Marine Policy 94 (2018) 20–27

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Developing confidence intervals for economic impacts: A multi-regional analysis of a recreational fishery in Korea

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ARTICLE INFO

Keywords:
Recreational fishing
Trip-related expenditures
Multi-regional input-output model
Bootstrapping
Confidence intervals

ABSTRACT

This study constructs confidence intervals for the economic impacts of recreational fishing in the Gyeong-Nam (GN) province of Korea, using a multi-regional input-output (MRIO) model for 16 provinces in Korea. Recreation-related expenditures are first bootstrapped, and then confidence intervals surrounding the change in total industry output of each province were calculated using two methods—normal approximation and bias-corrected percentile (BCP). The results show that, at the 95% confidence level, the interval endpoints of the economic impacts for the provinces are 8.9–10.3% percent above or below the point estimate from the original sample when calculated using the normal approximation method. The BCP method yields endpoints that are 8.7% below to 13.1% above the point estimate. The wide intervals of the economic impacts shown in this study imply that policy decisions based solely upon the point estimates could be misled.

1. Introduction

The analysis of economic impacts from policy changes provides policymakers with useful information on the magnitude of those impacts. Studies analyzing economic impacts typically use three different types of models – an input-output (IO) model, a social accounting matrix (SAM) model, or a computable general equilibrium (CGE) model. Very often, these studies provide impact assessments that are deterministic, calculating only the point estimates of the impacts. However, these impacts are subject to several different sources of uncertainty, including (i) uncertainty surrounding the IO coefficients (SAM coefficients when a SAM model is used), and (ii) uncertainty associated with the parameters used in the model (when a CGE model is used). IO coefficients may be prone to errors because they are often estimated based on secondary data, and because of the way the data are processed to estimate the IO coefficients (e.g., Kop Jansen [1] and ten Raa and Steel [2]). In addition, many of the parameters (elasticities) used in CGE models are from previous econometric studies, and are therefore subject to potential errors. This often requires sensitivity analyses for the parameters (see, for example, Seung and Lew [3] for a discussion of the parameter uncertainty issue in CGE modeling). Therefore, in addition to calculating the point estimates, it is desirable to estimate the likely range of the economic impacts by accounting for these uncertainties.

When using an IO or SAM model to compute the economic impacts of outdoor recreation in general, or recreational fishing in particular, there are at least two additional sources of uncertainty or variability that one can consider: (i) variations in trip-related expenditures arising from sampling variability, and (ii) uncertainty of the parameters estimated for the recreation demand model [4]. First, the estimates of recreation-related expenditures are random variables because the data are usually collected from a random sample of individuals through surveys. In this case, the true distribution of the expenditures in the population is unknown. Second, parameter uncertainty arises because recreation demand models for sport fishing are often estimated using regression models. These recreation demand models estimate the changes in recreationists' behaviors, such as changes in the number of trips and expenditures that they make. Therefore, changes in expenditures from recreation demand models are vulnerable to some degree of uncertainty.[1]

Many previous studies dealing with economic impacts from outdoor recreation/recreational fishing calculated only point estimates. Some

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[1] These recreation demand models often estimate only the consumer surplus generated from a recreational activity. However, this welfare measure, like other welfare measures (compensating variation and equivalent variation), is not comparable with the results from an economic impact analysis conducted within an input-output (IO) framework. This is because the IO model assumes that all the prices are fixed whereas the consumer surplus in these recreational demand models is derived given a downward-sloping recreational demand curve along which the price of recreational service changes. See also Hynes et al. [5] for further discussion.

https://doi.org/10.1016/j.marpol.2018.04.031
Received 3 January 2018; Received in revised form 26 March 2018; Accepted 25 April 2018

attempts have been made to determine the “range” of economic impacts. For example, English [6] estimated the range of economic impacts of recreational expenditures from visits to the Florida Keys using an IO framework. The study used a bootstrapping approach to consider the variations in expenditures, and developed confidence intervals around the economic impacts. Instead of a bootstrapping technique, Weiler et al. [7] estimated covariance using a regression demand model that assesses the change in number of visitors, and then constructed confidence intervals for the economic impacts of visitors to a national park gateway community using an IO model. The study first derived confidence intervals for the change in final demand arising from a change in the number of visitors, and introduced two endpoints (upper and lower bounds) to an IO model to derive the probable range of local economic effects. More recent studies [3,4] developed confidence intervals around the economic impacts of recreational fisheries in Southern Alaska. An innovative feature of these studies is that, when developing the confidence intervals, the studies considered both expenditure variation (sampling variation) and uncertainty of the parameters (stochastic variation) estimated for a recreation participation model.

All the studies discussed above used a single-region model. However, if a strong economic linkage exists among different regions, a single-region framework will miss a large portion of the economic impacts that occur not only in the original region where a policy shock (demand shock) is introduced, but also in the regions that have strong economic ties with the original region. In general, a policy shock to a region produces two different types of inter-regional effects: spillover effects and feedback effects. Spillover effects transpire in the other regions because the original region with the policy shock will have to import more commodities from the other regions to meet the increased industry output resulting from the policy shock. Feedback effects occur in the original region because, in turn, the other regions will need to import more commodities or inputs from it to produce the additional output. A single-region model would fail to capture these two effects.

The present study uses a bootstrapping approach, and construct confidence intervals for the economic impacts of spending by visitors at a recreational fishing site, Small Sea Ranch (SSR), in Gyeong-Nam (GN) province, Korea. To overcome the limitations of previous studies that relied upon single-region models, the present study uses a multi-regional input-output (MRIO) model to construct the confidence bounds surrounding the economic impacts for all the regions (provinces) in Korea.

This study extends a previous study by Kim et al. [8], which demonstrates that recreational fishing in the SSR area generates considerable economic impacts both in the GN province (approximately 68% of total impacts in Korea) and in non-GN provinces (approximately 32%) in Korea. Since a large fraction of the total economic impact spreads across the non-GN provinces, this empirical application is well suited for estimating confidence intervals of the economic impacts of the construction of the SSR that occur in the non-GN provinces as well as in the GN province. This is because the input variations (i.e., the variations in the trip-related expenditures in this study) are transmitted throughout all the industries in the GN and non-GN economies, yielding output variations (i.e., the variations in the economic impacts) in all provinces in Korea.

This paper is organized as follows. The next section provides a brief overview of the study area and the SSR. Section 3 briefly describes the MRIO model, followed by Section 4, which provides a summary description of the data used. Section 5 explains the bootstrapping methods. The results are presented in Section 6, and major findings are discussed in Section 7. Conclusions are presented in the final section.

2. Small Sea Ranch

Some of the problems faced by Korean fisheries are overfishing, contamination of sea water, and decreased fishing area resulting from the establishment of exclusive economic zones (EEZ) by Korea and its neighboring countries. These problems have caused a dramatic decrease in fish stocks and harvests, which in turn has led to a sharp reduction in commercial fishermen's income. In an effort to alleviate the financial distress of commercial fishermen caused by reduced income, the central government of Korea and the provincial governments have constructed sea ranches in near-shore waters. The sea ranches are intended to increase fishery resources through installation of artificial reefs that provide habitat for fish, as well as artificial seaweed beds.

The first sea ranch built in Korea was the Large Sea Ranch off Tong-Young area in southern Korea, which was built from 1998 to 2007 by the government of GN province with financial assistance from the central government. Since the ranch was constructed, the fish stock in the ranch has increased more than five times (from 118 t in 1998 to 750 t in 2006). As a result, commercial fishermen's income has increased roughly 26%, from 21,600 million Won[2] in 1998 to 27,314 million Won in 2006 [9].

The increase in commercial fishermen's income (and subsequent multiplier effects) is only one of two major economic impacts generated by construction of sea ranches. The other impact arises from the expenditures of visitors to the ranches for recreational purposes, including sport anglers and other tourists. These visitors spend money on transportation (e.g., fuel), food and drinks, lodging, and other goods and services while making trips to the ranches. It was estimated that visitors to Large Sea Ranch in 2007 spent a total of about 22,316 million Won [10]. Spending of this magnitude (the direct effect) may have produced substantial multiplier effects, creating new jobs and income in the economy of the GN province. Since the construction of Large Sea Ranch, many new sea ranches have been constructed in Korea. One of these new sea ranches is the SSR, which was built in 2015 in the Geoje area of GN province. A map showing the location of the study area and the SSR is displayed in Fig. 1 The construction of the ranch began in 2011 and was completed in 2015.

3. MRIO model

With few exceptions (e.g., Kim et al. [8] and Seung and Lew [11]), most of the studies investigating the economic impacts from recreational fisheries rely on a single-region model. The present study uses an MRIO model to overcome the limitation of a single-region IO model, which is the inability to estimate the spillover and feedback effects occurring among different regions. This study extends a previous study [8] to develop the confidence intervals around the economic impacts from recreational fishing in the SSR area. While Kim et al. [8] computed only the point estimates of the multi-regional economic impacts of the SSR using a 16-region MRIO model, the present study calculates the “range” of these economic impacts using the same MRIO model as used in Kim et al. [8]. The economic impacts for which the confidence intervals are developed include both the intra-regional economic impacts occurring in GN province and inter-regional (multi-regional) impacts transpiring in non-GN provinces. This section provides a brief description of the MRIO model.

The MRIO model can be represented by the following equation system:

$$\begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_r \\ \vdots \\ X_R \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1s} & \cdots & A_{1R} \\ A_{21} & A_{22} & \cdots & A_{2s} & \cdots & A_{2R} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ A_{r1} & A_{r2} & \cdots & A_{rs} & \cdots & A_{rR} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ A_{R1} & A_{R2} & \cdots & A_{Rs} & \cdots & A_{RR} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_r \\ \vdots \\ X_R \end{bmatrix} + \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_r \\ \vdots \\ Y_R \end{bmatrix}, \quad (1)$$

where $\mathbf{X_r}$ (r = 1, 2, …, R) denotes the (n x 1) column vector of industry

[2] *Won* is the monetary unit of the Republic of Korea (ISO code KRW). As of December 7, 2017, one $US is equivalent to about 1,092 Won.