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A Double Hurdle Model of Preferences for a Proposed Capacity Reduction Program in the Atlantic Shark Fishery

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The Atlantic shark fishery is considered to be overcapitalized. One approach to capacity management is the purchase and permanent retirement of fishing vessels, fishing permits, or both under voluntary buyback programs. Representatives of the commercial shark fishery have proposed such an approach to manage the over-capacity in their fishery in the Gulf of Mexico and Atlantic regions. This program would allow owners to submit willingness-to-accept (WTA) bids for their permits and vessels. This study uses econometric modeling to explain the potential participation and bid amounts from a survey of permit owners.

Key Words: contingent valuation surveys, discrete choice modeling, fishery management, overcapacity, shark fishery

JEL Classifications: Q22, C25

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Introduction and Background

Overcapacity in the world's oceans is an issue of increasing concern. Overcapacity occurs when fishing effort potential (comprised of the number, size, and efficiency of available vessels and crew) is too high relative to the resource base (i.e., the harvest potential exceeds the sustainable yield). This can cause the depletion of fish stocks as well as a reduction in the profitability of vessels participating in the fishery. Overcapacity has been recognized as a problem by many nations; at the 1999 FAO Committee on Fisheries, 120 nations adopted the International Plan of Action (IPOA) for the Management of Fishing Capacity with the objective to achieve "an efficient, equitable and transparent management of fishing capacity" (FAO 1999). Following the subsequent FAO Code of Conduct for Responsible Fisheries, the United States developed a National Plan of Action (NPOA) with regards to fishing capacity with the goal to "eliminate or substantially reduce overcapacity in 25% of the U. S federally managed fisheries by 2009" (NMFS 2004). The NPOA identified several measures to manage overcapacity including restricting the number of permits through permit management programs, controlling harvest through quota programs, and the purchase and permanent retirement of fishing vessels and/or permits with buyback programs. The latter programs, dubbed "buybacks" in this paper, are quickly becoming the preferred method of fishing effort reduction, primarily because they can be implemented relatively quickly and they target active fishermen and, thus, can more easily gain industry support (Larkin et al. 2004).

Several previous buyback programs have used a reverse bid process to determine the specific owners whose vessels and/or permits would be compensated for permanent removal from the fishery (or from all fishing activity) (Kitts, Thunberg, and Robertson 2001). With this method fishermen are assumed to estimate the value of their fishing assets (be it the vessel alone, vessel with gear, and/or all associated permits) based on the characteristics of those assets, the future revenue potential, and their own characteristics and potential employment alternatives (Larkin et al. 2004). In most programs, such as the recent Northwest ground fish fishery and Alaskan crab fishery buyback programs, owners must also modify their estimated value to account for any costs associated with the proposed method to permanently destroy the tangible fishing assets (e.g., costs to scrap or net salvage value). The reverse bid process asks owners to submit bids (presumably the modified values just described), which are then normalized by a measure of historic fishery participation (e.g., average landings during a control period). The 'reverse' refers to the act of sorting the normalized bids in ascending order such that the lowest values appear first and represent the least expensive in terms of reducing effort in the fishery on a unit landed basis. Fishermen remaining in the industry then agree to pay a tax on future landings to fund a loan in the amount of the sum of all accepted bids.

While buyback programs are generally effective in removing some proportion of capacity from the fishery in the short term, program design ultimately determines the effectiveness of buyback programs as long-run capacity reduction tools. Understanding how fishermen perceive such programs and how they value their fishing rights and assets will allow planners to anticipate the potential participation, extent of capacity reduction, and implementation costs that together determine the potential effectiveness and feasibility of conducting a buyback program. This study sought to determine the level of interest in a voluntary capacity reduction program and to determine what factors affect the level of interest and the estimated value of their fishing rights and assets. Such information is the first step in assisting in the design of an effective buy-back program that would have the greatest likelihood of being endorsed by the commercial shark fishermen in the Gulf of Mexico and Atlantic Regions.

The Atlantic Shark Fishery

The Atlantic shark fishery comprises four species groups; large coastal, small coastal, pelagic and deepwater shark (NMFS 2001).With respect to shark in the Gulf of Mexico and Atlantic region, those fisheries targeting large coastal shark species are of particular concern. Given that the large coastal shark stocks in the region are also considered to be overfished, the total allowable catch and, subsequently, the expected average catch for any given vessel has been increasingly difficult to anticipate. This is due, in part, to the implementation and/or modification of a diverse mix of management measures over the last several years including catch quotas, allowable gear, and fishing seasons and areas. As a result, the development of efficient management schemes to overcome existing overcapacity and overfishing have evaded managers.

Of particular interest to the vessel owners, however, is the issue of overcapacity, which represents a problem that is rooted in their own individual and collective decisions regarding capital investment, fishing power, and operational behavior. The commercial shark fishery in the Gulf of Mexico and Atlantic is classified as overcapitalized and shark fishermen have recently proposed that a buyback program be used to remove excess capacity in this fishery. The federal permit database showed that in 2004 a total of 605 shark permits were active (Table 1). These permits are classified as either “directed” for those who target and land higher proportions of sharks and “incidental” for those that do not target shark but are likely to land a few during each trip. Collectively, these 605 commercial shark permit holders in the Gulf of Mexico and Atlantic regions held nearly 2,700 other federal fishing permits including 304 swordfish and 302 Atlantic tuna permits. This pool of 605 commercial shark permits formed the population from which data for this study was collected.

Data and Methods

Information on the 605 permit owners and vessels (including landings histories from 2001 through 2003, the most recent complete years of available data) were obtained from various NMFS databases. This population was reduced to an effective population of 551 owners in early 2005 that continued to have a permit and a valid mailing address. A mail survey was sent to all 551 permit owners regardless of type of shark permit held or whether or not they reported any landings from 2001 through 2003. A total of 322 responses were received for an overall response rate of 59%.

The questionnaire contained three sections. The first was designed to elicit information on permit holders' fishing goals and management preferences. The second section collected specific information on their fishing operation, including whether they were willing to sell (WTS) their fishing enterprise (i.e., shark permit only or all permits and their vessel). It also included corresponding willingness to accept (WTA) compensation questions. The contingent valuation method (CVM), or WTA-type question, sought to elicit the likelihood that the permit owner would be WTA a given bid amount, which was generated for each vessel based on past landings using a predicted bid model from the successful bids in a recent buyback program. The WTA was elicited by asking respondents to identify how likely they would be on a scale of 0% (not at all likely) to 100% (absolutely sure) that they would accept the bid amount offered to forfeit their vessel and all associated fishing permits. The final section gathered socio-demographic information.

Decision model

This paper investigates the decision-making process of respondents concerning the potential participation of commercial shark fisherman in a voluntary capacity reduction program. In this study respondents were faced with two decisions, the first being whether or not to participate in the program (i.e., sell their shark permit, vessel, and all other permits). For those that were willing to sell, the second decision was how likely they would be (on a scale of 0% to 100%) to accept the dollar bid amount offered for their assets. An appropriate econometric model to use in this case is a version of the double-hurdle regression model.

The double-hurdle regression model was first developed by Cragg (1971) as an extension to the model used by Tobin (1958) to analyze censored data. Tobin's investigation of durable goods purchases relies upon a model where both the decision to purchase and the amount of purchase are a function of the same set of explanatory variables, albeit in separate equations. A probit model is typically used to estimate the first equation, while a standard regression model is generally used to model the second one. In his paper on the subject, Cragg (1971) postulated that it was unlikely to be the case that both equations would share the same set of explanatory variables; thus, he developed several different model variations and tested them against Tobin's model using data on durable goods purchases. Cragg's results suggest that his hypothesis was correct, stating that Tobin's model "…seems to fit these data most poorly" (p. 842).

Subsequently, the double-hurdle regression model has become a general framework employed in many different consumer-choice problems; and, because of its structure, it also lends itself well to CVM studies. Recent work by Martinez-Espineira (2004) and Mabiso (2005) are such examples whereby the first hurdle determines willingness to pay (i.e., participate), and the second hurdle establishes the amount of payment contingent upon clearing the first hurdle. A similar format is used in this study, where the first stage of this double-hurdle regression utilizes a probit model to estimate owner's willingness to sell (WTS) their fishing assets. The second hurdle differs from other double hurdle models by incorporating an ordered-probit analysis to assess, for those willing to sell, how likely are they to accept the dollar bid amount offered in the questionnaire. This adaptation follows directly from the format of the survey instrument; instead of asking for open-ended willingness to accept values, or even whether respondents would accept a randomly-generated bid amount, each permit owner was presented with a bid that was uniquely estimated for each vessel. As mentioned earlier, respondents were asked for their likelihood of acceptance on a 0% to 100% scale; specifically respondents were asked to identify the likelihood that was best reflected by percentages within this range that varied in 25% increments (i.e., it was a closed-ended question with five possible mutually-exclusive answers). As such, the dependent variable of the second hurdle is categorically ordered as either 0%, 25%, 50%, 75%, or 100%.

Given this question format, the appropriate general specification for the double-hurdle regression model for this study is as follows:

(1) $$WTS_i = X_i'\beta + \varepsilon_i .$$

Equation (1) is the first hurdle where WTS_i represents a binary dependent variable that assumes the value of one if the respondent is willing to sell all of their fishing assets (i.e., vessel with all permits) or zero otherwise, X_i is a vector of explanatory variables, β is the associated coefficient vector estimated by the regression, and ε_i is the error term. This equation is estimated using the probit technique that employs maximum likelihood calculations to generate the coefficient and error vectors.

The second and subsequent component of this double-hurdle regression is estimated with an ordered-probit model:

(2) $WTA_i = Z_i'\gamma + u_i$

where WTA_i is the polychotomous dependent variable ordered as follows: the 0 category represents those willing to sell, but have rejected the bid offer; the 1 category includes those respondents that are 25% to 50% sure they would accept the bid; and the final 2 category contains respondents with either a 75% or 100% likelihood of accepting the given bid. The vector of explanatory variables is represented by Z_i, γ is a vector of associated coefficients estimated by the regression, and u_i is the error term.

The models defined in equations (1) and (2) hypothesize that both the WTS and WTA responses are influenced not only by vessel characteristics but also by a combination of demographic and socio economic factors.

Empirical Models and Estimation Results

Probit Model to Estimate WTS

The vessels owners' WTS is assumed to be influenced by vessel characteristics, vessels earnings, and business aspirations, socioeconomic and demographic factors. The variables included in the empirical model are identified in the following equation and defined in Table 2:

(3) WTS = *f* (EXPAND, EXIT, IMPSHK, BUYALL, PRAWC, LENGTH, VAGE, SOLE, VDEBT, AGE, YRSEXP, COMPU, HEALTH, DEGREE, HHINC1, HHINC2, FISHINC, NOLAND)

The results show that permit owners' planning to exit the industry, those who support buyback programs and household income were the only variables that had a statistically significant impact (at the 5% level) on the owners' willingness to sell their vessel and all permits (Table 3). If the owner was planning to exit industry within three years (EXIT) or supported the use of buyback programs in general to reduce overcapacity (BUYALL), they were more willing to sell their vessel and all associated permits. The level of household income also appeared to have an impact on willingness to sell with household income of greater than $100,000 (HHINC2) having a positive impact on the WTS. Although vessel characteristics are often emphasized as the main consideration in the WTS decision, vessel condition variables such as vessel age (VAGE), vessel length (LENGTH) and debt on the vessel (VDEBT) were not statistically significant. Results of the model suggest that owners take into account their financial and economic welfare when considering selling and do not consider their vessels in isolation of these socio economic factors.

Ordered Probit Model to Estimate WTA

An ordered probit model was used to estimate the second part of the decision process faced by permit holders. For those who are willing to sell, the research question addressed the factors that influenced their willingness to accept the bid amount they were offered. The bid amount that was presented to each permit holder was a value for the vessel and all associated permits based on their landings from 2001 through 2003. An average of their two highest year's total revenues was first calculated for each vessel. For vessels reporting landings in only one of the three years, the value for that single year was assumed to be the average across all years. These values were assumed to represent one factor in the determination of the future annual earnings potential for continued commercial fishing. Total revenues were converted to expected bids for surrender of their vessel and all permits using a formula based on results of the recent Pacific Northwest groundfish buyback program which predicts a declining bid to total landings (as measured in dollars) ratio as total landings increases:

(4) Bid = 2.935 – 0.0000043 * Landings

(8.84) (3.23)

The equation, although simplistic, explained 91% of the variation in the bid amounts. The formula produced corresponding bids ranging from just over $15,000 to nearly $456,500 for average landed values falling within the range of the data used to estimate the regression. Owners of vessels with average annual total revenue below $5,000 (from their best two years in all fisheries) were presented with a value of $10,000. Owners of vessels with total average annual revenues above the range were presented with values equal to that average (values reached nearly $1.6 million).

The bid value the owner is willing to accept to relinquish the vessel and all permits is assumed to reflect the future earning potential of the vessel, which is in turn influenced by the of the age and size of the vessel as well as future goals of the fisherman and the availability of alternative earning opportunities, which are limited by the level of education of the owner as well as his or her age. With these hypotheses, the following model was estimated to explain the likelihood (or willingness) to accept the bid amount offered:

(5) WTA = *f* (BUYALL, AVALUE, SHTAX, LENGTH, VAGE, SOLE, VDEBT, AGE, YRSEXP, COMPU, DEGREE, HHINC1, HHINC2, FISHINC, NOLAND, IMR, MU2)

where WTA is the dependent variable with the three ordered categories of increasing likelihood of accepting as described earlier, the new explanatory variables AVALUE and SHTAX equal 1 if the permit owner has tried to calculate the value of their fishing assets or are WTP a tax on future shark landings to pay for the buyback, respectively, and 0 otherwise. The inverse mills ratio (IMR) is also included in the results table.

The model results showed that six variables were statistically significant at the 5 % level (Table 4). Significant variables were willingness to pay tax on shark landings (SHTAX), sole proprietorship (SOLE), owner age (AGE), fishing experience (YRSEXP), education level (DEGREE), and those without landings (NOLAND).

Previous U.S. buyback programs have relied on taxing future landings as a means of generating the funds to pay for the program. The statistical significance of the SHTAX variable indicates that those permit owners who are willing to pay such a tax (SHTAX = 1) are more likely to accept the bid offer. This is an interesting result since if they accept the offer, they will not be paying the tax since they will no longer be fishing (at least with the same permits and gear). This could be a case of strategic response even though the tax question was asked early on in the survey and the willingness questions were asked toward the end.

Model results showed that businesses owned as a sole proprietorship (SOLE = 1) were more likely to accept the bid offer, perhaps because they had the authority to make the decision for purposes of returning the survey. Older fishermen were more likelihood to accept the bid amount presented to them. This would be expected since the earning horizon would be shorter, *ceteris paribus*. Respondents with more commercial fishing experience were less likely to accept the bid, which may reflect their intention to continue fishing (i.e., work in the career where they have the most experience). It would be interesting to test whether these individuals were also the most efficient (e.g., by estimating technical efficiencies). The model also showed that those with a college level education were less likely to accept the bid amount offered. This is an interesting result since it is at odds with the conventional wisdom that higher education affords additional employment opportunities. Again, estimating technical efficiencies could explain this result.

The final significant variable indicated that whether the owner had landings influenced their WTA the bid. Not having landings (NOLAND = 1) negatively impacted WTA. Those owners who had not landed any catch over a period of three years 2001 to 2003 were less likely to accept the bid amount offered. This, to some extent, reflects the problem of latent permits (i.e., unused fishing capacity) and speculative behavior in the industry whereby vessels with active permits (i.e., those who have paid the annual fee) do not fish. If these permits are not captured in the buyout process they remain hidden in the industry, but since the permits associated with these vessels are current, they can re-enter the fishery anytime thereby eroding the gains from the buyout. The observance that shark permit holders without landings of any species across a recent three year period are not more willing to sell their vessel with all permits should be qualified by the fact that these owners were presented with a threshold bid value of $10,000 since equation (4) was not valid for these owners.

Conclusions

Results of the study suggest that a large proportion of shark permit holders are indeed willing to participate in a vessel and permit buy-back program for the proposed bids, but the preferences are based on more than the vessel characteristics (e.g., landings). Preferences for the proposed buyback program in the Atlantic shark fishery show that industry members consider socioeconomic and demographic factors along with vessel characteristics when valuing their assets. Thus, if these variables are not taken into consideration during the planning phase of the program, the effort removed may not be sufficient to support an effective program.

Survey and modeling methods provided a deeper insight into the motivation of vessel owners to participate in a vessel and permit buyback program. Having this information prior to design and implementation of a buyback program allows more directed planning. Being aware of their preferences allows makes it possible it possible to better target those groups that are key to an effective program, such as the larger operators who target shark as well as latent permit holders who may otherwise not participate. This effort also provides a better understanding of the incentives and disincentives to participation, one of which is the funding for such a program. Model results imply that the method of funding may be of importance in determining the participation in a buyback program for the shark fishery in the Gulf of Mexico and Atlantic. This is because those left in the industry after the buyout will be faced with the burden of bearing the cost of the program and if this compromises the profitability of the business then this may act as deterrent from participating in the buyback.

Data gathered by this type of study can also be extended to approximate the potential participation in a buyout in the specific fishery examined as well as approximate a dollar value of the costs that can be expected. Having a better idea of market values as perceived by fishermen can also help to more accurately estimate the potential capacity reduction associated with a buy-back program, the financial costs of such a program, and ultimately the economic feasibility of its implementation.

Lastly, the response rate and success of these preliminary estimations indicate that a priori efforts to examine fishermen behavior can help to more efficiently design and effective buyback program. The timing of such studies is important since fishery managers do not want to find out that their proposed effort reduction plan is off-base after bids have been received, especially for stocks that are overfished.

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Table 1. The Total Number of Federal Commercial Fishing Permits Held in Major Fisheries by the Type of Commercial Shark Permit Held by the Permit Owner

Fishery	Directed	Incidental	Total
Shark	249	356	605
Swordfish	118	186	304
Atlantic Tunas	122	179	302
King Mackerel	108	136	244
Spanish Mackerel	110	133	243
Reef Fish	81	104	185
Bluefish	56	94	150
Other (29 fisheries)	493	925	1418

Table 2. Description of Variables in the Probit WTS Equation (1)

Variable		Description
WTS	=	1 if willing to sell vessel and all permits, 0 not willing to sell
EXPAND	=	1 if owner plans to expand fishing business, 0 otherwise
EXIT	=	1 if owner plans to exit industry in next 3 years
IMPSHK	=	Importance of shark to the business: 0=not all important to 4=very important
BUYALL	=	1 if you support buyback for capacity management tool, 0 otherwise
PRAWC	=	1 if aware of potential for shark buyback, 0 otherwise
LENGTH	=	Vessel length in feet
VAGE	=	Vessel age in years
SOLE	=	1 if sole proprietorship, 0 if partnership or cooperation
VDEBT	=	1 if there is debt on vessel, 0 otherwise
AGE	=	Owner age in years
YRSEXP	=	Years experience in commercial fishing
COMPU	=	1 if use a computer for the fishing business
HEALTH	=	1 if in poor health, 0 otherwise
DEGREE	=	1 if have a college degree, 0 otherwise
HHINC1	=	2003 household income before taxes: $50,000 to $99,999
HHINC2	=	2003 household income before taxes: at least $100,000
FISHINC	=	Proportion of household income from fishing
NOLAND	=	1 if no landings for period 2001- 2003, 0 otherwise

Table 3. WTS Model Estimation Results (N = 180)

Parameter	Coefficient	Standard Error	t-statistic	P-value
Constant	-0.144	1.184	-0.122	0.903
EXPAND	0.025	0.345	0.071	0.943
LEXIT	1.121	0.463	2.424	0.015
IMPSHK	-0.019	0.125	-0.149	0.882
BUYALL	1.322	0.295	4.480	0.000
PRAWC	0.046	0.127	0.360	0.719
LENGTH	0.00016	0.0098	0.016	0.987
VAGE	-0.014	0.014	-1.050	0.294
SOLE	0.074	0.293	0.251	0.802
VDEBT	0.278	0.331	0.839	0.401
AGE	-0.0056	0.016	-0.362	0.717
YRSEXP	-0.0015	0.014	-0.106	0.915
COMPU	-0.170	0.311	-0.545	0.585
HEALTH	0.352	0.720	0.488	0.626
DEGREE	-0.116	0.295	-0.392	0.695
HHINC1	0.508	0.340	1.495	0.135
HHINC2	1.102	0.431	2.556	0.011
FISHINC	0.186	0.471	0.394	0.693
NOLAND	-0.482	0.421	-1.144	0.253

Table 4. WTA Model Estimation Results (N = 143)

Variable	Coefficient	Standard Error	t-statistic	P-value
Constant	-0.370	1.447	-0.255	0.798
BUYALL	0.651	0.640	1.018	0.309
AVALUE	-0.370	0.259	-1.433	0.152
SHTAX	0.837	0.302	2.774	0.006
LENGTH	0.018	0.010	1.737	0.082
VAGE	-0.0043	0.012	-0.344	0.731
SOLE	0.653	0.291	2.248	0.025
VDEBT	0.109	0.274	0.396	0.692
AGE	0.041	0.017	2.379	0.017
YRSEXP	-0.046	0.016	-2.903	0.004
COMPU	-0.139	0.273	-0.510	0.610
DEGREE	-0.789	0.262	-3.016	0.003
HHINC1	0.140	0.303	0.460	0.646
HHINC2	-0.441	0.368	-1.216	0.224
FISHINC	-0.170	0.451	-0.372	0.710
NOLAND	-2.400	0.477	-5.027	0.000
IMR	0.337	0.831	0.405	0.685
MU2	1.230	0.192	6.431	0.000