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Economic Evaluation of Chemical Construction Projects on Environmental Impact

Xiaomei Lin
Hainan College of Economics and Business, Haikou 571127, China
lxm5994@163.com

The purpose of this paper is to make an economic evaluation of chemical construction projects on environmental impact. By analyzing the serious pollution and damage caused by the chemical industry, the construction project of chemical industry is analyzed, while reasonable and effective evaluation indexes and methods are established. Cost benefit method was used for the analysis. The index system for economic evaluation of chemical construction project was established, including environmental cost index and environmental benefit index. According to the method of economic evaluation of environmental impact of chemical construction project, each index is calculated, and the calculation formula of the index is obtained. Finally, it is applied to the project of ethylene expansion and extension project in chemical plant. The experiment result shows that the economic benefit is obviously lower than the economic benefit of environmental impact assessment. Based on the above finding, it is concluded that the feasibility of the evaluation method is verified and satisfactory results are obtained, which show that the economic evaluation of the environmental impact of chemical construction projects is feasible.

1. Introduction

With the rapid development of economy, the world is facing more and more serious problems of ecological environment. The chemical industry is a highly polluting industry. Chemical production has caused serious pollution and damage to the environment, and restricted the sustainable development of the chemical industry and even the economy (Wang, 2015). The research and practice of environmental impact assessment of chemical construction projects have reached a fairly high level. However, considering the cost of environmental damage and the benefits obtained by environment improvement, the environmental impact assessment results are included in the project feasibility analysis. The choice of the project has more scientific significance (Inazumi and Manabe, 2016).

At present, the economic evaluation about the environmental effects of construction projects is mainly concentrated in the theory of welfare economics, the theory of environmental economic value, utility theory, the consumer surplus theory and cost - benefit analysis theory (Wang and Xu, 2015). Recent studies have focused more on the practical application of environmental impact economic evaluation, that is, the study of economic evaluation methods for environmental impact. The cost-benefit analysis method is used to establish an index system for economic evaluation of chemical construction projects (Choi and Ryu, 2015). It includes environmental cost index and environmental benefit index. According to the different objects of cost and benefit, the environmental cost index is divided into direct cost index and indirect cost index. The environmental benefit index is divided into direct economic benefit index and indirect economic benefit index (Crittenden and John, 2015). The method of economic evaluation for environmental impact of chemical construction project is used to calculate each index (Ozcan-Deniz and Zhu, 2015). The index of calculation formula is obtained. Finally, it is applied to T chemical plant ethylene expansion project. The results show that the economic benefit of the project is obviously lower than that of the environmental impact assessment. The feasibility of the evaluation method is verified and satisfactory results are obtained. It shows that the economic evaluation of the environmental impact of chemical construction projects is feasible.

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2. Methods

2.1 Overview of cost benefit analysis

Cost benefit analysis is also called national economic analysis and economic analysis. It is the basic method of environmental economic profit and loss analysis. It requires a damaging valuation for social and environmental benefits brought by building project (Scheumann, 2017). It can also be said that the quantitative monetary form is used to check the loss caused by environment pollution and the social and economic benefits. Cost benefit analysis should first define the environmental cost and environmental benefit, which is the premise of environmental cost benefit analysis. Environmental costs and benefits are defined to internalize internalization of environmental gains and losses (Li et al., 2016). This is the core of the effective control of environmental pollution through the economic mechanism itself.
Environmental costs include internal and external costs. Internal expenses are the costs necessary to achieve the objectives of the project. It is composed of two parts: production cost and environmental protection cost. External costs are the costs of external dis-economy resulting from the project and are mainly used for environmental hazards. Benefits can also be divided into internal and external benefits. The internal benefit is mainly the economic benefits brought by project output and the benefits of employment personnel, and the external benefits are the economic benefits of environmental impact (environmental improvement).

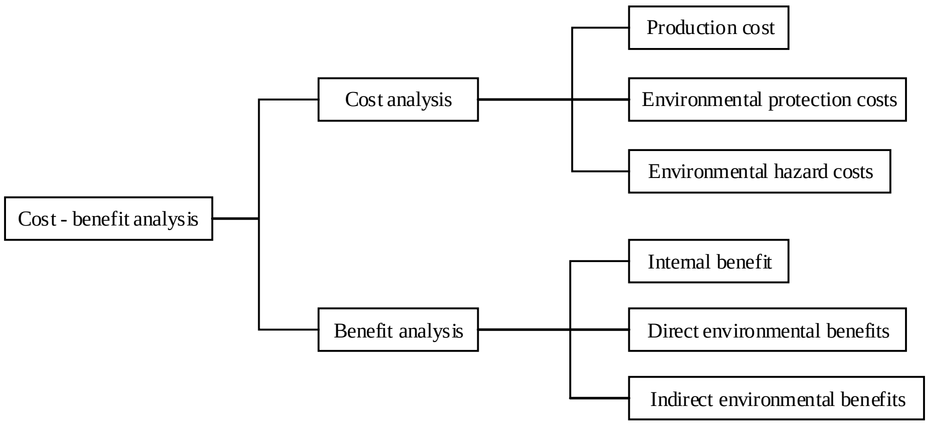

Figure 1: Cost benefit analysis

Cost benefit analysis steps: First of all, the economic gains and losses of environmental factors caused by the construction project are analyzed and quantified. Secondly, the investment of environmental protection facilities in construction projects is proposed. Thirdly, the expenses and benefits in an equivalent way are calculated. Finally, profit and loss analysis is carried out based on the costs and benefits, while the evaluation and decision for the program are also carried out.

2.2 Cost analysis

In general, the total cost of the project can be divided into production costs, environmental protection costs and environmental harm costs. And its benefits can be divided into two categories: project economic benefit and environmental improvement benefit. Each kind of cost and benefit contain several items.
The cost of the construction project includes internal and external expenses. Internal costs are the costs that must be spent in order to achieve the goals of the project. It mainly includes the basic construction cost and the operation and maintenance cost, which is composed of two parts such as the production cost and the environmental protection cost. External costs are the costs of the project causing external dis-economy and are mainly used in environmental hazards.
(1) Production expenses (PC)
Annual production costs include fixed investment, resource investment and operating maintenance costs. Assuming that resource prices reflect the scarcity of resources, the price itself has compensated for the depletion of resources and the ability to sustain economic growth.
Assuming that the fixed annual investment is C, the annual operating and maintenance fee is S. For resources, we assume that the required resource vectors for the project are A= (al, A2,...., an). The corresponding resource price vectors are q= (Q1, Q2,..., QN), and the production cost PC can be expressed as:

$$PC = C + S + \sum_{j=1}^{n} a_j q_i \qquad (1)$$

M represents resource cost $\sum_{j=1}^{n} a_j q_i$, and i represents the production expenses for the year i:

$$PC_i = C_i + S_i + M_i \qquad (2)$$

(2) Environmental protection cost (EPC)
This part of the cost is expressed directly as currency or calculated by monetary units, which is borne by the investors of the project. The main items are as follows:
Equipment purchase fee (C11); Operating costs of environmental protection equipment (C12): including fuel costs, power costs, workers' wages and so on; Environmental management fee (C13); Sewage charges (C14); Compensation and fines for environmental pollution (C15); The loss of resources for the discharge of pollutants (C16): including the occupation of cultivated land, trees and houses and other damages and fines; The other direct costs (C17): in addition to the above charges outside the immediate environment and other costs.
(3) Environmental damage cost (WPS)
Environmental damage cost refers to the environmental cost paid by the society for the project. It is the environmental loss caused by the environmental pollution and destruction during the construction and mining of the chemical project. This part of the cost is usually not directly represented by money, but can be quantified by a dose response relationship, which is monetized, and this part of the cost is borne by society. Generally speaking, the environmental damage cost consists of three parts: direct loss, indirect loss and enjoyment loss. Each index is calculated as follows:
Land loss (C21): the impact on the ecological environment caused by the occupation of land is the decrease of ecosystem output. We assume that the average annual output value of agricultural products is w, each year will have accounted for the original crop a% research into maturity. According to the EIA forecast, the average output reduction of crops is b% after the completion of the project. The formula is as follows:

$$C_{21} = W \times a\% \times \sum_{i=1}^{t} (1 + b\%)(1 + r)^t \qquad (3)$$

Forestry loss (C22): it refers to the loss of forestry value caused by the occupation and destruction of forest land by construction projects in the evaluation area. We assume that the market price of the first j trees is Pj, and the loss is Qj, with a total of n species of trees. During the whole life cycle of the project, the total loss of forestry is:

$$C_{22} = \sum_{i=1}^{t} \left[\sum_{j=1}^{n} P_j \times Q_j / (1 + r)^t \right] \qquad (4)$$

Loss of water resources (C23): It mainly refers to the reduction of fishery products in the evaluation area due to the air pollution and waste water pollution in the chemical factory. In the affected area of the project drainage, the annual catch of various kinds of fish is Wj tons, the market price is Pj yuan/ton, and the environmental evaluation predicts the discharge of the sewage after the project is completed. The rate of decrease in catch per fish was Kj with a total of M species. The total economic loss present value of C23 within T is calculated.

$$C_{23} = \sum_{i=1}^{t} \left[\sum_{j=1}^{m} W_j \times P_j \times K_j / (1 + r)^t \right] \qquad (5)$$

Human health loss (C24): Because of the environmental pollution and damage of particulates, the decrease of human health in the evaluation area is mainly caused by the increase of morbidity and mortality.
Loss of soil erosion (C25): it includes soil erosion caused by original land form and vegetation destruction. This index is calculated by the method of protective cost.
Biodiversity loss (C26): it refers to the loss of ecosystems caused by chemical pollution.
Enjoyment loss (27): Because of the pollution and destruction of the environment, the service quality of the landscape, air, green land and so on is reduced, thus causing the loss for enjoyment of people.

2.3 Benefit analysis

Internal economic benefits: The internal benefits of construction projects consist of the sales benefits of their products and the wages of their employees. We assume that the annual output vector of the project is Pi; the product price vector is r, then the project sales value is P=R. The total annual salary of employees is S, and the internal benefit of the project is Xc, which can be expressed as:

$$X_c = P_i \bullet r + S \tag{6}$$

The environmental economic benefits of chemical construction projects refer to the environmental losses which have been recovered due to environmental protection measures, the reduced sewage charges and fines, and the economic income obtained from the recycling of resources. It can also be expressed as environmental damage caused by the absence of any environmental protection measures, less environmental and economic losses that have been avoided by environmental protection facilities. It includes direct economic benefits (B1) and indirect economic benefits (B2).
Direct economic benefit B1: The direct economic benefit is the internal revenue obtained by chemical projects because of environmental protection measures. It includes the following items: Recycling of chemical pollution resources (B11); Purification and utilization of waste water (B12); Conservation of sewage charges, compensation and fines (B13); Other direct economic benefits (B14).
Indirect economic benefit B2: Indirect economic benefit refers to the economic benefits of the chemical project obtained by the surrounding areas and society outside the project because of adopting environment protect measure. It is similar to external cost and cannot be expressed as money directly. However, it can be quantified by dose response relationship, and monetization is an indicator that is not easy to monetize. Its main contents include: Decrease in land loss (B21); Decrease in forestry losses (B22); Loss of water resources (B23); Loss of human health (B24); Loss of soil erosion (B25); Loss of biodiversity loss (B26); Loss of enjoyment (B27); Other indirect economic benefits (B28).

2.4 Cost-benefit analysis

Present value of total cost GPC: The total cost of construction project GPC is equal to the sum of production costs, environmental protection costs and damage costs. The service life of the project (also known as the life cycle) is m years:

$$GPC = \sum_{i=1}^{m} \frac{GPC_i}{(1+r)^i} = \sum_{i=1}^{m} \frac{PC_i + GPC_i + W_i}{(1+r)^i} \tag{7}$$

In the formula, "I" refers to the annual variable; R refers to the discount rate; m refers to the service life of the project. Total benefit present value GB: The total benefit of construction project GB is the sum of project economic benefit and environmental improvement benefit. That is,

$$GB = \sum_{i=1}^{m} \frac{B_i}{(1+r)^i} = \sum_{i=1}^{m} \frac{XC_i + W_i}{(1+r)^i} \tag{8}$$

Present value of net benefit NB: The present value of net benefit NB is the difference between the present value of total benefit and the total cost:

$$NB = GB - GPC = \sum_{i=1}^{m} \frac{B_i - GPC_i}{(1+r)^i} \tag{9}$$

Benefit cost ratio K: The benefit cost ratio is calculated as follows:

$$K = GB / GPC \tag{10}$$

When K>1, the project is feasible, and the better the K value is more large. When K=1, it is not feasible to readjust the project or construction project.

3. Example application and analysis

The total investment of this project is 360,820,000 yuan. Among them, construction investment is 310,330,000 yuan. The construction period of the project is 3 years, and the life span is 10 years. Chemical construction projects have relatively strict requirements for pollutant discharge, and environmental protection facilities are relatively perfect. In the construction projects, investment in environmental protection takes up a large proportion. In order to ensure the discharge of industrial waste, the environmental protection investment in the expansion project includes the construction and reconstruction of the sewage treatment plant, the reform of the clean production plant, the control measures of environmental impact and so on. Investment in environmental protection facilities accounted for 8.72% of construction investment, that is, 31033× 8.72%=27,060,800 yuan.

3.1 Total cost benefit analysis of the project

Present value of total cost (GPC): After discounting the total cost of the project, GPC is: 132407.74+4903.68+0=1,373,114,200 yuan.
Present value of total benefit (GB): The total benefit of the project is 215,650,000+70,196,920 yuan per year. The total benefit of the project after discounting is 1,759,387,800 yuan.
Present value of net benefit (NB): The present value of net benefit NB is the difference between the present value of total benefit and the present value of total cost. That is, NB=GB-GPC.
According to the general requirement of the present value principle of net benefit, the project is feasible as long as the present value of the benefit of the project is greater than zero, or NB>0. In practice, however, it is desirable that the net present value of the project be as large as possible.
NB=GB-GPC=175938.78-137311.42=38627.36 > 0. Therefore, the project is considered feasible.
Benefit cost ratio (K): The benefit cost ratio is calculated as K=GB/GPC, and K is the benefit cost ratio in the formula. When K>1, the project is considered feasible. When K<1, it is not feasible to readjust the project scheme or construction project. This project is K=1.2813>1, therefore, the project is considered feasible.

3.2 Cost benefit analysis of project environmental impact

As for the costs and benefits of environmental protection alone, the total benefit after discounting is 432,062,000 yuan. The total cost after discounting is 49,066,800 yuan, and the benefit is K=43206.2/4906.68=8.8. It can be seen that the benefits of environmental protection investment are far greater than the cost, which is quite economical.
Without calculating the cost of environmental protection and environmental improvement, the annual financial profit of the project shows that the total profit is 446,850,000 yuan. It is larger than the net cost of calculating environmental protection costs and benefits of 386,273,600 yuan.

Table 1: Summary of cost evaluation results (Unit: RMB: Ten thousand yuan/year)

Production cost PC	21512		
Environmental protection cost	4903.68	Purchase fee C11	2706.08
		Operating cost C12	324.73
		Environmental management fees C13	27.06
		Sewage charges C14	Negligible
		Compensation and fines C15	
		Loss of resources in pollutant emission C16	36
Environmental damage cost	Negligible		
Total (discount)	137311.4		

Table 2: Summary of benefit evaluation results (Unit: RMB: Ten thousand yuan/year)

Direct environmental benefits B1	4104.89	Recovery and utilization of pollutant resources B11	3951.44
		Saving compensation for pollution discharge B12	141.15
		Other direct economic benefits B13	Negligible
Indirect environmental benefits B2	2914.80	Decrease in land loss B21	60.71
		Decrease in forestry losses B22	Negligible
		Decrease in water resources loss B23	Negligible
		Decrease in health loss B24	2768.48
		Decrease in water pollution losses B25	2
		Decrease in biodiversity loss B26	Negligible
		Decrease in enjoyment loss B27	82.612
		Other indirect economic losses B28	Negligible
Project economic benefit Xc	21565		
Total (discount)	175938.78		

The net benefit present value and benefit cost ratio from the calculated items: the net benefit is NB=38627.36>0, and the benefit cost ratio is K=1.2813>1, it can be seen that the project is feasible. The remaining calculations are shown in table 1 and table 2.

4. Conclusions

In view of the current environmental impact assessment of chemical construction projects, environmental and economic evaluation of chemical construction projects is put forward. The evaluation results of the qualitative evaluation of the environmental impact are included in the feasibility analysis of the project. From the view of sustainable development, the index system of environmental impact economic evaluation is established by applying cost benefit theory and environment theory. Taking the ethylene expansion project of T chemical plant as an example, the environmental impact economic analysis of the project is carried out. On the premise of considering the cost of environmental damage, the environmental damage cost of main pollutants and environmental improvement benefit of environmental protection investment are estimated based on environmental economic value calculation principle. Through theoretical research and empirical analysis, it shows that environmental economic evaluation is not only necessary, but also feasible.

Reference

Choi J., Ryu H.G., 2015, Statistical analysis of construction productivity for highway pavement operations. KSCE Journal of Civil Engineering, 19(5), 1-10.

Crittenden C., John C., 2015, Development of environmental indices for green chemical production and use. , 15(1), 286-299.

Inazumi S., Manabe M., 2016, Effectiveness evaluation on reuse of construction sludges considering uncertainties of environmental economics. Japanese Geotechnical Society Special Publication, 2(54), 1868-1873.

Li Z., Nie X., Zhang Y., Huang J., Huang B., Zeng G., 2016, Assessing the influence of water level on schistosomiasis in dongting lake region before and after the construction of three gorges dam. Environmental Monitoring & Assessment, 188(1), 1-10.

Ozcan-Deniz G., Zhu Y., 2015, A multi-objective decision-support model for selecting environmentally conscious highway construction methods. Journal of Civil Engineering & Management, 21(6), 733-747.

Scheumann W., 2017, The political economy of salinisation in public irrigation systems. Journal of Chemical Industry & Engineering, 953-954(953-954), 267-270.

Wang H., 2015, On the economic evaluation of oil and gas projects. Modern Industrial Economy & Informationization, 9(3), 285-344.

Wang P., Xu C., 2015, Research on the comprehensive evaluation of china’s environmental health, 2003–2010. Social Indicators Research, 122(3), 709-721.