

**New Methodology to
Select Projects in Public and
Public Utility Service Operations**

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In recent years, moves at assessing performance by means other than financial indexes have been spreading primarily within central and local government offices and agencies. However, in introducing performance evaluation systems, focus is now being given to accountability and organizational evaluations. Efforts to accumulate experience as objective data and use that data to improve operations as well as operational efficiency have not necessarily been stressed.

By focusing on the aspect of “accumulating experience as objective data and using the data to improve operations as well as operational efficiency” in developing performance evaluation systems, Nomura Research Institute (NRI) has developed two methods of objective project selection and has been introducing these methods in actual operations. The two methods are project selection to achieve goals at minimum cost and project selection within a finite cost.

These two methods are used to select which of ten or more candidate projects of several totally different types are to be actually implemented. In both of these methods, projects are selected by a two-step process: (a) evaluating each candidate project through certain procedures and (b) selecting the projects to be implemented in accordance with prescribed logic. The principal feature of these methods is that selection of the projects to be implemented can be based on evaluations from totally different aspects that are suitable for individual projects of totally different types.

This paper uses several cases to briefly introduce the logic portion applied to the project selection in particular from among the overall project selection procedures.

I Conventional Project Selection Relying on Precedents

If we venture to describe the essence of the operations carried out by private-sector companies, government ministries/agencies and public organizations in a single phrase, it would be to “generate profits by conducting projects and/or activities” or to “improve public welfare.” The question then arises on how entities such as ministries/agencies and companies select projects and activities for implementation. In other words, the basic question is what grounds are used to select projects and activities for future implementation.

Of course, it would be difficult to provide an answer unconditionally as the contents of projects and activities differ qualitatively between government and the private sector and between various types of businesses within the private sector. Accordingly, this paper discusses companies that provide infrastructural services such as communications, transportation, electric power, gas and water as well as central and local government agencies and offices.

These entities are required to make “social contributions” much more so than other companies such as manufacturers. With respect to government ministries and agencies, the significance of their existence is to provide for a “smoothly operating society,” rather than social contributions. Furthermore, companies providing infrastructural services are also required to give social considerations much more so than other companies, such as stable provision of services and environmental considerations because of the major impact they exert on society in various ways.

For example, let’s look at a company operating a railway. Railway Company A is naturally required to provide stable train service daily in accordance with its train schedule. In addition, this company may also be required to strengthen transportation capabilities by constructing four-track lines. The company might have been required to install air-conditioning facilities prior to installing other facilities and ahead of other organizations in a certain period in the past, and there may be lines where elevated railroads are required in order to eliminate jams at crossings. There may also be stations where facilities to prevent passengers from falling are necessary. There might have been times when efforts for energy savings required reducing the weight of trains as well as technologies similar to a “regeneration brake” to generate electric power when the train is slowing down and feed it to overhead lines.

As such, there will be no end to the social responsibility and contributions required of infrastructural service companies. In order to fulfill such a large number of responsibilities, how are these companies combining various projects?

I assume that many companies make decisions on the adoption of large projects that may occur once every few years (e.g., the elimination of jams at crossings by constructing elevated railroads) on an individual basis under their mid- and long-term plans. With respect to other individual projects that may number several dozen or more a year, such as the renovation of a station, the improvement of a crossing, the replacement of train cars and the introduction of automatic ticketing gates, it is assumed that ongoing decisions are being made regarding what investments will be made in light of the investment amount available for the relevant fiscal year, past experience and in consideration of the priority of other projects.

Then, what does “past experience” mean? Is it something subjective or is it experience resulting from the accumulation of objective data? Of course, objectivity probably depends on each company and each service department. However, it appears that there are many cases in which objective data are not sufficiently accumulated.

II Past Approaches to Performance Evaluation that Presented Weaknesses in Operational Improvement

In contrast to the conventional ways of proceeding with projects, the terms “policy evaluations” and “performance evaluations” have also become common in Japan in recent years, and accelerated moves have been seen among many central and local government agencies and offices to incorporate these evaluation concepts.

In short, policy evaluations and performance evaluations refer to a cycle of the following activities:

- (1) At the beginning of each term, formulating quantitative goals (target outcomes) to be achieved by the end of the term
- (2) Implementing projects in pursuit of achieving the goals
- (3) Determining to what extent quantitative goals were achieved by evaluating the results at the end of the relevant term, providing extensive explanations of such results to the public and, at the same time, reflecting such results in creating plans for the next term

Three major purposes are assumed as the basis of the introduction of this mechanism.

The first purpose is to fulfill the accountability of the administration by announcing the target outcomes as well as the extent of achievement of these targets. The second purpose relates to the viewpoint of evaluating each organization by the extent of its achievement and using such evaluation results for the management of the

organization. The third purpose is to accumulate the experience of the projects implemented every year as objective data and to use these data for future activities.

However, if we try to find problems in the current policy evaluations and performance evaluations, we see a stronger focus on accountability and organizational management. The attitude of using experience as the accumulation of objective data for improving efficiency in future projects tends to be relatively weak. As a result, strict verifications appear to be lacking with respect to the cost of each project, the effects brought about by each project, and how and to what extent each project contributed to the achievement of each target outcome.

In that case, what methods are conceivable in order to use experience as the accumulation of objective data?

This paper introduces methods consisting of the following three steps that assume experience as the accumulation of objective data, which are then used for the improvement of projects themselves as well as their efficiency:

- (1) Estimating what effects and to what extent each of many projects covering diversified fields can result based on the accumulated data
- (2) Establishing the optimal or best project combination in order for each company or department to achieve multiple performance goals
- (3) Increasing the accuracy of this mechanism by accumulating experience

The following section takes up road traffic as one of the areas where it is relatively easy to quantify the effects of individual projects and where progress is

being made in such studies. This case will be used to examine the specific contents of the above methods.

III Individual Project Effects and Combination of Projects to Achieve All Goals

For the sake of simplicity, a simplified model is presented here.

Prefecture B set up the following mid-term target outcomes for road projects up to fiscal 2008 (April 2008 – March 2009) (Table 1):

- (1) Reducing the number of traffic accidents resulting in fatalities and/or injuries from 55 to 50 per 100 million vehicle kilometers traveled (VKT)
- (2) Reducing lost time caused by traffic jams per prefectural citizen from the current 35 hours/person to 30 hours/person
- (3) Increasing the number of people within the 30-minute zone of the city center from the current 77 percent to 80 percent

At the same time, Prefecture B selected the following candidate projects and estimated the costs and effects described in Table 2:

- (a) Renovating several crossings
- (b) Constructing bypasses at several sites
- (c) Improving roads at several sites, e.g., creating two-lane roads and installing sidewalks

Table 1. Target Outcomes of Road Projects in the Next Five Years in Prefecture B

	Number of traffic accidents resulting in fatalities and/or injuries (per 100 million VKT)	Lost time caused by traffic jams (hours/person)	Population coverage (%)
Current value	55	35	77
Target value	50	30	80
Difference between current and target values	5	5	3

Note: VKT = vehicle kilometers traveled.

Table 2. Estimated Costs and Effects of Candidate Projects

Project	Cost (¥ billion)	Accident reduction effect (per VKT)	Lost time reduction effect (hours/person)	Coverage increase effect (%)
Crossing renovation (1)	2.0	1.6	1.2	0.0
Crossing renovation (2)	3.3	2.0	0.8	0.0
Crossing renovation (3)	3.0	1.5	0.9	0.0
Bypass construction in Section A	45.0	2.2	2.2	1.1
Bypass construction in Section B	25.0	1.8	3.0	0.6
Bypass construction in Section C	12.0	1.1	1.0	0.7
Improvement of ordinary roads in Section D	8.2	0.8	0.8	0.6
Improvement of ordinary roads in Section E	7.0	1.3	0.9	0.4
Improvement of ordinary roads in Section F	4.4	1.8	1.3	0.3
Improvement of ordinary roads in Section G	6.2	0.9	0.8	1.1

If these projects are assumed as candidate projects, how should they be combined to achieve the three target outcomes most efficiently (i.e., at a minimum cost)?

While this question appears easy, it is actually not so easy. First of all, it is impossible to devise an equation to resolve this question.¹

However, this question can be resolved by determining the achievability of the three goals with respect to all combinations involving the adoptability of the ten projects listed in Table 2 as examples and comparing the costs incurred by all reasonable combinations. However, the total number of eligible combinations amounts to $2^{10} - 1 = 1023$. It might be possible to make comparisons by some means or other if the number of combinations is around 1000. However, this number will jump to 2047 by adding one project to the above ten projects, and to 4095 if the number of projects is 12. If the number of projects is 30, more than one billion combinations must be compared.

Aren't there any simple means for resolving this question?

A method called the "branch-and-bound method" is available as a means of resolving this question.² Rather than comparing all combinations, this method removes combinations that are clearly inferior to optimal combinations that have already been discovered (combinations that satisfy all goals and require the lowest costs among all combinations discovered thus far). Inferior combinations mean those that cannot satisfy all goals, or that obviously require higher costs than optimal solutions discovered thus far even if all goals are satisfied.

This method dramatically reduces the number of combinations that must actually be compared. The use of the branch-and-bound method enables the conduct of practical studies to select a combination of projects to be implemented. (See the end of this paper for the answer to the question in this example.)

Suppose that the minimum necessary project cost to satisfy all goals as well as a combination of projects at such cost are obtained by means of the branch-and-bound method, what should be done if the budget is not sufficient for the project cost?

IV Selecting Projects within a Limited Budget

As the answer to the question of what should be done if the budget is not sufficient for the project cost, two methods can be considered. One method is to reduce the target outcomes themselves to a level that can be achieved within the budget. The other examines what goals must be achieved at a 100 percent level and for what goals a compromise can be made to an achievement level of 90 percent on the assumption that it is not possible to satisfy all target outcomes.

As the former method simply decreases the target level, no further explanation is necessary. This chapter discusses the latter method wherein the target level is not decreased, but examines ways of bringing the achievement level as close to the target outcomes as possible by selecting the most appropriate projects.

As the method described in Chapter III is predicated on the imperative requirement of "achieving all goals 100 percent," it is possible to pinpoint a sole combination³ that satisfies such a requirement yet incurs the minimum cost.

In contrast, the method discussed here is based on the relatively vague criterion of "obtaining project combinations that achieve the goals at the level as satisfactory as possible within the budget limitations." It is, therefore, not possible to reach a solution that "this is the sole answer that meets the conditions." Accordingly, efforts must be made to look for project combinations that can bring about some sort of satisfaction by repeating trials and errors.

The basic concept of the method introduced here is "implementing projects within the budget framework in the order of a higher T-score with respect to the cost effectiveness of each project."

There is a wide variety of project types even if limited only to road-related projects, and the effects brought about by each of them vary even in terms of their quality, not to speak of their range of influence. Consequently, it is not possible to rank these projects objectively simply by using their effects and costs.

For example, Projects 1 through 3 have only effects that help eliminate traffic jams, and the rankings of these projects in terms of higher cost effectiveness are Project 1 > Project 2 > Project 3. Furthermore, Projects 4 through 6 have only effects that help reduce the number of accidents, and the rankings of these projects in terms of higher cost effectiveness are Project 4 > Project 5 > Project 6. With these conditions, is it ever possible to prioritize these projects from an objective perspective?

Projects that have the same types of effects can be prioritized in the order of higher cost effectiveness. However, projects with differing types of effects cannot be directly compared for objective prioritization.

In order to prioritize projects offering different types of effects from an objective perspective, a process of standardization is applied. In this process, the average "effect/cost" for each corresponding target outcome is deducted from the "effect/cost" (as indicated in Table 3) for each project, and the results are divided by the standard deviation (Table 4). By going through this process, "effects/costs" corresponding to different target outcomes can be non-dimensionalized. This permits simply adding up differing "effects/costs."

This process can be expressed by the following formula.

Table 3. “Effects/Costs” (× 100)

Project	Accident reduction effect	Lost time reduction effect	Coverage increase effect
Crossing renovation (1)	8.00	6.00	0.00
Crossing renovation (2)	6.06	2.42	0.00
Crossing renovation (3)	5.00	3.00	0.00
Bypass construction in Section A	0.49	0.49	0.24
Bypass construction in Section B	0.72	1.20	0.24
Bypass construction in Section C	0.92	0.83	0.58
Improvement of ordinary roads in Section D	0.98	0.98	0.73
Improvement of ordinary roads in Section E	1.86	1.29	0.57
Improvement of ordinary roads in Section F	4.09	2.95	0.68
Improvement of ordinary roads in Section G	1.45	1.29	1.77
Average	2.96	2.05	0.48
Standard deviation	2.65	1.65	0.54

Table 4. Standardized “Effects/Costs” (Standard Scores of “Effects/Costs”) (≡ T-scores)

Project	Accident reduction effect	Lost time reduction effect	Coverage increase effect	Total standard score
Crossing renovation (1)	1.90	2.40	-0.90	3.41
Crossing renovation (2)	1.17	0.23	-0.90	0.50
Crossing renovation (3)	0.77	0.58	-0.90	0.45
Bypass construction in Section A	-0.93	-0.94	-0.44	-2.32
Bypass construction in Section B	-0.84	-0.51	-0.45	-1.81
Bypass construction in Section C	-0.77	-0.74	0.19	-1.32
Improvement of ordinary roads in Section D	-0.75	-0.65	0.46	-0.93
Improvement of ordinary roads in Section E	-0.41	-0.46	0.17	-0.71
Improvement of ordinary roads in Section F	0.43	0.55	0.37	1.35
Improvement of ordinary roads in Section G	-0.57	-0.46	2.40	1.38
Average	0.00	0.00	0.00	
Standard deviation	1.00	1.00	1.00	

$$\text{Standard score } SS_j = \sum_i^{N. \text{ of Target Outcomes}} \frac{\frac{E_{ij}}{C_j} - \left(\frac{E_i}{C}\right)}{\sigma_i}$$

E_{ij}: Effect on Outcome Measure “*i*” of Project “*j*”

C_j: Cost of Project “*j*”

$\left(\frac{E_i}{C}\right) = \frac{\sum_j^n \left(\frac{E_j}{C_j}\right)}{n}$: An average value among all projects with respect to the value obtained by dividing effect on Outcome Measure “*i*” by cost (*n* = number of projects)

σ_i : Standard deviation of all projects with respect to the value obtained by dividing effect on Outcome Measure “*i*” by cost

This method prioritizes individual projects on the basis of the so-called “total T-scores,” and higher-ranking projects are adopted in descending order as the projects to be actually implemented within the budget framework (Tables 5 through 7).

This method can be likened to the following case.

This year, ten students (Students a through j) wish to enter University C. University C plans to determine successful applicants by entrance examination covering three subjects, English, mathematics and Japanese.

The examination results of Students a through j are as indicated in Table 8. Of these students, five applicants must be selected.

Looking at the raw scores, Students a and b are likely to become successful applicants because they acquired scores above a certain level for all subjects. Although there are no subjects for which Student j acquired an especially high score, he did acquire scores at a certain level for two subjects. Therefore, can Student j become the third successful applicant? Or can Student g, who acquired a score of 100 only for mathematics although scores for other subjects are near zero, be the third successful applicant? Or can Student e, who acquired the top score in Japanese among the ten students although the score (60) is not so high, be the third successful applicant?

On the basis of the raw scores, it appears to be difficult to decide the third, fourth and fifth successful applicants. Accordingly, the raw scores were converted to T-scores to determine success or failure based on the total T-score (Table 9).

Consequently, Student j became the third successful applicant, and Students e and c were also accepted.

Table 5. Changing Order in Accordance with Total Standard Score

Project	Accident reduction effect	Lost time reduction effect	Coverage increase effect	Total standard score
Crossing renovation (1)	1.90	2.40	-0.90	3.41
Improvement of ordinary roads in Section G	-0.57	-0.46	2.40	1.38
Improvement of ordinary roads in Section F	0.43	0.55	0.37	1.35
Crossing renovation (2)	1.17	0.23	-0.90	0.50
Crossing renovation (3)	0.77	0.58	-0.90	0.45
Improvement of ordinary roads in Section E	-0.41	-0.46	0.17	-0.71
Improvement of ordinary roads in Section D	-0.75	-0.65	0.46	-0.93
Bypass construction in Section C	-0.77	-0.74	0.19	-1.32
Bypass construction in Section B	-0.84	-0.51	-0.45	-1.81
Bypass construction in Section A	-0.93	-0.94	-0.44	-2.32

Table 6. Effects and Costs of Projects Whose Order Changed (Order of Table 2 Is Changed)

Project	Cost (¥ billion)	Accident reduction effect (per 100 million VKT)	Lost time reduction effect (hours/person)	Coverage increase effect (%)
Crossing renovation (1)	2.0	1.6	1.2	0.0
Improvement of ordinary roads in Section G	6.2	0.9	0.8	1.1
Improvement of ordinary roads in Section F	4.4	1.8	1.3	0.3
Crossing renovation (2)	3.3	2.0	0.8	0.0
Crossing renovation (3)	3.0	1.5	0.9	0.0
Improvement of ordinary roads in Section E	7.0	1.3	0.9	0.4
Improvement of ordinary roads in Section D	8.2	0.8	0.8	0.6
Bypass construction in Section C	12.0	1.1	1.0	0.7
Bypass construction in Section B	25.0	1.8	3.0	0.6
Bypass construction in Section A	45.0	2.2	2.2	1.1

Table 7. Total Project Effect within the Budget Framework of ¥16 Billion

Project	Total cost (¥ billion)	Total accident reduction effect (per 100 million VKT)	Total lost time reduction effect (hours/person)	Total coverage increase effect (%)
Crossing renovation (1)	2.0	1.6	1.2	0.0
Improvement of ordinary roads in Section G	8.2	2.5	2.0	1.1
Improvement of ordinary roads in Section F	12.6	4.3	3.3	1.4
Crossing renovation (2)	15.9	6.3	4.1	1.4
The above four projects are implemented.				
Crossing renovation (3)	18.9	7.8	5.0	1.4
Improvement of ordinary roads in Section E	25.9	9.1	5.9	1.8
Improvement of ordinary roads in Section D	34.1	9.9	6.7	2.4
Bypass construction in Section C	46.1	11.0	7.7	3.1
Bypass construction in Section B	71.1	12.8	10.7	3.7
Bypass construction in Section A	116.1	15.0	12.9	4.8

Table 8. Results of Entrance Examination (Raw Scores)

Student	English	Mathematics	Japanese
a	100	80	50
b	60	50	40
c	80	8	10
d	1	20	40
e	10	2	60
f	0	12	50
g	2	100	1
h	4	88	2
i	3	92	1
j	40	60	15
Average	30.0	51.2	26.9
Standard deviation	37.6	38.2	23.3

Table 9. Conversion of Raw Scores to Standard Scores

Student	English	Mathematics	Japanese	Total	Order
a	1.86	0.75	0.99	3.61	1
b	0.80	-0.03	0.56	1.33	2
c	1.33	-1.13	-0.72	-0.53	5
d	-0.77	-0.82	0.56	-1.03	10
e	-0.53	-1.29	1.42	-0.40	4
f	-0.80	-1.03	0.99	-0.83	9
g	-0.74	1.28	-1.11	-0.58	6
h	-0.69	0.96	-1.07	-0.79	8
i	-0.72	1.07	-1.11	-0.76	7
j	0.27	0.23	-0.51	-0.01	3
Average	0.00	0.00	0.00	—	—
Standard deviation	1.00	1.00	1.00	—	—

Table 9 shows standard scores, which are essentially the same as T-scores frequently used for admission examinations.

It was pointed out previously that “this method helps to obtain a satisfactory solution by repeating trial-and-error methods, as it is not possible to find the sole answer.” However, the use of the method so far discussed will determine a single answer with no alternatives.

If the results obtained by this method are satisfactory to some extent, there is no problem. However, for example, let’s reconsider the road projects in Prefecture B. As indicated in Table 7, with a budget framework of ¥16 billion, two goals were not achieved although one goal was satisfied. Specifically, the target outcome of reducing accidents resulting in fatalities and/or injuries was achieved with 6.3 fewer incidents based on 100 million VKT (projected number of accidents: $55 - 6.3 = 48.7$). However, the target outcome of reducing lost time caused by traffic jams was not achieved as the effect resulted in 4.1 fewer hours/person (projected lost time: $35 - 4.1 = 30.9$). Similarly, the target outcome of increasing the population in the city center was not satisfied as the effect added only 1.4 percent (projected coverage: $77 + 1.4 = 78.4$).

If the above results caused no inconvenience, it would not be necessary to consider further measures. However, if strategic consideration requires that “no compromise can be made on the 100-percent achievement with respect to reducing lost time caused by traffic jams although about a 90-percent achievement rate is acceptable with respect to the number of accidents goal,” the problem remains concerning how this method deals with such a situation or whether this method can even deal with such a situation.

If the conclusion is stated first, it will become possible to deal with such a situation by “prioritizing targets by weighting individual target outcomes.”

In specific terms, the weight corresponding to each standard score is given to individual target outcomes at the stage of “Standard Scores of ‘Effects/Costs’” (i.e., the stage of Table 4). This will enable the setup of para-

meters (i.e., what goals are given priority and to what extent) in selecting projects.

If this weighting method is applied to the previous example of the entrance examination, it is possible to determine success or failure by applying a weight two times heavier to mathematics than that applied to the two other subjects because University C specializes in science and engineering (Table 10). As a result of doubling the weight of mathematics, Students g and i who were not successful when equal weight was applied could now pass the examination because their scores on mathematics were relatively high.

As such, work to evaluate projects by assigning weight is repeated again and again until a point of compromise between “satisfaction” and “giving up” can be found. This is the project selection work by means of this method.

V Expanding Fields of Application

The method introduced in this paper is one that selects projects to be implemented from among approximately more than ten candidate projects through procedures that are as objective as possible. The term “objective” here means something like “following certain logic” and does not totally exclude subjective evaluations.

For example, application of the “weight” assigned to each individual goal can be based on some statistical data by excluding any arbitrariness. It is also possible to assign such weight on a subjective basis in accordance with strategic considerations. To begin with, even a “goal” itself can be established arbitrarily on a subjective basis.

A point in which this method differs from conventional methods is that, in addition to the results of project selection, it can clearly show the preconditions and rationale used for selection in the form of the established goal, the value of any assigned weight and the logic adopted.

Table 10. Conversion to Weighed Standard Scores

Student	English	Mathematics	Japanese	Total	Order
a	1.86	1.51	0.99	4.36	1
b	0.80	-0.06	0.56	1.30	2
c	1.33	-2.26	-0.73	-1.66	7
d	-0.77	-1.64	0.56	-1.84	9
e	-0.53	-2.58	1.42	-1.69	8
f	-0.80	-2.05	0.99	-1.86	10
g	-0.74	2.56	-1.11	0.70	3
h	-0.69	1.93	-1.07	0.17	6
i	-0.72	2.14	-1.11	0.31	4
j	0.27	0.46	-0.51	0.22	5
Average	0.00	0.00	0.00	—	—
Standard deviation	1.00	2.00	1.00	—	—

Note: A weight of 2 is applied to mathematics only, and 1 is applied to other subjects.

The adoption of this method not only enables the selection of highly efficient projects, but also permits clear statements of the reasons for project selection. This feature will lead to improved accountability and, at the same time, will offer important information for an entity in selecting projects. Furthermore, the accuracy of the system can be gradually increased by continuing these procedures and by accumulating acquired data.

In recent years, companies providing public infrastructural services and central and local government agencies and offices have been strictly required to facilitate efficient work implementation and the fulfillment of accountability. For other private-sector companies, the era in which they can only pursue profits has already passed. They are now expected to move their business operations forward from diverse perspectives that take into account such issues as contribution to employment, environmental considerations and compliance with laws and regulations. We can see such trends in the diffusion of corporate social responsibility (CSR) and socially responsible investment (SRI).

As part of our efforts to take new approaches in this new era, NRI has developed logic and methodology that “evaluates a wide variety of projects from multiple viewpoints and selects project combinations from comprehensive standpoints” as introduced in this paper. NRI is actively deploying this new methodology in actual operations in a variety of fields.

One example is application of this project selection logic to the formulation of business operation plans by private-sector companies. This application represents a trial to establish optimal investment plans based on the costs and expected effects of diversified projects.

Another attempt is application to the selection of projects to be implemented after the consolidation of municipalities. Because the timing of consolidation is determined in advance in this case, steps of gradually increasing estimation accuracy over several years are not possible. Accordingly, rather than calculating the effects of individual projects, several factors for evaluating projects are determined, such as “the extent of con-

tribution to the improvement of the unity of a new city” and “the extent of contribution to the balanced development of a new city.” The projects are evaluated and selected based on these factors.

The methodology introduced in this paper can be flexibly applied to many other situations, such as the selection of various subsidy-based projects and official development assistance (ODA) projects.

In addition, as noted previously, trial-and-error methods require an enormous number of calculations and must be repeated many times in order to work with actual operations. Accordingly, NRI independently developed its own system to conduct these simulations.

This paper focuses on the introduction of project selection logic. This is because the portion that can be somehow generalized for introduction is only the logic portion from among the series of procedures involved in this method. The actual application of this logic requires that individual projects be evaluated in advance in such a way as to “calculate the effects and costs of individual projects in some form.” With respect to this precondition, we regret that we cannot introduce generalized procedures as these calculations must be tailored to the contents of each target project.

In the course of studying the application of such logic to actual operations, progress is being made in the accumulation of various types of expertise with respect to the methods used to estimate effects and to evaluate projects, although the amount is still small. We look forward to the active use of the project selection methodology introduced in this paper. We would be especially pleased if this method contributes to improved efficiency in business operations and management in various areas as well as to improved transparency.

Answer to the example of Prefecture B by the branch-and-bound method

The results of our previous example are given in Table 11 (the projects for which “1” is indicated in the Adopted column were adopted). According to these results, the minimum necessary cost to satisfy the three goals is 40.8.

Table 11. Study Results by the Branch-and-Bound Method

Project	Cost	Accident reduction effect	Lost time reduction effect	Coverage increase effect	Adopted
Crossing renovation (1)	2.0	1.6	1.2	0.0	
Crossing renovation (2)	3.3	2.0	0.8	0.0	
Crossing renovation (3)	3.0	1.5	0.9	0.0	1
Bypass construction in Section A	45.0	2.2	2.2	1.1	
Bypass construction in Section B	25.0	1.8	3.0	0.6	
Bypass construction in Section C	12.0	1.1	1.0	0.7	1
Improvement of ordinary roads in Section D	8.2	0.8	0.8	0.6	1
Improvement of ordinary roads in Section E	7.0	1.3	0.9	0.4	1
Improvement of ordinary roads in Section F	4.4	1.8	1.3	0.3	1
Improvement of ordinary roads in Section G	6.2	0.9	0.8	1.1	1
Total number of adopted projects	40.8	7.4	5.7	3.1	

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1. However, it is possible to obtain an approximate solution that can be applied to an actual case. The degree of accuracy of the approximate solution that is chosen as the initial solution affects the operation time by means of the branch-and-bound method, which is explained later.
 2. Reference was made to John Chinneck, "Practical Optimization: A Gentle Introduction," chap.12, available at <<http://www.sce.carleton.ca/faculty/chinneck/po/Chapter12.pdf>>, and other websites and publications.
 3. However, it is not possible to pinpoint a sole combination if there are multiple combinations that incur the same cost.
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