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The efficiency of the Environmental Management Charge in the Cairns management area of the Great Barrier Reef Marine Park*

Marina Farr, Natalie Stoeckl and Rabiul Alam Beg†

Using data from a survey of more than 1000 domestic visitors to the Northern section of the Great Barrier Reef (GBR) – predominantly those travelling on live-aboard dive boats – this research investigates the (tax) efficiency of the Environmental Management Charge (EMC). The travel cost method (with a zero truncated negative binomial specification) is used to estimate the price elasticity of demand, and those estimates are used to estimate the deadweight losses, the losses in visitor numbers that could be 'blamed' on the EMC and the associated taxation revenues for different types of trips. The welfare loss for each dollar of revenue raised from the EMC was estimated at less than one per cent for each type of trip considered. The analysis therefore suggests that, for these types of trips in this part of the reef at least, the EMC is a very efficient tax – particularly when compared with other taxes. This has important implications beyond the GBR, particularly in countries who struggle to find sufficient funds to properly manage world heritage areas: taxes such as these may be a relatively efficient and equitable means of collecting such revenues.

Key words: deadweight loss, elasticity, Great Barrier Reef, negative binomial, tax efficiency, World Heritage Areas.

1. Introduction

The Great Barrier Reef (GBR) is recognised for its world heritage value and importance. Extending more than 2000 km north–south on the continental shelf off Queensland, Australia, the GBR Marine Park area covers 348 700 km^2: it is globally unique in terms of its size and the diversity of

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† Marina Farr (email: marina.farr@my.jcu.edu.au) is a PhD Candidate (Economics) and Research Assistant, School of Business, James Cook University, Townsville, Queensland, Australia. Natalie Stoeckl, is an Associate Professor (Economics), School of Business, James Cook University, Townsville, Queensland, Australia. Rabiul Alam Beg, is a Senior Lecturer (Economics), School of Business, James Cook University, Townsville, Queensland, Australia.

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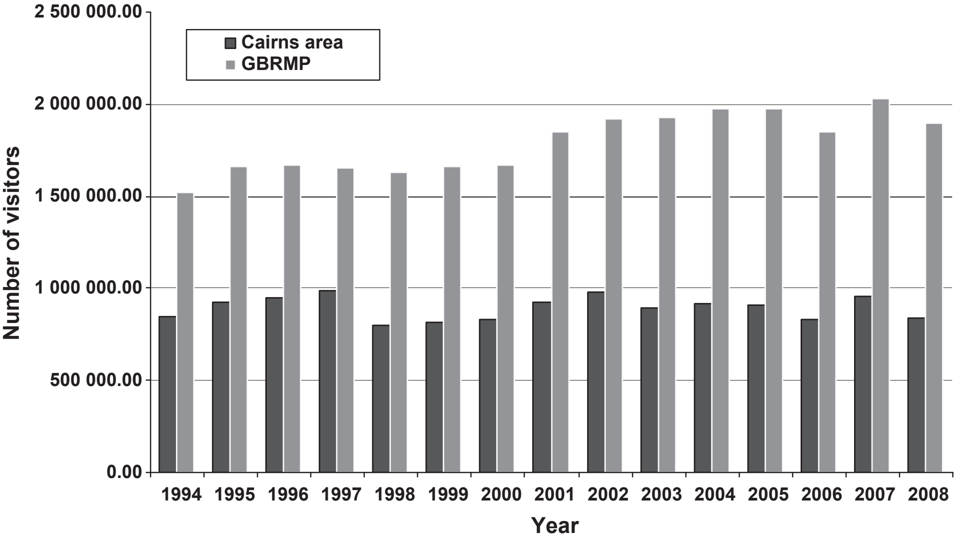

Figure 1 Total number of visitors to the GBR and Cairns management area (Data source: Great Barrier Reef Marine Park Authority 2009b).

plants and marine species contained within it [Great Barrier Reef Marine Park Authority (GBRMPA), 2009a].

The GBR is also vitally important to adjacent regional economies primarily because the tourism associated with it provides a major stimulus to economic activity in the region (Access Economics, 2007). Indeed, the GBR attracts approximately two million tourists per annum, 47 per cent of whom visit the Cairns region – see Figure 1 (GBRMPA, 2009b).

Clearly, degradation of the GBR would not only 'have catastrophic consequences' for the GBR tourism industry, but it 'would be a major scientific disaster' (Stanley and Hansen 1994, p. 8). It is, therefore, important to manage this resource carefully so as to protect its many values. Yet, careful management requires appropriate funding.

The GBR is currently managed by the GBRMPA. In 2005–2006 total revenues for the GBRMPA were $39.7 million: approximately $16.2 million was provided by the federal government in 'appropriations' and $7.2 million was collected via an Environmental Management Charge (EMC). The EMC was introduced in 1993 and applied across the entire GBR. It requires tourists who use commercial operators to travel to the reef to pay a fee to the operator and the fee must subsequently be remitted to the GBRMPA.

Since 1993, the amount of revenue that has been collected via the EMC has increased significantly partly because of the increasing rate[1] and partly because of the increasing number of visitors. Nowadays, the funds received as

[1] Although the EMC started at just $1.00 per passenger, since April 2007, each passenger is charged $5.00/day. Passengers, who are on their 4th and subsequent days of an extended trip with one operator, pay a maximum charge of $15.00 (GBRMPA, 2009c).

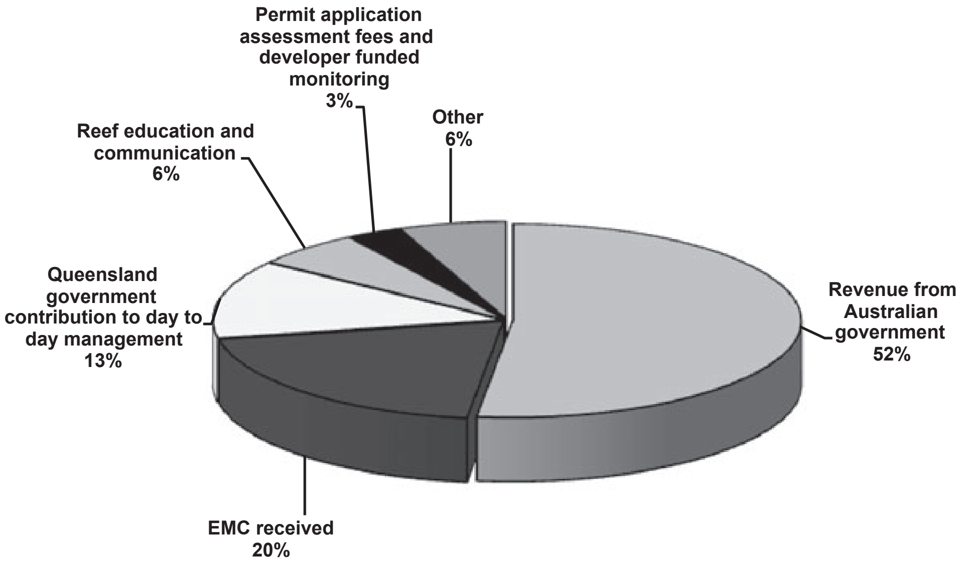

Figure 2 The GBRMPA's sources of revenue 2002–2003 (Source: Skeat and Skeat 2003).

EMC payments represent close to 20 per cent of the GBRMPA's income (Environment and Heritage Portfolio, 2007) – see Figure 2. However, between 2004–2005 and 2005–2006, EMC revenues have declined in nominal terms – as evidenced in Figure 3. Moreover, as the inflation rate was positive during this period, revenues must also have declined in real terms.

In the face of declining revenues, and of the possibility of increased demands for funds, a key question that arises, therefore, is 'Would it be sensible, or indeed desirable, to try and raise more revenue by increasing the existing EMC charge?' It is that, central question, which provides the focus of this paper.

Equity and distributional issues aside (for the moment), economic theory tells us that if seeking to answer questions such as those above, one should consider both deadweight losses (DWLs) and taxation revenues. Consequently, this paper estimates (i) the DWLs associated with the current EMC

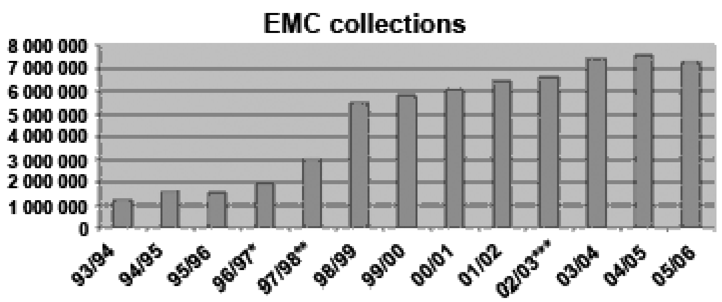

Figure 3 The EMC 1993–2006 (Source: Great Barrier Reef Marine Park Authority 2009c). *Standard charge increase from $1 AUD to $2 AUD. **Standard charge increase from $2 AUD to $4 AUD. ***Standard charge increase from $4 AUD to $4.50 AUD.

and (ii) the way in which changes to the EMC are likely to affect DWLs, visitation and taxation revenues.

Specifically, this paper uses the travel cost model to analyse data from a survey of more than 1000 visitors to the Northern section of the GBR. It generates estimates of the price elasticity of demand for different types of boat trips and uses those to estimate DWLs and EMC revenues associated both with the current EMC and with one that is twice the existing level. Although care must be taken when attempting to extrapolate results to other parts of the reef – because this survey focuses exclusively on the Northern section and predominantly on live-aboard dive boats – it does, nonetheless, allow us to draw some tentative conclusions about the efficiency of the EMC and the likely consequences (in terms of changes to DWL and visitor numbers) of changes in its level.

This paper is structured as follows: literature relevant to the price elasticity of recreation demand is briefly reviewed in the next section. The methodological approach used in this study is discussed in section three, whilst estimates of the price elasticity of demand for three different types of reef trips, together with the associated estimates of current DWLs and estimates of the possible changes in visitor numbers, in DWLs and in EMC revenues that could occur if the EMC was to increase are presented in section four. Concluding comments are provided in Section five.

2. Empirical estimates of the price elasticity of recreation demand

The non-market valuation literature presents many different approaches for estimating recreation demand including, but by no means limited to: the Contingent Valuation Method; the Contingent Behaviour Method; the Hedonic Price Method; and the Travel Cost Method (TCM). In many cases, the key aim of studies that use methodological approaches such as these is to generate empirical estimates of the consumer surplus (CS). As such, many of these empirical studies report only a final CS estimate. Yet, most methods require one to firstly estimate price elasticity and then to use these estimates in subsequent calculations of CS, and at least some of these studies report both CS and elasticity estimates. Consequently, there is much existing literature relevant to this topic – as summarised in Table 1.

Most evident here is the fact that the majority of studies have found that the demand for recreation is inelastic. *Ceteris paribus,* this indicates that recreation user fees in these regions are likely to be relatively efficient. Yet there is a paucity of research on the price elasticity of demand in the GBR, and although *a priori* expectations lead one to suspect that recreational demand in the GBR is likely to be inelastic, there are documented cases of elastic demand (as per the study of Lake Nakuru Park in Kenya – Table 1). It therefore seems prudent to use regionally relevant data to assess the actual DWLs associated with the EMC, rather than attempting to do so using elasticity

Table 1 Study on price elasticity of demand

Paper	Area	Method and general findings
Gum and Martin (1975)	Rural outdoor recreation in Arizona, the US	ITCM 0.12–0.56 (inelastic)
Walsh (1986)	23 outdoor recreation activities, the US	0.12–0.32 (inelastic)
Carpio *et al.* (2008)	Farm recreation trip visits, the US	ITCM 0.43 (inelastic)
Lindberg (2001)	Lake Nakuru Park, Kenya	CBM Foreign visitors 0.17–0.84 (inelastic) Residents 1.77–2.99 (elastic)
Knapman and Stoeckl (1995)	Kakadu National Park Hinchinbrook Island National Park, Australia	ZTCM 0.012 and 0.014 0.0005–0.0025 (highly inelastic)
Beal (1995b)	National park in south-east Queensland, Australia	TCM Day visits 0.055 Camping 0.087 (inelastic)
Greiner and Rolfe (2004)	Daintree Rainforest in the Cape Tribulation region, Australia	CVM 0.07–0.35 (inelastic)
Prayaga *et al.* (2009)	The Capricorn Coast region of the GBR, Australia	TCM and CBM (inelastic)
Grandage and Rodd (1981)	National parks, Australia	0.033–0.401 with 0.07 regarded as 'typical'(inelastic)

TCM, travel cost method.

estimates that have been 'transferred' from other studies. How that was done is described in the following section.

3. Methodology

3.1. The travel cost method (TCM) (zonal and individual models)

The TCM is one of the most popular methods for estimating recreation demand, and it is the one used in this study. Both zonal and individual TC models have been widely used, although individual models are generally preferred. In this case, however, few (if any) visitors travelling on live-aboard boat trips to the GBR take such a trip more than once a year (indeed, few people take such a trip more than once or twice a lifetime). Consequently, it was not possible to use an individual model. In this case, we therefore used the zonal TCM (ZTCM), focusing exclusively on domestic visitors and using Australian postcodes to define our zones.

Data were collected from six separate surveys on boats travelling to three different parts of the reef (see Figure 4). The information collected in these surveys provided data on more than 1000 (domestic) visitors on day and live-aboard dive boats that operated in the Cairns management area of the GBR during 2006, 2007 and 2008. Further details are provided below:

- A survey of passengers travelling to the GBR and Coral Sea Reefs (e.g. Osprey) on live-aboard dive boats was conducted over two seasons: 2007 and 2008. Questionnaires were distributed on five vessels (*Undersea Explorer*, *TAKA*, *Spoilsport*, *Nimrod Explorer* and *Spirit of Freedom*) that had regular scheduled trips along the Ribbon Reefs, the Osprey Reef and out into the Coral Sea. An estimated overall response rate was 34.7 per cent (Birtles *et al*. 2008).

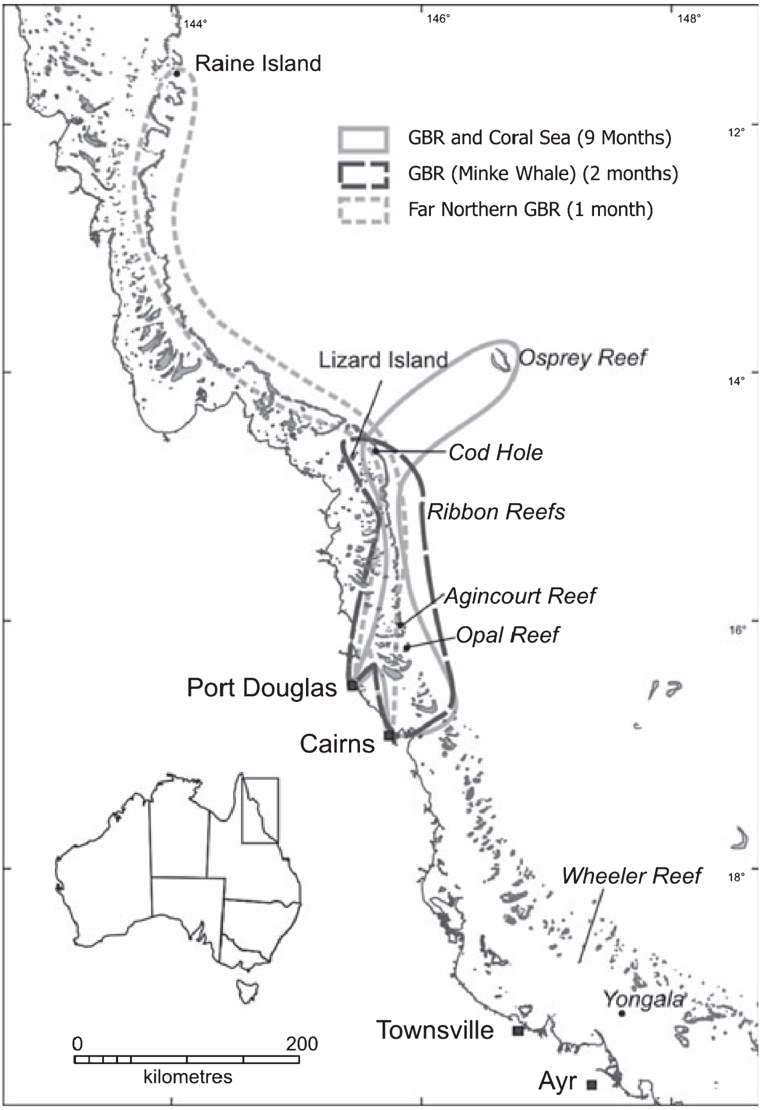

Figure 4 Research area. Map produced by: Edwards, A., Cartography Centre, School of Earth and Environmental Sciences, James Cook University (Source: Stoeckl *et al*. 2010).

- A survey was conducted of passengers undertaking both live-aboard dive-boat and day-boat trips to see minke whales over two seasons: 2007 and 2008. Questionnaires were distributed on all four swim-with whale endorsed live-aboard dive boats over the June–July dwarf minke whale season. The overall response rate for live-aboard and day trips was calculated as being between 44 and 49 per cent (Birtles *et al.* 2009).
- A survey of passengers travelling to the Far Northern section of the GBR (on live-aboard vessels) was conducted over two seasons: October–December 2007; and October–December 2008. Questionnaires were distributed on two live-aboard boats (*Undersea Explorer* and *Nimrod Explorer*), and the response rate for 2007 was calculated at 83 per cent (Stoeckl *et al.* 2010).

3.2. The models

Previous researchers (e.g. Ulph and Reynolds 1981; Brown and Mendelsohn 1984) note that one should seek to estimate a separate demand curve for different activities and for trips of different duration. Clearly, day trips and live-aboard trips are different types of activities of different durations, but trips that depart from different destinations are also, arguably, inherently different types of products. Consequently, we divided our database into three different subsets (live-aboard boat trips departing from Port Douglas, live-aboard boat trips departing from Cairns and minke whale day boat trips – all of which departed from Port Douglas) and estimated three separate visitation equations.

3.2.1. Defining zones

As noted earlier, zones were defined in accordance with Australian postcodes, primarily because this allowed a relatively high degree of geographic resolution, whilst also enabling us to use secondary data on the socioeconomic characteristics of residents from the Australian Bureau of Statistics (ABS) – which is available at the postcode level – to supplement our data set. The number of zones, number of visitors for each subset and origin of visitors are summarised below – see Table 2 and Figure 5.

Zero-visit zones (postcodes) were excluded from the analysis.

Table 2 Number of zones and number of visitors

	No. of zones	No. of visitors
Live-aboard boats Port Douglas	112	203
Live-aboard boats Cairns	184	306
Minke whale day boats Port Douglas	239	460

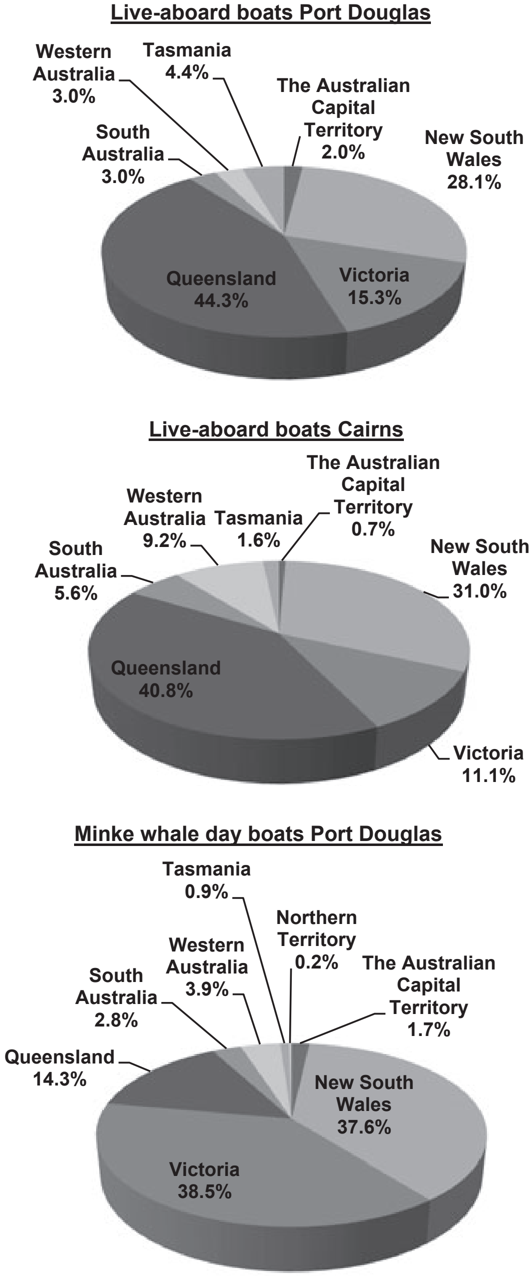

Figure 5 Origin of visitors.

3.2.2. Defining the dependent variable

Many zonal TC studies define the dependent variable in terms of visitation rates (e.g. the number of visits per head of population or per 1000 of population). However, as pointed out by Common (1973, p. 402), this imposes an unnecessary constraint upon the model, and it is possible to take account of population by including it as an independent variable. Consequently, we used the number of visitors per postcode as the dependent variable. This effectively censors the data at zero (Creel and Loomis 1990), and to disregard this would be to generate biased estimates (Hellerstein and Mendelsohn 1993). Subsection 4.1 provides a detailed discussion of how that issue was dealt with.

3.2.3. Independent variables

Socio-economic variables. It is important to include non-priced variables within the visitation equation. However, when conducting a zonal TC study, the unit of analysis is a zone (not an individual); one should, therefore, use data relevant to one's zones (Stoeckl and Mules 2006). In this study, we used socio-economic data (based on Australian postcodes) from the ABS (2006) Census. Table 3 provides some descriptive statistics for the variables used within our visitation equations.[2]

Travel costs (TC). There are several ways in which TC can be calculated and/or estimated. Arguably, the current literature shows a slight preference for the use of self-reported costs (Herath and Kennedy 2004; Prayaga *et al.* 2009); however in this case, such an option was not viable. Like previous studies (e.g. Common *et al.* 1999), we found that the costs reported by respondents were not credible,[3] and we thus needed to estimate travel costs ourselves.

There are no definitive 'rules' for how best to calculate travel costs: some studies have estimated TC as a function of the distance and the average cost of operating a vehicle per mile or km (Carpio *et al.* 2008; Fleming and Cook 2008); others have included entry fees (Beal 1995a; Prayaga *et al.* 2006), length of trip (Driml 2002; Poor and Smith 2004), the opportunity cost of time (Cesario 1976; Coupal *et al.* 2001; Bin *et al.* 2005) and on-site costs including the cost of food and accommodations (Chen *et al.* 2004; Herath and Kennedy 2004). Arguably, some of the most difficult issues confronting applied travel cost researchers are how to measure the opportunity cost of time and how to deal with multiple-site visitors. Those particular issues are addressed below, prior to presenting our 'equation' that details the way in which travel costs were estimated in this study.

[2] We also estimated various other models with other socio-economic variables (e.g. age, occupation and education). These variables were generally insignificant and coefficients of the TC were robust. (There was no change in the coefficient and its significance depending whether other socio-economic variables were included or not.) We have, therefore, omitted them from this analysis, noting that their omission does not significantly alter our final estimates of price elasticities and DWLs.

[3] For some visitors, it was between \$10 000 and \$21 000 and for some, it was zero or they did not report their costs at all.

Table 3 Descriptive statistics of the variables used in the models

Variables	Mean	Std. dev.	Skewness	Kurtosis	Minimum	Maximum
Live-aboard boats Port Douglas						
V	1.80	2.37	6.37	48.62	1	22
POP	18 000	14 332	1.60	3.01	1206	72 640
FINC($)	1410.71	430.98	0.83	0.02	798	2625
TC ($)	4281.60	903.98	−0.10	0.79	1525	7169
Live-aboard boats Cairns						
V	1.65	2.13	9.36	107.57	1	27
POP	17 800	13 571	2.11	7.83	128	99 482
FINC($)	1471.36	464.40	0.66	0.17	639	2674
TC ($)	3031.90	807.89	−0.12	0.07	1201	4959
Minke whale day boats Port Douglas						
V	1.92	1.64	3.84	21.76	1	15
POP	18 700	13 428	1.21	1.52	200	69 818
FINC ($)	1464.91	488.39	0.85	−0.12	629	2716
TC ($)	1631.20	829.58	−0.47	−0.57	158	3437

The opportunity cost of time: It is difficult to estimate the time visitors must spend travelling to and from the site under investigation. It is even more difficult to assign a cost to that time. This leaves two options:

- One can try to estimate the opportunity cost of time, for example, using some fraction of the wage rate (Cesario 1976; Coupal *et al*. 2001; Bin *et al*. 2005); or
- One can ignore the opportunity cost of time altogether (Beal 1995c; Whitten and Bennett 2002; Prayaga *et al*. 2006; Fleming and Cook 2008).

The first option is problematic because it is difficult to judge what is 'correct': this approach assumes that people are able to constantly trade-off hours spent at work, with hours spent in leisure (Fleming and Cook 2008). For self-employed people, it might be the case, but for people outside the labour force and especially for those with fixed working hours, it is not always relevant (Bockstael *et al*. 1987). Further, Beal (1995c) found that recreational travel to camping sites in Girraween and Carnarvon Gorge National Parks in Australia had 'no monetary opportunity cost for the majority of visitors' (p. 13).

In this study, the opportunity cost of time was, therefore, ignored. By doing this, the study may underestimate the TC (if the opportunity cost of time is positive). Thus, the decision to ignore the opportunity cost of time means that the coefficient on TC will be overestimated as will the price elasticity of demand and ensuing DWLs.

Multiple-site visitors: One of the assumptions of the TCM is that the only reason for travelling is to visit the site being studied. For single-site visitors, all TCs can be attributed to the site, but for multiple-site visitors, TCs 'need to be apportioned in some way between destinations' (Greiner and Rolfe 2004, p. 319). There are no definitive 'rules' on how to do this, although several different approaches have been suggested:

- Clough and Meister (1991) suggest that one should only measure the TC incurred on the day of the visit.
- Stoeckl and Mules (2006) advocate the use of dummy variables to account for multiple-site visitors so that 'the model, not the researcher, estimates the proportion of distance-related travel costs to be allocated to the site in question' (p. 501).
- Fleming and Cook (2008) exclude multiple-site visitors from the analysis.
- Beardsley (1971) suggests allocating a proportion of TCs between the various sites depending on the time spent by each visitor at each location.

In this study, international tourists were excluded from the analysis (as was suggested by Fleming and Cook 2008[4]), and Beardsley's method was used to deal with domestic multiple-site visitors. To be specific, when estimating TCs, responses to the following survey question were used to determine the proportion of TCs that could be allocated to the boat trip for multiple-site visitors.

If you had not been able to go on this boat trip, would you have still taken this trip to the Cairns/Port Douglas region?
(*please mark* [✔] *the appropriate box for the scenario that best fits your travel choices*)

☐ Yes, and I would have spent the same amount of time in the Cairns/Port Douglas region (*If so, please choose from box below*):
☐ Yes, but I would have spent less time/fewer days in the Cairns/Port Douglas region:
If so, how much? I would have spent ________________ fewer days in this region
☐ No, I would have travelled elsewhere
☐ No, I would not have taken the trip away from home at all
☐ I don't know

If a respondent indicated that:

- He/she would not have come to the region then the proportion of TC attributable to the trip (PRTC) was set to one.
- He/she would have come to the region anyway and spent the same amount of time – then PRTC was set at zero.
- He/she would have still come to region but would have spent less time then PRTC was set equal to: the reduction in time that would have occurred divided by the total time actually spent in the region.

By definition, $PRTC_i \leq 1$. So, by allocating only a portion of total costs (rather than the entire amount) for multiple-site visitors, we have placed a downward bias on our TC estimates. Any apparent 'incongruous' treatment of time (ignored when considering the opportunity cost of time, but accounted for when dealing with multiple-site visitors) thus ensures a consistent downward bias in our TC estimates. As such, our approach ensures a

[4] 66 per cent of international visitors from the database were multiple site visitors.

consistent upward bias in our slope, and DWL estimates. This allows for more definitive generic conclusions regarding the overall efficiency of the tax.

Given this information, equation (1) was used to estimate travel costs:

$$TC_i = (P + EMC) + (D_i \times 2 \times CARCOST) \times PRTC_i, \quad (1)$$

where TC_i, total travel costs from zone i; P, the advertised price of the trip,[5] EMC was obtained from the GBRMPA's webpage (Great Barrier Reef Marine Park Authority 2009c); D_i, the one-way travel distance between the respondents place of origin (zone i) and the survey site. This was calculated using the 'great circle distance' formula:

$$D_i = 1.852 \times 60 \times ARCOS(SIN(L1) \times SIN(L2) + COS(L1) \times COS(L2) \times COS(XG)), \quad (2)$$

where L1, latitude of the survey site (degrees);[6] L2, latitude of the respondents' place of origin (degrees); G1, longitude of the survey site (degrees); G2, longitude of the respondents' place of origin (degrees); XG, longitude of the second point minus longitude of the first point (degrees); CARCOST, the average cost, per km of travelling by car = 47.12 cents/km. This was estimated by calculating the mean of the whole of life costs of running the cheapest of four different classes of cars (light, small, medium and large);[7] $PRTC_i$, the proportion of TC attributable to the trip by postcode (zone) i.

Coefficients from the visitation equation were used to estimate price elasticities, consumer surplus and the DWLs associated with the existing EMC and with an EMC that is twice its current rate, as discussed in section 4.

4. Results and discussion

4.1. Estimating the demand with count data models

As noted earlier, the dependent variable is a non-zero integer and is, thus, censored at zero. Moreover, non-users of the site were not included in the survey, so the data are also truncated (Englin and Shonkwiler 1995; Wang *et al.* 2009). Consequently, one cannot use ordinary least squares (OLS) to estimate the visitation equation: poisson, truncated poisson, negative binomial or truncated negative binomial specifications are more appropriate in these circumstances and have been used in a number of recent studies (Cameron and Trivedi 1986; Creel and Loomis 1990; Prayaga *et al.* 2009; Wang *et al.* 2009).

[5] This was obtained from tour operators' websites.

[6] For each observation, latitude and longitude were determined by noting the latitude and longitude of each of the ABS's Census Population 2006 postcodes and survey sites (Geoscience Australia, 2009).

[7] National Roads and Motorists' Association Limited 2008.

A preliminary analysis of Poisson results for all three data sets showed that the conditional variance of the dependent variable was greater than the mean, implying overdispersion (Creel and Loomis 1990) and indicating that the standard poisson specification was inappropriate. The analysis was subsequently performed using a zero truncated negative binomial specification for each of the three groups of visitors investigated. Equation 3 (below) specifies the visitation equation:

$$V_i = \beta_0 + \beta_1 \mathrm{TC}_i + \beta_2 \mathrm{POP}_i + \beta_3 \mathrm{FINC}_i, \tag{3}$$

where V_i, number of visitors from postcode i; TC_i, total travel costs from zone (postcode) i; POP_i, population of zone (postcode) i; FINC_i, median family income ($/week) of residents of zone (postcode) i.

The results for estimated travel cost models are presented in Table 4. The estimates of the dispersion parameter (alpha) for all three models indicate that the data are overdispersed and that the zero truncated negative binomial models are indeed preferable to a Poisson model. The likelihood ratio (LR) chi-square test suggests that a high level of model fit for all three models is being achieved.

The signs of the TC coefficients in all three models are negative which is consistent with economic theory and with previous recreational demand studies. The coefficients are also highly significant at the one per cent level in model one (with a P-value ≤ 0.01); at the 10 per cent level in model two (with a P-value ≤ 0.10); and at the five per cent level in model three (with P-value $\le$ 0.05).

The other explanatory variables in models two and three have the expected positive signs and are highly significant at the one and five per cent levels.

Table 4 Travel cost models estimated with negative binomial specification

Variables	Left truncation (number of visits = 0)					
	Live-aboard boats Port Douglas (1)		Live-aboard boats Cairns (2)		Minke whale day boats Port Douglas (3)	
	Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.
Constant	−13.4243	1715.96	−18.7288	2330.92	−1.5826***	0.5071
TC	−0.00078***	0.0002	−0.00034*	0.00019	−0.00027**	0.0001
POP	−2.60e − 06	0.00001	0.00004***	0.00001	0.00002***	7.21e − 06
FINC	−0.00059	0.0005	0.00095**	0.00038	0.00088***	0.0002
Alpha	6.72e + 07	1.15e + 11	4.76e + 07	1.11e + 11	1.4053	0.8190
Log likelihood	−123.7295		−184.5198		−304.6674	
LR chi-squared	20.20***		31.08***		23.25***	
Likelihood-ratio test of alpha = 0:						
Chi bar squared	64.98***		74.64***		45.41***	

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

4.2. Estimating price elasticities of demand

The price elasticity of demand for all three types of trips was estimated using the formula:

$$E_p = \hat{\beta}_1 \times \frac{T\bar{C}}{\bar{V}}, \tag{4}$$

where E_p, the price elasticity of demand; $\bar{V}$, average number of visitors; $T\bar{C}$, average total travel costs.

The estimates of price elasticities for live-aboard boat trips from Port Douglas, live-aboard boat trips from Cairns and minke whale day boat trips from Port Douglas are −1.86, −0.62 and −0.23, respectively, and formal *t*-tests were conducted to determine whether demand could be classified as 'elastic', 'inelastic' or 'inconclusive'. These tests confirmed that

- Demand for live-aboard boat trips operating out of Port Douglas is price-elastic. Whilst this is inconsistent with estimates of the elasticity of demand for national parks in Australia, it is consistent with Lindberg's (2001) estimates of the price elasticities of demand for domestic visitors to the Lake Nakuru in Kenya (being between 1.77 and 2.99) and that
- Demand for minke whale day boat trips is clearly inelastic.

Tests associated with the price elasticity of demand for live-aboard boat trips operating out of Cairns were inconclusive: demand could be either elastic or inelastic.

That the demand for live-aboard boat trips from Port Douglas is more elastic than for live-aboard boat trips from Cairns and for minke whale day boat trips from Port Douglas is not altogether unexpected. The average price for live-aboard dive trips operating out of Port Douglas ($2662) is much higher than the average price of live-aboard trips from Cairns ($1556) and of day boat trips ($194). The more expensive trips are thus likely to (i) constitute a larger part of the budget than the cheaper trips; (ii) be undertaken less frequently than cheaper trips and (iii) be planned for longer in advance than cheaper trips (particularly when comparing day-trips with live-aboard trips). Each of these is key determinants of elasticity (Hoag and Hoag 2005), leading one to expect demand to be more elastic on the more expensive trips.

4.3. Estimating DWL and possible changes in revenues

Equation five was used to generate an estimate of the maximum DWL that could be associated with the current EMC – i.e. which would prevail given a perfectly elastic supply curve (Stiglitz 2000):[8]

[8] It is possible to estimate total DWL of taxes: the GST plus the EMC, but in this study only the additional DWLs associated with the EMC were estimated.

$$\mathrm{DWL} = \frac{1}{2}\hat{t}^2 pQE_p, \tag{5}$$

where $\hat{t} \equiv \frac{t}{p}$ is the tax rate (the ratio of the tax to the price); t, tax amount (the current EMC); p, the average advertised trip price; Q, the total number of visitors per annum. The total number of visitors per annum (Q) was 666 for live-aboard boat trips operating out of Port Douglas; between 5482 and 7134 for live-aboard boat trips operating out of Cairns (Stoeckl *et al.* 2010) – so the mean of 6308 was used; and between 102 917 and 114 514 for the minke whale day boat trips operating out of Port Douglas (Birtles *et al.* 2009) – so the mean of 108 715 was used.

In the first place, these estimates of the tax revenues and associated DWLs were calculated using the current EMC. The exercise was then repeated using an EMC equal to twice the current rate. Results are presented in Table 5, which clearly shows that the GBRMPA could double the EMC (and associated revenues) with very little impact on either visitor numbers,[9] or DWLs.

Much of current literature on DWLs associated with taxation focuses on the labour market, and the general conclusion being that personal income taxes are relatively inefficient and that the DWL per dollar of tax revenue (TR) ranges from about 20 per cent (Campbell and Bond 1987), to as high as 65 per cent (Findlay and Jones 1982; Ballard *et al.* 1985; Jorgenson and Yun 1991). Other studies report the average DWLs for all forms of taxation in the USA as being between 18 and 24 per cent of TR (Ballard *et al.* 1985; Jorgenson and Yun 1991) and the DWLs associated with import duties as being close to 40 per cent of TR (Irwin 2007).

In contrast, our study indicates that the DWL associated with a 100% increase in the EMC is very low – between 0.6 and 1.1 per cent of TR. This is relatively close to Shin and Burke's (2009) estimates of the DWL per \$ of TR associated with U.S. fuel taxes (0.2 per cent for a 100 per cent increase).

5. Conclusion

The majority of tourists who visit the GBR do so on day-boat trips. The sample used in this study is not, therefore, representative of all visitors to the GBR and results must be interpreted with caution. Nevertheless, this research does provide some valuable insights that shed light on our central research question: 'Would it be sensible, or indeed desirable, to try and raise more revenue by increasing the existing EMC charge?'

As noted in the introduction, such a question has both efficiency and equity components. To address the efficiency issue first, our findings suggest that the demand for live-aboard boat trips from Port Douglas is more elastic than for

[9] Specifically, the change in total visitor numbers as a fraction of total visitor numbers is small. That this occurs is because all operators are assumed to increase prices by the same amount, so that customers are not encouraged to turn to a competitor.

Table 5 Tax revenues and deadweight losses (DWLs) as a percentage of revenue raised with the current and higher EMC

	Price elasticity of demand (absolute value)	DWL ($)	EMC Revenue ($)	DWL for each $ of revenue raised	EMC as a % of advertised trip price	Projected loss in passengers from no-EMC base
Live-aboard boats Port Douglas						
Current EMC	1.86	52.07	9990	0.0052	0.56	7
Current rate doubled		210.47	9769	0.0106	1.13	14
Live-aboard boats Cairns						
Current EMC (mean)	0.62	284.59	94 620	0.0030	0.96	38
Current rate doubled (mean)		1145.22	188 089	0.0060	1.93	76
Minke whale day boats Port Douglas						
Current EMC (mean)	0.23	1604.12	543 575	0.0029	2.58	642
Current rate doubled (mean)		6420	1 080 730	0.0059	5.15	1284

live-aboard boat trips from Cairns and for minke whale day boat trips from Port Douglas. But this does not mean that the EMC is 'inefficient' for trips with elastic demand. Indeed, our analysis shows that the welfare loss for each dollar of revenue raised from the EMC on the trips considered in this study was very small: it was even significantly less than the welfare losses associated with fuel taxes – a tax that is oftentimes held forth as being 'efficient'. That this is so is because the tax itself is a relatively insignificant proportion of total trip price. So even when demand is elastic, the EMC represents less than one per cent of the price of the trip itself and therefore has relatively little impact on passenger numbers.

Moreover, our DWLs are, if anything, overestimated because this study:

- ignored the opportunity cost of time (thus underestimated travel costs and consequently overestimated DWLs);
- excluded international visitors (the EMC is an even smaller proportion of total trip costs for international visitors – hence their inclusion would only serve to strengthen our results);[10]
- counted only a portion of total costs for multiple-site visitors (again, underestimating TCs and hence overestimating DWLs); and
- assumed a perfectly elastic supply curve when estimating DWL.

In other words, our methodological approach has, wherever possible, erred on the side of generating DWL estimates that exaggerate 'true' population parameters. In this instance, the tax is efficient. Whether or not the EMC is

[10] Other researchers, e.g. Lindberg (2001), have found that international visitors have more price-inelastic demand than domestic visitors. If this is also true here, then our TC coefficients are likely to overestimate the responsiveness of visitation to changes in price, thus overestimating DWLs.

equally 'efficient' in other parts of the GBR and in other market segments, it is clearly an issue worthy of further investigation – but it seems unlikely that other studies would find vastly different results, particularly given the world heritage status of the reef and the lack of readily available substitutes.

As regards the 'equity' of the tax: if those who take trips to the reef while on holidays are, on average, earning higher incomes than the general population – as has been found in other recreational studies (e.g. Knapman and Stoeckl 1995) – then the EMC may also be more progressive than other forms of taxation. Further, in contrast to other more general taxes (like the departure tax that is paid by all international visitors to Australia, or the GST that is paid by all – irrespective of whether or not they visit the reef), the EMC clearly fits within the principal of 'user pays': those who use the reef contribute more to its upkeep than those who do not. Moreover, the EMC ensures that international visitors make a contribution to this important world heritage area whose protection would otherwise need to be funded entirely by Australians. Consequently, if one believes that 'equitable' taxes are those which are both progressive and which accord with the principal of 'user pays', then one cannot help but conclude that the EMC fits both criteria.

Importantly, this finding – that the EMC is both efficient and equitable – may not be unique to the GBR: environmental management charges in other parts of the world may also be both efficient and equitable. If so, then the policy implications are significant: those charged with protecting important conservation areas may not need to constantly struggle under the constraints of tight budgets. Whether or not it is necessary or practical to impose entrance fees must be assessed on a case-by-case basis. But these results suggest that management agencies may be able to generate revenues without causing significant declines in tourist numbers (and without incurring significant DWLs). They could then have funds available to re-invest in appropriate conservation activities. Although taxes are often feared, particularly by those within an industry affected by them, they are not unambiguously bad. In the absence of other revenue-raising alternatives it is possible that taxes such as these should be embraced – rather than feared – by those whose livelihoods are dependent upon the health of the environment.

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