Integrated Cost–Benefit Analysis with Environmental Factors for a Transportation Project: Case of Pinglin Interchange in Taiwan

Cheng-Min Feng[1] and Shu-Mei Wang[2]

Abstract: The concern over sustainable development gives rise to the importance of the environmental factors in evaluating an environment-sensitive project. In this regard, the widely adopted exercise which involves the environmental impact assessment (EIA) and the traditional cost–benefit analysis (CBA) in a sequential way may be flawed with a failure to calculate the resultant economic and environmental impacts in the same setting and at the same time. It is mainly because the EIA is qualitative in nature and hence the environmental impacts are hard and difficult to translate into monetary terms. In contrast, by monetizing the environmental impacts, the study shows that it is feasible to integrate the CBA with the environmental factors on an equal basis. The empirical base of the paper draws on the case of the Pinglin Interchange in Taiwan. In particular, the empirical results show that an integrated CBA may produce an entirely different conclusion from the one resulting from the common traditional EIA and CBA exercises. This is because the EIA focuses mainly on the quantity of pollution, but the latter depends on the socioeconomic context.

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Introduction

Over the last few decades "sustainable development" has become an issue of increasing concern around the globe, involving many policy agendas, including the transportation project. Many countries (such as the United States, United Kingdom, and Japan) take "environmental impact assessment (EIA)" as the environmental quality gatekeeper (Hayashi and Morisugi 2000). As a result, environment-sensitive projects of certain scale are often required to pass EIA before they are put into the cost–benefit analysis (CBA) process. Such a policy exercise, though it appears to give the environment a higher priority over the economic consideration, tends to lead to a situation where the environmental impacts and the economic impacts are not evaluated on an equal basis and at the same time, which may give rise to a misleading conclusion.

Many studies have put forward the concept of integrating the CBA with the environmental factors [to name just a few, Cesaro et al. (1997); Nakamura (2000)], but do not come out with an appropriate framework. In the past, the CBA failed to calculate the environmental impacts mainly because the environmental impacts are hard and difficult to translate into monetary terms. During the last decades, much work was devoted to developing methods for monetizing environmental effects, for example, the contingent valuation methods (CVMs), the travel cost method, and the hedonic pricing method. However, the application of these methods still falls short of expectations. More importantly, as far as this paper is concerned, the existing literature on the CVM does not go so far as to consider the environmental impacts and economic impacts at the same time.

Among the available methods, the CVM is by far the most widely applied (Mitchell and Carson 1989; Venkatachalam 2004). The major advantage of this approach, compared with the others, is that it may be applicable to value all goods and services and it is the only possible technique for the evaluation of nonuse values (Walsh et al. 1984; Brookshire et al. 1983), nonmarket use values (Choe et al. 1996; Loomis and du Vair 1993), or both (Niklitschek and Leon 1996; Desvousges et al. 1993) of environmental resources.

Another attraction of this method lies in the fact that in simpler cases it does not require a huge amount of data (of the not available or unreliable kind), as needed for the other techniques. Data can be treated at different levels of complexity according to the time and financial resources available and the specific format of questions used to capture the individual's value judgment.

The World Bank and Inter-American Development Bank have experimented with CVM in evaluating some international assistance projects (Ardila et al. 1998). Despite criticisms against the CVM (Venkatachalam 2004), a burgeoning of successful policy exercises supports the reliability and validity of CVM (McClelland 1997; Pradeaux 2000; Johnson and Baltodano 2004). The famous case at issue is the Exxon-Valdez oil spill accident for which the United States government assessed the environmental

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Table 1. Official CBA Results for Pinglin Interchange (Unit: NT$1,000/Year) [Adapted from TNEEB (2004)]

	Effects	Value
Road use	Time saving	95,749
	Vehicle operating cost saving	158,006
	Accident reduction	20,430
Local economy	Income increase	331,152
Public service cost	Waste disposal	−1,239
	Facility and maintenance cost	−54,000
Net effect value		550,098

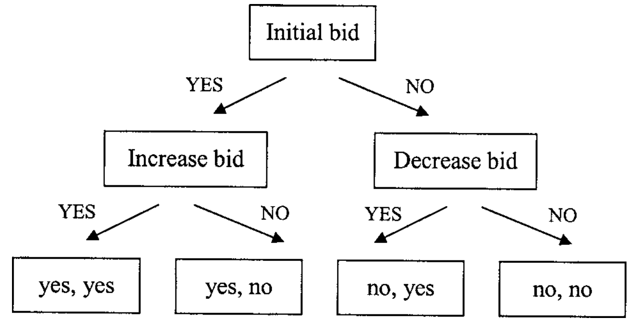

Fig. 1. Elicitation questions for survey: double dichotomous choice format

damages following the CVM. Nonetheless, the CVM deals only with the environmental impacts, paying no attention to the economic impacts.

Environmental goods' value depends on its socioeconomic context. The EIA reveals at most the effect of the environmental pollution resulting from a governmental/private project, but not the economic value of the environmental pollution. It should also be mentioned that the same unit environmental goods may have different prices (values) between the developed countries and developing countries. Therefore, there are strong grounds for suggesting that the CBA without environmental impact in monetary value may result in the ignorance of a disadvantaged minority and thus bias the final decision.

Against the above backdrop, this paper sets out to go a step further than the previous research by developing a step by step process which integrates the CBA with the CVM to assess the overall effects (both the environmental and economic impacts) on a transportation project. The empirical base of the paper draws on the case of the Pinglin Interchange in Taiwan. Admittedly, the case of the Pinglin Interchange is relatively small and simple, but the process presented in the paper may serve as a reference point for a bigger and more complex case.

Pinglin as a rural town in northern Taiwan, is famous for its green tea and rapidly growing tourism business. The government opened an originally regulated interchange to the steadily increasing tourists. The interchange lies within the catchment area of the Feitsui Reservoir, which supplies drinking water to nearly 4 million inhabitants within the Taipei metropolitan area. While the Pinglin Interchange has passed both the EIA and CBA, respectively, they were done in a different setting. The paper manages to incorporate the monetary values of the environmental impacts of the Pinglin Interchange into the original CBA framework. The empirical results give rise to a different conclusion from the current one.

The paper is organized as follows: Following this section, "Official CBA Results" presents the official CBA results. "CVM and Data Collection" discusses the methodology and data collection. "Analysis of Results" analyzes the empirical results. Finally, "Conclusions" concludes the paper.

Official CBA Results

To construct the Pinglin Interchange, the government first conducted the EIA, which was qualitative in nature and produced results in support of a favorable conclusion. This was followed by the official CBA, which calculated the monetary values of nonenvironmental effects that might result from the construction of the Pinglin Interchange.

Table 1 shows the official CBA results, which has evaluated three effects on the road use, local economy, and public service costs (TNEEB 2004). According to the official CBA, the Pinglin Interchange was expected to generate positive impacts of NT$550 million (United States $17 million) annually. The effects on the road use were positive, taking the form of time saving, vehicle operating cost saving, and accident reduction. The local economy would benefit from the flocking in of tourists to Pinglin. On the other hand, the construction of the Pinglin Interchange would incur public service costs, including waste disposal costs and facility and maintenance costs. The work of waste disposal would increase with the number of visitors, so the burden imposed on the government increases. To construct a regulation interchange would also require facility and maintenance costs. It should be noted that by referring to the results from the official CBA, the writers may be able to compare the results from the official CBA and our integrated CBA on the same basis, as presented in the next section.

CVM and Data Collection

This section discusses the elicitation model and data collection of the environmental effects. In the paper the writers use a double-bounded dichotomous choice (DB-DC) approach to estimate the monetary values of the environmental effects. The DB-DC approach is the most widely used elicitation technique for the CVM. The DB-DC approach elicits data via the questionnaire.

Elicitation Model

In the questionnaire survey, the respondents are asked if they are willing to pay (WTP) a specific amount "yes–no" to support an environmental good. If the answer is "yes," then a follow up question with a higher amount will be raised. On the contrary, if the respondents refuse the initial bid, then in the second round they will be tested with a smaller amount. The underlying idea is to reflect the respondents evaluation of their environmental utility. If the respondents think that their WTP for the described scenario exceeds the stated bid, then they will agree to pay, otherwise they will reject the bid. The observed respondents' decisions regarding the two bid amounts are offered in sequence as a proxy variable for the unobserved values. For each respondent, five possible response outcomes are produced: "yes–yes," "no–no," "yes–no," "no–yes," and 0. The complete elicitation procedure is shown in Fig. 1. To alleviate the potential information effect (Venkatachalam 2004), the respondents were provided with information about such issues as how the drinking water might be polluted by the Pinglin Interchange and how the health of the

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inhabitants within the Taipei metropolitan area might be affected by the polluted water. We are also aware of the starting point bias that may arise from CVM. To deal with this potential issue, we, following Thayer (1981), presented our biding questions to the respondents with three different starting bids (namely, NT$100, NT$500, and NT$1,000). The t tests are therefore executed, of which the results are shown in the Appendix. On top of that, the National Oceanic and Atmospheric Administration (NOAA) guidelines for the implementation of the CVM (NOAA 1992) were followed in our survey.

The model's coefficients are estimated by using the maximum likelihood technique. The log-likelihood function for the DB-DC model is defined as follows:

$$\ln L = I_0 \ln F(0) + I_{nn} \ln[F(A_1),F(0)] + I_{ny} \ln[F(A),F(A_l)] + I_{yn} \ln[F(A_h),F(A)] + I_{yy} \ln[1,F(A_h)] \quad (1)$$

Here I=indicator function which takes the value of one when responses are in a relevant category (y="yes," n="no," 0=WTP is zero); otherwise, its value is zero. For example, I_{ny} refers to a response where the first bid was not accepted, but the second bid was accepted. In addition, A refers to the initial bid; A_h to the increase bid; and A_l to the decrease bid. F=chosen cumulative density function; and $[F(A),F(A_l)]$=chosen cumulative density function between A and A_l. In this study, the CV estimation is identified as truncated normal

$$E[W] = \mu + \sigma \frac{\phi(-\mu/\sigma)}{1-\Phi(-\mu/\sigma)} \quad (2)$$

where $E[w]$=expected CV; μ=location parameter; σ=scale parameter; ϕ=standard normal probability density function (PDF); and Φ=standard normal cumulative density function (CDF). All parameters are calculated using the software package Excel according to the samples.

Data Collection

The survey was conducted over the period from April to October in 2004. According to the official EIA, Taipei metropolitan citizens include those who are affected by water pollution and road users including residents at Pinglin and tourists who are affected by water pollution, noise, and air pollution. Accordingly the survey conducted for the paper covered these two types of samples. To ensure that the sample as a whole is as representative as possible, the survey was administered not only on weekends, but also on weekdays. In the case of families, only one member of each family is selected to answer the questions. In the end, 466 reliable copies of questionnaires for the water pollution impacted group and 120 reliable copies of questionnaires for the road users were obtained. Those who met the respondent requirement were given a brief description of the study and were then asked if they would be willing to play a part in answering the questions prepared.

> We are now going to ask you a hypothetical question. Suppose you were told that Pinglin Interchange project will reduce the number of accidents and attract more vehicles to Pinglin Township. It will reduce water quality of the Feitsui Reservoir and increase noise and air pollution in Pinglin. The official EIA for the Pinglin Interchange is of quality, but some people worry the resultant long-term pollution may hurt health or increase the sanitation budget, even more cause many diseases, such as cancer, liver damage, calculus, anemia, endocrine disorder, and dementia. The study wants to know your willingness to pay for providing those environmental pollution, which may help us to calculate your welfare injure due to the water pollution, noise, and air pollution from Pinglin Interchange.
>
> Bear in mind that if you are willing to pay to protect the environment, you have to give up some other use for this money. For example, you may reduce your expenditure for entertainment or education (show Fig. 2).

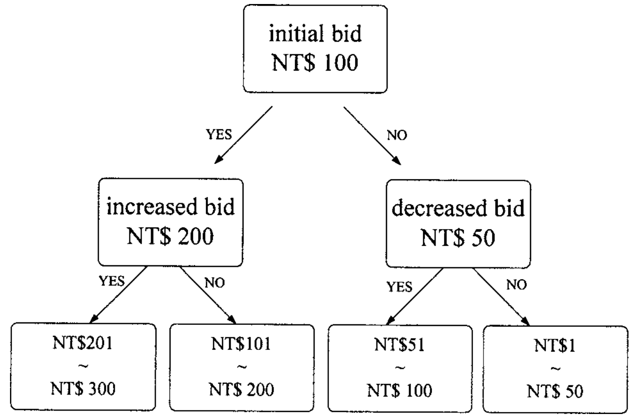

Fig. 2. Willingness to pay bid structure for pollution protection for Pinglin Interchange

1. Respondents being Taipei metropolitan citizens were asked:
   - How much money would you pay to counteract the water pollution every month?
2. Respondents being Pinglin residents or tourists were asked:
   - How much money would you pay to counteract the water pollution every month?
   - How much money would you pay to counteract the noise pollution every month?
   - How much money would you pay to counteract the air pollution every month?

The interview ended with several socioeconomic questions (e.g., age, gender, and income). In the end, the respondents prove to be representative of the inhabitants within the Taipei metropolitan area, as shown in the Appendix.

Estimating Monetary Values of Environmental Impacts

Table 2 shows the frequency and percentage of the WTP for the water pollution, noise, and air pollution. Following Eq. (2), the monetary values of the water pollution was estimated, as Eq. (3), at NT$99/man month. The monetary values of the noise pollution was estimated, as Eq. (4), at NT$92/man month. The monetary values of the air pollution was estimated at NT$107/man month [see Eq. (5)]

$$\text{The monetary values of the water pollution} = 81 + 114\frac{0.51(-81/114)}{1-0.30(-81/114)} = 99 \quad (3)$$

$$\text{The monetary values of the noise pollution} = 73 + 108\frac{0.50(-73/108)}{1-0.31(-73/108)} = 92 \quad (4)$$

Table 2. Statistics of WTP for Environmental Effects

WTP bids	Water pollution frequency (%)	Air pollution frequency (%)	Noise frequency (%)
NT$0	42 (9.01%)	8 (6.67%)	5 (4.17%)
NT$1–NT$49	203 (43.56%)	65 (54.17%)	14 (11.67%)
NT$50–NT$100	91 (19.53%)	22 (18.33%)	58 (48.33%)
NT$101–NT$199	68 (14.59%)	8 (6.67%)	38 (30.83%)
NT$200–NT$300	62 (13.30%)	17 (14.17%)	6 (5.00%)
Total	466 (100%)	120 (100%)	120 (100%)
μ	80.69	72.71	97.92
σ	113.88	108.28	113.38
ϕ	0.51	0.50	0.58
Φ	0.30	0.31	0.28
Estimated WTP (NT$)	99.36	92.49	107.23

Note: Calculated by the writers.

The monetary values of the air pollution

$$= 98 + 113\frac{0.60(-98/113)}{1-0.28(-98/113)} = 107 \qquad (5)$$

The writers are fully aware of the methodological issues related to CVM [for comprehensive reviews, see Klose (1999); Venkatachalam (2004)]. To demonstrate the statistical robustness of our empirical analyses, some of the descriptive statistics and statistical tests undertaken are shown in the Appendix, in order to present our analyses in a comprehensive way. In particular, as reported in the Appendix, our analyses prove to be free from the starting point bias.

Analysis of Results

This section presents and discusses the empirical result. The results of the official CBA and our integrated CBA are summarized in Table 3 and Table 4. The results of the empirical study show that the inclusion of monetized environmental effects in a cost–benefit analysis will lead to an entirely different outcome. In the case of the Pinglin Interchange, the net annual benefit was estimated at NT$550 million/year when the environmental effects are excluded. If the environmental effects are monetized and taken into consideration, the net deregulated effect will become negative NT$4,633 million/year.

Table 3. Monetary Values of Environmental Effects (Unit: NT$1,000/Year)

	Water pollution	Air pollution	Noise
Estimation monetary value[a]	0.114	0.106	0.123
Population of interest groups[b]	3,840,880	9,539	9,539
Environmental cost per year[c]	5,157,533	11,923	13,823

Note: (a) and (c) calculated by the writers.

[a]Results of CV estimation. The figures for 2010 are calculated from 2004 by assuming 2% annual growth rate which is the Taiwan Central Bank's 1 year deposit rate.

[b]The population of interest groups in 2010 (TNEEB 2004).

[c]=(a)*(b)*12.

Table 4. Results of Official CBA and Integrated CBA (Unit: NT$1,000/Year)

Effects		Official CBA	Integrated CBA
Road use	Time saving	95,749	95,749
	Vehicle operating cost saving	158,006	158,006
	Accident reduction	20,430	20,430
Local economy	Income increase	331,152	331,152
Public service cost	Waste disposal	−1,239	−1,239
	Facility and maintenance cost	−54,000	−54,000
Environmental cost	Water pollution	—	−5,157,533
	Air pollution	—	−11,923
	Noise	—	−13,823
Net effect value		550,098	−4,633,181

Note: Calculated by the writers.

Three aspects stand out from the empirical results. First, the results support the hypothesis made in the first section, namely: the widely adopted exercise for evaluating an environment-sensitive project that the EIA and the traditional CBA are conducted in a sequential way may not be sufficient and appropriate. The EIA is qualitative in nature and reflects technical views, which ignores that the monetary value of the environmental factor depends on the micro- and macroeconomic settings. The value of the same unit of environmental factor may have different prices in different socioeconomic contexts. Without denying the value of the EIA, the paper has managed to show that the socially optimal decision for an environment-sensitive project had better depend on an integrated CBA, incorporating both the resultant environmental impacts and economic impacts at the same time and in the same setting (namely in monetary terms), which neither the EIA nor the traditional CBA alone can adequately encapsulate.

Second, the case study highlights the importance of integrating the traditional CBA with CVM for the evaluation of an environment-sensitive project. The study has shown that the monetized evaluation of the environmental factor can be integrated into the traditional CBA framework, which will allow for the possibility of evaluating the economic and environmental impacts on an equal footing. Although the case study focused mainly on traffic related pollution, such as air, noise, and water, other environmental goods may be evaluated by using the same framework.

Third, the case study has demonstrated an easy way to integrate the CBA with the CVM. The CVM can be conducted by independent researchers, like the writers. When taking away the environmental factors, our study works on a consistent basis as the traditional or official CBA. As a result, it can be economical to adopt an integrated CBA, as proposed in the paper. The research results may facilitate the development of a fully integrated CBA which addresses as many kinds of monetized impacts as possible. In addition, by referring to the case of the Pinglin Interchange, our results have come out with a different conclusion from the current one. Should the government have had our empirical results before making the decision, different regulations may have been adapted, for example, regarding the traffic volume control, user fee charging, and more environment-friendly infrastructure.

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Table 5. Socioeconomic Background of Respondents

Item/description	Sample set[a] Mean/percentage	Weighted average of population of Taipei City and county (Taipei metropolitan area)[b] Mean/percentage
Average age	44.29	40.06
Average monthly income (NT$10,000)	5.67	6.52
Sex		
Male (%)	45.30	49.45
Female (%)	54.70	50.55
Education		
Primary school (%)	20.80	36.12
High school (%)	39.10	30.40
College (%)	23.20	30.2
Graduate school (%)	17.00	3.3
Occupation		
Government employee (%)	21.00	—
Corporate employee (%)	38.80	—
Self employee (%)	23.40	—
Others	16.70	—
Residential		
Taipei City and County (%)	85.67	—
Others (%)	14.33	—

[a]Calculated by the writers.

[b]Official statistics of Taipei City Government and Taipei County Government.

Table 6. Statistics of the WTP for Environmental Effects (Starting Point: NT$100)

WTP bids	Water pollution frequency (%)	Air pollution frequency (%)	Noise frequency (%)
NT$0	42 (9.01%)	8 (6.67%)	5 (4.17%)
NT$1–NT$49	203 (43.56%)	65 (54.17%)	14 (11.67%)
NT$50–NT$100	91 (19.53%)	22 (18.33%)	58 (48.33%)
NT$101–NT$199	68 (14.59%)	8 (6.67%)	38 (30.83%)
NT$200–NT$300	62 (13.30%)	17 (14.17%)	6 (5.00%)
Total	466 (100%)	120 (100%)	120 (100%)
μ	80.69	72.71	97.92
σ	113.88	108.28	113.38
ϕ	0.51	0.50	0.58
Φ	0.30	0.31	0.28
Estimated WTP (NT$)	99.36	92.49	107.23

Table 7. Statistics of WTP for Environmental Effects (Starting Point: NT$500)

WTP bids	Water pollution frequency (%)	Air pollution frequency (%)	Noise frequency (%)
NT$0	55 (11.80%)	9 (7.50%)	4 (3.33%)
NT$1–NT$199	401 (86.05%)	111 (92.50%)	112 (93.33%)
NT$200–NT$499	10 (2.15%)	0 (0%)	4 (3.33%)
NT$500–NT$799	0 (0%)	0 (0%)	0 (0%)
NT$800–NT$1000	0 (0%)	0 (0%)	0 (0%)
Total	466 (100%)	120 (100%)	120 (100%)
μ	93.55	92.48	104.98
σ	105.95	96.18	115.78
ϕ	0.59	0.63	0.60
Φ	0.28	0.26	0.27
Estimated WTP (NT$)	101.10	94.85	111.65

Conclusions

The concern over sustainable development gives rise to the importance of the environmental factors in evaluating an environment-sensitive project. In this regard, the widely adopted exercise which involves the EIA and the traditional CBA in a sequential way may be flawed with a failure to calculate the resultant economic and environmental impacts in the same setting and at the same time. It is mainly because the EIA is qualitative in nature and hence the environmental impacts are hard and difficult to translate into monetary terms. In contrast, by monetizing the environmental impacts, the study has shown that it is possible and feasible to integrate the CBA with the environmental factors on

Table 8. Statistics of WTP for Environmental Effects (Starting Point: NT$1,000)

WTP bids	Water pollution frequency (%)	Air pollution frequency (%)	Noise frequency (%)
NT$0	321 (68.88%)	89 (74.17%)	88 (73.33%)
NT$1–NT$499	145 (31.12%)	31 (25.83%)	32 (26.67%)
NT$500–NT$999	0 (0%)	0 (0%)	0 (0%)
NT$1000–NT$1999	0 (0%)	0 (0%)	0 (0%)
NT$2000–NT$4000	0 (0%)	0 (0%)	0 (0%)
Total	466 (100%)	120 (100%)	120 (100%)
μ	77.79	64.58	66.67
σ	139.45	127.07	129.10
ϕ	0.47	0.45	0.46
Φ	0.32	0.32	0.32
Estimated WTP (NT$)	111.28	98.34	100.42

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Table 9. Statistical Tests of WTP for Water Pollution

Starting point	NT$100	NT$500	NT$1,000	NT$500	NT$1,000	NT$100
Mean	80.69	86.05	77.79	86.05	77.79	80.69
Variance	6,472.97	1,202.87	13,425.00	1,202.87	13,425.00	6,472.97
Observations	466.00	466.00	466.00	466.00	466.00	466.00
Degree of freedom	632.00	—	548.00	—	829.00	—
t value	−1.32	—	−1.47	—	−0.44	—
$P(T<=t)$ single-tailed	0.09	—	0.07	—	0.33	—
Critical value single-tailed	1.65	—	1.65	—	1.65	—
$P(T<=t)$ two-tailed	0.19	—	0.14	—	0.66	—
Critical value two-tailed	1.96	—	1.96	—	1.96	—

Table 10. Statistical Tests of WTP for Air Pollution

Starting point	NT$100	NT$500	NT$1,000	NT$500	NT$1,000	NT$100
Mean	72.50	92.50	64.58	92.50	64.58	72.50
Variance	6,516.81	699.58	12,075.46	699.58	12,075.46	6,516.81
Observations	120.00	120.00	120.00	120.00	120.00	120.00
Degree of freedom	144.00	—	133.00	—	218.00	—
t value	−2.58	—	−2.71	—	−0.64	—
$P(T<=t)$ single-tailed	0.01	—	0.00	—	0.26	—
Critical value single-tailed	1.66	—	1.66	—	1.65	—
$P(T<=t)$ two-tailed	0.01	—	0.01	—	0.53	—
Critical value two-tailed	1.98	—	1.98	—	1.97	—

Table 11. Statistical Tests of WTP for Noise Pollution

Starting point	NT$100	NT$500	NT$1,000	NT$500	NT$1,000	NT$100
Mean	97.92	105.00	66.67	105.00	66.67	97.92
Variance	3,293.94	2,411.76	12,324.93	2,411.76	12,324.93	3,293.94
Observations	120.00	120.00	120.00	120.00	120.00	120.00
Degree of freedom	232.00	—	164.00	—	178.00	—
t value	−1.03	—	−3.46	—	2.74	—
$P(T<=t)$ single-tailed	0.15	—	0.00	—	0.00	—
Critical value single-tailed	1.65	—	1.65	—	1.65	—
$P(T<=t)$ two-tailed	0.31	—	0.00	—	0.01	—
Critical value two-tailed	1.97	—	1.97	—	1.97	—

an equal basis. As a result, the paper arguably has gone a step further than the traditional CBA and CVM.

In short, the essence of the paper is to develop and experiment with an integrated cost–benefit model for an environment-sensitive transportation project, by incorporating CVM as part of the model to monetize the environmental impacts, which should form an indispensable part of the overall cost–benefit analysis. As a matter of fact, such a view has been incorporated even in the traditional CBA for a long time, but the widely adopted approach of EIA plus (traditional) CBA has failed to realize the concept. Set against this, the integrated CBA method proposed in the paper may help shed new light on the overall evaluation of an environment-sensitive project.

In studying this issue, the Pinglin Interchange appears to provide an interesting case. Although within this issue, a high-profile case such as the Taiwan high speed railway, the biggest build–operate–transfer (BOT) case, is large in scale and draws much attention, this is obviously not the case in the Pinglin Interchange. However, the Pinglin Interchange does provide a manageable case to experiment with the development of an integrated CBA with environmental factors for an environment-sensitive project. Indeed, the paper goes a step further than the previous research by exploring the issue at the practice level, which hopefully may be more insightful.

In particular, the empirical results show that an integrated CBA may produce an entirely different conclusion from the one resulting from the common evaluation exercise of combining the EIA and the traditional CBA. Specifically speaking, while the common evaluation exercise led to a favorable conclusion, the results of our integrated CBA suggest that the construction of the Pinglin Interchange may not be cost effective in terms of the joint effects of the environmental and economic impacts. This is because the EIA focuses mainly on the quantity of pollution, but the latter depends on the socioeconomic context. In addition, compared to the widely used CVM, which deals only with the environmental impact and does not focus attention on the economic impact, the integrated CBA presented addresses both the economic and environmental impacts in monetary terms at the

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Table 12. Indifference Range of Estimated Monetary Values of WTP

Type of pollution	Means of WTP	Indifference range at the confidence level of 95%
Water pollution	99	91–108
Air pollution	92	84–101
Noise	107	101–113

same time. In other words, the failure to evaluate the environmental and economic impacts on the same scale (in monetary terms) and at the same time may not lead to a socially optimal decision for an environment-sensitive transportation project. By implication, an environmentally acceptable transportation project, such as the Pinglin Interchange, though it is justifiable in terms of the EIA, may not necessarily be a socially optimal project.

Finally, to make the socially optimal decision for an environment-sensitive project has been troublesome for the planners because they have to take into account both the resultant environmental impacts and economic impacts. Instead of developing something new, the paper arguably has managed to find a short cut to the above mentioned problem by integrating the CVM and traditional CBA on the same scale.

Appendix

The essence of the paper is to develop and experiment with an integrated cost–benefit model for an environment-sensitive transportation project, by incorporating CVM as part of the model to monetize the environmental impacts, which should form an indispensable part of the overall cost–benefit analysis. The writers are fully aware of the methodological issues related to CVM [for comprehensive reviews, see Klose (1999); Venkatachalam (2004)]. To demonstrate the statistical robustness of our empirical analyses, some of the descriptive statistics and statistical tests undertaken are shown in this Appendix.

First of all, the respondents prove to be representative of the inhabitants within the Taipei metropolitan area, as shown in Table 5. To avoid the starting point bias in implementing the survey we, following Thayer (1981), presented our biding questions to the respondents with three different starting bids (namely, NT$100, NT$500, and NT$1,000). The statistics of the WTP for the environmental effects in relation to the individual starting points are presented in Tables 6–9 respectively. We run the *t* tests between each pair of the starting points to examine whether or not differences in the starting point would affect the estimated WTP values. The results, as shown in Tables 9–11, suggest that the estimated WTP values are free from the starting point bias. Therefore, to simplify our analyses, we base our analyses on the results of NT$100 as the starting point.

We are also aware of the existence of the indifference range regarding the estimated monetary values, as shown in Table 12. However, in conducting our integrated CBA, we need just the means of the WTP values.

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