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Convergent validity of stated preference methods to estimate willingness-to-pay for seafood traceability: The case of Gulf of Mexico oysters

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Abstract

In this study we compare willingness to pay for a seafood traceability system from contingent behavior demand and contingent valuation referendum vote models using data from a survey of Gulf of Mexico oyster consumers following the BP oil spill in 2010. We estimate a random effects model of oyster demand using contingent behavior data and find that a traceability program increases demand and consumer surplus. We estimate a referendum model for the seafood traceability program using contingent valuation data. We find that welfare estimates from the contingent behavior and contingent valuation methods are convergent valid under certain conditions.

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1. Introduction

Determination of the validity of willingness-to-pay estimated with stated preference methods is important for their use in benefit-cost and other policy analyses. One approach for establishing convergent validity is through a valuation comparison study in which theoretically similar valuation estimates from two or more methodologies are compared. Estimates that are statistically similar (i.e., overlapping confidence intervals) achieve convergent validity increasing the confidence in both valuation estimates. There is some consensus that the contingent valuation method can achieve convergent validity with revealed preference methods (Carson *et al*. 1996).

Previous seafood demand valuation studies have used only one type of stated preference data such as contingent behavior (Huang, Haab, and Whitehead 2004, Parsons, *et al*. 2006, Morgan, Martin, and Huth 2009, Morgan *et al*. 2013, Beaumais and Appéré 2013, Morgan, Whitehead, and Huth 2015, Morgan *et al*. 2016), contingent ranking (Johnston and Roheim 2006), contingent valuation (Whitehead *et al*. 2012, Salladarré *et al*. 2016) and discrete choice experiments (Johnston *et al*. 2001, Fonner and Silvia 2015, Bi, House, and Gao 2016, Petrolia, Walton and Yehouenou 2017). Whitehead, Haab, and Parsons (2003) present both contingent behavior and contingent valuation welfare estimates but are unable to compare these under similar scenarios.

In this study we compare willingness-to-pay for a seafood traceability program from similar contingent behavior and contingent valuation scenarios using data from a survey of Gulf of Mexico oyster consumers following the BP oil spill in 2010. We estimate a random effects model of oyster demand using contingent behavior data and find that a traceability program increases consumer surplus. We estimate willingness-to-pay for the traceability program using contingent valuation data. We find that convergent validity is achieved statistically between contingent behavior and contingent valuation methods under certain conditions but differences in welfare estimates are large.

2. Stated Preference Survey

We conducted an internet-based survey of oyster consumers (aged 18 and over), sampled from the U.S. states in which there are documented cases of oyster-related deaths: Florida, Alabama, Mississippi, Louisiana, Texas, and California. Due to a request from Georgia Sea Grant, we also sampled consumers from that state. The survey was administered in November and December, 2010, approximately 7 to 8 months after the *Deepwater Horizon* oil spill by Online Survey Solutions. The survey asked respondents questions designed to elicit attitudes regarding the spill, seafood safety concerns, expectations regarding the length of the oyster harvest ban in Louisiana, and stated preference consumption behavior based on expected ban length and the imposition of a new seafood traceability system.

We asked a total of eight stated preference questions. After a revealed preference question about the number of oyster meals consumed, respondents were asked seven similarly worded contingent behavior questions.[1] In each of these questions respondents were asked

[1] Our results do not change if the revealed and stated preference data are jointly estimated. These results are available upon request.

whether, compared to the number of meals they revealed they consume in a typical year, they expected to eat more, less, or the same number of oyster meals next year.[2] Respondents were then prompted to state how many more or less oyster meals they would eat.

The first contingent behavior question asked about oyster meals under status quo conditions. The second and third contingent behavior questions asked respondents to state whether they would eat more, less, or the same number of meals under price increase and price decrease scenarios (while being informed that the price of all other food products remained the same). Each respondent was presented with one randomly assigned price increase of $1, $3, $5, or $7 and one randomly assigned price decrease of either $1, $2, $3 or $4.

Respondents were also asked stated preference questions under different information treatments. In the fourth contingent behavior question, respondents were informed that following the *Deepwater Horizon* oil spill, the State of Louisiana Health and Hospitals closed several Louisiana shellfish areas to the harvest of oysters and other shellfish. Respondents were then asked to imagine that the Louisiana ban on harvesting oysters from affected areas lasts for about another *X* months, where *X* was randomly assigned and varied across respondents from a list of four possible values: 1, 3, 6 or 9. Then, supposing that the average price of their oyster meals stays the same, respondents were asked for the number of meals they would eat.

In the fifth question respondents were presented with a traceability scenario:

> Seafood traceability can be thought of as a system for maintaining and making available detailed information on a particular seafood product throughout each step of harvest, processing, distribution, and sales. In land based agriculture traceability is termed “farm to fork”. Here it might be termed “harvest to home” as the path from the harvest bed to the final consumer is recorded and traceable.

Respondents were told to assume that the Louisiana ban continues for the same period of time as in the previous question, but now there is a traceability system in place making the labeling of the location of catch for all oyster products mandatory such that the state of harvest is always known to the consumer. Again assuming that the average price of an oyster meal is unchanged, respondents were asked to state the number of annual oyster meals that they would consume.

In the sixth scenario respondents were asked a similar behavior question having been told that the Louisiana ban on oyster harvesting from all affected areas is lifted “right now” but again, the traceability system is in place. The seventh contingent behavior question asked respondents to state their expected number of annual oyster meals with the ban lifted, a traceability system in place, but now due to the additional costs incurred by oyster producers to label their product, the program will result in an increase in the price of an average oyster meal for all consumers. The price increase assigned to consumers was the same one they received in the earlier scenario.

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[2] Respondents were informed that oyster meals included any meal in which the main course was oysters, or oysters were an important ingredient in the dish (like gumbo), or meals in which they are an oyster appetizer. Pictures were also displayed to provide examples of oyster meals.

The oyster consumption questions were followed by the eighth stated preference scenario, the contingent valuation referendum vote:

> Suppose that the seafood traceability system is put to a national referendum. The system will make mandatory the labeling of the location of catch for all oyster products such that the state of harvest is always known to the consumer. However, because of the additional costs incurred by oyster producers to label their product, the program will result in an increase in the price of an average oyster meal for all consumers. Imagine that you have the opportunity to vote in this national referendum. If more than 50% of those voting vote for the FDA Oyster Food Safety Modernization Act, the FDA would be required to put the new Act into practice. If you could vote today and you knew that the price of your average oyster meal would go up by [ΔP] but the price of all other food would stay the same, would you vote for or against the proposed law?

Respondents could answer "for," "against," or "undecided." The price increase [ΔP] is the same as presented to respondents in the contingent behavior questions. Those who voted "for" the policy were asked a question about their certainty: How sure are you about your choice to vote for the proposed law? Respondents could answer "not sure at all," "not very sure," "somewhat sure," or "very sure."

3. Data

There were 795 oyster consumers that completed the survey. Almost one-half of these had participated in a similar survey before the BP oil spill (see Morgan *et al*. 2016). A number of respondents answered the demand questions in ways that suggest a lack of attention to the scenario or basic irrationality. For example, 101 respondents increase/decrease their stated preference consumption of oyster meals with a price increase/decrease and 126 respondents state that they would consume fewer oyster meals with a traceability program. For the purposes of this paper we discard 162 respondents in order to test convergent validity for the subsample that behaves rationally with respect to price and would prefer the traceability program at zero cost. We use the remaining 633 respondents in the contingent behavior and contingent valuation analyses.

In Table 1 we present the contingent behavior oyster meals for the seven hypothetical scenarios. In the baseline scenario, respondents state that they will consume 15 oyster meals. When the price increases oyster meals fall to 13 and when price decreases oyster meals rise to 17. With the Gulf shellfish harvest ban in effect oyster meals are 15. The traceability program increases oyster meals slightly with the ban in place and slightly more when the ban is removed. With the traceability program and a price increase oyster meal consumption is about one meal greater compared to the price increase scenario.

Table 1. Contingent Behavior Oyster Meals

Scenario	Mean	Median	Min	Max
Baseline	14.92	6	0	336
Price Increase	12.81	4	0	288
Price Decrease	17.01	7	1	413
Ban	15.08	6	0	336
Ban and Traceability	15.38	6	1	336
Traceability	15.48	6	0	336
Traceability and Price Increase	13.78	6	0	336
Cases = 633				

Forty-four percent of respondents voted "for" the seafood traceability program in the referendum, 28% voted "against" and 27% were "undecided." We recode "for" votes to against/undecided for those who are not "very sure" about their vote to adjust for the potential of hypothetical bias (Blumenschein *et al*. 1998). For example, in Table 2 at a price change of $1 58% of respondents voted "for" the proposal and 34% of respondents are "very sure" about their "for" vote.[3]

In Table 2 we present the referendum votes in the contingent valuation scenario for the seafood traceability system. The percentage of "for" votes falls from 58% to 36% as the price change increases from $1 to $5 and increases to 39% at $7. The "very sure for" votes fall from 34% to 16% at $5 and increases to 18% at $7. The differences in each treatment of the frequency of "for" votes across the price changes is statistically significant according to the chi-squared statistics with three degrees of freedom.

Table 2. Referendum Votes

ΔP	"For" Votes	Very Sure "For" Votes	Sample Size
1	58%	34%	180
3	42%	22%	147
5	36%	16%	158
7	39%	18%	148
Total	44%	23%	633
$\chi2$ (df=3)	19.62	19.00	

4. Regression Results

We estimate a count data demand model with the contingent behavior data:

$$ln\mu_{it} = \beta_0 + \beta_1 \Delta P_i + \beta_2 BAN + \beta_3 TRACE + u_{it} \quad (1)$$

where μ_{it} is the mean oyster consumption, ΔP is the change in the price of an oyster meal, u_{it} is a random error, individuals are indexed *i* = 1, …, 633 and *t* = 1, …, 7 denotes annual oyster

[3] Similarly, elicitation and analysis of uncertainty in the contingent behavior data is a direction for future research.

meals under seven stated preference scenarios. Variables for the fishing ban (*BAN* = *X* months when *t* = 4 and 5) and the traceability program (*TRACE* = 1 when *t* = 5, 6 and 7) are included.

We choose a random effects negative binomial model to better account for the over-dispersion in the data. The random effects negative binomial model results if $\exp(u_{it})$ is assumed to follow a gamma distribution with over-dispersion parameters varying across groups following a beta distribution with mean and variance dispersion parameters (a, b) (Huang, Haab, and Whitehead 2004).[4]

Table 3 presents the regression results from the random effects negative binomial oyster demand model. The coefficient on the change in oyster meal price is negative and statistically significant. The coefficient on BAN is not statistically significant so the expected length of the remaining ban is not important in altering behavior. The coefficient on the traceability program is positive and statistically significant indicating an increase in oyster demand.

Table 3. Random Effects Negative Binomial Model of Oyster Demand
Dependent variable = MEALS

	Coefficient	S.E.
Constant	2.713	0.113
ΔP	-.0403	0.00138
Ban	-0.00180	0.00431
Trace	.0382	0.0124
a	14.84	1.228
b	0.834	0.061
Sample size	4431	
Periods	7	
Cases	633	
LL	-10,938	
AIC	21,887	

The probability of a very sure "for" votes to the referendum question is the probability that the willingness-to-pay is greater than or equal to the change in price (Cameron 1988, McConnell 1990):

$$\Pr(for) = Pr(WTP \geq \Delta P) = F(\alpha - \gamma \Delta P) \quad (2)$$

where F is the logistic distribution and α and γ are logit coefficients.

The logit referendum model is presented in Table 4. The coefficient on the change in the oyster meal price is negative and statistically significant indicating theoretical validity of the data. The constant is negative and statistically significant which indicates that much of the

[4] The random effects Poisson model produces similar estimates with a statistically significant over-dispersion parameter.

probability distribution function is in the negative range of the price change. In the next section we truncate the willingness-to-pay distribution at a zero price change in order to estimate positive WTP.

Table 4. Logit Referendum Vote Models
Dependent Variable = Very Sure For Vote

	Coefficient	S.E.
Constant	-0.605	0.176
ΔP	-0.162	0.0432
χ^2	14.60	
Cases	633	

5. Convergent Validity

With the semi-log functional form the baseline consumer surplus per meal is: $CS = -1/\beta_1$ (Bockstael and Strand 1987). The change in consumer surplus per meal as a result of the traceability program is: $\Delta CS = -\beta_3/\beta_1$. Consumer surplus estimates are calculated together with 95% confidence intervals constructed using a bootstrapping procedure (Krinsky and Robb 1986). The consumer surplus per meal estimate is $24.82 (with a 95% confidence interval of $23.15 to $26.50). The traceability program increases consumer surplus per meal by $0.95 with a 95% confidence interval of $0.37 to $1.53. The consumer surplus estimates are robust to alternative econometric models such as random effects Poisson and random and fixed effects ordinary least squares models (these results are available upon request).

Mean willingness-to-pay per meal, $WTP = -\alpha/\gamma$, is negative when not constraining willingness-to-pay to be positive (Hanemann 1984). The conditional mean willingness-to-pay per meal, $WTP = -\ln(1 + exp(\alpha))/\gamma$, constrains willingness-to-pay to be positive (Hanemann 1989). The 95% confidence interval is constructed using a bootstrapping procedure (Krinsky and Robb 1986). The willingness-to-pay per meal is $2.69 with a 95% confidence interval of 1.23 to 4.15.

We find that differences in the consumer surplus and mean willingness-to-pay estimates are not statistically significant since the 95% confidence intervals overlap. However, this obscures large differences in the point estimates. Mean willingness-to-pay is 183% higher than the consumer surplus estimate from the demand model.

When referendum data exhibits "fat tails" as ours does in Table 2[5], welfare measures will be less robust to alternative models relative to textbook data. The conditional mean welfare measure is not robust to alternatives such as the log-linear logit model (median *WTP* = $0.27 [-$0.03, $0.56] with the 95% confidence interval in brackets) and the Turnbull (Haab and McConnell 1997) nonparametric estimate (*WTP* = $1.47 [$1.20, $1.74]) which are not sensitive

[5] Fat tails exists when increases in the cost amount does not reduce the percentage of yes responses (Parsons and Myers 2016).

to the tail of the distribution. However, these two estimates also lead to the conclusion of convergent validity with the consumer surplus estimate.

On the other hand, the conditional mean willingness-to-pay estimate is robust to comparison with the Kriström (1990) nonparametric estimate (*WTP* = \$2.65 [\$2.23, \$3.06]) (Boman, Bostedt, and Kriström 1999). But the confidence interval of the Kriström estimate does not overlap the confidence interval for the consumer surplus estimate. This lack of convergent validity is due to the narrow Kriström confidence interval which is partially an artifact of the smoothing of the data at the upper two bid amounts.[6]

6. Conclusions

Willingness-to-pay estimates from contingent behavior and contingent valuation methods are convergent valid but the differences in point estimates are large. This statistical result increases confidence in both estimates but, since stated preference data is typically conducted with an eye towards policy analysis, a meaningful question is: what measure of welfare should be used? Given our results we would recommend that the midpoint of the contingent behavior and contingent valuation estimates, \$1.82 per meal, be used with each individual estimate included for sensitivity analysis.

To illustrate, consider that aggregate benefits of the traceability program are equal to the product of the benefit per meal and the number of meals. Our estimate of the number of Gulf of Mexico oyster meals is based on average annual landings of 17.93 million pounds of Eastern oysters in the Gulf of Mexico (2014). With a 100-pound sack containing about 250 oysters and assuming the average oyster meal containing about 6 oysters, this equates to consumers eating about 7.47 million Gulf of Mexico oyster meals annually. Based on this estimate of oyster meals the annual benefit of the traceability program with the midpoint *WTP* is \$13.59 million with worst and best case benefit estimates of \$7.10 million and \$20.09 million. These benefit estimates could be compared to the costs of an oyster traceability program to determine program efficiency (Miller et al. 2014). Given the wide range of potential welfare measures from stated preference data, convergent validity of the benefit estimates lends more confidence to the comparison of market based cost estimates with stated preference benefit estimates.

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[6] Another consideration is that the willingness-to-pay and consumer surplus estimates do not converge unless the referendum responses are coded as a for vote only when respondents are very sure. The conditional mean willingness to pay from the linear logit for the un-recoded for votes is \$6.35 [\$2.52, \$10.18]. The median willingness to pay from the log-linear logit is \$1.78 [\$0.91, \$2.66]. The mean Turnbull and Kriström willingness to pay estimates are \$2.91 [\$2.58, \$3.24] and \$6.93 [\$5.79, \$8.07].

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