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Assessing the effects of carbon footprint cost on sport tourists' recreational benefits

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Abstract

This study examines how the inclusion of carbon footprint costs influences the recreational benefits and pro-environmental behaviors of sport tourism participants. By monetizing participants' pro-environmental behavior, this study provides a novel contribution to the valuation of environmental impacts in sport tourism. When carbon footprint costs are modeled as an independent variable within the Travel Cost Method framework, estimated recreational benefits increase by approximately NT$23. Despite the additional carbon costs, runners traveling by private car generate recreational benefits that exceed the associated environmental costs, reflecting the presence of an environmental value–action gap.

Keywords

carbon footprint cost, environmental value-action gap, pro-environment, recreation benefits, travel cost method

Introduction

The concept of Pro-Environmental Behavior (PEB) is defined as behavior that proactively aims to conserve or protect the natural environment. PEB encompasses multiple behavioral domains, including transportation, recycling, consumption, and energy-saving practices (Diekmann and Preisendörfer, 2003). Among these, transportation behavior plays a particularly important role in shaping individuals' carbon footprints, as it involves choices among different travel modes such as private cars, public transportation, or bicycles (Kraft et al., 2025). The direct emissions are caused by travelling to sport destinations, which can be estimated based on information about individual travel distances and transportation means (Mathez et al., 2013).

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In the context of recreational sport, the trips about travel distances and mode of transportation can be assessed in surveys and converted into CO2-e (Wicker, 2018). Previous research only focusing on aggregate emissions rather than identifying the determinants of individual-level carbon footprints (Kraft et al., 2025). By incorporating transportation-related carbon emissions into individual travel costs, Travel Cost Method (TCM) enables the valuation of environmental externalities that have often been omitted from traditional applications of the method. TCM helps address the lack of explicit environmental cost estimation (Wicker et al., 2023).

Specifically, this research aims to calculate the carbon costs associated with the various transportation modes used by participants and to estimate the recreational benefits derived from marathon participation. The estimated monetary value of these recreational benefits provides sufficient information to further examine runners' and the environmental value–action gap.

Literature review

The carbon footprint represents the global warming potential of greenhouse gases relative to carbon dioxide. According to the emission scope framework, direct emissions (Scope 1) arise from on-site fuel consumption, including that generated by vehicles, transportation, and travel (Pandey et al., 2011). These travel-related emissions can be quantified using travel distances and transportation modes, and subsequently converted into CO_2-equivalent values (Wicker, 2019).

The evidence suggests that a higher carbon footprint is negatively associated with subjective well-being, implying that individuals with lower emissions tend to report higher levels of well-being (Schmitt et al., 2018). However, people who have environmentally conscious do not necessarily demonstrate environmentally friendly behavior (Wicker, 2018) that call it environmental value–action gap (Blake, 1999). The environmental concern only leads to pro-environmental behavior in low-cost situations. High-cost situations are those situations where the costs in terms of time, money, and convenience (Wicker, 2018).

Methodology

The Travel Cost Method is one of the most widely used economic valuation tools for estimating the recreational benefits of recreational activities, and measures consumer surplus by relating visitors' travel expenditures to the demand for trips (Carson et al., 1996). Travel cost typically includes transportation expenses, on-site spending, and the opportunity cost of time (Pascoe et al., 2014).

In the empirical model, a count data model was employed to estimate individual consumer surplus. Single-site count data models are typically estimated using either the Poisson or the Negative Binomial distribution. Let the parameter λ_i be specified as an exponential function, such that the conditional mean is λ_i , and variance is $\lambda_i(1 + \alpha\lambda_i)$. This study conducts an over-dispersion test to examine whether the variance exceeds the mean in the count data. When $\alpha = 0$, the Negative Binomial model reduces to the Poisson in count data (Cameron and Trivedi, 1986). The consumer surplus (CS) of tourists equals the area under the expected demand function, E $(x_i) = \lambda_i$ and the willingness to pay for access is (Yeh et al., 2016):

$$CS = \int_{p_o{}^0}^{p^c} x(\cdot)dC = \left[\frac{e^{\beta_0+\beta_1 C}}{\beta_p}\right]_{C=C^0}^{C\to\infty} = -\frac{x}{\beta_p} \quad (1)$$

In equation (1), C represents the total travel cost, and β_p denotes the coefficient of travel cost. The consumer surplus per trip is equal to $-1/\beta_p$.

This study made a survey during the Tianzhong Marathon held in November 2016. A total of 585 valid responses were collected from 650 sample. The socioeconomic profile indicated that

Table 1. Transportation modes of carbon footprint.

Modes	Participant frequency	Factors Kg CO_2e/km	Carbon cost/km
Bicycle	93	0	0
Motorcycle	85	0.0951	NT$0.0285
Private car	279	0.115	NT$0.0345
Commercial car	5	0.133	NT$0.0399
BUS	23	0.04	NT$0.012
Train	19	0.06	NT$0.018
HSR	81	0.032	NT$0.0096

*Carbon footprint price is NT$300 per ton of CO_2e, equivalent to NT$0.3/kg.

333 participants were male and 252 were female. Regarding marital status, 245 participants were single, while 340 were married. In terms of age distribution, the largest group was aged 31–40 (225 participant), followed by those aged 30 and below (215 participants).

The carbon footprint cost of participants was estimated based on their round-trip travel distances from home to the destination, multiplied by the corresponding mode-specific emission factors. According to Taiwan Carbon Trading and Research Center, the average carbon emission factors are presented in Table 1.

The dependent variable in this study is the number of marathon participations over the past year. The independent variables include travel cost, substitute-site travel cost, marital status, age, and the natural logarithm of monthly income. The substitute site is Sun Moon Lake in Nantou, which was the most frequently selected alternative destination among participants.

The travel cost variable consists of transportation expenses, on-site expenditure, and opportunity cost in the Baseline Model, but excludes carbon footprint cost. In the Carbon Cost Model, travel cost is expanded to include carbon footprint cost in addition to the other cost components. In the Extended Model, carbon footprint cost is treated as an independent explanatory variable rather than being incorporated into the travel cost. The opportunity cost of recreation time is defined as the time spent traveling to and staying at the site, and is valued at one-third of the wage rate of income foregone. Descriptions of the variables are presented in Table 2.

Table 2. Description of the variables and summary statistics.

Variable	Definition	Mean	SD
TRIPS	The number of observed trips individuals participated to marathon events over the past year.	3,92	2.77
COST	Travel costs to Tianzhong Marathon, which is measured in New Taiwan dollars (NT$).	2140	2082
CCOST	The travel cost that includes the carbon emission cost (NT$).	2145	2085
SCOST	Travel costs of substitute site—Sun Moon Lake (NT$).	1806	2073
CSCOST	The substitute travel cost that includes the carbon emission cost (NT$).	1810	2076
LNINCOME	The natural logarithm of monthly income	10.55	0.41
AGE	The age of runners.	33.98	9.00
MARITAL	Dummy variable, 1, if runner is married; 0, single.	0.58	0.49
CARBON	Carbon emission cost for transportation.	4.08	4.87

Table 3. Estimation of travel cost model.

Variable	Baseline	Carbon cost	Extended
Constant	−3.1628 (3.49)	−3.1627 (3.50)	−3.1764 (3.48)
COST (CCOST)	−0.00074835 (−2.60)***	−0.00074833 (−2.60)***	−0.0007358 (−2.54)**
SCOST (CSCOST)	0.00077616 (2.69)***	0.00077614 (2.69)***	0.00029261 (2.58)***
LNINCOME	0.3467 (3.71)***	0.3467 (3.71)***	0.3473 (3.68)***
AGE	0.0179 (3.69)***	0.0179 (3.69)***	0.0176 (3.64)***
MARITAL	0.2370 (3.25)***	0.2370 (3.25)***	0.2328 (3.17)***
CARBON	—	—	0.0074 (0.82)
α	0.3605 (7.44)***	0.3605 (7.44)***	0.3594 (7.45)***
Chi-squared	234***	234***	233***

Note. **p < 0.05, ***p < 0.01, and t values in parentheses.

Results

Since the over-dispersion test revealed that the coefficient α significantly differs from zero, the Negative Binomial model is employed in this study. The goodness-of-fit tests for all models were statistically significant, indicating a good fit to the data. The coefficients of the travel cost and substitute cost variables are consistent with the law of demand and are statistically significant across all models. However, when carbon cost is treated as an independent variable in the Extended Model, its coefficient is statistically insignificant, suggesting that carbon cost does not influence runners' participation behavior. Specifically, older participants may have higher disposable income and stronger preferences for running, while married participants may derive greater utility from recreational experiences. The detail lists in Table 3.

The recreational benefit is calculated as $-1/\beta_p$, in both in the Baseline Model and the Carbon Cost Model, it was NT$1, 336; regardless of whether carbon cost was added to the travel cost. Since carbon costs are typically internalized for each participation. When carbon cost is included as an independent variable in the Extended Model, the recreation benefit is NT$1359. The incremental recreational benefit associated with incorporating carbon cost is approximately NT$23, even though is insignificant in the Extended Model.

Conclusion

This study provides new empirical evidence on how incorporating carbon footprint costs into the TCM influences the estimated recreational benefits of marathon participants. The results indicate that when carbon emission cost is internalized into travel cost, its monetary magnitude is extremely small relative to total travel expenses. Consequently, environmental costs are largely overshadowed by other components of travel cost in tourism-related activities. Moreover, when carbon cost is isolated from travel cost and treated as an independent variable, it does not significantly influence the number of participation. These results reflect the environmental value–action gap. The findings indicate that the travel behavior of sport participants is largely unaffected by carbon costs. Since Taiwan's carbon price only NT$300 per ton, is unlikely to exert any meaningful behavioral impact. The private cars are the most commonly used transportation mode among participants for convenience. From a policy perspective, policymakers may need to consider increasing carbon pricing levels or implementing complementary measures to achieve meaningful behavioral change. These could include improving access to public transportation, providing event-based shuttle services, and offering incentives for low-carbon travel options. Such combined approaches may enhance the effectiveness of carbon reduction strategies by lowering the perceived cost and inconvenience of adopting more sustainable travel behaviors.

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