Coordination Analysis of Environmental Protection Investment Economics in Sustainable Development

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***Abstract* — For a long time, high-consumption, high-pollution and low-output economic development mode has generated a lot of environmental pollutants in emerging country, especially in China. In this paper, authors analyze the impact of environmental protection investment on environmental quality and environmental economic benefits, and then study on the coordinated development of economy and environment by constructing a coordination model. At the same time, authors analyze the practical application by using Quanzhou city of Fujian province as an example. The result shows that environment protection investment can provide a certain degree of decision basis for achieving the sustainable development. The conclusion is that coordination of environmental investment analysis model reflects the general characteristics of environmental investment, quality and environmental economic losses, change of model parameters represent different effects specific environmental investment project on the environment economic benefits and investment value, the model has a good practicality. In practice, this model can offer objective decision-making basis for the economic development, industry and investment policies, making policy scientific, rationalization, thus ensuring the smooth implementation of China's sustainable development strategy.**

Keywords - Sustainable development; Environmental protection investment; Coordination analysis; Environmental quality

I. INTRODUCTION

At present, the environmental problems already draw common concern of the whole society. Environmental governance investment is an important means to promote the harmonious development between economic growth and environmental governance. The World Bank in a 1997 study showed that based on the experience of developed countries, country in the period of rapid economic growth, in order to control environmental pollution effectively, environmental conservation investment in a certain time should reach 1% - 1.5% of GDP continuously and steadily, up to 3% can make the quality of the environment significantly improve. Since 2003, investment of environmental pollution control in our country has had a preliminary scale, as shown in Table1. From total look, investment increased year by year, grew to 9037 billion yuan in 2013 from 1628 billion yuan in 2003, increased by several times, but the proportion of GDP is more stable; from the perspective of structure, a government-led urban environmental infrastructure construction investment will make up the largest part, "Three Simultaneous" construction projects of environment protection investment comes second, followed by the proportion of industrial pollution control investment is the smallest[1].

From the point of view of overall economic growth, environmental investment, as expenses to stop pollution and the protection of the ecological balance, is an important guarantee of solving environmental problems [2]. So, to study the harmonious economy and the environment development, especially to quantitatively analyze the impact of environmental investment upon environmental quality and environmental and economic efficiency, will have a great practical significance upon the making of business policy and investments [3].

II. MECHANISM ANALYSIS OF ECONOMIC DEVELOPMENT AND ENVIRONMENTAL PROTECTION INVESTMENT

The contribution of investment to economic growth is both the supply effect and the demand effect. Supply effect typically means investment can increase effective supply [4]. Through investment to increase the production scale and production capacity, thus increasing the effective supply and promoting economic growth, the demand effect of the investment refers to investment expansion can increase the demand chain, can accelerate the development of the means of production and other related industries. The development of other sectors of production will drive employment growth, increasing income levels, stimulating consumption and so on.

As a class of relatively independent and special in national economic and social development investment, investment in environmental protection has general nature of fixed asset investment and has different characteristics from the general investment in fixed assets [5]. Especially in terms of investment returns, two differences are very big. 1) Environmental investment themes are often at odds with interests, efficiency of environmental protection investment

TABLE I. ENVIRONMENTAL POLLUTION CONTROL INVESTMENT SITUATION IN OUR COUNTRY IN 2003-2013 (BILLION YUAN)

	The total investment in environmental pollution control(Ie)	Urban environmental infrastructure construction investment	industrial pollution control investment	"Three Simultaneous" construction projects of environment protection investment	Proportion of Urban environmental infrastructure construction investment to Ie	Proportion of Industrial pollution control investment to Ie	Proportion of "Three Simultaneous" construction projects of environmental protection investment to Ie	Proportion of Ie to GDP
2003	1628	1072	222	334	66%	14%	21%	1.20%
2004	1910	1141	308	461	60%	16%	24%	1.20%
2005	2388	1290	458	640	54%	19%	27%	1.30%
2006	2566	1315	484	767	51%	19%	30%	1.20%
2007	3387	1468	552	1367	43%	16%	40%	1.30%
2008	4490	1801	543	2147	40%	12%	48%	1.50%
2009	4525	2512	443	1571	56%	10%	35%	1.40%
2010	6654	4224	397	2033	63%	6%	31%	1.67%
2011	6026	3469	444	2112	58%	7%	35%	1.27%
2012	8254	5063	501	2690	61%	6%	33%	1.59%
2013	9037	5223	850	2965	58%	9%	33%	1.59%

is not mainly in the investment sector itself, while in the area of environmental protection investment in industry, agriculture, social welfare and so on, and in the society as a whole [6]. 2) Environmental investment returns mainly shows in the environmental benefits and social benefits, economic benefits are not obvious. However, according to experts at home and abroad study, environmental investment not only would not affect the whole society efficiency, but also promote economic development. 3) Investment mechanism is different from other economic impacts on investments. Its impact on the national economy is mainly demand effect rather than supply effect, its contribution to the national economy mainly through stimulating demand and promoting the development of the means of production and other related industries [7]. Through the increase and decrease of income to stimulate consumption growth, thus contributing to economic growth. Environmental investment stimulating is of multiplier effect on the demand, as shown in Figure 1. In the figure, Δy represents incremental revenue, ΔI represents incremental investment, when investment increases ME1, investment curve will rise from I0I0 to I1I1, and now increase in the amount of income Y0Y1 is a multiple of increase in investment ME1; when investment decreases NE0, investment curve will drop from I0I0 to I2I2, this time, reduction in the amount of income Y0Y2 is a multiple of reduction in investment NE0. In the multiplier principle of investment, the functional relation between investment and income is as follows.

$$Y = (T + I) / (1 - U) \tag{1}$$

Where, T, U represents spontaneity consumption and marginal propensity to consume respectively. If using W represents T / (1-U), with k = 1 / (1-U) for the investment multiplier, then the formula is

$$Y = W + kI \tag{2}$$

Investment multiplier reflects the potential investment efficiency in economic systems and in general its effect requires several months or even longer time span to show up. It needs more time to make all of the investment multiplier effect visible.

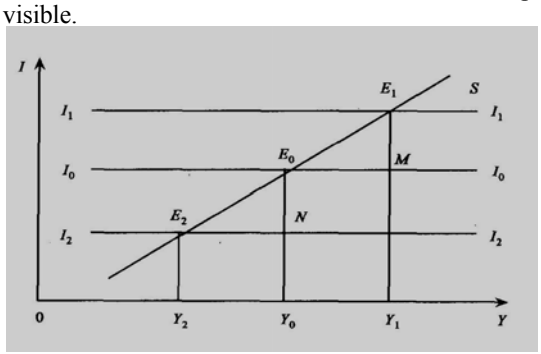

Figure 1. The Mechanism of Environmental Protection Investment Multiplier.

III. THE ANALYTIC COORDINATION MODEL OF ENVIRONMENTAL INVESTMENT

Scholars' studies so far both at home and abroad upon coordinate development in environmental protection had demonstrated different problem-solving approaches and angles. The principal models are widely used so far. (1) Input and output model, which studies the pollution control cost through an analysis of pollutant releases in each department under a certain level of economic growth [8]. (2)Linear programming model tries to optimize the relationship between environmental (protection) investment and environmental pollution limited by some resources of economy, technical and materials. Model of this kind has been widely used in industrial production by some factories in the solution of regional or national problems from pollution control to improvement of both atmosphere pollution and water pollution [9]. (3) Project the model of environmental expense. This model aims to optimize the environmental investment by establishing a given kind of optional relationship between the designing parameter of the project and environmental investment costs [10]. (4) System dynamic model. It studies the improvement of environmental investment from an angle of system coordination of environment, technology, economy, pollution and education. Each of these four models has its own advantages as well as some unavoidable problems when used in investment analysis of environmental protection. For instance, some suppositional relation between environment and economy is linear and thus has quite a great discrepancy from the real situation. The relationship between environment and different varieties of economic system is mostly non-linear, and that between environmental (protection) investment and environmental status is also highly complex and non-linear. Some of the models reveal a relatively poor applicability for they only apply to the very special kind of projects, while others place a much higher demand for data quality and quantity. Theses models are not very applicable for the simple reason that our country started environmental protections rather late and relevant data are far from adequate [11].

Consequently, it has become quite a pressing and urgent task to work out a simple, feasible and practicable model to analyze environmental investment efficiency. This thesis tries to probe into the impact of environmental investment upon environmental features and puts forward an analytic coordination model for environmental investment, and finally, by taking Quanzhou Fujian as an example, discusses the applicability of this model by positive evidences.

Environmental investment refers to the expenses used to prevent pollution to keep the ecological balance [12].

It's a highly complicated thing to categorize environmental investment, for various kinds of methods have been used by different countries or the world. According to the proposal of Ministry of Environmental Protection and the differentiation principle, environmental protection can be divided into

· Investment for industrial pollution protection.

· Expenses for synthetic renovation of urban environment.

· Expenses for synthetic protection of regional environments.

· Investment for the protection and improvement of ecological

· Investment for the administration of environment and environmental service.

The environmental investment will result in a decrease of the amount of pollutants released, and its benefits lie in the decrease of economic loss caused by pollution. (See Fig .2)

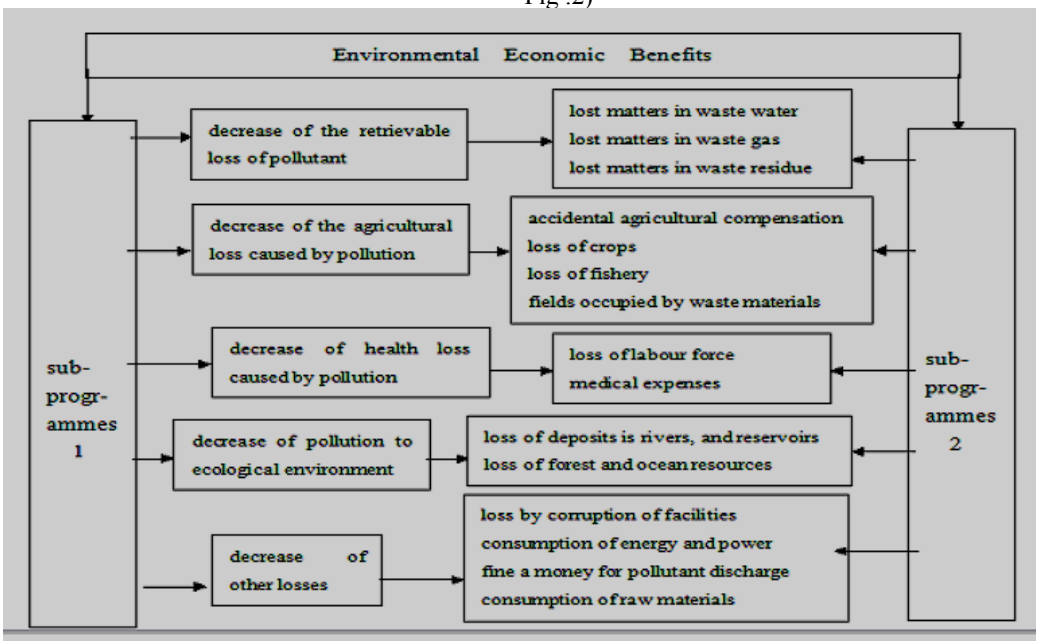

Figure 2.The Principal Program of Environment Economic Benefits

It's believed that apart from the characteristics of specific environmental investment programs, the abstract relationship between environmental investment and the amount of pollutants discharged as well as the environmental economic benefits share some generalities [13].

· The great amount of pollutants discharged corresponds with the high-strength environmental investment, which the environmental economic loss tends to be small.

· The small amount of pollutants discharged corresponds with low-strength environmental investment, which the environmental economic loss tends to be great.

· Curve f_1 of environmental investment is the monotonous progressive increase function of the amount of pollutants discharged, while f_2 is the monotonous progressive decrease function of the amount of pollutants discharged. f_1

Thus we may infer the feature of total expenses ($f = f_1 + f_2$) curve is

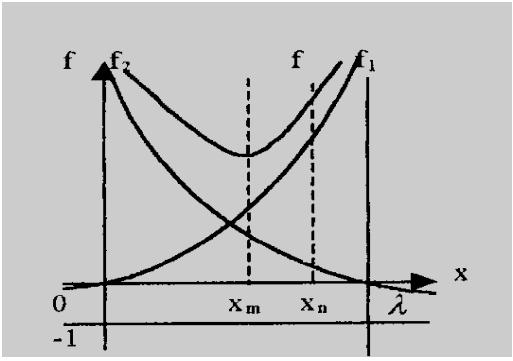

Figure 3. Curve of Expenses Investment of Environment Protection

f minimizes when there is a minimum number in the total expense, that is, $x = x_m$.

· When the discharged amount; if $x < x_m$, that $f_1 < f_2$.

Under the above premise, when the amount of pollutant emissions increases, the environmental economic loss will decrease while the environmental investment value will increase. Their sum forms a U-shaped curve of expenses (See picture 1) . So there exists an optimization area of the environmental investment $(x_m - x_n)$, and the key to this optimization area is to establish a mathematical model of curve f .

According to the above-mentioned feature of the relationship between environmental investment and environmental quality as well as environmental economic benefits, we assume λ to be the amount of pollution. If a lot of pollution or the environmental investments of pollution renovation in a given area is to be analyzed, then it can take the equal pollution load on the basic which the following model is raised.

$$f = f_1 + f_2 = k[x/(\lambda - x)]^{\alpha} + F[(\lambda - x)/x]^{\beta}$$

$$k > 0, \quad F > 0, \quad \alpha > 0, \quad \beta > 0,$$

$$and \quad the \quad const ant, \quad (x < \lambda)$$

$$have \quad \frac{df}{dx} = 0 \qquad or \qquad \frac{df_1}{dx} = \frac{df_2}{dx}$$

The negative sign indicates the contrary contribution of the discharged amount to environmental investment and environmental economic loss. Using the above formula, we can find the optimization point x_m .The economic benefit is that the increase or the additional value of environmental investment needed by discharged amount of pollutant equals the decrease of the environmental economic loss caused by discharged amount of pollutants [14].

IV. THE APPLICABILITY ANALYSIS OF THE COORDINATE MODEL OF INVESTMENT ANALYSIS FOR ENVIRONMENTAL PROTECTION

Previously we have pointed out not only the generality of the relationship between environmental investment and environment quality together with environmental economic benefits but also the characteristics of the total expense curves [10]. It's held to be reasonable that the applicability of the analytic coordination model is good if it can reflect those characteristics and adapts to special situation of a particular program of environmental investment merely through the change of parameters. The applicability analysis of the model goes like this.

$$f = f_1 + f_2 = k[x/(\lambda - x)]^{\alpha} + F[(\lambda - x)/x]^{\beta}$$

$$k > 0, F > 0, \alpha > 0, \beta > 0, \quad and \quad the \quad const ant, \quad (x < \lambda)$$

$$\frac{df_1}{dx} = k\alpha x/(\lambda - x)]^{\alpha - 1} \times [\lambda/(\lambda - x)^2] > 0$$

$$\frac{df_2}{dx} = -F \times \beta \times [(\lambda - x)/x]^{\beta - 2} \times \lambda/x^2 < 0$$

$$make \quad \frac{df}{dx} = 0 \quad have \quad x_m = \frac{\lambda}{1 + \exp[\ln(k \times \alpha/F \times \beta)/(\alpha + \beta)]}$$

$$\frac{d^2 f}{dx} = k \times \alpha \times [x/(\lambda - x)]^{\alpha - 2} \times [1/(\lambda - x)^2] \times [\lambda^2(\alpha - 1) + 2 \times x \times$$

$$\times \lambda/(\lambda - x)] + F \times \beta \times [(\lambda - x)/x]^{\beta - 2} \times [1/x^3] \times$$

$$[\lambda^2 \times (\beta - 1) + 2 \times \lambda \times (\lambda - x)/x]$$

$$then \quad \left.\frac{d^2 f}{dx^2}\right|_{x = x_m} > 0$$

So, the functions of the treatment cost model are as follows.

· Environmental investment curve f_1 to the derivative about the amount of pollutants discharged is the monotonous progressive increase function of that discharged amount.

·Environmental economic loss curve f_2 to the derivative about the amount of pollutants discharged is actually the

monotonous progressive decrease function of that discharged amount.

In $x_m = \dfrac{\lambda}{1+\exp\left[\ln\left(\dfrac{k\times\alpha}{F\times\beta}\right)\Big/(\alpha+\beta)\right]}$ except that an only minimum of existing is a minimum.

In other words, this model can fully reflect the generality of the relationship between environmental investment and environmental economic loss as well as environmental quality. The economic significance of the parameters $k, F, \alpha,\ and\ \beta$ in the model lives in

(1) k, f are parameters of scale, only affecting the size has not the curve shape of environmental investment and environmental loss. So that k and f is reflect the size of investment and environmental loss in a given environmental investment program that almost has nothing to do the amount of the pollutants discharged.

(2) α and β are parameters of shape. They are used to show the susceptibility of environmental investment and environmental economic loss in a given environmental investment program to the change of the amount of pollutants discharged. If α and β are large, it means the environmental economic loss caused by the change of the same amount of pollutants and the investment needed will be large, too, or vice versa.

So, the different values that k, F, α, B take can reflect the characteristics of a given environmental investment program. Therefore I can say this model has very good practicability as an analytic coordination model of optimizing the environmental investment.

V. Positive Analysis of Analytic Coordination Model of Environmental Investment Optimization

After discussing the analytic coordination model of environmental investment optimization, let's come to a positive analysis of it according to its feature of applicability [15]. From Collection of Environmental Statistic Data during1999 and 2014 by Environmental Protection Bureau of Fujian Province, we can find that this analytic coordination model can make a very good analysis of environmental investment in the pollution renovation of exhaust gas release. The detailed data are listed below.

TABLE II 1999—2014 CITY OF QUANZHOU SO_2 DISCHARGE AND GET RID OF QUANTITY STATISTICAL FORM

Year	Emission (T)	Getting Rid (T)
1999	3228.4	301
2000	3416.83	241
2001	5987	412
2002	5312	454
2003	5221	468
2004	4219.5	424.88
2005	5103.35	585.29
2006	5489	532
2007	2858.36	444.52
2008	5784	274.69
2009	3535.51	411.81
2010	12453.8	8671.31
2011	20046	1161
2012	13828.81	3207.22
2013	17717.69	5586.16
2014	17674.39	2204.26

$$f = f_1 + f_2 = k\times[x/(\lambda-x)]^{\alpha} + F\times[(\lambda-x)/x]^{\beta}$$

$$k, F > 0 \qquad 0 < x < \lambda$$

$$Environmental\ \ investment = f_1 = k\times[x/(\lambda-x)]^{\alpha}$$

$$\log f_1 = \log k + \alpha\log x + \alpha\log(\lambda-x)$$

$$= \log k + \alpha[\log x + \log(\lambda-x)]$$

$$Economic\ \ losses\ \ of\ \ environmental\ \ pollution = f_2$$

$$f_2 = F\times[(\lambda-x)/x]^{\beta}$$

$$\log f_2 = \log F + \beta\log(\lambda-x) + \beta\log x$$

$$= \log F + \beta[\log(\lambda-x) + \log x]$$

$$Environmental\ \ investment\ (f_1)\ \ equation$$

$$\log f_1 = 5.2385 + 3.0070[\log\frac{x}{\lambda-x}]$$

$$(14.3243)\quad (3.2239)$$

$$Environmental\ \ pollution\ (f_2)\ \ equation$$

$$\log f_2 = 7.7408 + 1.7727[\log\frac{\lambda-x}{x}]$$

$$(33.9287)\quad (3.0464)$$

$$\Rightarrow F = 188.3873$$

$$k = 2300.312$$

Examine through t , [t value >2] the variable is remarkable.

VI. The Applicability Analysis of the Coordinate Model of Investment Analysis for Environmental Protection

After the applicability analysis and positive of analysis of the analytic coordination model of environmental investment, the opinions are as follows,

(1) This analytic coordination model reflects the general features of environmental investment, environmental quality and environmental economic loss. The change of the parameters indicates the different influences of a given environmental investment program upon the value of environmental economic benefits and environmental investment. The model enjoys a very good practicability.

(2) The expense curve is very sensitive to the changing of shape parameters of the model and this analytic coordination model has extensive adaptability.

(3) The non-linear relationship between environmental investment and environmental economic benefits and improvement of environmental quality can be fully demonstrated in this model.

(4) The demand for the historical quantity and quality is relatively low, and because of the characteristics of its explicit function model, its practical ability is better than others'.

(5) Though this analytic coordination model is worked out by an analysis on the level of regional economy, it will

still have an extensive application value to analyze the environmental investment of our country. In addition, it will also provide some references to macro policy making of the national environmental investment and the medium level of strategy of environmental investment in regional economy as well as the micro analysis of the environmental investment in businesses and enterprises.

Environmental investment expands domestic demand, and builds up a pollution control facility, adds the ability to control pollution and provides the setting to improve the quality of the environment, which meets the relevant environmental quality requirements. Meanwhile, it creates the gross domestic product (GDP), increases the tax dollars, provides new employment opportunities and stimulates the economy. In the current situation of excessive supply on a buy's market, investment for environmental protection has a significant multiplier effect. From an economic point of view, environmental investment stimulating effect on GDP is closely related to the economic situation. According to the American economist Paul Samuelson's multiplier theory, the multiplier effect of investment only shows in excessive supply, excess labor and resources economic environment conditions. At present, our country is in such an economic environment. So GDP created by pollution control investment which is about 1.59% of GDP as a percentage of total GDP is 1.70 percent in 2013, showing the multiplier effect is 1.47, indicating that the current environment is the great opportunity to strengthen infrastructure construction.

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REFERENCES

[1] Den buter F A, Hofkes M Q, "Sustainable Development with Extractive and Non-Extractive Use of the Environment in Production", Environmental and Resource, vol.6, No.4, pp. 341-358, 2010.

[2] Withagen C. Pollution, "Abatement and Balanced Growth", Environment and Resource Economics, vol.5, No.9, pp. 1-8, 2011.

[3] Agent R M,Grayson R B, "Integrated models for environmental management Issues of process and design", Environment International, vol.6, No.2, pp. 693-699, 2011.

[4] Vaughan,W.J.and S.Aradila, "Economic analysis of the Environmental Aspects of Investment projects", Inter-American Development Bank, 2012.

[5] MA Xiu-yan, "Problem of Investment Environmental Protection in Sustainable Development Strategy Visual Angle is studied", Make the Investment to Study, vol.5, No.8, pp. 44-47, 2010.

[6] C, "Constantinides Methodology for the use of cost-benefit analysis in environmental investment projects a review of the island of Rhodes analysis", UNEP (OCA)/MED WG.45/5, vol.8, No.2, 2012.

[7] Thi Binh Minh Nguyen and A.T.M Nurul Amin, "The Role of Foreign Direct Investment in Urban Environment in Urban Environmental Management Some Evidence from Naomi Vietnam", Environment, Development and Sustainability, vol.1, No.7, pp. 279-297, 2011.

[8] D.W.Pearce, J. J. Warford, "World without End", Oxford University Press, 2012.

[9] GONG Yu-rong, SHEN Song-dong, "Study on status and Problems of Environmental Investment", Industry Technical Economy, vol.2, No.5, pp. 83-84, 2012.

[10] ZHONG Jian-sheng etc, "Research of a General Model in Analysis of Investment Environment Protection", System Engineering, vol.1, No.4, pp. 52-56, 2012.

[11] Clem A Tisdell, "Protection of the Environment in Transitional Economics", Regional Development Dialogue, Vol.18, No.1, pp. 79-100, 2011.

[12] B.W.Ang,Ki-Hong Choi, "Decomposition of Aggregate Energy and Gas Emission Intensities for Industry A Refined Divisia Index Method", Energy Journal., vol.18, No.7, pp. 144-156, 2010.

[13] MA Jin etc, "A Coordination Optimizes Model of Regional Industry Investment and Environmental Protection Invest in its Trial, System Engineering", Theory and Practice, vol.5, pp. 35-40, 2008.

[14] ZHANG Qiao, "The Elastic Coefficient of Environmental Pollution Treatment Ability and Application", Environment and Sustainable Development, vol.7, pp. 1-3, 2000.

[15] Pan Jiehua, "The Way of Sustainable Development in the Economic Analysis of the Way", Beijing, People's University of China Press, 2010.