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Hedonic Valuation of Sportfishing Harvest

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Abstract *A hedonic valuation strategy is introduced to estimate the marginal value of sportfishing harvest. The strategy uses market prices, thereby avoiding some of the measurement problems associated with the constructed or proxy prices used in common valuation methods. A charter fee hedonic equation is estimated using data from the market for offshore charter fishing in the Gulf of Mexico. The marginal value of sportfishing harvest is identified using spatial variation in harvest rates and fish sizes. A two-stage minimum distance estimator is used to address potential omitted variables and cluster-sampling issues. Our results demonstrate that valid estimates of the marginal value of sportfishing harvest can be derived directly using market prices. The estimated marginal value per fish is consistent with published estimates using alternative methods. Thus, the hedonic approach suggested in this article offers promise as an independent validation of the typical methods used to value sportfishing harvest.*

Key words Sportfishing, charter boats, hedonic, revealed preference, valuation.

JEL Classification Codes Q22, Q26, Q51.

Introduction

There is a considerable amount of research on the value of sportfishing harvest (Johnston *et al.* 2006). The dominant methodologies estimate anglers' willingness-to-pay (WTP) either by direct elicitation with contingent valuation or by linking the opportunity cost of access to different harvest characteristics using travel cost models. In either case, the valuation measure is not derived from actual market prices. Rather, stated preference methods use a hypothetical, constructed-market price, while travel cost models use an estimated proxy price that is assumed to vary directly with WTP. For example, sportfishing applications of the travel cost model infer harvest values based on distance and travel time to fishing sites, with an assumed cost per mile and estimates of the opportunity cost of time as proxies for the price of fishing trips. Hence, estimated values are only as accurate as these calculated proxy prices. The problems in measuring accurate "travel prices" are well-known (Englin and Shonkwiler 1995; Landry and McConnell 2007; Lew and Larson 2005; Randall 1994). Randall (1994) goes as far as concluding that "travel cost methods cannot stand alone" and that validation is required using fundamentally different valuation methods. Similarly, the hypothetical nature of stated preference methods has been questioned, especially for the lack of a true budget constraint (Harrison 2006; Murphy *et al.* 2005).

This article reports on a third strategy to estimate the value of sportfishing harvest with data on markets for fishing services offered by charter operations. The approach uses actual market prices—charter fees—thereby avoiding many of the aforementioned

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measurement problems and assumptions. As such, this article uses different data types and a different method to corroborate the values for sportfishing harvest estimated with the dominant methodologies. High levels of confidence in valuation results are especially important if cardinal welfare measures are needed, such as when deciding resource allocation between the recreational and commercial sectors. Further, from a data collection perspective, the hedonic model is operational with market data and does not require special surveys to collect information on an angler's location choices or stated preferences. A similar strategy was applied by Hunt *et al.* (2005a, b) to value landscape features of remote fishing camps, including the availability of a particular target species, but not the WTP for the quality or quantity of sportfishing harvest.

The underlying rationale for the hedonic strategy in the context of recreation demand was recently summarized by Landry and McConnell (2007, p. 1):

> When services and activities are commercially available onsite, market prices will reflect relative scarcity of environmental amenities, costs associated with production of services and activities, as well as consumers' willingness to pay for such services.

Our adaptation of the hedonic method considers how the "onsite" market prices of charter fishing trips reflect the relative scarcity of harvest attributes and how this relates to anglers' WTP for these attributes.[1]

The hedonic strategy for the valuation of sportfishing harvest with market data about charter fishing trips operates under four primary assumptions. First, we assume that clients for charter services can move freely around ports in the charter market, but that the suppliers of charter services cannot because entry into and movement among ports by charter boats is restricted by institutional factors in the short to medium term. We have more to say on this in the discussion related to our Gulf of Mexico case study. Second, we assume that harvest *expectations* can be linked to a port. Again, because this argument must be made with reference to a particular fishery, we defer further discussion of this point until later. These first two assumptions set up the potential for trips operating from ports with higher expected harvest quality to command higher charter fees. In other words, because ecosystem services, such as harvest characteristics, are not spatially fungible, the benefits of these services are spatially explicit (Boyd and Banzhaf 2007).

The third assumption for the hedonic strategy defines expected harvest quality at each port in terms of historical averages of harvest characteristics (*e.g.*, harvest per angler or weight per fish) over all charters operating out of the same port. This idea of expected quality shared by charters operating from the same ports embodies the Tirole (1996) notion of collective reputation as mean group quality. As Landon and Smith (1998, p. 369) explain:

> In a market with a large number of firms,..., it may be very costly for consumers to acquire information on the past quality of goods produced by all firms. It is typically less costly for consumers to acquire information on collective (or group) quality that can be used as an indicator of the quality of goods produced by individual firms in the group.

[1] Our approach can be thought of as a special case of the hedonic onsite model proposed by Landry and McConnell (2007). However, by focusing on the price of only one product, for-hire sportfishing trips, we avoid the endogeneity issues associated with the combination of time and goods that complicate the onsite cost model. The proposed approach is also distinct from the hedonic travel cost model (Brown and Mendelsohn 1984), which has been criticized for attempting to estimate a hedonic surface using non-market "prices" (Bockstael and McConnell 1999).

For example, information about the expected harvest per trip from different ports is generally available in guide books, fishing reports, magazines, and, of course, via the Internet. This leads to the fourth assumption of the hedonic strategy, which requires that the set of expected harvest characteristics at each port is correctly perceived by anglers and charter operators and thus reflected in the equilibrium charter trip price.

Due to data limitations, ports are aggregated to county-level in our Gulf of Mexico application, and all trips occurring within a county are assigned the same harvest attributes.[2] Consequently, charter fees are measured at the trip level, whereas the harvest expectations—average keep rates and weight per fish over the past five years—are measured at the county level. This creates two potential measurement problems that we address in the specification and estimation of the hedonic model. First, there is potential for correlation among trips within the same county that could lead to biased standard errors (Moulton 1990). Second, the estimates of marginal WTP for expected harvest characteristics can be biased if there are omitted county-level factors that affect charter trip prices and county-level harvest expectations. Both of these concerns are addressed using a minimum distance estimator introduced by Wooldridge (2003) for cluster-samples.

We begin with an introduction of the hedonic theory of product differentiation as applied to the charter trip market. Next, the hedonic model is specified and the estimation method is described. This is followed by a description of the the data and a presentation of the results for the Gulf of Mexico application. The article concludes with a summary of the findings and some additonal observations regarding the application of the hedonic model in the charter trip market.

Hedonic Model

The purpose of this section is to adapt the hedonic theory of product differentiation and welfare measurement to markets for charter fishing services. We focus on the portions of the theory that enable us to measure the welfare effects of marginal changes in charter trip harvest attributes. The valuation of large changes in harvest characteristics is not attempted because the data necessary to identify the marginal bid (*i.e.*, inverse demand) function is not available for our application.

Charter boats offer sportfishing trips that can differ in a variety of characteristics: duration, passenger capacity, species targeted, expected harvest, etc. In most cases, a charter trip can be completely described by these characteristics, and anglers purchase the charter trip that satisfies their demand for trip characteristics. An angler will be willing to pay relatively more for a trip that offers a characteristic that is valued highly. To the extent possible, charter boat operators will respond by offering more trips with relatively valuable attributes. Therefore, following the Rosen (1974) model of product differentiation, the mix of charter trips offered and their prices reflect the interaction of buyers and sellers with respect to characteristics in a competitive market.

In equilibrium, anglers have made their utility-maximizing choices of charter trips, and the resulting charter prices just clear the market given the existing trip offerings and characteristics and the prices of alternative trip configurations. Any differences in equilibrium trip prices can be explained in terms of differences in trip characteristics. The relationship between prices and characteristics defines a hedonic price function:

$$p = g(z;\gamma), \tag{1}$$

[2] This approach parallels the methods commonly used in applied sportfishing demand models (Bockstael, McConnell, and Strand 1989; Whitehead and Haab 2000).

where z is a vector of trip characteristics and γ is a vector of parameters describing the shape of the hedonic function. The derivative of the hedonic function with respect to an attribute gives the implicit price of that attribute.

The problem for the charter boat firms is to maximize profit, $\pi = Mg(z;\gamma) - c(M,z;\varphi)$, where $c(M,z;\varphi)$ describes the cost of producing M trips with characteristics z, and φ is a vector characterizing individual producers. Note that there is a set of trip attributes that are provided costlessly to the charter firm once it has set up its operation. These are either trip attributes (passenger capacity, vessel speed) related to structural characteristics of the vessel (length, engine) that are fixed after the initial boat purchase, or spatial attributes associated with the home port. In our case, the expected harvest characteristics that are available within a day trip of the home port are the spatial attributes of interest.

Spatially defined expected harvest characteristics are exogenous to the production process of any individual charter operation and serve as indicators for anglers of the quality of the fishing experience at each port. Specifically, the expected harvest rate and fish size from any given port will depend on the distribution of biomass, the incidence of regulations, and charter captains' skill. As noted in the Introduction, the spatially defined expected harvest characteristics are intended to measure the collective fishing reputation for charters fishing out of the same home port, and serve as an *ex ante* indicator of average fishing quality.

Following Rosen (1974, p. 42), the minimum payment a charter boat firm requires to maintain a given profit level, Π^0, on any of the M charter trips with a given spatially defined expected harvest characteristic, z_1, is described by the offer function, $o = o(z_1, z_{-1}^0, \Pi^0; \varphi)$, that holds profit and all other attributes constant at Π^0 and z_{-1}^0, respectively. Since spatially defined expected harvest characteristics are given exogenously once the port of operation is established, the offer price for these attributes depends only on the level of profit attainable. Therefore, if we also assume that that the potential supply of trips is fixed once the port of operation is selected, the equilibrium "price" of spatially defined expected harvest characteristics is determined entirely by angler demand for these characteristics.[3]

We further assume that entry into and movement among ports by charter boats is restricted by institutional factors in the short to medium term. This assumption is plausible in many coastal areas where marina space is limited or, as is the case in the Gulf of Mexico application considered below, there is a moratorium on new charter boat permits. Note that charter firms cannot arbitrage fee differentials between two ports by operating from a port with lower expected harvest rates and fishing off a nearby port with higher expected harvest rates. This is due to the relative importance of fuel costs in charter fishing operations (Liese and Carter forthcoming) and because harvest characteristics are assumed to be reputational attributes that can only be changed by switching home port. However, as one reviewer pointed out, the extent of spatial arbitrage is actually an empirical issue that can only be examined with reference to the geographic range that can be reasonably covered on a single day trip. We address this concern in the description of the data for our case study.

The angler's problem for any trip is to maximize the preference function, $u(x,z;\beta)$, subject to the budget constraint, $y = g(z;\gamma) + x$, where β is a vector of parameters for the preference function and x is a composite commodity with a price normalized to unity. The first-order conditions for the solution to the angler's problem imply that the optimal choice of an expected harvest attribute, say z_1, occurs where the implicit price of a change in the expected harvest attribute equals the angler's marginal WTP (MWTP) for that change on any given trip:

[3] We thank an anonymous reviewer for helping us clarify the supply-side assumptions in the model.

$$\frac{\partial u}{\partial z_1} - \frac{\partial g}{\partial z_1}\frac{\partial u}{\partial x} = 0 \Rightarrow \frac{\frac{\partial u}{\partial z_1}}{\frac{\partial u}{\partial x}} = \frac{\partial g}{\partial z_1}. \tag{2}$$

This expression does not suggest that the derivative of the hedonic price function with respect to z_1 is a MWTP function for changes in the expected harvest attribute (McConnell and Phipps 1987). Only at the chosen level of z_1 does the derivative of the hedonic function equal the angler's MWTP for the expected harvest level. At this point, it measures the additional money that the angler with a specific set of income, preferences, and characteristics would pay to purchase a charter trip with a (one unit) higher level of the expected harvest attribute. Other anglers with a different set of income, preferences, and characteristics would have a different equilibrium point on the hedonic schedule. In this case, Bayer, Ferreira, and McMillan (2007) show that the average estimated implicit price will approximate the mean MWTP when the attribute varies more or less continuously throughout the market. To demonstrate, we adapt the simple example in Bayer, Ferreira, and McMillan to the charter boat market.

Take, for example, an extreme case where there is a single discrete (*i.e.*, non-continuous) charter trip attribute defined by whether or not a charter trip can offer the catch of a certain species. If the species could be offered from only a few ports, then the hedonic price would reflect the MWTP of an angler with a relatively strong taste for the species. In this case, the mean MWTP is less than the implicit price because the majority of anglers are not willing to pay the equilibrium hedonic price. If we now consider a more continuous attribute, such as the expected harvest attribute discussed above, then there are several margins. The margins correspond with the differences in each pair of ports ranked according to the expected harvest attribute. In this case, averaging the equilibrium implicit price over all trips in the sample and weighting by the number of charter trips from each port approximates the mean MWTP over all anglers:

$$\overline{MWTP_1} \approx N^{-1}\sum_{i=1}^{N}\frac{\partial g(z_i;\gamma)}{\partial z_{1,i}} \approx \sum_{j=1}^{J}\phi_j \frac{\partial g(\bar{z}_j;\gamma)}{\partial \bar{z}_{1,j}}, \tag{3}$$

where N is the total number of trips and ϕ_j is the proportion of total trips taken from port $j = 1,2,...,J$. The averages, $\bar{z}_j$ and $\bar{z}_{1,j}$, in the second summation arise because anglers on trips from the same port will be at the same margin and have the same MWTP when harvest characteristics are measured at the port-level.

Before leaving the discussion of the hedonic model, it is instructive to clarify the definition of the price used in the charter hedonic equation. The prices in this model are the equilibrium fees for different types of charter trips established via the market forces of supply and demand. Importantly, these are the fees that reflect the spatially defined expected harvest attributes so that ports with relatively greater levels of the attributes command higher equilibrium fees. This occurs because anglers sort themselves among charter trips from different ports, in part, according to their preferences and WTP for expected harvest attributes. The sorting defines the shape of the hedonic frontier and is also based on the distribution of angler characteristics, including income, distance from each port, etc. In this way, a measure of expected travel distance or accessibility could be included as an *attribute* in the charter fee hedonic, but the related travel costs should not be added to the charter fee because these costs are already reflected in the equilibrium fees.[4] The omission of an access distance attribute would bias the implicit price (*i.e.*, marginal value) of expected harvest attributes if this distance is correlated with the expected harvest attributes. This could happen if fishing pressure is relatively higher at ports that are easy to access. Without an access distance attribute in the charter fee hedonic, an estimation strategy to deal with omitted variables is needed. Such an estimation strategy is proposed below in the context of the Gulf of Mexico case study.

Data

The data for the estimation of the hedonic model of harvest value in the charter boat market comes from three sources, all of which are affiliated with the U.S. Marine Recreational Information Program (MRIP).[5] In all cases we started with sub-samples consisting of single-day charter trips fishing offshore of Louisiana, Mississippi, Alabama, and the west coast of Florida. The distance between ports of the for-hire fishery in this Gulf of Mexico region and the focus on day trips (by far the most common trip duration) generally ensures that each port has its own fishing area. However, due to data limitations, we have to aggregate home ports to the county-level so that there are only as many "ports" as there are county areas. This aggregation is common practice in the sportfishing demand literature (see footnote 2).

Information about charter fees was obtained from an economic add-on to the weekly MRIP For-Hire telephone survey (FHS-e) conducted over a one-year period starting July 2002. Each week a sample of charter captains was randomly selected from a master registry of vessels to answer questions about their charter activities in the prior week. Captains were asked about the number and general characteristics of the trips they took and were further asked to report cost and price information for one of these trips. There was no information collected about the catch on any of these trips.[6]

We began with the MRIP FHS-e sub-sample of single-day, offshore trips that either bottom fished or fished via trolling, casting, or while drifting. The final sample consisted of 584 trips by 365 vessels with complete price and trip information. Trips were not reported from every coastal county in the study area, and we assigned observations in counties with fewer than three reported trips to adjacent counties to maintain confidentiality. This reduced the number of county areas from 28 to 23. The second column of table 1 shows the number of sample observations in each county from the MRIP FHS-e.

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[4] Inclusion of travel costs in the trip price, as is done in the hedonic travel cost model (Brown and Mendelsohn 1984), would introduce additional noise into the hedonic relationship because the equilibrium market prices should already reflect the angler decisions about the trade-off between travel distance and charter fee. All else equal, a fishing charter that is easy to access will be able to charge a higher fee, unless remoteness is a valuable attribute (Hunt *et al*. 2005b). For example, consider two charter trips that are identical in every way except in the distance from the angler and price. If the price of the trip farther away is low enough, then the angler will choose it over the closer, more expensive trip. Again, the equilibrium market prices for charter trips will reflect these trade-offs by all anglers and a similar set of choices by charter firms.

[5] More information about the MRIP is available online at: <http://www.st.nmfs.noaa.gov/st1/recreational/overview/overview.html>.

[6] A separate MRIP dockside intercept survey collects information about harvest as part of the Marine Recreational Fisheries Statistics Survey (MRFSS). However, there is no clear way to link the records from the MRFSS with those from the For-Hire telephone survey. Both samples are unlikely to be the same. Furthermore, information on the actual *ex-post* harvest for each trip would not necessarily proxy *ex-ante* harvest expectations, and there are not enough MRIP intercept records during the year of the FHS-e to produce accurate, county-level average harvest rates.

The third through eighth columns of the table show the MRIP FHS-e county averages for the charter fee excluding tips, number of passengers, hours per trip, vessel length, and percentage of trips that bottom fished and fished in federal waters. Beyond this last trip characteristic, we do not have information on where charter vessels in our study go once they leave the dock. However, we can speculate about the potential geographic scope of the charter trips relative to their county of origin. Trips lasted 7.5 hours, on average, 4.5 hours of which were spent fishing. This suggests that vessels spent an average of three hours steaming to and from the fishing grounds on each trip. Assuming a relatively fast cruising speed of 20 mph, this gives a range of 30 miles each way. The average coastline distance of the 23 county areas in our case study is about 55 miles, suggesting that vessels are likely to fish within the boundaries of their county of origin. Furthermore, 70% of the trips in the sample fished in federal waters, which start 10 miles offshore of Florida waters and 3 miles offshore of the other coastal states. This reduces the expected lateral range of any given trip even further.

The data in the final three columns of table 1 come from the MRIP angler intercept survey. Columns nine and ten are intended to represent the expected harvest characteristics or fishing reputation for each county area. There are many ways to characterize the expected quality of a fishing trip using harvest data (Freeman 1995). Harvest expectations for each county in the study area are proxied with historical averages of keep per unit effort (KPUE) and weight per fish. The results using ten-year historic averages were nearly identical to the results using five-year averages. We focus on the results for the five-year averages to be consistent with the approach used to proxy site quality in site-choice sportfishing demand models (Bockstael, McConnell, and Strand 1989; Whitehead and Haab 2000). Results with the ten-year averages are available upon request. Averages across all species are used because there was not enough data to generate averages for individual species for each county area and because there was a high degree of correlation among the averages for individual species. The five-year averages are calculated from the MRIP angler intercept survey data for each county area. To be consistent with the MRIP FHS-e, only single-day charter trips fishing offshore with hook and line are included in the sample. There were 10,586 such trips sampled in the five years (1997–2001) prior to the MRIP FHS-e. The KPUE across all species is calculated for each charter trip intercepted as the total observed harvest in numbers of fish divided by angler hours given as the product of the hours fished on the trip and the number of fishing party members. The data for the 98,526 fish measured on these trips were used to calculate the average weight per fish.

The final column of table 1 shows the weighting factor (ϕ_j from expression (3)) to be used in the mean MWTP calculations. The 2003 MRIP FHS-e data does not necessarily provide an accurate measure of the current distribution of trips across county areas. Therefore, ϕ_j was estimated as the average annual percentage of offshore charter trips observed in each county area from the MRIP angler intercept survey from 2000 to 2006.

Table 1 shows the considerable variation across counties in the mean charter fee and other characteristics across the counties, especially the harvest characteristics. We can examine the variation of each variable across counties more carefully with the intraclass correlation coefficient (ICC) shown in the last *row* in table 1. The ICC represents the amount of trip-level variance that can be "explained" by county membership (Moulton 1987).[7] For example, the county-level harvest variables in the ninth and tenth columns have an ICC of 1 because they do not vary at all within each county, and all variation is explained at the county level. The ICC parameter for the charter fee suggests that roughly 30% of the variance in the dataset occurs across counties. It is this variation that we expect to explain with the county-level harvest characteristics.

[7] The ICC calculations were performed based on an ANOVA model using the ICC1 function in the *multilevel* package for R (Bliese 2008; R Development Core Team 2009).

Table 1
Gulf of Mexico County Averages and Intra-County Correlation Coefficients

	For-Hire Economic Survey							Angler Intercept Survey		
County[1]	# of Observations[2]	Charter Fee ($)	# of Passengers	Duration of Trip	Vessel Length (feet)	Federal Water Trips (%)	Bottom Fishing Trips (%)	KPUE[3]	Weight per Fish Kept (kg)[4]	MWTP Weighting Factor (%)[5]
1	123	819	5.9	7.3	38	81	77	2.0	1.5	7.4
2	14	907	5.6	9.6	38	100	86	3.8	1.5	0.3
3	48	808	5.8	8.4	42	75	79	1.4	1.5	8.5
4	3	492	5.0	8.2	27	100	100	1.2	0.9	0.0
5	6	371	2.7	7.5	25	17	17	0.4	1.5	1.3
6	18	465	4.1	6.3	32	61	83	0.7	1.5	1.5
7	37	708	7.0	7.8	36	84	78	1.7	1.6	1.3
8	12	637	4.0	8.1	32	75	75	0.9	1.5	0.6
9	6	425	3.5	6.3	29	50	33	0.9	1.3	1.2
10	4	469	3.8	7.5	24	75	75	1.0	1.2	0.4
11	11	558	5.0	7.1	30	73	82	0.7	1.4	0.8
12	68	532	3.3	6.6	32	69	24	0.5	3.2	39.6
13	104	771	6.4	7.5	44	53	66	1.3	2.0	21.4
14	3	333	3.0	6.5	21	0	0	0.2	1.4	0.6
15	38	545	4.4	6.9	33	66	45	1.0	1.9	6.7
16	24	414	3.8	5.6	27	50	38	0.7	2.0	1.4
17	6	467	4.0	8.7	27	50	67	0.9	1.1	0.3
18	7	736	5.6	9.9	34	100	100	1.7	2.7	0.7
19	6	925	4.8	10.2	38	100	67	1.3	2.4	0.4
20	9	1,372	10.3	9.5	46	100	78	2.1	1.9	1.0
21	14	1,007	4.4	10.6	35	86	14	1.3	3.0	1.5
22	17	620	4.1	8.1	27	53	18	2.2	2.0	0.9
23	6	984	10.2	8.9	44	67	67	0.9	2.4	2.2
All obs.	584	707	5.3	7.5	37	70	61	1.3	1.9	
ICC		0.32	0.34	0.20	0.30	0.11	0.24	1.00	1.00	

[1] Coastal counties: LA through FL with some adjacent counties combined due to sample size.
[2] Observations from the 2002/2003 MRIP For-Hire Economic Survey.
[3] Average number of fish harvested per angler per hour (MRIP angler intercept 1997–2001).
[4] Average weight per fish harvested in kilograms (MRIP angler intercept 1997–2001).
[5] Annual share of charter trips intercepted by county (MRIP angler intercept 2000–2006).

Specification and Estimation

We assume that offshore charter trips in the Gulf of Mexico are all offered in the same market and attempt to identify the effects of cross-county variations in expected harvest characteristics on the equilibrium market price while controlling for other factors that determine charter fees. In support of the assumption regarding the geographic scope of the market for offshore charter trips, table 2 provides historical statistics on how far anglers traveled to fish on charter boats in the Gulf of Mexico. Distance data is derived using angler zip code data collected by the MRFSS angler intercept survey. Table 2 shows sample statistics for the study period and the five preceding years, by county and in total. Overall, charter anglers traveled around 700 miles, on average, to fish. This is clearly skewed by very large distances and implies the use of air travel, though we have no data on the mode of travel. However, at over 400 miles, the median distance traveled is still very far and suggests the charter trip was part of a longer multi-day visit for a (large) majority of customers. At the county level, in most cases, the average distance traveled to fish is also quite far. Even the counties where average distance traveled to fish is relatively low, there are still anglers coming from far away, as indicated by the maximum distance traveled. This evidence suggests that anglers could consider the entire Gulf of Mexico as one market for offshore charter trips or, at the very least, that there is enough overlap such that the pricing in the sub-markets is integrated.

Theory does not offer guidance for the exact specification of the hedonic price function for offshore charter trips. However, Ekeland, Heckman, and Nesheim (2004) demonstrate the implausible assumptions implicit in the structural market model that implies a linear hedonic equation. In the case of the charter price hedonic, we expect that the WTP (*i.e.*, the implicit price) for an additional unit of an attribute will decline as the total level of the attribute increases. To address this potential nonlinear relationship, squared terms and interactions of the continuous trip-level characteristics are included in the specification. Preliminary work also found that a charter fee hedonic with logarithmic and quadratic transformations of county-level harvest characteristics fits equally well, and both fit better than linear specifications (Carter, Agar, and Waters 2008). Therefore, we focus on the following specification of the hedonic equation:

$$
\begin{aligned}
ln(p_{mj}) = {} & \gamma_0 + \gamma_g g_{mj} + \gamma_t t_{mj} \\
& + \gamma_{gg} g_{mj}^2 + \gamma_{tt} t_{mj}^2 + \gamma_{gt} g_{mj} t_{mj} \\
& + \gamma_l l_{mj} + \gamma_d d_{mj} + \gamma_b b_{mj} + \gamma_{db} d_{mj} b_{mj} \\
& + \gamma_h \ln h_j + \gamma_w \ln w_j + \varepsilon_{mj}, \qquad m = 1,..,M_j,\ j = 1,..,J,
\end{aligned}
\tag{4}
$$

where for trip m in county j, p is the charter fee, g is the number of passengers, t is the duration of the trip, l is the charter vessel length, d a dummy for federal water trips, b a dummy for bottom fishing trips, h is the county-level average harvest per angler per hour, and w is the county-level average weight per fish. The γ terms are parameters to be estimated, and ε_{mj} is an independently distributed error term. Note that the dependent variable is in logarithms because an examination of the profile of log-likelihoods for the parameters of the Box-Cox power transformation suggests that logarithmic transformation of the charter fee provides a better fit than the absolute level.[8]

There are two issues associated with the estimation of the hedonic equation. First, the charter fee is measured at the trip level, whereas the the primary attributes of interest, the harvest characteristics, are measured at the county level. As shown in table 1, the ICC measures suggest that the observations within each county are correlated in terms of the charter fee and the trip-level independent variables. Of course, the county-level variables are perfectly correlated for observations from the same county. In this case, estimation by OLS could lead to standard errors that are biased downwards, especially for the county-level harvest variables (Moulton 1990). Recent research has shown, however, that the

[8] The log-likelihoods for the lambda parameter of the Box-Cox power transformation were computed with the *boxcox* function in the MASS package for R (R Development Core Team 2009; Venables and Ripley 2002). A 95% confidence interval for lambda ranged from 0.05 to 0.30.

standard corrections (*e.g.*, cluster-robust standard errors or random-effects estimation) are not reliable in cases with a relatively small number of groups (Wooldridge 2003, 2006). Our study with 23 counties is such a case.

Table 2
One-way Distance Traveled (Miles) to Fish on a Charter Boat in the Gulf of Mexico by County of Intercept: 1997–2003

County	# of Obs.	Average	Median	Min.	Max.
1	1,062	459	365	2	2,874
2	25	167	79	3	567
3	832	408	327	3	2,916
4	9	467	196	28	1,266
5	91	363	120	2	2,835
6	181	949	1,216	1	3,403
7	107	280	97	6	1,593
8	19	355	253	14	2,312
9	53	858	1,129	1	3,012
10	48	226	122	4	1,255
11	26	632	153	6	3,106
12	5,489	1,008	1,253	0	5,156
13	2,409	438	352	7	4,535
14	68	563	188	4	2,590
15	851	618	239	2	4,694
16	167	702	747	1	2,959
17	33	260	178	28	1,002
18	48	204	163	19	681
19	42	352	191	31	1,218
20	14	282	154	17	919
21	104	379	174	47	1,782
22	125	307	191	24	1,625
23	551	389	315	2	2,435
All obs.	12,354	708	435	0	5,156

Source: Angler home zip code to intercept site from the MRFSS intercept survey.

The second estimation issue is the potential for omitted variables that are correlated with the harvest variables and charter fees at the county level. For example, population or factors such as marina dockage fees that affect the cost of trips could also be related to the fishing quality in a county. Such correlated omitted factors could lead to biased estimates of the parameters on the harvest characteristics in the hedonic equation.

We use a two-stage minimum distance (MD) estimator suggested by Wooldridge (2003, 2006) to address the two issues related to the estimation of the charter fee hedonic. The estimator is consistent and $\sqrt{M}$ -asymptotically normal for $M \to \infty$, where M defines the maximum number of trips per county, such that $M_j = \rho_j M$ for $0 < \rho_j \leq 1$. This is in contrast to the typical panel or cluster type estimators that, in this case, would require a large number of counties and a fixed number of trips per county (*i.e.*, $\sqrt{J}$ -asymptotically normal for $J \to \infty$). The first stage uses a least-squares dummy variable (LSDV) estimator to obtain the parameters on the trip-level variables and a vector of county fixed-effect parameters. The estimating equation is the same as equation (4) with a vector of county fixed effects $\Gamma_0 = \gamma_{01},...,\gamma_{0J}$ instead of γ_0, and without the county-level harvest terms, $\gamma_h \ln h_j + \gamma_w \ln w_j$. The county-level harvest terms are removed because they cannot be separately identified from the county.

In the second stage, the vector of estimated county fixed-effect parameters, $\hat{\Gamma}_0 = (\hat{\gamma}_{01},... \hat{\gamma}_{0J})$, is used along with the vector's estimated variance matrix, $\hat{V}$, from the first stage to estimate the parameters on the county-level harvest variables as:

$$\theta = (X'\hat{V}^{-1}X)^{-1}X'\hat{V}^{-1}\hat{\Gamma}_0, \tag{5}$$

where X is a data matrix with a constant and the harvest characteristics, ln h and ln w. The variance matrix for this estimator is $(X'\hat{V}^{-1}X)^{-1}$. Essentially, the second stage hypothesizes that the variation in the county-level fixed effects can be completely explained by variations in the harvest characteristics; *i.e.*, $\gamma_{0j} = \alpha + \gamma_h \ln h_j + \gamma_w \ln w_j$. The validity of these hypothesized restrictions can be tested with an overidentification statistic $(\Gamma_0 - \hat{\Gamma}_0)'\hat{V}^{-1}(\Gamma_0 - \hat{\Gamma}_0)$. This statistic is distributed χ^2 with $J - K - 1$ degrees of freedom, where K is the number variables in X. If the overidentifying restrictions are rejected, then there are still unobserved factors that influence the variation in charter fees across counties. Otherwise, according to Wooldridge (2003, p. 137), we can: "have some confidence in the specification and perform inference using the standard normal distribution for t statistics." In general, county-level factors, including county averages of the trip-level variables, can be added to X in the second stage until the overidentification test cannot be rejected (Wooldridge 2006).

Results

The key results of the analysis are shown in table 3, where the parameters listed correspond with those shown in equation (4). Parameter estimates using OLS are shown in the third column, and estimates using the minimum distance (MD) method are shown in the last three columns. Recall that the first stage of the MD method is estimated via LSDV to obtain the county fixed-effect parameters.[9] The OLS and LSDV estimates for the trip-level parameters and model fit are similar, but an F-test from Moulton (1987) for the null of no county-level fixed effects is rejected (2.09, df1=20, df2=552, p=0.003), suggesting that the LSDV specification is statistically superior to OLS. Focusing on the LSDV estimates, all trip-level parameters, except the one for the interaction of passengers with duration, are significant at the 0.05 level. The significant trip-level parameters have the expected signs: the charter fee increases at a decreasing rate in the number of passengers and trip duration; bottom fishing trips and those in federal waters are relatively more expensive, but these effects are not cumulative; and trips on larger vessels command a higher price. Based on these parameters and the means over all observations reported in table 1, another hour or another passenger adds \$70 or \$31, respectively, to the price of a charter trip, and the implicit price per foot of vessel length is \$8.[10] Similarly, the additional value of a bottom fishing trip in federal waters is \$123 compared to a trolling, casting, or drifting trip in state waters.

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[9] The 23 county fixed-effects parameters are not reported in the LSDV column of table 3. These parameters are available upon request.

[10] These simple implicit price estimates are given by the derivative of the right-hand-side of equation (4) with respect to the variable of interest times the mean charter fee over all observations from table 1. For example, the implicit price of another passenger at the sample averages is \$707*(0.050 – 0.002*2*5.3 passengers/trip + 0.002*7.5 hours/trip)=\$30.97.

Table 3
Estimation Results

Variable	Parameter	OLS	Minimum Distance Estimator LSDV	MD1	MD2
Constant	γ_0	4.649*** (0.094)		4.649*** (0.133)	4.350*** (0.601)
# of Passengers	γ_g	0.044** (0.015)	0.050** (0.015)		
Duration of Trip	γ_t	0.139*** (0.022)	0.164*** (0.022)		
# of Passengers Squared	γ_{gg}	–0.002* (0.001)	–0.002* (0.001)		
Duration of Trip Squared	γ_{tt}	–0.004* (0.001)	–0.005*** (0.002)		
Passengers*Duration	γ_{gt}	0.002 (0.002)	0.002 (0.002)		
Bottom Fishing	γ_b	0.126** (0.041)	0.143*** (0.041)		
Federal Water Fishing	γ_d	0.144*** (0.035)	0.138*** (0.037)		
Federal Water*Bottom	y_{db}	–0.080 (0.050)	–0.107* (0.051)		
Vessel Length	γ_l	0.012*** (0.001)	0.011*** (0.001)		
Log(KPUE)	γ_h	0.128*** (0.023)		0.128*** (0.032)	0.090* (0.035)
Log(Weight per Fish)	γ_w	0.191*** (0.044)		0.191** (0.062)	0.074 (0.083)
N		584	584	23	23
R^2		0.786	0.801	0.487	0.875
Adjusted R^2		0.782	0.790	0.406	0.724

Standard errors of the parameter estimates are shown in parentheses.
Significance levels: *p < .05; **p < .01; ***p < .001.
The R^2 and adjusted R^2 are for MD1 and MD2 for the second stage regressions.

There are two versions of the second stage of the MD estimator. Both versions use the 23 county fixed-effects parameters from the LSDV estimator as the dependent variable. The first minimum distance estimator, MD1, only includes the county-level harvest variables in the second stage, whereas the second minimum distance estimator, MD2, adds county means of the trip-level variables as controls.[11] Thus, the combined LSDV-MD1 results are most comparable with the OLS results. The parameter estimates on the county-level harvest variables are the same in the OLS and MD1 specifications. The estimates of the standard errors are also similar, but the t-tests of parameter significance are based on 23-3 df in the MD1 estimator and 584-12 df in the OLS estimator. Therefore, a finding of parameter significance is relatively more difficult in the MD1 estimator.

Based on the χ^2 overidentification statistics for the MD1 and MD2 models, the additional county-level control variables in MD2 are necessary to identify the parameters on the harvest variables. The null of overidentification is rejected in MD1 (41.877, df=19, p=0.002), but cannot be rejected in MD2 (10.231, df=10, p=0.420). Estimates of the coefficient of determination are consistent with this result, suggesting that the MD2 model with the county means of the trip-level variables fits the county fixed effects better than the MD1 specification without these additional controls. These results suggest that the MD2 specification controls for the unobservable county-level factors that could bias the parameters on the harvest variables. The parameters on the harvest rate and fish weight are smaller and the standard errors larger in the specification in the MD2 column relative to the specification in the MD1 and OLS columns. In the MD2 specification, the parameter on fish weight is no longer significantly different from zero, but the parameter on the harvest rate (KPUE) is significantly different from zero at the 0.05 level.

For reference, the parameter estimates on the county-level means of the trip-level variables that were used as controls in the MD2 model are shown in a table in the Appendix. Given the nonlinearity of the hedonic equation, we expect the parameters on the county-level means to be different than the corresponding parameters on the trip-level variables. The parameters on the county-level means are of secondary interest and serve mainly as proxies for unobserved variation in charter fees at the county-level that could be correlated with the harvest characteristics.

The parameter γ_h from the MD2 specification can be used together with the approximation in equation (3) and the information in table 1 to calculate the mean MWTP for a change in the expected harvest rate. The specification in equation (4) implies the following expression for the mean MWTP for a one-unit change in the KPUE:

$$\overline{MWTP_h} \approx \sum_{j=1}^{J} \phi_j \gamma_h \frac{\overline{p}_j}{h_j}, \tag{6}$$

where $\overline{p}_j$ is the mean charter fee in county *j*, and ϕ_j is the MWTP weighting factor. Using the formula, the weighted average MWTP for an extra fish per angler for each hour fished is \$67.57 with a 95% confidence interval of \$9.85 to \$125.29.[12] Dividing this estimate by the weighted county-average duration of a trip of 7.22 hours gives an estimate of the MWTP for an extra fish per angler per trip of \$9.36 (±7.99) that is most comparable with estimates in the literature. Similar calculations performed using the MD1 estimate give a similar mean MWTP of \$13.25 (±6.98) per angler for each additional fish. Both of these estimates are slightly lower than the mean (outlier-free) estimate of \$14.33 (2003 dollars) reported in the meta-analysis by Johnston *et al.* (2006) based on 48 different studies of U.S. recreational fisheries. Given that the species regularly caught in the Gulf

[11] All of the county-level factors from other data sources (population, median property values, etc.) that we tried were not statistically significant in the hedonic regression.

[12] These numbers and those that follow differ from calculations using only the information in tables 1 and 3 due to rounding in the tables.

of Mexico are at the low end of the value spectrum considered by Johnston *et al.*, the results from the hedonic approach are very consistent with the published estimates using other methods.

We can also consider the MWTP for a change in the expected weight per fish, even though the MD2 parameter (γ_w) on this variable was not statistically different from zero at any reasonable confidence level. In this case, the specification in equation (4) implies a mean MWTP for a change in the expected weight of each fish kept of:

$$\overline{MWTP_w} \approx \sum_{j=1}^{J} \phi_j \gamma_w \frac{\overline{p}_j}{w_j}. \tag{7}$$

The weighted average MWTP for an extra pound on each fish using this formula and the the kilograms to pounds conversion factor of 2.205 is \$10.48. Dividing this estimate by the weighted county-average number of fish per angler per trip of 7.42 gives an estimate of an angler's MWTP for an additional pound on one fish of \$1.41. Again, this estimate is unreliable with a 95% confidence interval ranging from \$–2.09 to \$4.91. The same MWTP calculation using the MD1 results generates an average value of \$3.64 and suggests a 95% confidence interval ranging from \$1.16 to \$6.12. Nonetheless, these results are comparable with the only other estimate of angler MWTP for an extra pound of fish that we were able to find. Cameron and James (1987) used 1984 contingent value survey results to estimate that British Columbia anglers were willing to pay \$1.16 and \$7.65 (in 2003 dollars) to increase the weight by one pound of the *largest* chinook and coho salmon caught, respectively.[13]

Summary and Conclusions

This article introduces a novel approach to valuing recreational fishing harvest using data from markets for sportfishing services. The approach uses the hedonic theory of product differentiation to model the variation in charter trip fees associated with variations in trip and harvest attributes across locations. This hedonic approach to estimating the marginal value of sportfish harvest is intended as an independent verification of accepted methods, such as the travel cost model and contingent valuation. Given the sensitivity of estimates to the assumptions of accepted methods, another methodology can be used as a further check on convergent validity.

The hedonic approach was applied to estimate the relationship between charter fees and the expected number of fish kept and the expected weight per fish in the market for offshore charter fishing in the Gulf of Mexico. The hedonic function was estimated using OLS and minimum distance estimators. The minimum distance estimators were used to deal with clustering and omitted variables. The average MWTP per fish was calculated based on the estimated charter fee hedonic equation. The estimates are within the range of values reported in other research.

In using actual market prices, the hedonic approach can provide cardinal measures of MWTP that are free of the measurement problems that trouble methods, such as travel cost models or contingent valuation, that use proxy or hypothetical prices. Cardinal measures of MWTP may be important, for example, when evaluating the efficiency of resource allocations among competing uses. It is important to note, however, the key

[13] The 2003 dollar valued estimates of the 1984 values were calculated as (185.5/105.50)*\$0.6574 and (185.5/105.50)*\$4.349, where the 2003/1984 CPI (CUSR0000SA0) ratio is shown in the parentheses.

assumptions that underlie the valuation estimates derived from the hedonic model. Specifically, we are assuming that the market for charter services is in a perfectly competitive equilibrium and that variations in (county-level) expected harvest characteristics are reflected in the distribution of charter fees. For this to happen, the spatial distribution of the harvest characteristics needs to be understood by both firms and anglers, and charter vessels cannot completely arbitrage away price differences across counties. The latter is possible if harvest characteristics are viewed as reputational attributes that can only be changed by switching home ports (counties), which may be infeasible in the short to medium term. Assumptions were also made in the empirical application of the hedonic model. However, most of these assumptions, such those relating to the functional form and error distributions, are typical in applied valuation research.

In closing note that, as with all hedonic valuation methods, information about preferences beyond MWTP is not forthcoming without further assumptions or data (Palmquist 2005). Such information is necessary to evaluate the welfare effects of large changes in harvest characteristics. The application of methods designed to identify or bound the value of large changes to the hedonic charter model will have to wait until we are able to obtain additional samples of charter fees and harvest attributes from other time periods or other charter fishing markets. Collecting information on charter fees by adding a few questions to existing data collections, such as the For-Hire Survey of the MRIP, would be a good start.

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Appendix
Estimation Results for the MD2 Control Variables
(County-Level Averages–CLA)

Variable	Parameter	StdErr	tValue	pValue
CLA – # of Passengers	0.261	0.148	1.766	0.105
CLA – Duration of Trip	–0.135	0.107	–1.265	0.232
CLA – # of Passengers Squared	0.015	0.006	2.552	0.027
CLA – Duration of Trip Squared	0.023	0.008	2.810	0.017
CLA – Passengers*Duration	–0.055	0.024	–2.296	0.042
CLA – Bottom Fishing	–0.702	0.248	–2.832	0.016
CLA – Federal Water Fishing	0.199	0.126	1.576	0.143
CLA – Bottom*Federal Water	0.685	0.290	2.360	0.038
CLA – Vessel Length	0.006	0.005	1.311	0.216