Appendix A

Additional details on conceptual and empirical model

Lagrangian function and first-order conditions for conceptual model

The Lagrangian equation is given by

$$L = \sum_{t=1}^{T} U(r_t, \ell_t, Q_t, x) + \lambda \left[y - \sum_t c_t r_t - x \right] + \mu \left[L + H - \sum_t (r_t d_t + \ell_t) \right]$$

We assume that the numeraire good and non-recreation leisure days have positive demand and thus the constraints are always binding and the associated Lagrangian multipliers are positive. The resulting Kuhn-Tucker first-order conditions are

$$\begin{aligned}
\frac{\partial L}{\partial r_t} &= U_{r_t} - \lambda c_t - \mu d_t \leq 0, \;\; r_t \geq 0, \;\; r_t \frac{\partial L}{\partial r_t} = 0, \;\; t = 1, ...T, \\
\frac{\partial L}{\partial x} &= U_x - \lambda = 0, \\
\frac{\partial L}{\partial \ell_t} &= U_{\ell_t} - \mu = 0, \;\; t = 1, ...T, \\
\frac{\partial L}{\partial \lambda} &= y - \sum_t c_t r_t - x = 0, \\
\frac{\partial L}{\partial \mu} &= L + H - \sum_t (r_t d_t + \ell_t) = 0.
\end{aligned}$$

From the second first-order condition we know $U_x = \lambda$. We can divide the first first-order condition by λ to yield:

$$\begin{aligned}
\frac{U_{r_t}}{\lambda} &\leq c_t + \frac{\mu d_t}{\lambda}, \;\; t = 1, ...T, \\
r_t \left[\frac{U_{r_t}}{\lambda} - c_t - \frac{\mu d_t}{\lambda} \right] &= 0, \;\; t = 1, ...T.
\end{aligned}$$

Substituting U_x for λ in the denominator when U_{r_t} is the numerator results in Equation (2).

Derivation of estimating equations

Using the functional form for the ψ parameters described in the text and the α identifying restriction ($\alpha_t = \alpha_1 = \alpha$), the utility function specification in Equation (2) can be written as

$$U(r_t, Q_t, x) = \sum_{t=1}^{T} \frac{\gamma_t}{\alpha} \exp(\beta_Q' Q_t + \beta_S' S + \varepsilon_t) \left[\left(\frac{r_t}{\gamma_t} + 1 \right)^{\alpha} - 1 \right] + \frac{1}{\alpha} \exp(\varepsilon_1) x^{\alpha}.$$

The partial derivative of the utility function with respect to a recreation trip and the numeraire good is equal to

$$U_{r_t} = \frac{\gamma_t}{\alpha} \exp(\beta_Q' Q_t + \beta_S' S + \varepsilon_t) \frac{\alpha}{\gamma_t} \left(\frac{r_t}{\gamma_t} + 1 \right)^{(\alpha-1)} = \exp(\beta_Q' Q_t + \beta_S' S + \varepsilon_t) \left(\frac{r_t}{\gamma_t} + 1 \right)^{(\alpha-1)}, \quad \text{and}$$
$$U_x = \lambda = \frac{1}{\alpha} \exp(\varepsilon_1) \alpha x^{(\alpha-1)} = \exp(\varepsilon_1) x^{(\alpha-1)}. \tag{A-1}$$

We can rearrange the KT conditions in Equation (1) to yield:

$$U_{r_t} \leq \left(c_t + \frac{\mu d_t}{\lambda} \right) \lambda, \quad t = 1, ...T.$$

We substitute in the expressions for U_{r_t} and λ from Equation (A-1) and use the full virtual price term p_t, where $p_t = c_t + \mu d_t / \lambda$, to yield

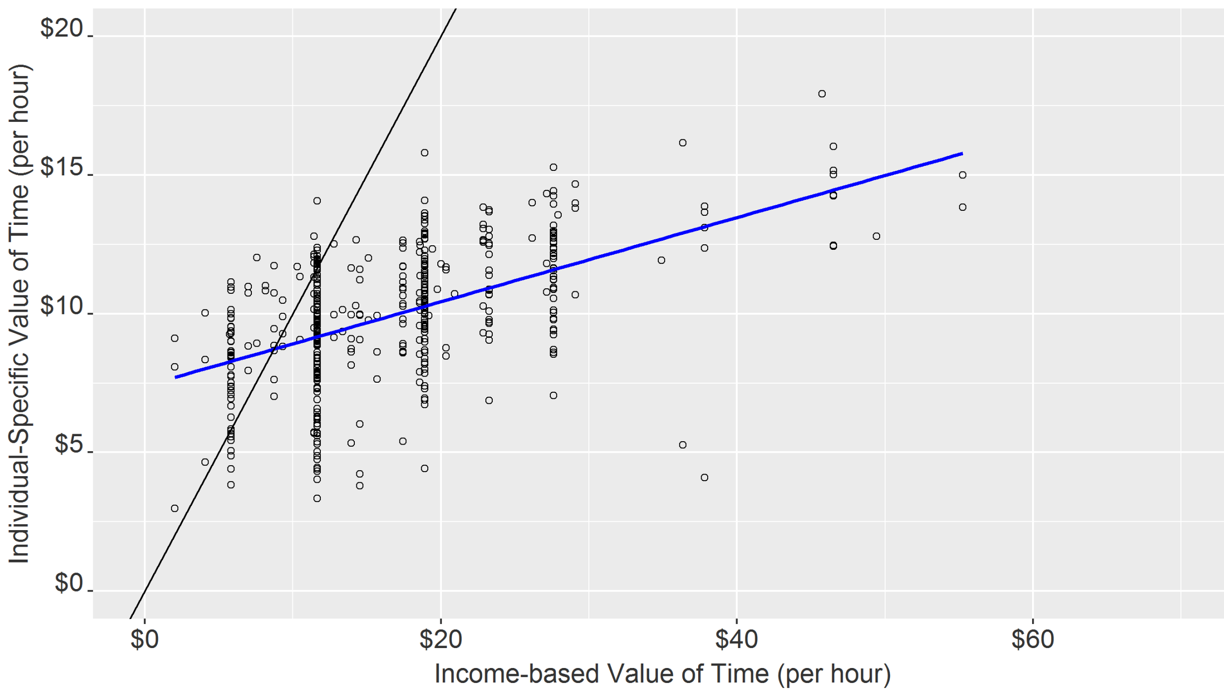
$$\exp(\beta_Q' Q_t + \beta_S' S + \varepsilon_t) \left(\frac{r_t}{\gamma_t} + 1 \right)^{(\alpha-1)} \leq (p_t) \exp(\varepsilon_1) x^{(\alpha-1)}, \quad t = 1, ...T.$$

Taking logarithms of both sides yield the estimating equations as

$$\begin{aligned}
&V_t + \varepsilon_t = V_1 + \varepsilon_1 \quad \text{if } r_t^* > 0 \\
&V_t + \varepsilon_t < V_1 + \varepsilon_1 \quad \text{if } r_t^* = 0, \quad \text{where} \\
&V_t = \beta_Q' Q_t + \beta_S' S + (\alpha - 1) \ln \left(\frac{r_t}{\gamma_t} + 1 \right) - \ln (p_t), \quad \text{and} \\
&V_1 = (\alpha - 1) \ln(x).
\end{aligned}$$

Bhat (2008) details how these equations are used in estimating the KT model.

Figure A1: Relationship between Value of Time Estimates using Individual-Specific and Income-Based Approaches in Fezzi et al. (2014)



Notes: This figure plots the value of time measures from the individual-specific and income-based approaches to valuing time using the data in Fezzi et al. (2014). Each dot represents a single individual (n = 457). The black 45 degree line indicates a perfect correspondence in estimates between the two approaches. The blue line is a linear regression of the individual-specific VOT on a constant and the income-based VOT.

Appendix B: Travel cost calculations

In this appendix, we describe the approach to calculating the travel costs of a headboat fishing trip in the GOM. The cost of traveling to each port is calculated using both non-monetary opportunity costs of time represented as μ/λ in the conceptual model and monetary cost information represented as c_t. The approach to calculating VOT using the income-based and individual-specific approaches are explained in the text and here we outline the approach to calculating the monetary costs of traveling to each port and the fees to take a headboat fishing trip.

The monetary travel costs are calculated generally following the approach described in the Deep Water Horizon Recreation Assessment Study's (DHW study) technical memoranda documents (Industrial Economics, 2015; Leggett, 2015). We consider that individuals can either fly or drive to each port and travel costs are calculated as a weighted average of these costs where the weights are the probabilities of choosing each mode of travel. Formally, the cost C_{iojt}^{TC} to individual i incurred from traveling from origin o to port j in time period t is represented as

$$C_{iojt}^{TC} = \pi_{ioj} C_{iojt}^{Fly} + (1 - \pi_{ioj}) C_{iojt}^{Drive}$$

where π_{ioj} represents the probability that individual i will choose to fly when traveling from origin o to port j. Origin locations are assigned by geocoding the zip code provided by respondents in the survey. Time period t refers to one of the four seasonal time periods in each of the two years.

The Costs of Driving

Driving costs are calculated using information on both monetary and non-monetary expenses. Data on average per-mile fuel costs (f_t) and average per-mile non-fuel vehicle operation costs (nf_t) including tires, maintenance and depreciation is collected from the AAA (American Automobile Association, 2015, 2016).[1] One-way driving distances (in miles) and time (in hours) between any given points a and b are estimated from Google Maps using the R

[1] Costs are obtained for an average sedan and depreciation costs are calculated using 5,000 mile deviations (higher and lower) from the 15,000-mile annual depreciation scenario reported by the AAA following the DWH approach. Specifically, the AAA estimates that in 2014 depreciation costs for the average sedan are $252 less if the car is driven 5,000 miles less than the 15,000-mile scenario and $204 more if the car is driven an additional 5,000 miles. The average per-mile depreciation costs is $0.0511 (($252/5,000) + ($204/5,000))/2).

package ggmaps (Kahle and Wickham, 2013). The average cost of a night at a hotel (h_t) is obtained from the American Hotel and Lodging Association (American Hotel & Lodging Association, 2015). The number of nights is derived by dividing total driving time by 12 and rounding down to the nearest integer. These monetary costs of driving are divided by the fishing party size reported by each individual (ρ_i) in the survey. If the reported party size is greater than 5, then the costs are divided by 5 to reflect the capacity of a typical sedan.[2] Thus, the one-way driving costs is calculated as,

$$C_{it}(a,b) = \left[(f_t + nf_t) * distance(a,b) + h_t * nights(a,b)\right]/\rho_i + VOT_{it} * time(a,b),$$

where VOT_{it} is the value of leisure time for individual i in time period t. These one-way costs are multiplied by two to derive the round-trip cost to each individual.

$$C^{Drive}_{iojt} = 2 * C_{it}(origin_{io}, port_j)$$

The Costs of Flying

To calculate the costs of flying, we first identify several possible flying routes for each individual and then choose the flying route with the least cost. Specifically, the four closest origin airports m to each individuals' residences are identified along with the four closest destination airports n to each visited port, for a total of 16 potential flying routes for each individual to each port.[3] The costs of flying is then estimated to be the minimum cost route amongst these possible pairs:

$$C^{Fly}_{iojt} = min_{m,n}\left\{C^{Fly}_{iojtmn}\right\}$$

The costs of flying can be divided into five parts: the costs of driving from the origin location o to the origin airport m, the costs of parking at the origin airport, the flight costs from the origin airport to destination airport n near the port j, the cost of renting a car, and the cost of driving from destination airport to the port (Leggett, 2015). These different components

[2]If the party size information was missing, then the median party size of 3 is used in its place.

[3]We only consider airports that have annual enplanements of over 100,000 (Industrial Economics, 2015). Enplanement data is obtained from the Federal Aviation Administration (FAA) Calendar Year 2014 Passenger Boarding and All-Cargo Data lists.

are represented using the following expression:

$$C^{Fly}_{iojtmn} = 2 * C_{it}(origin_{io}, airport_{iom}) + C^{Parking}_{mt} + C^{Flight}_{itmn} + C^{Rental}_{t} + 2 * C_{it}(airport_{jn}, port_j)$$

Both driving portions of the costs are calculated using the same methodology as the cost of driving directly to the port as described previously. Average parking costs for large/medium and small airports are based on data used in the DHW study. The number of parking days is calculated using the number of total nights away reported by respondents and all parking costs are weighted by the reported party sizes. Average rental car costs are based on data reported by the American Hotel and Lodging Association (American Hotel & Lodging Association, 2015).

Total round-trip flying costs from origin airport n to destination airport m is calculated as

$$C^{Flight}_{itmn} = VOT_{it}(time^{airport} + time^{flight}_{tmn} + time^{layover}_{tmn}) + price^{ticket}_{tmn}$$

where VOT_{it} is the value of time, $time^{airport}$ is the time spent at the origin and destination airports before and after the flights and is assumed to be 4 hours for each round-trip, $time^{flight}_{tmn}$ is the flight time between airports, $time^{layover}_{tmn}$ is the time spent during any layovers, if any, and $price^{ticket}_{tmn}$ is the round-trip ticket price.

These last three terms are based on data from the Airline Origin and Destination Survey (DB1B) conducted by the Office of Airline Information of the Bureau of Transportation Statistics. The DB1B dataset represents a 10% sample of airline tickets from reporting carriers in the United States every year. The DB1B consists of three different data tables (*ticket*, *market*, and *coupon*) that can be joined by an Itinerary ID variable. The *ticket* data table is the most aggregated and includes information on ticket fare costs and the origin of the flight but does not include destination. It represents each purchased ticket by one observation (either one-way or round-trip). The destination information is found in the *market* data table which includes one observation per direction of travel (i.e. one observation for a one-way ticket and two observations for a round-trip ticket). The *coupon* data table includes one observation per flight of the journey and has information on estimated and actual flight time per leg as well as the number of layovers. We obtain data for each quarter of 2014 and 2015.

For each origin-destination airport pair, the average number of layovers and flight time are obtained from the *coupon* database for each quarter of 2014 and 2015. Some flight routes had missing time data for certain time periods. In these cases, a regression model is estimated using distance (in miles) and number of layovers as explanatory variables to predict the expected flight times for a small subset of routes. For each layover, 60 additional minutes are added to the total flight time based on data from Sabre Airline Solutions (Industrial Economics, 2015). The ticket fares are taken from the *ticket* data table and the 30th percentile fare is used as the expected flight costs (Industrial Economics, 2015). Finally, the average flight times and costs for each quarter are converted to our four seasons.

Probability of Flying

The probability of flying is modeled as a function of distance using data on actual mode choices from the 2009 National Household Travel Survey (NHTS). The NHTS survey collects information on mode of transportation and distance for a nationally representative sample of travel behavior. After excluding trips that are less than 250 miles, we are left with 2,393 trip decisions that are used in a logit model of the decision to fly or drive based on miles and miles squared. The estimated intercept and distance parameters are used to predict the probability of flying for respondents in our data. Following DHW study, we assign a zero probability of flying to all respondents who reside less than 250 miles away from the port and to respondents who live less than 500 miles away and have income less than $70,000 per year or more than 2 household members. Figure B1 shows the predicted probability of flying for respondents in our data based on their distance to the port.

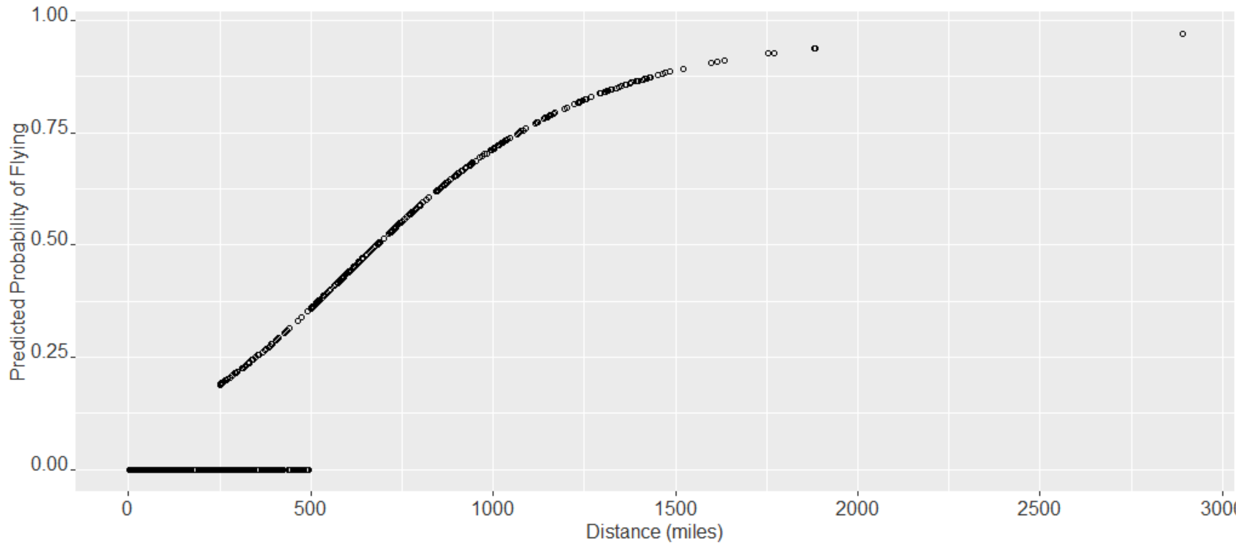
Multiple Ports

The vast majority of respondents only visited one port. Respondents visiting more than one port, the different ports are usually close by. For individuals that traveled to more than one port, we average the travel costs over visited ports to derive an average cost of a trip to the Gulf of Mexico.

Second Homes

For respondents reporting a second home in the region, we also calculate the expected travel costs from their second home to each visited port. A total of 53 respondents reported second homes in the region with valid zip codes. We used the travel costs from the second home if these expected costs are lower than the travel costs estimated from the main residence.

Figure B1: Predicted Probability of Flying for Individuals as a Function of Distance



Total Costs of a Fishing Trip

In addition to the costs of traveling to the port, headboat fishermen also pay a trip fee to go fishing. Thus, the total costs of a headboat fishing trip for individual i is comprised of the costs of traveling from origin o to port j and the costs of a fishing trip of length l from port j in time period t:

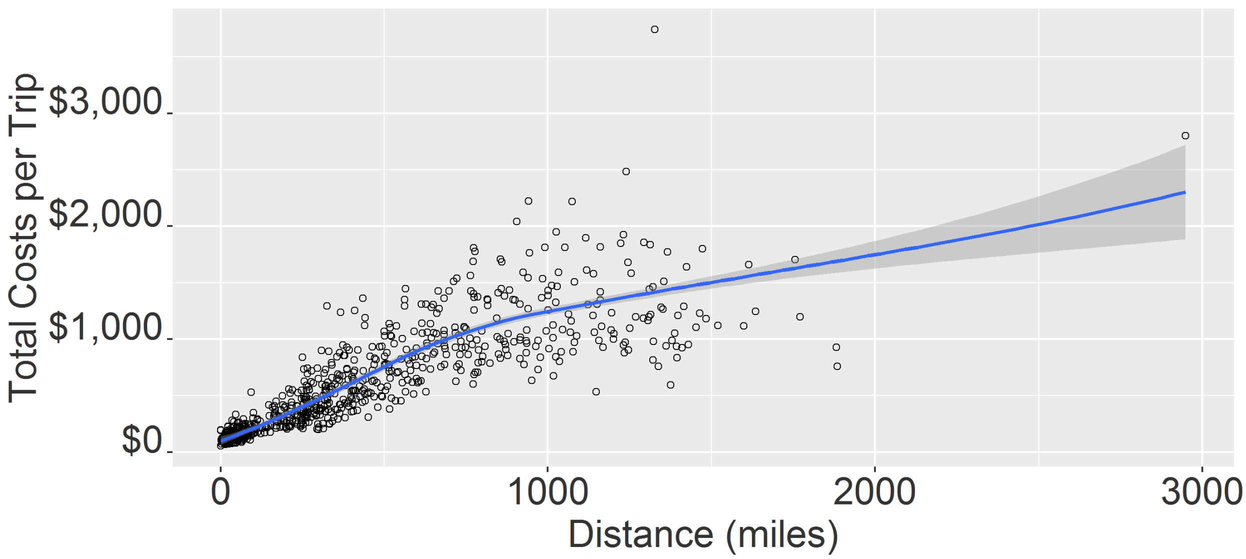
$$C_{ijtl} = C^{TC}_{iojt} + C^{Fish}_{jtl}$$

These fees typically depend on the specific port and the length of the fishing trip but may also vary seasonally. For the recall data, we collect information on the rates charged by headboat operators in 2014 and 2015 at each port from an online survey of headboat operators. The average trip fees for headboat trips in each port ranged from \$50 to \$130 for partial day trips to \$80 to \$250 for full day trips. For ports with missing trip fee information, we used the closest port's trip fee data in its place.

Travel Cost Summary

Figure B2 shows the relationship between the total costs per trip and distance for all individuals using the VOT_{ISS} estimates. As shown, travel costs have a nonlinear relationship with distance due to the high fixed costs of flying.

Figure B2: Relationship between Total Travel Costs per Trip and Distance



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Appendix C: Two-page initial headboat fishery survey

GULF OF MEXICO HEADBOAT ANGLER SURVEY

Please take 3 to 5 minutes to answer the following questions. This survey is being conducted to understand angler experiences in the Gulf of Mexico. Your participation is completely voluntary. If you prefer not to answer a question, feel free to skip it and go on to the next question. The information you provide will only be used for research purposes. All responses are confidential. No one will be identified in any reports coming out of the survey.

This survey research is being conducted by Joshua Abbott (Arizona State University). If you have any questions about this research, please contact me at joshua.k.abbott@asu.edu. If you have any questions about your rights as a participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.

By continuing to the survey, I acknowledge that I am at least 18 years old, have read the above information, and provide my consent to participate under the terms above.

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1. Today's date: month________/day________/year__________

2. Current time: _____:______ am/pm

3. Name of the company/boat: ___________________________ /_________________________

4. Duration of fishing trip (to nearest hour): _____________ hours

5. Counting yourself, how many people were in your personal fishing group today?

☐☐ people

6. How many years have you been saltwater fishing? ☐☐ years

7. How often do you go offshore saltwater fishing in a typical year?
□ Less than once □ 1-2 times □ 3-6 times □ More than 6 times a year

8. Do you own a boat that is capable of fishing in the Gulf of Mexico (including nearshore fishing)?
□ Yes □ No

9. How many nights away from home (if any) are you spending on this trip? ☐☐ nights

10. Are you a repeat customer of this company? □ Yes □ No □ Don't know

11. What is the primary purpose of your trip?
□ This fishing trip □ Beach recreation □ Visiting family □ Other (specify)________________

Please turn over (more on back) →

12. How far in advance did you book today's fishing trip?
□ A week or less □ More than a week but less than a month □ More than a month

13. How much did you pay per person in fees and tips for today's trip?
Fee__________________ Tips____________________

14. Did you pay an additional surcharge for red snapper or gag grouper that you landed (Y/N)? If so, how much did you pay per fish? ___________________________

15. By species (if possible) how many fish did you personally catch and keep on today's trip?

Species	# caught	# kept
Red snapper		
Gag grouper		
All other catch		

16. How satisfied are you with today's fishing experience?
□ Very satisfied □ Satisfied □ Neutral □ Dissatisfied □Very dissatisfied

Comments____

____

17. What is your gender? □ Male □ Female

18. What year were you born? 1 9 ☐☐

19. What is the 5 digit US zip code (or country) of your place of residence? ☐☐☐☐☐

20. What was your household's total income before taxes in 2013?
□ Less than $24,999 □ $75,000 - $99,999 □ $150,000 - $199,999
□ $25,000 - $49,999 □ $100,000 - $124,999 □ $200,000 - $249,999
□ $50,000 - $74,999 □ $125,000 - $149,999 □ Greater than $250,000

Thank you for your participation! If possible, we would like to contact you via email to complete a brief internet questionnaire about your opinions on today's fishing experience. Please provide an email below where we can contact you. Your email will be kept confidential, will not be given away or sold to anyone, and will not be used for marketing by any company. *By providing an email, you are providing your consent for us to contact you for this follow-up internet survey.*

Email (please print): ___________________________________@_________________________

By providing your email, you will be entered into a drawing for a free fishing trip!