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Reference-Dependent Preferences in Gulf of Mexico Shrimpers' Fishing Effort Decision

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This paper provides empirical evidence that reference-dependent preferences help to explain the amount of effort exerted by shrimpers in the Gulf of Mexico. Using survival analysis, the authors find that shrimpers tend to prolong their trip when their current trip revenue goal remains unattained. Furthermore, this tendency became more pronounced after 2001 in association with a significant decline in the shrimp price. This may partially explain the less obvious decrease in fleet effort vis-à-vis sharp decline in fleet size following the price change.

Key words: fishing time, Gulf of Mexico shrimpers, reference-dependent preferences, survival analysis, travel time

Introduction

Heidhues and Köszegi (2005) define reference-dependent preferences as individual's evaluation of economic outcomes relative to relevant "reference points" rather than relative to absolute measures.[1] When observed in the labor market, an individual who tends to increase his or her labor supply in order to achieve his or her income goal in response to a wage-rate decline exhibits target-earning behavior, an extreme version of reference-dependent preferences (Farber, 2008). This kind of behavior has been observed in occupations in which workers have flexibility in choosing work hours, such as taxi drivers (Camerer et al., 1997; Farber, 2005, 2008; Crawford and Meng, 2011) and bicycle messengers (Fehr and Goette, 2007). In addition, Holland (2008) provides anecdotal evidence that commercial fishermen exhibit target-earning behavior as a result of their flexibility in choosing working hours.[2] The underlying reason for this nontypical behavior of increasing working hours at a lower wage rate might be related to workers' narrow choice bracketing[3] (Read,

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[1] For a detailed discussion on the theory of reference-dependent preferences, see Munro and Sugden (2003).

[2] Holland (2008) quoted a fisherman as saying, "If you've had a couple of really good tows in the morning and then you drop off, then you are more likely to go home early. If it's stayed steady all day, then you are more likely to stay and get what you can out of it" (p. 336).

[3] Narrow choice bracketing, as opposed to broad choice bracketing, happens when an individual "distinguish[es] between choices made with an eye to the local consequences of one or a few choices" rather than "with an eye to the global consequences of many choices" (Read, Loewenstein, and Rabin, 1999, p. 172). Specifically, "a set of choices are bracketed together when they are made by taking into account the effect of each choice on all other choices in the set, but not on choices outside of the set. When the sets are small, containing one or very few choices, we say that bracketing is narrow, while when the sets are large, we say that it is broad" (Read, Loewenstein, and Rabin, 1999, p. 172).

Loewenstein, and Rabin, 1999) and their tendency to avoid losses with respect to their income goal for a trip.[4]

While Holland (2008) provides some anecdotal evidence of fishermen's target-earning behavior, empirical testing of this behavior pattern in fisheries is lacking. The primary objective of this paper is to test whether effort exerted by individual fishermen is related to their reaching some empirically specified revenue target. In conjunction with this objective, we also test whether changes in dockside shrimp prices influence shrimpers' target-earning behavior. Furthermore, by including the difference between actual trip revenue and revenue goal in the model, we test whether the effect of loss exceeds the effect of gain.

Industry Review

The shrimp industry is the largest income generator among commercial fisheries in the Gulf of Mexico. The offshore component of the fleet, which is mainly made up of vessels in excess of sixty feet and is the primary focus of the current study, accounts for two-thirds of harvested weight and over three-quarters of dockside revenue. The vast majority of offshore vessels are owner operated. In addition, there are few fishing regulations relevant to the Gulf offshore shrimp fleet.

While it is the largest income generator among Gulf of Mexico commercial fisheries, the shrimp industry has been deteriorating in its economic viability due to declining output price and an increase in input costs. While output price had been gradually declining since the 1980s, an accelerated (likely unprecedented) and largely unexpected downward price spiral transpired in late 2001. The industry, caught in the middle of this "cost-price squeeze," has been evolving to remain financially viable since the turn of the century. For instance, the fleet size has been contracting, with about 18% of the vessels exiting the industry between 2001 and 2004. However, offshore effort, defined as days fished, decreased by only about 8%, implying that after the economic downturn, remaining vessels might have increased their individual effort levels by (a) increasing the number of trips, (b) exerting more effort (i.e., days fished) per trip, or (c) some combination. In addition, summary statistics show that the average number of annual trips made by shrimpers declined steadily after 2000 (see figure 1). Thus, one can conclude that shrimpers remaining in the industry might have exerted more effort by increasing the amount of effort associated with an individual trip rather than increasing the numbers of trips.

Literature Review

Given the decline in shrimp prices after 2001, an explanation for the less obviously decreasing effort on individual trips, based on the neoclassical theory of labor supply, would be that the income effect dominates the substitution effect. Gautam, Strand, and Kirkley (1996) provide a detailed illustration of this in the commercial fishery setting, in which a backward-bending labor supply curve is presented. They find that increases in per day profits initially result in an increase in trip length and less time spent onshore, but beyond some point captains will trade days at sea for an increase in days onshore. For the labor supply to increase at a one-time price decrease (contemporaneous effect), they argue that the per day profit level would have to be sufficiently high ($307 per day for 1987). Given that the shrimp industry has been experiencing negative annual profit in the years of sharp price decline,[5] the influence of a contemporaneous effect appears implausible. Gautam, Strand, and Kirkley (1996) also illustrate the long-run effect of the price change on labor supply (intertemporal

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[4] This is not equal to loss aversion in its formal definition, which is stricter. Loss aversion refers to people's tendency to strongly prefer avoiding losses to acquiring gains (Kahneman and Tversky, 1984).

[5] A survey administered by the United States International Trade Commission indicates that operating margins for vessel owners (prior to subtraction for salaries) fell from 1.4% in 2001 to -9.8% in 2002 before recovering marginally to -6.6% in 2003.This survey was conducted as part of an antidumping investigation to determine whether the domestic industry was being materially injured as a result of imports.

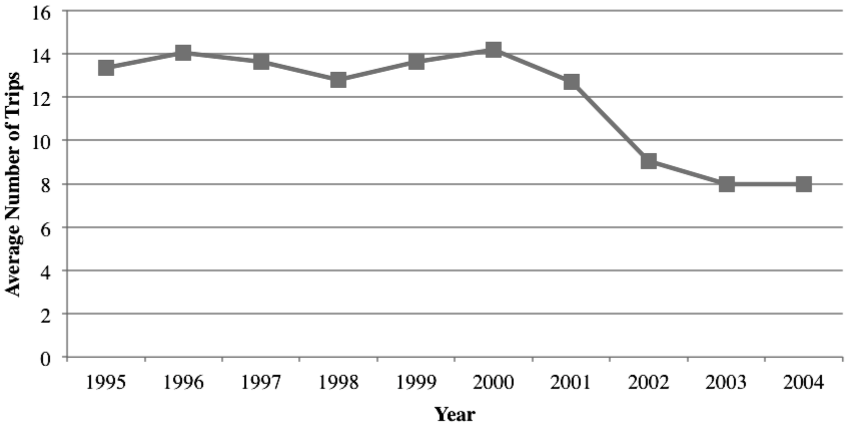

Figure 1. Average Trips per Year, 1995–2004

effect). They argue that if a fisher expects a continuing price decline, he would work more because the opportunity cost of leisure is less expensive in the future relative to the current period. However, there is no adequate evidence in our case that shrimpers expected continually declining prices.[6]

In addition, the argument of intertemporal utility maximization in Gautam, Strand, and Kirkley (1996) can be questioned in light of recent empirical evidence that individuals tend to be myopic in their decision-making processes. Thaler (1985), Garland and Newport (1991), Kahneman and Lovallo (1993), and Read and Loewenstein (1995), for example, argue that people often only focus on the effect of a decision on their income for a specific, short period. A logical timeframe for fishery is that of a trip. Many studies have used the combination of taking one trip at a time, which is closely related to narrow bracketing (Camerer et al., 1997), along with reference-dependent preference, which is a personal trait (Abdellaoui, Bleichrodt, and Paraschiv, 2007), to explain the downward-sloping labor supply.

Dunn (1996) states that workers are willing to give up more leisure to prevent a loss in revenue than to gain an equivalent amount of leisure. Fehr and Goette (2007) provide evidence that bicycle messengers would reduce their effort during a shift when the wage rate increased. Camerer et al. (1997) imply that taxi drivers are myopic and would drive more on low-earning days. Farber (2008) develops a model of the stopping rule that incorporates reference-dependent preferences for taxi drivers and confirms that drivers are "almost certain to stop after they reach their reference income level for the day." Crawford and Meng (2011) set targets for both working hours and income for taxi drivers. They argue that if realized wage is lower than expected, the hour target is reached first. Nguyen and Leung (2013) also suggest that the decision on trip length is made on trip-by-trip basis. They conclude that Hawaiian fishermen tend to fish less when trip revenue is high.

This study contributes to the literature in three ways. First, it is one of the few empirical studies to incorporate reference-dependent preferences theory and test target-earning behavior in fisheries. By doing so, it provides an alternative explanation for fishers' prolonged fishing time in association with a lower wage rate. Second, to our knowledge, this study is the first one to employ a duration model in fishers' working-hour decision while incorporating analyses of both trip length (as in Camerer et al., 1997; Nguyen and Leung, 2013) and the limiting probability of ending the trip (as in Farber, 2008). Third, unlike the analysis by Farber (2008), in which the target level is assumed to be random, the revenue target in our study is determined by the revenue level of shrimpers' previous trips. This empirically determined revenue target makes the results more stable.

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[6] In fact, it seems that some shrimpers were expecting the price in 2003 to be "stronger" (Coleman, 2002).

Conceptual Model

Similar to Nguyen and Leung (2013), this study assumes that shrimpers consider one trip at a time and make decisions on trip length (including fishing time and travel/searching time) accordingly. Furthermore, shrimpers are assumed to have a revenue goal (reference point) for each trip. To incorporate the reference point into the econometric model, we follow the simplified conceptual model in Farber (2008) by allowing a utility function whose marginal utility might significantly change after reaching the reference level, at which point the utility function has a kink:

$$U(r_t,t) = (1+\rho d[r_t < T])(r_t - T) - H(t), \tag{1}$$

where r_t is the revenue obtained after t hours, ρ is the "kink" parameter for the utility function, and $d[r_t < T]$ is an indicator function of whether the actual revenue reaches the target. Furthermore, T represents the revenue target, which can be allowed to vary by trip, and $H(t)$ is the function for labor, which is negatively related to utility. Assuming that the marginal utility during the next period of time is "at the higher pre-reference rate" (following Farber, 2008, p. 1071),[7] the marginal utility from the next period of fishing is

$$MU_{t+1} = e_{t+1}(1+\rho d[r_t < T]) - H'(t+1), \tag{2}$$

where e_{t+1} is the earnings from the next period of time spent fishing and $H'(t+1)$ is the derivative of $H(t)$ with respect to time evaluated at the next point of time. Given a nonincreasing expected earnings,[8] a shrimper will quit fishing when the expected marginal utility of continuing to fish first becomes negative. Furthermore, if ρ is positive, then the marginal utility will have a break at the point where $d[r_t < T]$ goes from zero to one, at which point the utility function has a kink.

After spending a certain amount of time at sea, a shrimper can calculate the forward-looking expected value of continuing to fish, which will depend on many factors, including hours worked so far at sea either fishing or searching and variables that affect expectations about future earnings possibilities. It is also supposed to be affected by accumulated revenue in an unusual manner: when accumulated revenue is less than the reference level, there is an opportunity for the shrimper to derive utility from additional revenue at the higher "pre-reference" rate (Farber, 2008)

Following Farber (2008), we construct our empirical model to include a latent variable Y that represents the forward-looking expected value of continuing to fish:

$$Y = \boldsymbol{z\beta} + \alpha d[r < T] + \gamma(r-T) + \delta d[r < T] \times (r-T), \tag{3}$$

where $\boldsymbol{z}$ is a vector of other factors influencing the trip length (e.g., vessel length, age, distance, etc.) and $d[r < T]$ is a dummy variable indicating whether the target is reached (with a value of one indicating that the target is not reached and zero otherwise). In addition, we also include the exact amount of difference between the revenue and the target $(r-T)$ and the interaction term between the difference and the target dummy variable to capture different effects of gains versus losses.

Given that daily ending decision information is not available for multiday trips in the shrimp fishery as in Farber (2005, 2008), our empirical model describes the limiting probability of ending a trip in a given interval provided that the trip has lasted until the beginning of that interval (i.e., a duration model is used). In particular, a proportional hazards (PH) model is applied.[9] The conditional

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[7] Following Farber (2008), this implies that the accumulated revenue is anywhere below the reference income level (even if earnings from this period of time cause accumulated revenue to exceed the reference level). It also implies that $d[r_t < T] = d[r_t + e_{t+1} < T]$.

[8] Discussion on the optimization model in the case of an increasing expected wage rate can be found in Farber (2008).

[9] Most models can be classified as either a proportional hazard (PH) model or an accelerated failure time (AFT) model. The PH model is widely used in the economics literature.

hazard rate[10] of a PH model can be factored as

$$\lambda(t|x) = \lambda_0(t,p)\phi(\boldsymbol{X},\boldsymbol{\beta}), \tag{4}$$

where $\lambda_0(t,p)$ is the baseline hazard and is a function of t alone, with p being the parameter of the duration distribution, and $\phi(\boldsymbol{X},\boldsymbol{\beta})$ is a function of $\boldsymbol{X}$, the explanatory variables alone. A common functional form for $\phi(\boldsymbol{X},\boldsymbol{\beta})$ is $e^{\boldsymbol{x\beta}}$.

The systematic component of the empirical model can be obtained by taking the natural log of $\phi(\boldsymbol{x},\boldsymbol{\beta})$. Therefore, the model including all the hypotheses we are testing is specified as

$$\begin{aligned} Y = \ln[\phi(\cdot)] \quad &= \quad \boldsymbol{z\beta} + \alpha d[r<T] + \gamma(r-T) + \delta d[r<T] \times (r-T) + \\ &\qquad \alpha_a d[r<T] \times a + \gamma_a(r-T) \times a + \delta_a d[r<T] \times (r-T) \times a, \end{aligned} \tag{5}$$

where a is a dummy variable equal to one for years after 2001, zero otherwise.

The specification in equation (3) allows us to test two hypotheses. The first is that a shrimper would decide to end his fishing activities later if he did not reach the target revenue, which would be the case if the estimate of α is different from zero and is negative. The second hypothesis is that losses might exert a stronger influence on shrimpers' trip-ending decision relative to gains, which would be supported if the estimated $\gamma + \delta > \gamma$, with positive signs for both the estimated γ and $\gamma + \delta$. In addition, since the "trip-prolonging" effect of not reaching the revenue goal for trips made after the 2001 price decline is of particular interest, the interaction terms of the dummy variable a with the reference dependent preference variables are also included in the model, as specified in equation (5). This allows us to test the third hypothesis (H_0^a) of different "trip-prolonging" effect for trips made after September 2001, which would be supported if the estimated α_a is different from zero.

Data, Variable Description, and Reference-Point Determination

Data Sources

The primary data used in our analysis is interview data from Shrimp Landings File, which provides trip-by-trip information for the vessels interviewed by port agents from 1995 to 2004. This covers 28,887 trips made by about 980 vessels, which accounts for about 10% of the fleet data. This subset of the SLF is then merged with the Coast Guard Vessel Operating Unit File and the Shrimp Permit File, which provide detailed information on individual vessels' characteristics, including vessel length and age.

Variable Description

Trip length (days at sea) measures general fishing effort. However, fishing time, which accounts for approximately one half to two thirds of the total trip length, represents an appropriate measure of real effort. The other two components are travel time and searching time, which account for the difference between trip length and fishing time. Distance and visiting multiple sites likely influence fishing time since they represent increased costs measured in opportunity costs and financial outlays. Another cost-relevant variable is diesel price, which is included in the model as the diesel price index adjusted for inflation.

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[10] Life-duration models can be used to estimate the probability of ending fishing at a certain point of time given the fishing has lasted until the moment before that point. The probability distribution of duration is specified by the cumulative distribution function: $F(t) = Pr(T \leq t)$, or the probability that the duration variable T is less than some value t, and the density function is $f(t) = dF(t)/dt$. The survival function $S(t) = 1 - F(t)$ is the probability that duration equals to or exceeds t. The hazard function, or the rate of failure at $t + \Delta$, given survival up to t, is defined as: $\lambda(t) = \lim\limits_{\Delta t \to 0} \frac{\Pr[t \leq T < T + \Delta t | T \geq t]}{\Delta t} = \frac{f(t)}{S(t)}$.

Table 1. Explanatory Variables

Variable	Description
Fishing time (in 24-hour days)	Time spent fishing for each trip
Travel/searching time (in 24-hour days)	Time spent searching for a site and traveling there
Trip length	Sum of fishing time and travel/searching time
Year (1995–2004)	Discrete variables indicating specific year
State (FL, LA, MS, TX, AL)[a]	Discrete variables indicating specific state
Distance	Distance from homeport to the center of the grid[b] that a vessel visited (expressed in miles)
Multiple site	Discrete variable equal to one if the vessel visited more than one site
Vessel length	Indication of vessel mobility and fuel capacity (expressed in feet)
Freezer	Categorical variable equal to one if a vessel is equipped with a freezer
Age	Age of the vessel expressed in years
TX closure	Discrete variable equal to one when the Texas Closure is in force
BRD	Discrete variable equal to one for those years that bycatch excluder devices are mandated
Diesel price	Diesel price index after tax and adjusted for inflation
Target dummy	Categorical variable equal to one if the revenue target for a trip is not reached
Difference	Represents the difference between actual revenue and target revenue (expressed in 100 dollars)
Difference × *Target dummy*	Interaction term of the target dummy variable and the variable *Difference*
a	Discrete variable equal to one for years after 2001

Notes: [a]FL represents Florida, LA represents Louisiana, MS represents Mississippi, TX represents Texas, AL represents Alabama.
[b]A grid is defined by the subarea and fathom zone of a fishing spot. Please refer to Ran, Keithly, and Kazmierczak (2011) for details.

To account for the effects of vessel characteristics, we include in the model vessel length, vessel age, and a dummy variable representing whether the vessel is equipped with a freezer. Vessel length serves as a proxy for the mobility and comfort level of the vessel. Vessel age is related to a vessel's seaworthiness as well as its potential financial burden. Two regulatory measures, the Texas Closure[11] and the mandatory use of bycatch excluder devices (BRDs)[12] are included in the model to control for the influence of management measures (Anderson, 2005). A complete list of variables included in the analysis is presented in table 1, and the summary statistics for the variables are presented in table 2.

The primary variable of interest is the revenue target discrete variable, the construction of which involves two other variables, actual per day revenue (r) for a trip and the revenue target (T). However, the revenue target (T) is unobservable. Further, actual daily revenue (r) might cause division bias due to the fact that it is directly calculated from trip length, which is related to the dependent variable of the model. Both of these issues and how these issues are treated in our analysis are discussed below in more detail.

Reference-Point Determination

Instead of assuming the target to be random, as Farber (2008) assumed, which could yield unstable results, we argue that reference revenue should be calculated using empirical data. Based on our interviews with Louisiana shrimpers and in conjunction with interviews reported by Holland (2008), we use average revenue from previous trips as the reference point. Four cases are considered in order to avoid an arbitrary assignment of the time frame in calculating the average revenue. The first case (Model 1) covers trips taken in the previous year. The second case (Model 2) covers trips taken last

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[11] Texas Closure, a seasonal management measure implemented in the early 1980s to protect juvenile shrimp, precludes harvesting in all waters off the Texas coast from mid-May to mid-July.

[12] Regulations require BRDs on vessels fishing in federal waters after May 1998 (Florida and Texas subsequently mandated the use of BRDs in state waters).

Table 2. Summary Statistics

Variable	Mean	Std Dev	Min	Max
Travel/searching time	9.64	7.72	0.10	80.50
Fishing time	8.02	6.23	0.10	45.00
Multiple site	0.16	0.37	0.00	1.00
Distance	148.34	164.14	4.71	975.27
Age	22.89	8.35	0.00	72.00
Vessel length	67.22	6.09	36.00	93.00
TX closure	0.13	0.34	0.00	1.00
BRD	0.64	0.48	0.00	1.00
Diesel price index	1.02	0.13	0.77	1.49
Target dummy	0.54	0.50	0.00	1.00
Difference ($100)	−0.27	6.04	−126.44	23.59
Difference × *Target dummy*	−2.24	4.05	−126.44	0.00
a	0.25	0.43	0.00	1.00
Freezer	0.75	0.43	0.00	1.00

year during the same season as the current trip.[13] The third case (Model 3) covers trips taken during the same season in the current year. The fourth case (Model 4) covers trips made prior to the current trip during the same season in the current year.

Negative Biasedness

To cope with the potential negative biasedness of the current trip's average revenue variable (r), we use as an instrumental variable the average revenue from other shrimpers who fished in the same month and that are in the same size category, similar to Camerer et al. (1997). We believe this is a good instrument in that the correlation between the actual variable and the instrumental variable is high (around 0.65), while others' monthly average revenue is exogenous from the dependent variable.

Per day revenue is used as the standardized means to compare the revenues from different trips. The underlying assumption is that, at the minimum, fishing will continue at least until the fixed costs are covered. This is implied in our using the duration model to analyze the limited probability of ceasing fishing given that an individual has fished so far.

Results and Interpretation

The estimation results are listed in tables 3 and 4, where trip length, fishing time, and travel/searching time are the dependent variables. A parametric hazard model with Weibull distribution is chosen due to its better fit.[14] In the tables, we also list the estimation results of hypothesis H_0^a for both the fishing time and the travel time models to test whether shrimpers' target-earning behavior remained the same after the price decline in 2001.

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[13] Seasons are defined according to the monthly shrimp abundance in combined grids. We use three seasons in the analysis: January through May, June through August, and September through December.

[14] The four models with different revenue target calculation all turned out to have similar results. Therefore, only the results from model 1 are presented. For more details on the robustness verification, please refer to Appendices A, B, and C. All of the models include year, state, month dummy variables, which are not presented due to space limitations.

Table 3. Parameter Estimates for Trip Length and Fishing Time Models (N=28,887)

Variables	**Trip Length**	**Fishing Time**	$\boldsymbol{H_0^a}$
Constant	-2.805^{***}	-1.257^{***}	-1.260^{***}
	(0.156)	(0.157)	(0.164)
Multiple site	-0.394^{***}	-0.420^{***}	-0.420^{***}
	(0.017)	(0.017)	(0.017)
Distance	-0.003^{***}	-0.002^{***}	-0.002^{***}
	(0.000)	(0.000)	(0.000)
Age	0.010^{***}	0.011^{***}	0.011^{***}
	(0.001)	(0.001)	(0.001)
Vessel length	-0.025^{***}	-0.024^{***}	-0.024^{***}
	(0.001)	(0.001)	(0.001)
Freezer	-0.652^{***}	-0.640^{***}	-0.640^{***}
	(0.016)	(0.016)	(0.016)
TX closure	-0.178^{***}	-0.146^{***}	-0.149^{***}
	(0.024)	(0.024)	(0.024)
BRD	0.117^{***}	-0.079^{*}	-0.074^{*}
	(0.043)	(0.044)	(0.044)
Diesel price	0.315^{***}	0.461^{***}	0.456^{***}
	(0.112)	(0.112)	(0.123)
Target dummy (α)	-0.105^{***}	-0.104^{***}	-0.093^{***}
	(0.019)	(0.019)	(0.019)
Difference (γ)	0.045^{***}	0.035^{***}	0.036^{***}
	(0.003)	(0.003)	(0.003)
Difference × *Target* (δ)	-0.045^{***}	-0.031^{***}	-0.033^{***}
	(0.004)	(0.004)	(0.004)
a × *Target* (α_a)			-0.160^{**}
			(0.081)
a × *Difference* (γ_a)			-0.0097
			(0.018)
a × *Difference* × *Target* (δ_a)			0.013
			(0.019)
$\ln(\rho)$ *for weibull*	0.601^{***}	0.434^{***}	0.434^{***}
	(0.005)	(0.005)	(0.004)

Notes: Numbers in parentheses are standard errors in parentheses. Single, double, and triple asterisks (*, **, ***) indicate significance at the 1%, 5%, and 10% level.

The estimated results listed in both tables, in general, have the expected signs.[15] A positive estimate indicates a more rapid ending of the trip length as the value of the variable increases,[16] while a negative estimate implies prolonging the trip with the increase in the variable. The model of primary interest is that of fishing time. For the fishing time model, shrimpers tend to exert more effort in association with longer traveling distance, with the hazard of ending fishing decreasing by around 20% in association with 100 miles' increase in distance traveled, *ceteris paribus*. Similarly, visiting more than one site is related to the decreased hazard of ceasing fishing by about 34%. In addition, the limited probability of prolonging fishing activities is found to increase with the "newness" of the vessel, possibly due to the financial burden associated with having a mortgage on more recently built vessels and a need to exert more effort to make mortgage payments. Larger vessels and vessels equipped with freezers are also found to fish longer. Fishing time is also found to increase associated

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[15] We did not include multiple site and distance in the travel time model, due to the possible endogenous problem in that model.

[16] When the coefficient of a variable x is, say, b, then a unit increase in x will increase the hazard (or, the limiting probability of ending a trip in current period given the trip has lasted till the beginning of the period) by $e^b - 1$.

Table 4. Parameter Estimates for Travel/Search Time Model (N=28,887)

Variables	**Travel Time**	H_0^a
Constant	−0.798***	−0.910***
	(0.151)	(0.158)
Age	0.010***	0.010***
	(0.001)	(0.001)
Vessel length	−0.029***	−0.029***
	(0.001)	(0.001)
Freezer	−0.675***	−0.673***
	(0.016)	(0.016)
TX closure	−0.305***	−0.306***
	(0.024)	(0.024)
BRD	0.267***	0.286***
	(0.043)	(0.043)
Diesel price	−0.174	−0.068
	(0.113)	(0.123)
Target dummy (α)	−0.162***	−0.151***
	(0.019)	(0.019)
Difference (γ)	0.037***	0.038***
	(0.003)	(0.003)
Difference × *Target* (δ)	−0.035***	−0.038***
	(0.004)	(0.004)
a × *Target* (α_a)		−0.162**
		(0.079)
a × *Difference* (γ_a)		0.002
		(0.017)
a × *Difference* × *Target* (δ_a)		0.011
		(0.018)
$\ln(\rho)$ *for weibull*	0.405***	0.405***
	(0.005)	(0.005)

Notes: Numbers in parentheses are standard errors in parentheses. Single, double, and triple asterisks (*, **, ***) indicate significance at the 1%, 5%, and 10% level.

with that period of time when the Texas Closure is in force. This is as expected, given that Texas closure "forces" a vessel to choose a less desirable location due to the closure of its first choice. This may involve more searching and fishing time due to their unfamiliarity with other sites (Ran, Keithly, and Kazmierczak, 2011). The implementation of the BRD regulation is associated with an increase in fishing time, probably to cover the shrimp loss as a result of the regulation.

The model with travel time being the dependent variable exhibits similar results, except for the parameter estimates of BRD and diesel price. Specifically, the implementation of BRD regulation is associated with a decrease in travel time, possibly due to a reduction in sorting time (i.e., separating the shrimp from the bycatch finfish for each trawl), which provides the shrimpers the opportunity to fish in areas closer to shore that have higher abundances of bycatch species. Another interesting observation is that while the increase in diesel price is associated with a reduction in fishing time, it does not influence the travel time. This may be due to the higher fuel usage during trawling than during searching and traveling.

As for the revenue target dummy variable, we have negative and statistically significant (at 1% significance level) parameter estimates for all the models. This indicates that if the current trip revenue does not reach the reference revenue, there is a higher probability that the individual will prolong traveling and fishing activities (the positive signs of γ and $\gamma + \delta$ also confirm this result). Specifically, if the revenue target is not reached on a particular trip, the hazard of ending fishing decreases by almost 10%. Likewise, if the revenue target is not reached on a particular trip, the hazard of ending traveling decreases by 15%.

To examine whether shrimpers have stronger feelings about losses than gains, we compare the estimated coefficient of the positive difference (γ) to that of the negative difference ($\gamma + \delta$). The results show that even though γ and $\gamma + \delta$ have expected signs, shrimpers are not necessarily more sensitive to losses than to gains. This might be due to the measurement error in our calculation of the revenue difference variables, since it is the difference of an instrument variable and an estimated unobservable variable. Another possibility is that shrimpers might have an hour target in addition to revenue target, as described in Crawford and Meng (2011). If their wage rate is lower than expected, they would cease fishing once the hour target is reached. Thus, they might behave as though they were less sensitive to losses.

Hypothesis H_0^a uses parameter estimates for α_a, γ_a, and δ_a to assess whether shrimpers are more willing to prolong the trip in times of deteriorating financial conditions from 2001 to 2004 and, if so, whether they are more loss averse compared to before. The results from both the fishing time and the travel time models are similar: only the parameters for the target dummy variables are significant. Specifically, if the revenue target is not reached after the price decline in 2001, the hazard of ending the fishing activity will decrease by 22% (while the decrease for the period before September 2001 is 9%). Similarly, the hazard of ending traveling for trips after 2001 will decrease by 27% (while the decrease for the period before 2001 is 14%). In general, these findings lead one to conclude that, after 2001, shrimpers' tendency to prolong the trip became stronger if the revenue goal remained unattained.

Discussion

The rapid financial deterioration in shrimping activities beginning in late 2001 resulted in a decline in fleet size, with about 18% of the vessels exiting the industry from year 2002 to 2004. The reduction in fleet size, however, was not matched by a proportionate decline in offshore effort. One might argue that it is because shrimpers' labor supply curve is backward-bending, with income effect dominating substitution effect upon reaching certain income level. However, profits would have to be relatively high for this to happen, which was not the case for Gulf of Mexico shrimpers. Another possibility is that increased vessel exits resulted in an increase in catch per unit effort (CPUE) among the remaining vessels, which encouraged them to fish more. However, due to the significant shrimp-price decline in 2001, the value per unit effort fell sharply, which should have discouraged fishing activities.

To examine the mismatch between the change in fleet size and effort, we analyze the fishing-time decision of the Gulf of Mexico shrimpers using a duration model. Based on reference-dependent preference theory, which indicates that individuals evaluate outcomes by referring to certain "reference point" (target, in our case), we find that shrimpers tend to fish longer when their revenue target remains unattained. This, in part, may explain the mismatch. Furthermore, shrimpers' tendency to prolong fishing became stronger after 2001, when it became more difficult to reach their revenue goal because of a decline in dockside shrimp price.[17]

In addition, the structural change in the fleet might have partially contributed to the mismatch. In particular, the number of large vessels (those equal to or larger than eighty feet in length) more than doubled after 2001 compared to the early 1990s. Since large vessels fish longer, on average, the increase in their numbers likely also caused the increase in their total efforts to some extent.[18]

As of December 5, 2002, vessels fishing for *Penaeid* shrimp in the federal waters of the Gulf of Mexico were required to have a permit. Subsequently, a moratorium was placed on the issuance of

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[17] Consistent with similar studies, less experienced shrimpers tend to fish longer (Camerer et al., 1997). However, many less-experienced individuals left the industry after 2001. Therefore, it is unlikely that the inexperienced shrimpers contributed much to the stronger tendency to fish longer after 2001.

[18] Large vessels account for about 10% of the fleet size.

new permits. In 2009, a total of 1,907 vessels were legally allowed to shrimp in the federal waters of the Gulf of Mexico. This moratorium, while significant because it represented the first attempt to limit effort in the offshore component of the industry, might not have the expected impact on the fleet, because the fleet size had already begun to contract due to unfavorable economic conditions. Moreover, since the remaining vessels tended to exert more fishing effort per trip, the effectiveness of the moratorium in controlling fishing effort may be moot. Caution needs to be taken when one implements management such as limited entry to control for fishing effort. Having made this comment, however, similar studies in other fisheries are certainly warranted to determine whether our findings are, in general, representative of a large suite of fisheries or merely reflect an isolated case.

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Appendix A: Robustness Check for Fishing Time Model

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Multiple site	-0.420^{***}	-0.429^{***}	-0.405^{***}	-0.431^{***}
	(0.017)	(0.019)	(0.015)	(0.024)
Distance	-0.002^{***}	-0.003^{***}	-0.002^{***}	-0.003^{***}
	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.01^{***}	0.010^{***}	0.007^{***}	0.002^{*}
	(0.001)	(0.001)	(0.001)	(0.001)
Vessel length	-0.024^{***}	-0.025^{***}	-0.027^{***}	-0.033^{***}
	(0.001)	(0.002)	(0.001)	(0.002)
Freezer	-0.640^{***}	-0.644^{***}	-0.594^{***}	-0.527^{***}
	(0.016)	(0.018)	(0.015)	(0.020)
TX closure	-0.146^{***}	-0.176^{***}	-0.112^{***}	-0.302^{***}
	(0.024)	(0.026)	(0.022)	(0.040)
BRD	-0.079^{*}	-0.091^{*}	-0.009	-0.113^{**}
	(0.044)	(0.047)	(0.040)	(0.057)
Diesel price	0.461^{***}	0.417^{***}	0.500^{***}	0.035
	(0.112)	(0.123)	(0.103)	(0.144)
Target dummy (α)	-0.104^{***}	-0.053^{***}	-0.164^{***}	-0.223^{***}
	(0.019)	(0.018)	(0.015)	(0.021)
Difference (γ)	0.035^{***}	0.032^{***}	0.083^{***}	0.007^{*}
	(0.003)	(0.003)	(0.003)	(0.004)
Difference $\times$*Target* (δ)	-0.031^{***}	-0.032^{***}	-0.105^{***}	-0.007^{*}
	(0.004	(0.004)	(0.004)	(0.004)
Constant	-1.257^{***}	-1.220^{***}	-1.259^{***}	0.026
	(0.157)	(0.174)	(0.136)	(0.195)
$\ln(\rho)$ *for weibull*	0.434^{***}	0.436^{***}	0.452^{***}	0.403^{***}
	(0.005)	(0.005)	(0.004)	(0.006)
Observations	28,887	24,851	33,724	17,737

Notes: Numbers in parentheses are standard errors in parentheses. Single, double, and triple asterisks (*, **, ***) indicate significance at the 1%, 5%, and 10% level. All models include state, month, and year dummy variables.

Appendix B: Robustness Check for Trip Length Model

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Multiple site	-0.394^{***}	-0.408^{***}	-0.390^{***}	-0.402^{***}
	(0.017)	(0.019)	(0.015)	(0.024)
Distance	-0.003^{***}	-0.003^{***}	-0.003^{***}	-0.004^{***}
	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.010^{***}	0.011^{***}	0.008^{***}	0.002^{**}
	(0.002)	(0.001)	(0.001)	(0.001)
Vessel length	-0.025^{***}	-0.024^{***}	-0.029^{***}	-0.034^{***}
	(0.001)	(0.002)	(0.001)	(0.002)
Freezer	-0.652^{***}	-0.665^{***}	-0.668^{***}	-0.562^{***}
	(0.016)	(0.018)	(0.015)	(0.021)
TX closure	-0.178^{***}	-0.241^{***}	-0.174^{***}	-0.359^{***}
	(0.024)	(0.026)	(0.022)	(0.040)
BRD	0.117^{***}	0.147^{***}	0.154^{***}	0.124^{**}
	(0.043)	(0.047)	(0.040)	(0.057)
Diesel price	0.315^{***}	0.306^{**}	0.316^{***}	-0.0906
	(0.112)	(0.123)	(0.104)	(0.145)
Target dummy (α)	-0.105^{***}	-0.043^{**}	-0.136^{***}	-0.179^{***}
	(0.019)	(0.018)	(0.015)	(0.021)
Difference (γ)	0.045^{***}	0.033^{***}	0.053^{***}	0.011^{***}
	(0.003)	(0.003)	(0.003)	(0.004)
Difference $\times$*Target* (δ)	-0.045^{***}	-0.034^{***}	-0.097^{***}	-0.014^{***}
	(0.004)	(0.004)	(0.004)	(0.004)
Constant	-2.805^{***}	-2.918^{***}	-2.802^{***}	-1.574^{***}
	(0.156)	(0.173)	(0.137)	(0.194)
$\ln(\rho)$ *for weibull*	0.601^{***}	0.598^{***}	0.613^{***}	0.585^{***}
	(0.005)	(0.005)	(0.004)	(0.006)
Observations	28,887	24,851	33,724	17,737

Notes: Numbers in parentheses are standard errors in parentheses. Single, double, and triple asterisks (*, **, ***) indicate significance at the 1%, 5%, and 10% level. All models include state, month, and year dummy variables.

Appendix C: Robustness Check for Travel/Search Time Model

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Age	0.010^{***}	0.013^{***}	0.011^{***}	0.007^{***}
	(0.001)	(0.001)	(0.001)	(0.001)
Vessel length	-0.029^{***}	-0.029^{***}	-0.030^{***}	-0.036^{***}
	(0.001)	(0.001)	(0.001)	(0.002)
Freezer	-0.675^{***}	-0.725^{***}	-0.756^{***}	-0.625^{***}
	(0.016)	(0.018)	(0.015)	(0.020)
TX closure	-0.305^{***}	-0.351^{***}	-0.259^{***}	-0.487^{***}
	(0.024)	(0.026)	(0.022)	(0.039)
BRD	0.267^{***}	0.275^{***}	0.264^{***}	0.303^{***}
	(0.043)	(0.047)	(0.040)	(0.057)
Diesel price	-0.174	-0.210^{*}	-0.179^{*}	-0.390^{***}
	(0.113)	(0.125)	(0.105)	(0.146)
Target dummy (α)	-0.162^{***}	-0.063^{***}	-0.113^{***}	-0.105^{***}
	(0.019)	(0.018)	(0.015)	(0.021)
Difference (γ)	0.037^{***}	0.017^{***}	0.011^{***}	0.008^{**}
	(0.003)	(0.003)	(0.003)	(0.004)
Difference $\times$ *Target* (δ)	-0.035^{***}	-0.022^{***}	-0.068^{***}	-0.011^{***}
	(0.004)	(0.004)	(0.004)	(0.004)
Constant	-0.798^{***}	-0.905^{***}	-0.982^{***}	0.061
	(0.151)	(0.168)	(0.134)	(0.187)
$\ln(\rho)$ *for weibull*	0.405^{***}	0.393^{***}	0.396^{***}	0.386^{***}
	(0.005)	(0.005)	(0.004)	(0.006)
Observations	28,887	24,851	33,724	17,737

Notes: Numbers in parentheses are standard errors in parentheses. Single, double, and triple asterisks (*, **, ***) indicate significance at the 1%, 5%, and 10% level. All models include state, month, and year dummy variables.