Effectiveness and Limitations of Cost-benefit Analysis in Policy Appraisal

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1. Introduction

Faced with the double challenges of economic downturn and the fiscal crisis, economists are divided into two camps: that which emphasizes demand, and that which emphasizes supply. The position emphasizing demand places emphasis on the principle of effective demand as discovered by Keynes, and holds the view that demand plays a major role in setting macro-production levels and that supply is decided by demand. This position also attributes the economic downturn to insufficient demand and the other side of the coin, that is, over-savings in the private sector. Therefore, the role of budget deficits to reduce this imbalance is positively appraised. On the other hand, the position that emphasizes the supply side focuses on the deterioration of productivity in the Japanese economy and insists on structural reform to improve production power.

Both sides are in agreement, however, on the point that the efficiency in the public sector is important. They insist that the public projects needed currently by society should be executed by abandoning less useful projects. They say that appraisal of efficiency should be properly made in public policies. But how is the efficiency of public policies to be appraised? The appraisal method that economics has traditionally provided is cost-benefit analysis. But is cost-benefit analysis a complete method? Is it a method that can contribute to increasing the efficiency of government activities in response to social expectations?

This paper first describes how the economic foundation of the cost-benefit analysis method is structured. The theoretical limitations of cost-benefit analysis become clear through this alone. Next, examples from actual cost-benefit analyses are presented. Cost-benefit analyses of both public works and environmental policies are taken as examples. Finally, the effectiveness of cost-effectiveness analysis, which is the restrictive application of efficiency criteria on which cost-benefit analysis is based, is described by combining both actual points and those that can be theoretically defined.

2. Foundation of cost-benefit analysis in view of welfare economics

2.1 Concept of efficiency on which cost-benefit analysis is based

Cost-benefit analysis is a tool for judging efficiency in the case where the public sectors supply goods, or where the policies executed by the public sectors influence the behavior of private sectors and change the allocation of resources. The concept of efficiency in that case is made on the premise of the market economy.

The market economy consists of the spontaneous transaction of goods and services. A remarkable characteristic of spontaneous transaction is that there is no person who loses in the transaction itself.

A buyer of goods, who obtains the goods by paying money, is willing to obtain the goods because the amount he

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Meanwhile, a seller of the goods, who receives money in exchange for relinquishing the goods, relinquishes them because the amount he or she can get is large enough. A seller will not be willing to relinquish the goods if the amount of money is too small. This assumes that there is a minimum amount of money needed to make a seller willing to relinquish the goods. In economics, this monetary amount is called "WTA: willingness to accept". No one is willing to sell goods unless they can be sold at a price greater than WTA.

In the case where a buyer is the consumer of the goods, WTP for the buyer will depend greatly on the buyer's subjective appraisal of the goods, in other words, the utility the goods bring. WTA for a seller will also depend on a subjective appraisal in a case where the seller is also a consumer of the goods. There is little relationship to a seller's subjective appraisal, however, in cases where the seller is a producer of the goods or only a distributor of the goods. Instead, WTA is equal to the costs of supplying the goods.

The agreement of selling and buying in the market means that a buyer bought at a price lower than WTP and a seller sold at a price greater than WTA. A buyer who bought at a price lower than WTP will have the better subjective utility, and a seller who sold at a price greater than WTA should make a profit from the sale that exceeds the costs. That is to say, market transactions do not fail to bring gain to the parties in a transaction.

In a case where everyone makes gain or a person makes gain with no one suffering a loss as a result of change, the change is defined as a "Pareto improvement." The market transaction is defined as efficient in that it brings about the Pareto improvement.

Cost-benefit analysis is the method by which this concept of efficiency can be applied to publicly supplied goods as well. Provided that the publicly supplied goods bring utility to people, these people are assumed to possess WTP for the publicly supplied goods. WTP of these people represents the benefit of supplying such goods. On the other hand, WTA is the cost for supplying the goods. The estimation of the aggregate amount of cost and benefit is cost-benefit analysis, from the standpoint that the supplies are efficient if the total amount of such benefits, including those for all the people concerned, exceeds the total costs.

Difficulty exists, however, in transferring the efficiency concept for market goods to publicly supplied goods. The efficiency concept in the meaning of a Pareto improvement cannot be applied because the goods targeted by cost-benefit analysis are supplied goods of a public nature. Projects supplying the goods of roads, bridges, dams, sewerage, etc. are targeted for cost-benefit analysis. These goods are publicly supplied because they cannot be adequately supplied through the market. The reason is that they have the nature of "public goods."

When compared with public goods, which is the opposite of private goods, private goods have the following characteristics. First, no more than one person can use the private goods at the same time because the process of using the goods is a private process. Second, the private goods cannot be used unless a consideration is paid. Third, the users can ordinarily decide whether they use the private goods or not and the degree to which they use them. Public goods do not have these characteristics at all or only to some degree. Among these characteristics, there are two relevant points involving the efficiency concept in cost-benefit analysis; that people can use public goods without paying the consideration and that they have no choice as to use or non-use, or as to the degree of usage.

Take toll-free roads, for example; the users will utilize them to the maximum benefit obtainable from using them because the frequency of such use can be chosen. The extent of benefit obtained from the roads differs depending on the person because the destinations the roads connect, the distance between the roads and residential areas, the means of travel, necessary visiting points etc. are different from person to person. The benefits obtained by an individual from such road projects do not always exceed the cost burden to the individual, even if the total benefits from the roads exceed the total costs for providing the services by constructing and maintaining the roads. There are some people who only bear the costs, without enjoying the benefit at all. There are therefore some people who suffer net losses due to the supply.

In the case of public goods for which people cannot choose the use in terms of amount or frequency, this phenomenon appears more remarkably. In the services for "safety" the police and the fire fighting supply, the services for "flood control" dams supply, the services for "sanitation" and "quality of the water environment" sewerage systems supply, use, non-use or quantity of the services cannot be chosen by the users. The benefits of these services (WTP) naturally differ among the users. There are therefore people who suffer net losses thereby, even if the total benefits exceed the total costs for supplying them.

In private goods, the services are enjoyed privately, and the considerations arise inevitably. Through this process, cases where individual benefits fall below individual costs or where costs exceed the amount of considerations do not arise. The total benefits exceeding the total costs thus agree with a Pareto improvement. On the contrary, total benefits exceeding total costs does not mean a Pareto improvement in public goods. However, if the efficiency of a change which does not bring a Pareto improvement cannot be judged, one cannot judge whether the change through which only one person suffers a net loss is effective or not. Therefore, the applicable range for the efficiency concept narrows extremely. The concept called the "compensation principle" by Kaldor and Hicks overcame this and expanded the application range of the efficiency concept [1,2].

In compensation principles, the assumption is made that there are people who suffer a loss and people who realize a gain due to change. If all people can receive a net profit by properly compensating people for the losses suffered from the gain earned by those who realized a gain, such change is said to bring a "potential Pareto improvement". It is apparent that if the total benefits exceed the total costs, the potential Pareto improvement is brought. The efficiency concept, which was expanded to the concept of the potential Pareto improvement, is the foundation for cost-benefit analysis.

2.2 Relativity of efficiency concept

The fact that the efficiency on which cost-benefit analysis is based brings about a potential Pareto improvement implies the essential limitation of cost-benefit analysis.

First, the fact that a Pareto improvement is brought if the compensation is properly made does not mean requesting the actual compensation. There are therefore, inevitably, people who suffer losses due to the change bringing about a potential Pareto improvement.

Therefore, secondly, we cannot avoid the phenomena that the losses arise in relatively poor classes and the benefits are enjoyed by relatively wealthy classes. As a result, the distribution of benefits and costs might lead to inequality. In this sense, efficiency could be against the equality of distribution. In reality, efficiency and the equality of distribution are two independent criteria of economic welfare ([3] pp.8-10, [4] pp. 22, 23, 26, [5] p.9).

Third, beside the equality of distribution, there could be various values that are independent from efficiency and sometimes oppose it. Such values as justice, fairness, human rights, ecology itself and the sustainability of human society are values that differ from efficiency. Although these values are often accepted together under the "equity" concept [6,7], they are sometimes compatible with efficiency and sometimes oppose it.

Fourth and last, distribution and equity criteria not only exist independently of efficiency, but efficiency also depends on distribution and equity. Efficiency has been measured by deducting costs from benefits, and needless to say, benefit represents WTP, and cost represents WTA. Although WTP becomes the gauge of the benefit because it is considered to reflect the strength of people's desire, it cannot be decided only by the strength of desire. The payment ability and the availability of other goods have a far greater influence on WTP than the strength of desire.

WTP has to be an effective amount of willingness to pay, in other words, the willingness to pay supported by the payment ability. WTP depends on distribution because the payment ability is determined by income or wealth, and income or wealth depends on distribution ([8] 80, p. 160). WTA depends on distribution as well. Thus, it can be said that both cost and benefit amounts tend to become larger if they arise in wealthy classes, and they tend to become smaller if they arise in poor classes. It is therefore highly possible that changes where the wealthy classes enjoy the benefits and the poor classes bear the costs meet the efficiency criteria compared with changes otherwise. This shows that the different distributions prove to be efficient or inefficient, even in projects supplying quite the same goods. In this sense, efficiency depends on distribution.

Change that requires the costs to be borne by the poor classes and the benefits to rise in the wealthy classes tends to fix the inequality of the distribution in the present circumstances or could even further accelerate the inequality. Consider the movement of waste from rich countries to poor countries, for example. Such movement must be actually efficient (in the meaning that the benefits exceed the costs), considering the low level of environmental conservation requirements, the relatively little resources to be spared for environmental conservation, and furthermore, the relatively cheap labor costs for the waste disposal in poor countries. The efficiency, however, arises due to the disparity between the rich and the poor. The validity of applying the efficiency criteria has to be questioned in these circumstances ([8] pp.159-163).

WTP and WTA, which provide the gauge of efficiency, depend not only on distribution. They also depend on the possible choices open to an individual for various goods. For instance, car prices influence the benefits of roads because WTP for roads becomes larger when cars are available at lower prices rather than higher prices. And also, the benefits from roads become larger at places where there is no railway or where the railway fares are expensive and facilities inconvenient, rather than places where the railway can be used conveniently and reasonably. The change—from the state where the railway is conveniently available to the state where the railway becomes inconvenient or unavailable—generally means the deterioration of economic welfare for users, but at that time the benefits of roads appear to increase. Accordingly, it can be stated that the changes in the benefit of some goods do not represent the change in welfare under circumstances in which the availability of other goods fluctuates ([3] pp.23-25, [9] pp.76, 187-193, Japanese translation pp.132-133, 327-339). It is a hard-and-fast rule that comparison of the two different states of benefits must not be made in the fluctuation of the availability of other goods.

The availability of other goods changes according to various factors. These factors are not only the prices or supplying conditions of the other goods, but also institutions and laws. Institutions and laws are the products of history and the products of complicated decision-making considering various values composed by equity. In this sense, the efficiency depends on the equity as well.

3. Actual findings from cost-benefit analyses for public projects

Appraisal using cost-benefit analysis has been introduced in many public projects behind the growing tendency to introduce policy appraisal. In the public projects run by local public organizations, the reappraisal of projects subsidized by the state government has been made obligatory, and cost-benefit analysis is applied to many public projects. Reappraisals have been accomplished also in Fukui City where the author is concerned on 15 projects from 1999 through 2001, and cost-benefit analysis was particularly adopted as an appraisal method for the projects listed in Table 1.

Table 1. List of cost-benefit analysis for reappraisal of public projects in Fukui City.

Project name	Total plan				Appraisal of projects		Cost-benefit analysis		
	Scale	Project costs (¥million)	Year of start	Year of completion	Appraisal year	Conclusion	Benefit (¥million)	Cost (¥million)	B/C
Construction of Western Echizen No.4 line forest road	10.2km	570	1985	2005	1999	Continue	493	561	0.88
Development and improvement of lots surrounding Fukui Station	15.8ha	41,600	1992	2006	2000	Continue	38,216	18,106	2.11
Repair of Nagahashi fishery port	Seawall and others	660	1994	2003	2000	Continue	194	166	1.17
Repair of Mawatarigawa river foundation	520m	10,500	1993	2003	2001	Continue	9,413	531	17.72
Construction of Ago No.1 line forest road	4.0km	320	1992	2007	2001	Suspend	87	227	0.38
Construction of Kamomedani line forest road	3.1km	270	1991	2006	2001	Suspend	78	124	0.63

Among the projects listed above, suspension of the construction projects for Ago No. 1 line forest road and for Kamomedani line forest road was decided as the result of project appraisal. The findings of cost-benefit analysis greatly influenced the decision. The reasons for suspending the projects were that the ratio of benefit vs. cost (B/C) of these projects (remaining part of the projects) fell far below 1, to 0.38 and 0.63, respectively, and also fell below 0.88 of B/C for the same forest road construction project of Western Echizen No. 4 line, for which "continuation" had been decided in the appraisal of two years before.

This example seems to show the effectiveness of cost-benefit analysis in reasonably appraising public projects, but things are not so simple.

The cost-benefit analysis for the three forest road projects is based on a special method devised by the Fukui City Public Projects Appraisal Committee. Basically, the benefits of forest roads are considered to include the following.

①Benefits received by producers and consumers due to the increase in lumber production, which is brought about by the construction of forest roads

②Benefits brought by production cost savings in forestry

③Benefits of the good effect, from the environmental conservation aspect, due to the active forestry production activity

④Benefits for community roads

⑤Benefits for securing domestic lumber resources

However, the Fukui City Public Project Appraisal Committee took into consideration only the benefits brought by the cost savings in forestry in their appraisal method [10]. The reasons follow.

Firstly, it is very difficult to estimate the benefits obtained by the producers and consumers based on the increased lumber supply. It is possible that the new forest roads will facilitate more forestation and accordingly increase the volume of lumber supplies in the future. However, these things will materialize only in the distant future and without assurance. This should therefore be neglected for the time being. The effect of promoting lumber production through forest road construction, if expected, would be obtained from the increased cutting of trees already planted. If we assume that the forest dealers take economically reasonable behavior, construction of forest roads will result in lowering the costs for all necessary work in the delivery of lumber and realizing profit, which we cannot realize without the forest roads. The forest roads could bring such a change and increase the supply of lumber from trees already planted. The estimation of such increase in the supply, however, requires the prediction of future lumber prices, which is difficult. Moreover, in view of the reality in which the lumber is currently supplied at unprofitable prices, despite the costs incurred throughout the growing period of the trees, the increase of the lumber supply predicted on the economically reasonable assumption might become unrealistic.

Secondly, maintaining forests neatly through forest road development may lead to preventing mountain deforestation. On the other hand, the construction of forest roads itself might have an adverse impact on the ecosystem there, and some people point out that certain kinds of trees used for forestry are not always favorable for environmental protection, especially for the water environment. In conclusion, the effect which forest road construction has on environmental conservation cannot be stated as plus or minus.

Thirdly, it seems that the forest roads are rarely used as community roads.

Forthly, securing domestic wood resources is insurance for unstable future supply-demand situations and prices of worldwide wood resources, and the potential benefits therein will be great. However, in order to measure this potential benefit, it is necessary to estimate WTP values and so on, based on the people's willingness to obtain domestic lumber at fixed prices regardless of the unpredictable imported lumber prices. Such surveys have not yet been made and cannot be made in a short period.

Eventually, it was assumed that the benefits from the forest roads would stem from the saved portion of forestry production costs in Fukui's cases. Considering only the lumber from trees already planted, the production costs consist of the maintenance costs (forestation costs) needed during the trees' growth period and the costs for logging and removal. The cost savings from the forest roads are possible because one can reach the nearest working spot by car and, as a result, can shorten the walking distance to the working place. And especially, the removal costs are saved because the distance to the transporting vehicles can be shortened. We therefore estimated how much cost was saved by forest road construction in each process of growing trees and removing logged trees (refer to [10] for details).

As a result of this cost-benefit analysis, the Committee concluded that the project should be continued, though the costs exceeded the benefits in Western Echizen No. 4 line forest road. The reasons for this conclusion were that the recorded benefit items were limited under the constraint of money conversion, and that there could be the additional benefits in terms of a prospective, though indefinite, solution for resource problems in the future.

After the Fukui City Public Projects Appraisal Committee made the appraisal on Western Echizen No. 4 line, the Forestry Agency of Japan issued guidance on cost-benefit analysis for forest road projects [11][1)]. The following eight items are discussed in this Forestry Agency guidance as benefits required for forest road construction: 1. production effect in forestry; 2. efficiency in forestation etc.; 3. cost reduction effect in forest management; 4. mountain village promotion effect; 5. general traffic effect; 6. disaster prevention effect; 7. decreased maintenance cost effect, and; 8. production effect in agriculture and stockbreeding.

Among these, the production effect in forestry includes (1) cost reduction effect in lumber production (2) lumber use promotion effect (3) lumber production promotion effect (4) lumber production securing effect. Item (1) means the cost reduction of logging and removal according to the method of the Fukui City Committee. Item (2) is related to the promotion of thinned wood utilization. Item (3) is related to the increase in the volume of lumber shipped. Items (2) and (3) were not taken up by the Fukui City Committee because of difficulty in the prediction method. Item (4) refers to the effect due to the improvement projects for existing forest road functions and needs no consideration in the Fukui City projects.

The saving of forest maintenance costs under the Fukui City Committee method is equivalent to the “cost reduction effect in forestation works” stated in the 2nd item, the “efficiency in forestation etc.” in the guidance issued by the Forestry Agency. The article “public function of forest” is also presented in “efficiency in forestation etc.” This is equivalent to the effect for environmental conservation, which was not appraised because it was unclear whether it would bring benefits or costs under the Fukui City Committee method. The third item of “cost reduction effect in forest management” refers to the effect for the costs of patrolling and instructing, and costs for protecting from damage caused by insects and mountain fires, and it is ignored from the start under the Fukui City Committee method. The 4th item of “effect of promoting mountain villages”, the 5th item of “general traffic effect” and the 6th item of “disaster prevention effect” are not taken into consideration under the Fukui City Committee method because they are not regarded as influential. The 7th item, “decreased maintenance cost effect” is related to pavement, thus the forest roads targeted by the appraisal in Fukui City are not related to this item. The 8th item of “production efficiency in agriculture and stockbreeding” is also unrelated to the projects in Fukui City.

The result of the cost-benefit analysis on the above three forest road construction projects under the guidance of the Forestry Agency are presented below in Table 2, together with the results of the Fukui City Committee method.

One can see that the benefits exceed costs in all projects based on appraisal under the Forestry Agency guidance

Table 2 Cost-benefit analysis for forest road construction projects
Comparison between the Forestry Agency Guidance Method and the Fukui City Committee Method

Project name	The Forestry Agency Guidance Method			The Fukui City Committee Method			[B/C in the Forestry Agency guidance method] ÷ [B/C in the Fukui City Committee method]	Cost per area (¥million per ha)
	Benefit (¥million)	Cost (¥million)	B/C	Benefit (¥million)	Cost (¥million)	B/C		
Western Echizen No. 4 line	2,854	875	3.26	493	561	0.88	3.7	3.14
Ago No.1 line	305	227	1.34	87	227	0.38	3.5	8.11
Kamomedani line	264	124	2.12	78	124	0.63	3.4	4.74

1) The guidance is entitled “Cost-effectiveness Analysis”, but the title should be regarded as synonymous with “Cost-benefit Analysis”. The former expression is more frequently used in the field of governmental appraisal of public projects in Japan.

method. The big discrepancy between the two methods is caused by the differing concept toward the benefit appraisal. Of the benefit items in the Forestry Agency guidance method, the effect of promoting lumber production accounts for the larger part. In the case of the Western Echizen No. 4 line, it accounts for 90%. The lumber production effect accounts for 88% of the total benefits for both the Ago No. 1 line and the Kamomedani line.

The benefit from the lumber production promotion effect is calculated by multiplying the volume of logged lumber by lumber market prices. The volume of cut lumber increased by the forest road construction is obtained by multiplying the logged area (ha) increased through the forest road construction by the lumber volume per area (620m^3/ha). The logged area with the forest road construction is obtained by multiplying the area of planted forests within the forest road zone by the cutting rates corresponding to the age group over 40 years (1 age group = five years) and dividing that figure by 40. The logged area per year without the forest road is deducted from the logged area per year with the forest road thus obtained and the remainder multiplied by 1/2 of the construction period (years) plus 40 is the logged area increased by the forest road. The logged area without forest roads is determined based on the forest area grown over five years (logged area).

In the case of the Western Echizen No. 4 line, 218.72 ha is obtained by multiplying the 477.41 ha of artificially planted forest area within the zone by the cutting rates corresponding to the age group. The value of 5.47 ha is obtained by dividing the figure thus available by 40. The forested area over the past five years is 3.28 ha, and 0.7 ha is obtained by dividing that figure by 5 (i.e. logged area per year). Therefore, the logging area increased by the forest roads is 4.77 ha per year, and 238.64 ha is obtained by multiplying this figure by 1/2 of the construction period (years) plus 40 i.e. 50.5. The figure of 149,286m^3 is obtained by multiplying 238.64 ha by the lumber volume of 620m^3/ha, and the amount of ¥8.593 billion equivalent for the lumber production promotion effect is obtained by multiplying 149,286m^3 by the lumber market price of ¥57,000/m^3. The figure thus obtained is discounted to ¥2.57263 billion (4% discount rate).

As shown above, all existing planted forests are logged according to age group, and it is assumed that most forests (87%) are logged because of the forest road construction. The first problem in this estimation is that the whole figure, obtained by multiplying the lumber volume logged due to the forest roads by the lumber prices, is regarded as the benefit. In view of cost-benefit analysis fundamentals, however, the figure obtained by subtracting the increased costs inherent in production from the whole figure should be regarded as the benefit arising from the forest roads. The guidance of the Forestry Agency opposes this view, stating “the costs for logging, removing and collecting lumber are also returned to the parties concerned as an economic effect of the construction of the forest roads.” However, this is a basic mistake made by a misunderstanding of the fundamentals of cost-benefit analysis. If the argument neglecting actually incurred costs can be used for “return to the parties concerned”, it could be argued, for example, that even the project costs for constructing the forest roads are not regarded as a cost, because they are returned to “the parties concerned” in forest road construction as an economic effect. If so, it follows that all public projects will be able to be performed at no cost. The fact that the costs are actually incurred for logging, removing and collecting lumber means that the materials and labor have been spent for their purpose, whether the return is made or not, and it is a cost from the viewpoint of the national economy.

The Fukui City Public Project Appraisal Committee did not adopt the method of the Forestry Agency, a method that overestimates the benefit because of its clearly flawed logic. They regarded the cautious predictions of the value of the benefit by the Fukui City Committee method as being nearer to the truth. The decision to continue with the Western Echizen No.4 line, which had a B/C value of 0.88, was based on this prediction, and took into account the uncertain nature of the benefit estimates.

It is not really clear, however, whether this uncertainty leads to benefits being overestimated or underestimated. It is highly possible that even the predicted value of the benefit using the Fukui City Committee method is overestimated, considering that the actual completion of the forest roads does not necessarily mean that all the existing planted forests will be logged.

Subsequently, it seems that whether the benefit exceeds the cost, i.e. whether B/C exceeds 1 or how far it deviates from 1, is not a factor in deciding whether a project proceeds or not. When the B/C values of the three projects in Table 2 are compared, however, they are ranked as Western Echizen No. 4 line, Kamomedani line, Ago No. 1 line in order of size, an order that is the same whether the Fukui City Committee method or the Forestry

Agency guidance method is used. Furthermore, the relative size of B/C is almost equal no matter which method is used. The B/C value for the guidance method of the Forestry Agency is 3.4 to 3.7 times that of the Fukui City Committee method.

This result is not surprising, since the costs for the forest roads increase almost in proportion to their length, and the benefit basically depends on the size of the planted forest area in the zone, though the age composition of the forests is also a factor, regardless of which method is used. The value B/C for the Western Echizen No. 4 line project is high because the area of the planted forest in the zone is large compared with the length of the road. Therefore, the ranking shown with the value of cost per area of the planted forest will result in the same ranking as for B/C values. The cost per area of the artificial forest covering the three forest roads is presented at the right side of the column in Table 2.

The method of calculating the cost per unit of the effect of a project, measured by a specific physical unit, is called “cost-effectiveness analysis.” As has been shown, the cost-effectiveness analysis can be used instead of cost-benefit analysis to rank projects in order of their B/C values, and the cost-effectiveness analysis has the advantage of avoiding the problems of great uncertainties in cost-benefit analysis.

In reality, the mere ranking of projects can become an important source of information in making decisions about a project. In the case of Fukui City, construction projects for forest roads for three years from the year of 1999 to 2001 cost ¥42 million, ¥45 million and ¥47 million, respectively. The amount of ¥120 million for forest road projects was the highest amount spent in the past 18 years. Hypothetically speaking, it would take 10 years to complete the Western Echizen No. 4 line at this pace, even if the entire forest road project budget were to be invested in it. Consequently, it would be reasonable to choose to concentrate investment on the Western Echizen No.4 line project for the time being, as this project enjoys a high investment effect. The cost-effectiveness analysis is adequate to justify such an option.

4. Actual findings from cost-benefit analyses for environmental policies

Next, we will look at the suggestions obtained from applying cost-benefit analysis to the appraisal of non-public project policies.

Environmental regulations cause extra costs for the measures, additional manufacturing costs, and losses of certain benefits due to the obligation to refrain from the use of convenient materials etc. In exchange for all of these, public goods, i.e., environmental quality improvement, are supplied. If the benefit of these public goods can be estimated as a monetary amount, the cost-benefit analysis can be conducted.

Monetary appraisal of any benefit from environmental improvement has been said to be difficult, because it consists of “intangible values.” Environmental economists have been spending much energy in appraising it, although the estimation is difficult since opportunities to observe individual WTPs are limited in actual market transactions. It has been thought particularly difficult to appraise the benefit of policies regulating harmful environment-polluting substances which have a great effect on human health and from time to time invite death. However, the policies that regulate substances affecting human health have become a field in which cost-benefit analysis can be applied relatively easily within the environmental policies. This is due to the development of methods to quantitatively appraise the risk to human health and to cumulatively measure the WTP for risk reduction.

The method to appraise the risk of cancer caused by health hazardous substances has been developed in tandem with a study on the probability of these carcinogenic substances that people take in [12]. A method has also been developed to convert the probability of developing cancer into years lost in average life expectancy, and furthermore, the risks of diseases other than cancer are also shown using the same method [12,8]. Another method has been developed to assess the effects of harmful substances by measuring the reduction in the healthy lifespan of people. This involves an index in which healthy individuals are allocated a value of 1, individuals with non-fatal diseases are weighted by factors of less than 1, and the weighted number of years a person has lived is described as his ‘healthy lifespan’ [13,14].

The examples in Table 3 below show an analysis of the costs for countermeasures needed to redress the effects of harmful chemical substances on human health, measured in terms of the costs of increasing life expectancy by one year. These regulations were all actually put into practice.

Table 3. Costs for extension of life expectancy by one year, based on the measures for harmful chemical substances

Case	Cost for extending life expectancy by one year (¥million/[man·year])	Reference
Prohibition of chlordane, a termiticide	45	[15]
Prohibition of mercury electrode method in producing sodium hydroxide	570	[16]
Production of mercury-free dry batteries	22	[12]
Regulation on benzene content in gasoline	230	[17]
Regulations on NOx for automobiles	86	[18]
Regulation on dioxin in waste incineration facilities (urgent measure)	7.9	[19]
Regulation on dioxin in waste incineration facilities (permanent measure)	150	[19]

Cost-benefit analysis for these regulation policies can be made from the results in Table 3 when the people's WTP for extending life expectancy by one year becomes available. WTP for the diminution of death rates, which is the same as the extension of life expectancy, has been frequently measured, mainly in the U.K. and the U.S.A. The major methods used are the "wage risk method," which calculates WTP from the relationship of the height of occupational risk and the amount of wages, and the "questionnaire method," which directly asks for WTP by presenting a hypothetical risk reducing merchandise ([8] pp.101-118). The value obtained by dividing WTP for the reduced risk portion by the range of the reduced risk is called the "Value of a Statistical Life (VSL)." It is WTP for reducing the risk, which is converted to a life for convenience.

In 1983, the U.S. Environmental Protection Agency issued the guidance that the Value of a Statistical Life used for the policy appraisal by them should be $0.4-7.0 million [20]. In 1989, Fischer et al. who had compiled various studies on the Value of a Statistical Life defined $1.6-8.5 million as a reasonable value at the 1986 price level (¥280-1,500 million at the 1999 price level) [21]. The Value of a Statistical Life used by the U.S. Environmental Protection Agency when they conducted their 1997 post-assessment of the Clean Air Act between 1970 and 1990 was $4.8 million [22]. The Value of a Statistical Life used in the appraisal of road construction projects in U.K. is about 0.9 million pounds (about ¥1.60 million) [25]. In Japan, there are estimated values of ¥1.67-3.55 billion [23], and ¥60-510 million or ¥2.1 billion [24] (all based on the questionnaire method). The former value is calculated based on WTP for a decrease in the life-time death rate instead of the annual death rate, however, and the Value of a Statistical Life amounts to ¥6.7-14 billion when converted into a decrease in the annual death rate. These values might be regarded as too high, as well as having some problems in the questioning design.

Accordingly, the Value of a Statistical Life is approximately a few hundred million yen. Supposing the figure is ¥400 million and converting it into the value for life expectancy, it amounts to ¥10 million for one year ([8] p. 145). If the value does not exceed ¥4 billion, it may be considered that the value for life expectancy will not exceed ¥100 million per year.

When we combine these calculations with the results in Table 3, if we adopt a life expectancy value of ¥10 million a year that seems certain, the urgent measures on dioxin will be the only ones that satisfy the criteria for cost-benefit analysis among the existing environmental regulations. The regulations which can be justified when cost-benefit analysis is applied are assumed to be approximately half of those actually executed even if the value of life expectancy is ¥100 million a year.

Therefore, the strict application of cost-benefit analysis will result in denying most of the existing regulations on harmful environment-polluting substances. Speaking adversely, the actual regulations are actually executed with costs that cannot be justified by cost-benefit analysis.

5. Limitation of cost-benefit analysis and the way to actual policy appraisal

In chapter 2, we have stated that the efficiency criteria on which cost-benefit analysis is based depend on distribution and equity and that they are relative. When the efficiency conflicts with other values, it is actually impossible, let alone imaginable, to create economic welfare criteria that integrate all values. It was Mishan who insisted on the realistic idea that only ethical consensus in society could justify the use of efficiency criteria [26].

If the tendency that the use of efficiency criteria cannot be accepted from standpoints of various values including distribution and equity strengthens, then ethical consensus cannot be obtained. Mishan stated in 1980, "a number of reputable economists have argued that the existing valuations of fuels and minerals, and the their current rates of consumption, cannot be justified by reference to any criterion that would exclude the opinions of future generations" [6]. This statement refers, in today's terminology, to the use of efficiency criteria possibly being hampered by the view of sustainability. And he also pointed out, "there is a growing agreement that in as much as the untoward consequences of consumer innovations (one think in this connection of food additives, chemical drugs and pesticides, synthetic materials and a variety of new gadgets) tend to unfold slowly over time, their valuations at any point of time by the buying public (as determined by the market prices to which individual purchases adjust) may bear no relation to whatever to the net utilities conferred over time [6]". This suggests that the appraisal of benefit, on which individual subjective appraisal is based, could be unsuitable as an element for welfare criteria.

There is potential value in forests as sources providing wood resources regardless of current market values. This potential value is connected to sustainability and is hard to understand in terms of cost-benefit analysis. It is naturally possible, from the premise of cost-benefit analysis, that consideration of such value may hamper the use of cost-benefit analysis. It seems that there are values to be considered independently from the calculable value of benefit in regulating cumulative harmful chemical substances. This will also be related to sustainability. It may be assumed that there are values that cannot be understood in view of the benefit based on WTP in the environment as a part of public properties.

Also, uncertainty in the benefit appraisal itself becomes larger from the long-term standpoint of sustainability of resources or environment. The necessity of applying the estimated WTP to public goods itself also increases the uncertainty of the benefit. These elements reduce the reliability of cost-benefit analysis as a strict quantitative analysis and lower the effectiveness of efficiency criteria to other various values.

Nonetheless, the importance of putting policy-decision on a transparent and objective basis suggests that some sort of appraisal must be done. In view of these circumstances, the utilization of cost-effectiveness analysis, which is highly feasible and reliable, is desired.

In Chapter 3, it has been stated that the relative value of B/C is stable despite the uncertainty of the benefit appraisal, that cost-effectiveness analysis is adequate to assess the cases using only the relative value of B/C, and that cost-effectiveness analysis saves most of the problematic measurements.

In Chapter 4, Table 3 shows that there are a lot of environmental regulations that cannot be justified when cost-benefit analysis is applied. Table 3 also shows that the costs for extending life expectancy by one year vary greatly. This suggests that cost-effectiveness analysis should be applied. In other words, the effective role of cost-effectiveness analysis is needed, as it ranks policies by priority in order of efficiency according to unit cost. The Table also suggests the future utilization of cost-effectiveness analysis in policy appraisal by making the policy examples shown in this Table a standard.

Of course, cost-effectiveness analysis is not the only method for policy appraisal, but it is promising as a steady and highly reliable method. It is a restrictive application of efficiency criteria and is easy to harmonize with values other than efficiency. Welfare economics does not tell us to stick to cost-benefit analysis or efficiency criteria. It just tells us to use the restrictive application of efficiency criteria in accordance with reality.

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