	1121	1019	1050
Nantong	308	318	339	375	361	320	340	297	379	399	365
Zhenjiang	1147	1187	1227	1102	1122	1005	828	804	769	797	814
Hangzhou	657	660	685	701	684	654	566	544	498	468	342
Ningbo	1849	1879	2055	2022	2327	2235	1939	1918	1935	1945	1765
Jiaxing	568	605	795	920	1029	903	859	789	699	709	744
Huzhou	658	774	756	819	831	755	661	603	498	434	479
Shaoxing	605	612	736	763	739	661	569	533	481	438	409
Zhoushan	308	326	543	362	392	329	336	342	344	665	580

4. Analysis on the Spillover Effect of Environmental Pollution Loss in Hangzhou

4.1. Impact on labor productivity

Existing research shows that environmental pollution can lead to a decline in the level of workers' health, and poor health level will have a significant impact on the labor supply and labor productivity. Bruvoll, *et al.* [8] examined the actual economic development in Norway, and based on the general equilibrium model, it was found that environmental pollution contributes to labor productivity by affecting the health of workers and consumption of natural resources. Hanna and Oliva[9], based on an empirical study of labor supply data and pollution data in the surrounding regions before and after closure of a Mexican oil refinery, show that environmental quality improvement has a significant effect on labor supply levels. Graff and Neidell[10]conducted a study using labor productivity data from California farm workers and local environmental pollution data to show that environmental quality improvement has a significant positive effect on labor productivity, the ozone concentration of 10ppb can be decreased to enhance the labor productivity of about four point two percentage points. In order to verify the impact of environmental pollution on labor productivity in Hangzhou, we refer to the theoretical analysis framework of Yang Jun [5] on the impact of pollution on labor productivity and the effect of labor productivity:

$$LP = c + \alpha_1 CP_t + \alpha_2 CP_t^2 + \alpha_3 TI_t + \alpha_4 RD_t + \alpha_5 WE_t \quad (3)$$

The formula (3), LP for labor productivity, CP environmental pollution index, the per square kilometer industrial carbon dioxide emissions (tons / km) ,TI is the degree of dependence on foreign trade, the import and export volume accounted for the proportion of GDP; RD for R & D investment, said the technological activities of industrial enterprises said; proportion of the second industry in GDP. Data time period of 2012 - 1998, from the corresponding year of the "statistical yearbook of Hangzhou". By using Stata13.0 and OLS method, the following results are obtained by stepwise regression:

$$LP = -237739.1 + 212.64 CP_t - 0.05 CP_t^2 - 31711.93 TI_t + 2.67 RD_t + 2244.103 WE_t$$

$$t = (-0.829) \times (2.042) \times (-1.911) \times (-0.574) \times (4.524) \times (0.418)$$

$$R^2 = 0.968 , \; F = 48.44 , \; DW = 2.252$$

From the regression results: (1) an estimate coefficient of environmental pollution index is significantly positive, the square of the estimated coefficient is significantly positive, which is between Hangzhou environmental pollution and labor productivity are significant inverted "U" relationship, that when the scale of carbon dioxide emissions more hours per square kilometers, with the deepening of environmental pollution, labor productivity increased significantly, when large scale environmental pollution, environmental pollution changes on labor productivity growth effect will be decreased, and the environmental pollution when the scale reaches a certain level, its impact on the labor productivity will be significant negative. This is because of the increasingly serious environmental pollution will have a negative effect on the health of workers and the level of consumption, significantly reduce labor income paid labor, thus inhibiting its willingness to pay, and reduce the current labor productivity. According to the results of the model (3), the turning point in the direction of the effect of environmental pollution loss on total labor productivity in Hangzhou is 2126.4 tons per square kilometer of industrial carbon dioxide emissions. From 2012 to 2002, the value of environmental pollution, most of the year are at the right end of the inflection point. This shows that the limit of the current environmental pollution level in Hangzhou has been close to the workers and the patient will become the main trend of the relationship in the future for a long period of time the environmental pollution and the overall labor productivity is negative, which also highlights the urgency of implementing the Hangzhou Scientific Outlook on Development to achieve change in the mode of economic development. (2) TI and WE had no significant effect on the total labor productivity. (3) R&D investment has a significant positive impact on total labor productivity, which indicates that the technological upgrading of R&D investment can significantly improve labor productivity while promoting economic development.

4.2. Spatial spillover effect

In the Yangtze River Delta, the regional distribution of the loss of urban per capita environmental pollution appears to be in a certain state, which reflects the spatial dependence of the regional economic and geographical behavior. The true spatial dependence reflects the spatial interaction in reality, such as the flow of regional economic factors, innovation diffusion and technology spillover. When the interdependence space observations of the individual, can adopt the spatial lag model and spatial error model (SAR) (SEM) and contains the spatial lagged endogenous variables and exogenous variables spatial Durbin model (SDM) is described.

This paper selects the panel data of 2002 - 2012 years of the 13 Yangtze River Delta city, using spatial econometric model suitable for parameter estimation, an empirical test on the factors affecting the per capita loss of environmental pollution, and close to the city's spatial spillover effect. The dependent variable is the environmental pollution loss per capita, the independent variable is mainly from the three effect model of Grossman and Krueger [11], which is the scale effect, structural effect and technical effect. The scale effect refers to the economic scale, affect the loss of environmental pollution, represented by the city real per capita GDP (PGDP) and its square. Structure effect refers to the change of industrial structure lead to the loss of environmental pollution changes, represented by the proportion of the second industry in GDP. Technical effect refers to the change of environmental pollution loss due to technological progress, measured by the number of technical personnel in industrial enterprises in each city RD. In addition, the use of foreign trade dependence to capture the impact of import and export trade on environmental pollution, the use of real income levels to reflect the level of government efforts to protect the environment ER [12]. All of the data are derived from the statistical yearbook of the cities, and the spatial weighting matrix is obtained from the rules of spatial distance.

Table 3. The estimation coefficient of the spatial model of the 13 cities in the Yangtze River Delta

Estimated coefficient	α	δ	β_1	β_2	β_3	β_4	β_5
	3392.8 (1892.6)	-0.510* (0.253)	0.0118 (0.027)	3.77E-07 (5.6E-07)	30.71*** (4.379)	-0.007*** (0.002)	144.2 (80.94)
Estimated coefficient	β_6	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6
	-0.003 (0.007)	0.19 (0.118)	5.1E-06* (2.3E-06)	-118.9*** (25.32)	-0.015* (0.007)	1320.3*** (299.9)	0.012 (0.024)

Note: (1) the standard deviation of the values in brackets is the coefficient; (2) the * * *, * * and * are respectively expressed at the level of 1%, 5% and 10% respectively.

The empirical test we conducted a mixed regression, SAR, followed by panel SEM and panel SDM four models, Moran 's I test and LR test results support the analysis of SDM model is the loss of environmental pollution is the most appropriate. Therefore, this paper sets the spatial object model (SDM) in the form :

$$DAM_{it} = \alpha + \mu_i + \lambda_i + \delta\sum_{j=1}^{13} w_{ij} \times DAM_{it} + \beta_1 \mathrm{PGDP}_{it} + \beta_2 \mathrm{PGDP}_{it}^{\ 2} + \beta_3 WE_{it} + \beta_4 \mathrm{RD}_{it}$$
$$+\beta_5 TI_{it} + \beta_6 \mathrm{ER}_{it} + \theta_1\sum_{j=1}^{13} w_{ij} \times PGDP_{it} + \theta_2\sum_{j=1}^{13} w_{ij} \times PGDP_{it}^{\ 2} + \theta_3\sum_{j=1}^{13} w_{ij} \times WE_{it} + \theta_4\sum_{j=1}^{13} w_{ij} \times RD_{it}$$
$$+\theta_5\sum_{j=1}^{13} w_{ij} \times TI_{it} + \theta_6\sum_{j=1}^{13} w_{ij} \times ER_{it}$$

The main city of Yangtze River Delta spatial Durbin model (SDM) the empirical coefficients are shown in Table 3, model estimation results show that: (1) the per capita loss of environmental pollution is not only affected by the location of city industrial structure and technological progress, but also by the influence of the adjacent area of the City dependent economic scale and industrial structure, technological progress and trade. In the case of other conditions unchanged, where the city of technological progress, the adjacent areas of the city economic scale, second industries accounted for the proportion of GDP increased and the technical progress of the cut area of the city per capita loss of environmental pollution has a positive effect; and the area where the city second industries accounted for the proportion of GDP increased, the adjacent areas of the city of foreign trade the degree of dependence on increasing the per capita will be the loss of environmental pollution in the region of the city. (2) the spatial Durbin model, and tested at the 10% level, which indicates that the city per capita loss of environmental pollution exists negative spillover effect, the inter regional inter city to a certain extent the performance of the policy or policy for the interaction difference of the alternative. The distribution in the region, the per capita city environmental pollution will exhibit considerable loss in discrete characteristics; in policy initiatives, cross regional city behavior on the contrary, as a regional city by reducing environmental pollution loss measures, and its adjacent areas by increasing city but loss measures. Some scholars call this phenomenon as the transfer effect. There are differences about this phenomenon may be related to various industry positioning city of Yangtze River Delta and the stage of economic development, such as the line center of the city of Shanghai in 2012 the city's GDP exceeded 2 trillion Yuan for the first time, the third industrial added value accounted for the first time reached 60%, basically entered the service economy development stage, Hangzhou, Nanjing, Ningbo, Wuxi and other Yangtze River Delta city still mostly in the late stage of industrialization or industrialization across the late stage of industrialization. At the same time, this kind of negative external effect also indicates that the cities in environmental pollution control reflect a certain degree of non cooperative state.

5. Countermeasures and Suggestions

5.1. Speed up the adjustment of industrial structure and optimization of industrial layout

Industrial structure adjustment, spatial layout optimization and economic development has an inherent law, generally speaking, the adaptability of the city to the industry and capacity to a large extent subject to its development stage. At present, Hangzhou is in a critical period of the later stages of industrialization to the service economy across the stage, facing the situation of environmental pollution is increasingly serious, urgent to low carbon targets for the adjustment of industrial structure, aiming at environment to adjust the direction of the industry, with the ecological harmony as the goal to adjust industrial layout. Specifically speaking:

(1) further speed up the development of modern service industry

The service industry has the characteristics of low pollution, low consumption and high added value, which plays an important role in optimizing the industrial structure, promoting the coordinated development of the first, the second and the third industries. In order to further accelerate the development of modern service industry in Hangzhou, the need to do the following work: (1) clear departments in various fields of modern service industry management benefit, the establishment of the city's modern service industry coordination mechanism, overall development in various fields of modern service industry. (2) the establishment of a modern service industry public service platform. Led by the government, customs, taxation, centralized management of information industry and commerce, transportation, commerce, trade, finance, commodity inspection and other relevant departments of the municipal government, relying on the portal, built for various services in the field of professional websites, and provide the relevant planning, policies and regulations, industry oriented, statistical data, technical standards and approval project services. (3) to strengthen the modernization of the traditional service industry and its integration. The traditional service industry is the foundation of the modern service industry, and the modern service industry is the development of the traditional service industry. The application of information technology penetration degree is the main difference and the symbol of the modern service industry and traditional service industry, application, culture through the information network technology promotion, service model innovation, transformation of traditional service industry, make it into a modern service industry added value, improve its services, and gradually the advantage of scale and brand effect.

(2) transformation of high energy consumption, high pollution, high emissions of heavy and chemical industries, foster the development of emerging industries

Industrial energy consumption and industrial output elasticity of internal structure, spatial layout and effective energy utilization rate and other factors are closely related, therefore recommended that: (1) the government on the basis of industry influence coefficient and influence coefficient of low carbon, combined with the existing industrial base, regional layout planning determines the regional industrial development planning, at the same time, encourage enterprises to increase the introduction of technology and technological transformation of papermaking, printing and dyeing, chemical and other heavy polluting sectors with high energy consumption, vigorously develop high-end equipment manufacturing, energy conservation and environmental protection and new energy and other strategic emerging industries, in energy saving and emission reduction to promote industrial restructuring and upgrading; (2) the development and promote the construction of eco industrial park. Hangzhou can proceed from the local actual situation, select a number of industrial strength is abundant, the environmental pollution is more serious, more prominent highlights of the park or eco industrial enterprises as pilot units for overall planning and development, construction of eco industrial park in different industrial sectors, in different industrial enterprises to establish cleaner production typical. The overall advancement of the way, and gradually build up eco industrial system, the formation of sustainable development mode of circular economy. (3) actively guide the formation of low carbon industrial clusters. Low carbon industrial cluster is one of the important factors affecting the international competitiveness of industrial low carbon, the relevant departments and agencies to local conditions, as far as possible to create conditions to improve the structure and level of regional advanced production factors and specialized factors of production, in order to promote the related low carbon industry gathered in certain areas. Through the scale effect of agglomeration, the effect of "dry middle school" and a relatively complete set of low carbon industry chain, reduce the cost of enterprises, stimulate the vitality of the industry and boost the industrial structure of low carbon transformation.

(3) lead the transformation of urban development model with intelligence and low carbon

Try to avoid a series of problems of city sprawl expansion, the decline in air quality, water pollution and shortage, environmental governance infrastructure and environmental resources loss, steadily promote the coordinated development of Hangzhou city urbanization and industrialization in the framework of the construction of ecological civilization.

5.2. Further optimize the structure of energy consumption, improve energy efficiency

Energy consumption and environmental pollution are mirror images, energy structure and energy efficiency are the key factors that affect the urban environmental pollution. Energy as a modern social development essential production and living materials, in the national economy and social progress plays a fundamental role in promoting the development of urbanization more can not be separated from the input of energy. Present a kind of interaction and mutual influence of the mutual coupling relationship between the city and the energy consumption, a city of increasing economic growth and people's living level, consumption level, and produce more energy consumption, on the other hand, to improve the level of city will lead to improvement of the industrial structure, institutional change and technological progress. In order to improve the structure of energy consumption, energy efficiency and optimize the allocation of energy consumption increase, and inhibit the increase of total energy consumption. Hangzhou's urbanization rate in 2011 has reached 73.9%, close to the end of the city. Therefore, in order to reduce the loss of environmental pollution in Hangzhou, continue to promote energy consumption structure optimization, improve energy efficiency has become the inevitable choice in the context of the new urbanization in Hangzhou city. Specifically speaking:

(1) improve the cleanliness of the energy consumption structure.

Environmental pollution pressure, energy efficiency is low, which is the traditional coal based energy consumption structure to bring the negative effect. For Hangzhou, in order to effectively alleviate the current trend of frequent fog and haze, a pressing matter of the moment is to further reduce the proportion of coal consumption, improve hydropower, nuclear power, wind power, natural gas and other clean energy, the proportion of consumption. To further implement the intensity of energy consumption and total energy consumption of "double control" system, focusing on promoting the heavy pollution and high energy consuming industries to enhance remediation special action and the ecological environment construction, through the elimination of backward production capacity, promote the introduction of green, energy-saving technology and engineering measures, and strive to improve the comprehensive utilization rate of energy, reduce the energy consumption pressure on the environment. In the adjustment of industrial structure and the construction of ecological civilization.

(2)vigorously develop the use of renewable energy, reduce the excessive dependence on fossil fuels.

In order to energy demand and environmental pollution pressure facing Hangzhou industrialization, informatization, city in the process, we must increase efforts to adjust the energy structure, and from the ideas and actions on the importance of the development and utilization of new energy and renewable energy. It is recommended that you choose the solar energy, geothermal energy, wind energy, tidal energy, biomass energy in rural areas and a number of Hangzhou has a certain foundation and utilization of renewable energy technology has a wide prospect of application, increase investment in scientific research and technology development efforts. At the same time, the key enterprises and key products as the starting point, play the guiding role of market mechanism and government, promote the use of renewable energy technology research and engineering project combination, to accelerate the development and utilization of renewable energy technology industrialization.

(3) increase the strength of new energy and environmental pollution control personnel training.

In recent years, the government has invested a lot of money in environmental infrastructure construction and environmental pollution control facilities. In order to engineers and technicians of environmental governance industry needed, suggestions related to higher occupation colleges and occupation high school opened with a lot of environmental pollution control and related professional courses, through the close cooperation between school and enterprise, training a group of "knowledge", business oriented line of sewage treatment facilities, waste disposal facilities, operation management and high-quality practical operators and engineers. At the same time, in view of the current industrial structure transformation of energy and new energy innovation talents shortage of reality, can take foreign and local culture combination, focus on the cultivation of innovative talents of high level, top-notch new energy and excellent team of talent through preferential policies and measures of incentive, to guide its agglomeration innovation line. To create a social atmosphere of energy-saving emission reduction, through credit rating and other measures to guide and encourage enterprises to firmly establish the sense of social responsibility, take the initiative to control the total energy consumption, give priority to the use of clean energy and reduce environmental pollution behavior throughout all aspects of production and operation.

5.3. Support and guarantee mechanism for green technology progress

Green technology, also known as environmental friendly technology, refers to the technology related to environmental protection. The State Intellectual Property Office believes that green technology is a technology system that can reduce pollution, reduce consumption and improve the ecological environment. Correspondingly, some scholars will cause the traditional technology of environmental pollution and ecological destruction called "black technology". The progress of green technology is directly to save resources and energy, avoid, eliminate or reduce environmental pollution, improve production efficiency, directly involved in the production process of some of the knowledge, ability and material means. Restricted to its own technical strength and switching cost of current manufacturing enterprises in Hangzhou and the "double green innovation subject, externality problems, the lack of power by the active energy biased technological progress bias shift to energy saving and clean production of green technological progress. As a kind of environmental friendly technology, has a strong positive externalities of green technological progress, in order to effectively compensate for the "market failure" and "government failure", the diffusion of green technology innovation and green technology to encourage enterprises, promote the suggestions of constructing support and guarantee mechanism of green technological progress from the following three aspects:

(1) institutional incentives

The private benefits of green technology innovation is lower than the social returns, coupled with the development of green technology uncertainty and high risk characteristics, which makes the profit maximizing enterprises unwilling to take the initiative to green technology innovation. And institutional innovation incentives to build the most direct economic links between the main body of innovation and innovation results, and makes the private rate of return to the main innovation of social income. Specifically: (1) through the further clarity of natural resources and environmental resources property rights system, so that the scarcity of natural resources and environmental resources can be reflected in the market price, thereby inducing enterprise development and diffusion to maximize profits were competing for green environmental protection energy-saving emission reduction technology; (2) through the appropriate system of extended producer responsibility so, the producer is responsible not only for use in the process of environmental responsibility for product manufacturing and product, but also for all products in the life cycle of use and scrapped after the environmental responsibility bear some responsibility, in order to encourage enterprises to give priority to the use of cleaner production technologies, and actively promote clean production mode; (3) improve the green patent protection system, and earnestly safeguard the main innovative achievements of the innovation behavior and income distribution, stimulate innovation power of enterprises, and strive to make the green Technological innovation achievement to achieve economic benefits, ecological benefits and social benefits of the three coordinated and unified the best balance point.

(2) economic incentives

The government and relevant departments through government procurement, green technology and green special funds, financial subsidies tax incentives and other economic incentives, to internalize the externality of green technological innovation; to improve the application of green technology research and development investment and financing policy, to provide multiple channels of investment and financing support for the development of green technology, application and development and industrialization; encourage enterprises through the introduction of technology, equipment renovation and further strengthen cooperation, and constantly promote the green technology progress.

(3) appropriate to increase the intensity of environmental regulation, and promote flexible and diverse forms of environmental regulation

The impact of environmental regulation on green technology innovation is not only related to the intensity of environmental regulation and form, but also by the green technology innovation types, effects of different stages of green technological innovation and different area, industry, enterprise features and other factors. At present, Hangzhou increasingly severe haze situation, environmental protection and the relevant law enforcement departments on the one hand to effectively increase corporate environmental pollution behavior of law enforcement and punishment, to curb the development of non green technology; on the other hand, flexible use of emission standards, emissions trading, sewage charges, sewage permits and subsidies and other forms of environmental regulation, guide enterprises according to their own development a reasonable choice of the direction of technological progress, so as to realize the energy biased technological progress to the progress of green technology gradually transition.

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