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Overoptimism and the undervaluation of ecosystem services: A case-study of recreational fishing in Townsville, adjacent to the Great Barrier Reef

Marina Farr [a], Natalie Stoeckl [b,*]

[a] College of Business, Law and Governance, James Cook University, Townsville, QLD 4811, Australia
[b] Division of Tropical Environments and Societies, James Cook University, Townsville, QLD 4811, Australia

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ABSTRACT

There are numerous methods for estimating the value of different types of ecosystem services. Some methods use observed behaviours to draw inferences about value, but (observed) behaviours are based upon expectations, which can be incorrect. Using data from anglers living in Townsville, adjacent to the Great Barrier Reef (GBR) in a travel-cost model, we show how expectations about the number of fish people believe they will catch on a recreational fishing trip greatly influence estimates of the value of catch reductions (a loss in angler welfare). Experienced fishers have much more accurate expectations about catch than infrequent fishers, highlighting that valuation estimates derived from observable behaviours are most robust when the service being valued is well-known and when people are able to accurately judge the outcome of their behaviours. More broadly, it is clear that under conditions of uncertainty – such as climate change – overly optimistic visions of the future will likely lead us to undervalue (and thus potentially degrade) key ecosystem services – perhaps substantially.

1. Introduction

There are numerous different techniques for estimating the value of non-priced ecosystem services: some rely on market prices, some draw inferences from observed behaviours (e.g., the travel cost method), and others use hypothetical markets (stated preference approaches, such as contingent valuation and choice modelling). Methods that use hypothetical markets have been critiqued because actual behaviour (e.g., the amount actually paid) does not always correspond to stated intent (e.g., expressed willingness to pay): estimates can be unreliable unless researchers control for hypothetical response bias (Loomis, 2014). But this does not necessarily mean that methods which rely on observed behaviours are unequivocally reliable. This is because the behaviours that determine prices in the market place (e.g., the decision to visit a wetland) are based upon expectations (Deneckere and Peck, 2012), and expectations are not always borne out. Social psychologists suggest that there are good reasons for believing that there may be significant differences in *ex-post* and *ex-ante* constructs, primarily because individuals tend to revise their expectations or motivations after an event has happened. Consequently, estimates of value that are derived using *ex-ante* constructs (e.g., people's expectations of the birds they are likely to see while visiting a wetland) will not always equal those derived using *ex-post* constructs (e.g., the bird-life actually encountered while there).

Researchers have used several different stated preference methods to investigate differences in *ex-ante* and *ex-post* values for things such as Museum entry (Bedate et al, 2012), transport (Brathen and Hervik, 1997), events (Süssmuth et al, 2010) and regulation (Harrington et al., 2000). Statistically significant differences are commonly found (see Appendix A). But studies that have assessed differences in estimates of the value of ecosystem services using *ex-ante* and *ex-post* constructs are harder to find. Some related examples include studies of green energy (Whitehead and Cherry, 2004) and reduction in flood risk (Farrow and Scott, 2011). These studies employed stated preference techniques. To the best of our knowledge, however, no one has yet sought to assess differences between models that use *ex-post* and *ex-ante* measures in revealed preference studies of ecosystem services valuation.

This paper addresses that gap, focusing on one particular type of ecosystem service, namely recreational fishing, using a revealed preference technique (the *Travel Cost method*). We focus on recreational fishing in a town adjacent to the Great Barrier Reef – a

* Corresponding author.
E-mail addresses: marina.farr@my.jcu.edu.au (M. Farr), Natalie.Stoeckl@jcu.edu.au (N. Stoeckl).

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world heritage area critically impacted by recent coral bleaching events associated with climate change, and one in which there is evidence to suggest that 'local protection of fish stocks' and improved water quality may, given enough time, improve the prospects for recovery (Hughes et al., 2017). Improving our understanding of the drivers of recreational fishing demand in this area, may thus help scientists develop enabling recovery strategies.

2. Methods

2.1. General approach: background to the TCM

The TC method originated from a letter, penned by Hotelling in 1947, which suggested that it would be possible to estimate a demand function for national parks by examining the relationship between visitation and distance travelled (Boyet and Tolley, 1966). Model development was largely undertaken by Clawson (1959) and Clawson and Knetsch (1966). Their model, termed the Zonal TCM (ZTCM) considered the total number of visitors going to a recreational area, who originated from different 'zones' (each, further away from the site of interest). Newer forms of model (termed the Individual TCM (ITCM)) were subsequently developed by Brown and Nawas (1973) and Gum and Martin (1975)). ITCMs do not uses 'zones' – instead, they consider the total number of visits that individuals make to a recreational area (in a given time period). Individual models generally allow for more nuanced analysis of demand, but can only be used if there are significant differences in the number of trips that individuals make to the site, per time period (Farr et al., 2011).

The theoretical basis of the TCM, is the household production function, which assumes that a household will combine its labour, income, environmental quality, and other goods to produce a good or service for its 'own consumption and welfare (i.e., household's utility)' (National Research Council, 2005, p. 266). This allows one to specify what is termed a "trip generating function" that relates to a recreation site (depicted here for an individual TCM, but easily modified if using a zonal model):

$$V_i = f(TC_i, d_i, q_i), \tag{1}$$

where:

> V*i* is the number of fishing trips taken by angler *i* to a recreational fishing site during the season;
> TCi is the cost of travelling to (and from) the fishing site;
> *di* is a vector of angler's socio-demographic characteristics (e.g., household income, age, gender) and;
> q*i* is a vector of characteristics/quality of fishing site (e.g., expected catch, water turbidity).

Estimating the model is non-trivial task given: the non-normal dependent variable, complex relationships between independent variables; and potential problems with endogeneity, endogenous stratification, truncation and censoring. The dependent variable counts either the number of trips, per period, taken by people who live in a particular region (for the ZTCM), or the number of trips, per period, taken by an individual (ITCM). So the dependent variable is, by definition, a nonnegative integer: censored at zero (Creel and Loomis, 1990) and truncated (Wang et al., 2009). Ordinary least squares regression (OLS) is likely to generated biased estimates, so count data models (e.g., Poisson, truncated Poisson, negative binomial, truncated negative binomial) are generally required (Wang et al., 2009; Prayaga et al., 2010; Amoako-Tuffour and Martínez-Espiñeira, 2012). It is also often necessary to estimate models in multiple steps, thus controlling for relationships between independent variables.

Once the equation is estimated empirically, the TC coefficient can be used to predict the response of visitors to changes in travel costs. Visitors are assumed to react to price changes in the same way that they react to changes in travel costs which allows researchers to infer the number of trips visitors would undertake at various (assumed) prices (du Preez and Hosking, 2011). This information can be exploited to estimate the consumer surplus (CS) associated with visits; recreational use value (RUV – essentially CS extrapolated into the future) and/or to estimate the changes in CS and/or RUV (Hanley and Spash, 1993) that could occur because of changes in the environmental quality of the recreational site (e.g., recreational catch) (National Research Council, 2005).

Travel costs are included in every TC model, although there are no definitive rules about how best to measure them (Farr et al., 2011). Some researchers use the TC reported by respondents ((Herath and Kennedy, 2004, Prayaga et al., 2010). Others calculate TC themselves, accounting for numerous contributing factors which include: distance travelled (Stoeckl, 2003; Farr et al, 2014); the average cost of operating vehicle per mile or km (Fleming and Cook, 2008; Carpio et al., 2008); on-site costs of accommodation and food (Chen et al., 2004), length of the trip (Poor and Smith, 2004); entrance fees (Prayaga et al., 2006), angling costs (e.g., expenditure on bait, tackle, rods and reels, boat fuel) (Zeybrandt and Barnes, 2001; Pascoe et al., 2014) and/or the opportunity cost of time (Bin et al., 2005).

In addition to TC, there are other explanatory variables, which help predict visitation. Those commonly used by TC researchers include various socio-economic and site quality variables (e.g., income, gender, age, education, employment status, party size, substitute price for the site, recreational catch) (Poor and Smith, 2004; Blackwell, 2007; Carpio et al., 2008; du Preez and Hosking, 2011; Martinez-Espineira and Amoako-Tuffour, 2008).

Economic theory also suggests that the demand for a particular good or service will be influenced by expectations (Deneckere and Peck, 2012; Heyne et al., 2006), and recreational fishing decisions are made on the basis of 'expectations' about site quality and likely fishing experience (Bockstael, McConnell and Strand (1989) and McConnell (1988)), which includes expectations about catch (Morey and Waldman, 1998; Hunt et al., 2005). Researchers rarely have access to data about expected catch so they often use measures of historical or actual catch per trip (an *ex-post* measure) in lieu of expectations (an *ex-ante* measure) (Bergstrom, et al., 2004; Taylor et al., 2012; Englin et al., 1997; du Preez and Hosking, 2011). As argued by Schuhmann and Easley (2000, p. 439), however, expected (*ex-ante*) and actual (*ex-post*) catch 'are fundamentally different in their construction and purpose' – so these constructs are likely to be associated with, and reveal, quite different behaviours and values.

It is this last issue that speaks to the heart of this paper: our aim being to compare TC models that use *ex-ante* and *ex-post* constructs of catch, determining which variables are/are not associated with the different measures of catch, and what differences, if any, there are in value estimates, generated from the different models.

2.2. Study area

Extending for more than 2000 km along the north eastern coast of Australia, the Great Barrier Reef (GBR) World Heritage area (Fig. 1) is 'an integral part of the Australian national identity' (Day, 2015, p. 5). The GBR extends from 'shallow estuarine areas to deep oceanic waters' and is known for 'its large maze of colourful reefs' and 'its intricate architecture' which 'provides a home for a huge number of animals and plants' (Great Barrier Reef Marine Park Authority (GBRMPA), 2017a). The land area of eastern