What Do Fishermen Tell Us That Taxi Drivers Do Not? An Empirical Investigation of Labor Supply

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Recent empirical findings have cast doubt on the neoclassical model of labor supply. However, estimation issues, and not workers' behavior, may be responsible for these findings. This paper investigates this possibility by examining the daily labor supply of Florida lobster fishermen. I invariably find that fishermen work more when earnings are temporarily high, behavior that is consistent with a neoclassical model of labor supply. Furthermore, methods that do not control for measurement error and endogeneity of the wage not only produce downward-biased estimates of labor supply elasticities but also generate a spurious negative and significant elasticity of daily hours.

I. Introduction

Does remuneration influence labor supply and, if so, to what extent? This is and has been a central question in labor economics and public policy discourse. If an increase in remuneration is transitory, so that income effects

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are negligible, neoclassical models of labor supply predict an increase in labor supply. In the last several decades, empirical research has sought to test this prediction and provide estimates of the magnitude of the response. Early studies did this by relating annual changes in hours worked to annual changes in the average hourly wage.[1] Contrary to the neoclassical model's predictions, the estimated wage elasticities are at best small (around 0.20), often statistically insignificant, and occasionally negative. However, if annual wage changes are not purely transitory, so that observed wage changes are correlated with an unobserved change in expected lifetime wealth, elasticity estimates will be biased downward if leisure is a normal good. Furthermore, if workers are not fully capable of adjusting their hours worked in response to annual wage changes, which is likely the case in these earlier studies, estimates will be furthered biased toward zero.

To address these concerns, a recent and innovative literature has begun using data from industries that exhibit daily variation in both earnings and the quantity of labor supplied. The type of workers studied by this literature includes taxicab drivers, bike messengers, and baseball stadium vendors.[2] The premise of these studies is that observed daily wage variation is transitory, so income effects can be ignored, and workers are autonomous, so they are able to adjust labor supply in response to wage fluctuations. Given these labor market conditions, such studies should consistently find larger labor supply elasticities relative to earlier studies if the neoclassical model is an appropriate characterization of labor supply and the auxiliary assumptions of the model are satisfied. Contrary to this prediction, two studies—Camerer et al. (1997) and Chou (2002)—report large and statistically significant negative wage elasticities in the New York City and Singapore taxicab industries, respectively. Several explanations for these results have been suggested, and determining which explanation is responsible is critical for policy evaluation.[3]

As discussed in Oettinger (1999) and Farber (2005), one explanation is a flawed estimation methodology. Given the nature of the taxi industry and the data that researchers have been given access to, it is not clear that these studies offer valid elasticity estimates. First, it has proven difficult to identify exogenous variation in the daily wage, and endogeneity of the wage—either in the sense in which labor supply affects the wage or in the sense of an

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[1] See, e.g., MaCurdy (1981), Browning, Deaton, and Irish (1985), and Altonji (1986).

[2] See, e.g., Camerer et al. (1997), Oettinger (1999), Chou (2002), and Fehr and Goette (2007).

[3] See Farber (2008) for a discussion of policy implications.

omitted variable that independently affects both the wage and labor supply—can generate negative bias in the estimated wage elasticity.[4] Second, these studies do not have access to a complete panel of taxi drivers, so any bias due to self-selection cannot be controlled for when modeling daily hours worked. If daily shocks affect the probability of participating and hours worked in the same direction, which seems likely, the wage and the error term in the hours equation will be negatively correlated, thereby producing negative bias in the estimated elasticity.[5] Finally, using the observed wage, rather than a proxy, runs the risk of introducing measurement error. Because hourly earnings are calculated by dividing total daily earnings by total hours worked, measurement error will induce a negative correlation between the calculated wage and hours worked. All of these issues have the potential to bias the estimated elasticity downward.

Another explanation for these results is a flawed model of labor supply. In light of their results, Camerer et al. (1997) suggest that rather than intertemporally substituting leisure for labor when wages are temporarily high, taxi drivers have daily income targets, leading them to work less when wages are high and more when wages are low. The idea that workers make labor supply decisions based at least in part on reference points like income goals provides theoretical grounds for empirically observing a negative wage elasticity. But, while many studies have found evidence supporting the existence of reference dependence in labor supply decisions, the importance of reference dependence to overall labor supply remains unclear for a couple of reasons. First, the majority of studies on reference dependence focus solely on the daily hours decision, and overall labor supply is likely also a function of daily participation and effort per hour.[6] So,

[4] For example, a positive shock to earnings in industries in which cab drivers typically hold second jobs will induce some cab drivers to shift out of the taxi industry, thereby decreasing aggregate taxicab labor supply and increasing the equilibrium taxicab wage. Similarly, any event that simultaneously decreases one's preference to drive a cab and increases demand for taxicab services generates negative bias if it is not controlled for. Examples might include holidays, sporting events, or subway breakdowns, which increase the cost of acquiring a cab from a leasing company and increase demand for transportation via taxicab.

[5] Consider a shock that reduces a cab driver's reservation wage (e.g., a negative shock to household employment). Such a shock makes a driver more likely to participate and more likely to work longer hours for any given wage. Since the econometrician only observes hours when the wage exceeds the reservation wage, low wages are more likely to be observed when accompanied by a positive shock to participation and hours. This induces a negative correlation between observed wages and hours worked.

[6] Camerer et al. (1997), Chou (2002), Farber (2005, 2008), and Crawford and Meng (2011) study taxicab drivers and focus on the daily hours decision only. Camerer et al. (1997) argues that taxi drivers have limited ability to adjust their schedules, so that the participation decision should be negligible. However, given data limitations, this cannot be tested. In the laboratory, Abeler et al. (2011) and Gill and Prowse

while it is possible that daily hours decrease in response to temporary increases in the wage, the effect of wage changes on overall labor supply is unknown. Second, due to data limitations, with the exception of Camerer et al. (1997) and Chou (2002), these studies do not attempt to estimate a wage elasticity of daily hours, so while reference dependence may be a legitimate aspect of preferences, it is unclear whether it is strong enough to produce a negative elasticity.

This paper aims to shed light on both possible explanations. Using an unusually large and unique complete panel data set of Florida lobster fishermen, I estimate a neoclassical model of labor supply where labor supply is a function of daily participation and daily hours worked. Importantly, daily variation in participation, hours worked, and earnings is present: during the season, fishermen are free to choose when and for how long to fish and, given the nature of fishing, both landings and the dockside price vary from day to day. To my knowledge, this is the largest data set used for these purposes, with almost 1,000 fishermen observed on a daily basis for an average of five fishing seasons, or more than 300 days, and it is the only studied industry in which workers vary both daily participation and daily hours and this variation is observable. The contributions of this work are threefold.

(i) To my knowledge, this is the first study to estimate the wage elasticity of daily hours worked using a framework that controls for self-selection bias, endogeneity of the wage, and measurement error in hours.[7]

(2012) find evidence of reference dependence in the provision of effort. However, given the setting, daily participation, i.e., whether or not subjects choose to show up, is not studied. To my knowledge, Fehr and Goette (2007) and Giné et al. (2010) are the only studies that examine reference dependence in the context of overall labor supply. Giné et al. (2010) investigates how last week's earnings, conditional on last week's labor supply, affect today's participation in the South Indian fishing industry. The authors find evidence of a negative effect of recent earnings on the probability of participating today, which is suggestive of reference dependence in participation. Fehr and Goette (2007) investigates how Swiss bike messengers vary their labor supply in response to an exogenous increase in the message commission rate. In particular, Fehr and Goette look at how the number of shifts worked and the number of messages delivered per shift during the 4-week commission hike differ from the baseline. They find a substantial increase in shifts worked but a slight decrease in messages delivered per shift as a result of the increased commission rate, suggestive of reference dependence in effort provision.

[7] While Fehr and Goette (2007) refers to "shifts worked" as an hours decision and "messages delivered per shift" as an effort decision, shift lengths are always 5 hours and workers in their sample never work more than one shift per day. As such, choosing an optimal number of shifts to work is more analogous to a daily participation decision than to a daily hours decision since daily hours are constant. Given labor market characteristics, Oettinger (1999) and Giné et al. (2010) assume that workers are unable to vary daily hours worked and therefore assume an hours elasticity of zero.

Specifically, I control for self-selection by exploiting the fact that preferences for fishing differ by day-of-week and on days preceding hurricane activity and that day-of-week fishing preferences also differ by age, while earnings do not vary across these dimensions. To deal with potential endogeneity and measurement error, I use an imputed wage. The effect of the imputed wage on labor supply is identified under the assumption that earnings vary with the moon cycle while preferences for work do not.

(ii) I am able to compare elasticity estimates that control for self-selection, endogeneity, and measurement error with estimates that do not in order to identify the extent to which these issues affect results. In particular, I can test whether these econometric issues are able to generate spurious negative and significant elasticities in a real labor market.

(iii) Industry characteristics and the richness of the data permit estimation of both the wage elasticity of participation and of daily hours worked. To my knowledge, estimation of both of these margins has not been tackled within the same study. While results will certainly be industry specific, it is informative to observe over which margin workers are most willing to adjust labor supply.

When I control for self-selection, endogeneity, and measurement error, estimates of both elasticities are positive and significant across a number of specifications. Estimates of the wage elasticity of daily hours range from 0.062 to 0.066, and estimates of the wage elasticity of participation range from 1.05 to 1.26, suggesting that fishermen are more willing to adjust labor supply at the extensive margin in response to temporary variations in earnings. Estimates of the participation elasticity are similar to the experimental results reported in Fehr and Goette (2007) and are roughly twice the size reported in Oettinger (1999) and Giné, Martínez-Bravo, and Vidal-Fernández (2010), which may reflect industry differences and differences in credit constraints, respectively. While these results suggest an important role for intertemporal substitution in models of fishermen's labor supply, they do not imply the nonexistence of reference dependence. However, they do imply that, for the average fisherman, any propensity to set daily hours based on income goals is not strong enough to erode the propensity to intertemporally substitute leisure for labor when the wage is temporarily high.[8] Fehr and Goette (2007) and Giné et al. (2010) arrive at similar conclusions.[9]

Models of daily hours that do not correct for self-selection, endogeneity, and measurement error produce the opposite result: a negative and signifi-

[8] While this appears to be true on average, models estimated separately for each individual suggest that some fishermen (17%) may actually reduce hours when earnings are temporarily high. See Sec. V.A for a discussion.

[9] "The behavioral forces that worked in favor of intertemporal substitution outweighed any opposing forces" (Fehr and Goette 2007, 300). "Compared to participation elasticities, the effects of recent earnings are small" (Giné et al. 2010, 19).

cant estimate of the wage elasticity. Similarly, models of daily participation that do not correct for endogeneity and measurement error produce estimates of the participation elasticity that are roughly three-quarters the size of estimates that do control for these issues, a result similar to that found in Oettinger (1999). These analyses highlight the importance of controlling for endogeneity and measurement error, in particular when estimating elasticities.

II. Background Information on the Florida Spiny Lobster Fishery

Commonly referred to as spiny lobsters, *panulirus argus* are warm-water, clawless lobsters found in the western Atlantic waters from North Carolina to Brazil.[10] In the United States, spiny lobsters are primarily harvested in Florida's southernmost counties, Monroe and Dade, both in Atlantic waters and the Gulf of Mexico. The Florida fishery consists of a recreational sector and a commercial sector of trappers and divers. Commercial fishermen are responsible for the majority of annual landings (typically 75%–80%), and trappers are responsible for the majority of commercial landings (typically 85%–95%). Trappers are also more likely than divers to be full-time fishermen who rely on fishing as a main, if not their only, source of income. For these reasons, and for identification reasons described in Section III.A, I focus my analysis solely on commercial trap fishermen. The data I have access to, which are discussed in detail in Section IV, allow me to track individual saltwater products licenses across time. Very few individuals own more than one license, and virtually all license holders operate their own vessel. Therefore, a license, vessel, or captain reasonably identifies the same unit. Throughout the text, I use the term "fisherman" or "trapper" to refer to such a decision-making unit.

The commercial lobster trap fishery is governed by a number of regulations. All commercial fishermen must possess a valid saltwater products license in order to catch and sell lobsters, and harvesting lobsters below a minimum size and females carrying eggs is prohibited. To encourage spawning, the season is closed from April 1 to August 5. Beginning in 1992, a transferable trap permit program was implemented that capped the total number of traps allowed in the industry. Trappers were issued trap permits based on the number of pounds of lobsters sold the previous two out of three seasons and were subsequently allowed to buy and sell permits from one another. Fishermen use hydraulic pullers to hoist buoy-marked traps into vessels. Because it is difficult for law enforcement to determine

[10] Background information is compiled from the Florida Fish and Wildlife Conservation Commission's Division of Marine Fisheries Management, the Food and Agriculture Organization of the United Nations, Shivlani et al. (2004), and personal accounts from fishermen.

whether fishermen are pulling only their own traps when it is dark, fishermen are permitted to pull traps only during daylight hours. Conditional on satisfying these regulations, trappers are permitted to fish as frequently and for as many hours as they wish, and there is no restriction on the quantity they can sell. They are also free to fish in any nonprotected location, to move traps as often as they choose, and to buy or sell trap permits at any time.

Lobsters can generally survive out of water for 12–14 hours provided that they are kept cool and damp. Beyond this, vessels either need to be outfitted with aerated water tanks to keep lobsters alive or with a supply of ice and a holding chamber to keep meat fresh. During the sample period, most vessels were not equipped to store lobsters in either capacity. Consequently, fishermen are rarely observed to remain at sea for more than a day at a time. Upon returning to port, fishermen sell live, whole lobsters to wholesale dealers at a spot price typically known to fishermen prior to leaving the dock. Dealers either cook lobsters whole or remove and freeze the tails on site before selling them. Only in the past few years, outside the period studied here, has there been a market for live lobsters. As a result, spiny lobsters are relatively storable and easy to transport.

In addition to industry entry costs, such as acquiring a vessel and trap certificates, fishermen face daily participation costs, which primarily consist of bait, fuel, and crew. Bait expenditures vary with the number of traps pulled, although many fishermen do not even use bait, preferring to use live undersized lobsters to attract legal lobsters instead. Because fishermen must travel some distance before arriving at their first trap, there are both fixed and variable costs associated with fuel. Arrangements vary, but most fishermen requiring crew pay a fixed daily rate. Crew are typically hired on a continuing basis and are expected to be available whenever the captain chooses to fish, which may be on weekends, for numerous days in a row, or not at all for several days due to inclement weather or poor expected earnings, for example.

A trapper's daily earnings are a function of the price and quantity of lobsters sold. Both of these vary on a daily basis. The daily price varies according to global supply and demand. While spiny lobsters consistently rank among the top five commercial fisheries in Florida in terms of dockside value, Florida is generally responsible for only 4%–7% of annual global catch. Furthermore, many lobster species similar in appearance and taste to *panulirus argus* are harvested in other parts of the world. Given Florida's small global contribution, the storability and transportability of lobsters, and the availability of close substitutes, daily prices should be reasonably exogenous to the local supply of lobsters.

Daily catches vary for a variety of reasons, and much of this variation is predictable. Lobsters tend to be more abundant early in the season when new recruits from the summer closure are bountiful and lobsters have not migrated to other waters. A lobster's preferred habitat is a dark, enclosed area, such as under coral heads, where it is protected from prey. During the new moon, when they are protected by dark waters, lobsters are more likely to venture out of reefs and find their way into traps. Consequently, catches are higher in the days surrounding the new moon. For the same reason, catches tend to be higher on rainy days when cloud cover reduces visibility. Lobsters also tend to relocate from reefs to traps when waters are rough, such that catches are typically higher following strong winds.

III. Empirical Models of Labor Supply

A. Individual-Level Model of Labor Supply

A fisherman's total supply of labor is a function of daily participation, daily hours worked, and effort exerted per hour. Given data availability, I focus on the participation and hours decisions only.[11] To the extent that fishermen provide more effort when earnings are high, the overall wage elasticity of labor supply will be downward biased, and vice versa. Following MaCurdy (1981), I estimate the following Frisch (or λ-constant) hours of work equation:

$$\ln H_{it} = \delta_h \ln W_{it} + \mathbf{Z}_{it}\gamma_h + F_{hi} + \epsilon_{hit}. \quad (1)$$

This equation specifies fisherman i's hours worked on open-season day t as a function of hourly earnings, W_{it}, a vector of observables conditioning labor supply, $\mathbf{Z}_{it}$, a fisherman-specific fixed effect, F_{hi}, and an unobserved, independent, random component, ϵ_{hit}. The subscript h is used to distinguish components of the hours model from the participation model, which is discussed next. The inclusion of individual fixed effects permits fisherman-specific heterogeneity in hours worked that is constant throughout the fisherman's tenure in the sample, such as unobserved components of wealth and motivation.

To capture temporal variation in preferences for fishing, $\mathbf{Z}_{it}$ includes a set of year indicator variables, a set of month indicator variables, and indicator variables for Saturday and Sunday. I also include interactions of Saturday and Sunday with an indicator variable equaling 1 if the fisherman

[11] While I do observe the number of traps pulled for a subset of trips, it is not clear how this maps into effort. For example, it is more time consuming to pull a trap full of lobsters than an empty trap because time must be spent unloading it. (Note that traps are usually dropped in waters between 20–50 feet deep, making it virtually impossible to tell whether traps have lobsters in them or not before pulling them.) Simply looking at traps pulled per hour not only masks this, but it might also mistakenly suggest a negative relationship between earnings and effort. Moreover, fishermen claim that they expend fairly constant effort, taking as long as needed to pull each trap.

is older than 30 years of age in order to capture differences in weekend fishing preferences between young and old fishermen.[12] The vector $\boldsymbol{Z}_{it}$ also contains a number of weather-related variables: (i) average daily wind speed, measured in meters/second (m/s), and its square; (ii) a 2-day lag of average daily wind speed, measured in meters/second, and its square; (iii) total daily rainfall, measured in inches; and (iv) three indicator variables that capture hurricane activity—whether a hurricane is anticipated to hit land within the next 3 days, whether a hurricane is presently ashore, and whether a hurricane made landfall in the past 3 days.[13] Finally, to capture variations in nonfishing opportunities, $\boldsymbol{Z}_{it}$ also includes the monthly, seasonally-adjusted unemployment rate for the state of Florida.[14]

Fishermen determine whether or not to participate each day by comparing utility from participation, $U(H > 0)$, with utility from nonparticipation, $U(H = 0)$.[15] If fisherman i is observed to participate in the lobster fishery on open season day t, then it is assumed that $U(H > 0) \geq U(H = 0)$. Therefore, the probability of participation, $P(\text{participation}_{it} = 1)$, is $P[U(H > 0) - U(H = 0) \geq 0]_{it} = \Phi(\varepsilon_{pit})$, where $\Phi(\cdot)$ is the standard normal cumulative distribution function and ϵ_{pit} is the combined random error component of $[U(H > 0) - U(H = 0)]$. When fishermen decide whether or not to participate, they do so by comparing expected hourly earnings, or the "wage," with their "reservation wage." Therefore, the structural equations for the probability of participation and daily hours worked share the same explanatory variables. The structural participation equation is given by

$$P(\text{participation}_{it} = 1) = \Phi(F_{pi} + \delta_p \ln W_{it} + \boldsymbol{Z}_{it}\gamma_p), \tag{2}$$

[12] Note that while age does vary for fishermen remaining in the sample for more than 1 year, age itself cannot be included because it is colinear with year indicators and fisherman fixed effects.

[13] The National Oceanic and Atmospheric Administration's (NOAA) historical weather buoy database (http://www.ndbc.noaa.gov) records weather conditions every hour at numerous buoys spanning the coast of Florida. To determine daily wind speed, for each buoy, I average hourly wind speed from midnight until noon for each open season day in the sample. Results are robust to other averaging methods, such as using only the first 6 hours or using the full 24 hours of data each day. I assign daily wind speed to each fisherman-day observation using data from the buoy closet to the modal area fished by each fisherman in each month. NOAA's National Climatic Data Center (http://www.ncdc.noaa.gov/) records daily precipitation data at almost 400 monitoring stations across Florida. I match fishermen to the closest station using the zip code associated with the fisherman's license. Information on hurricanes is taken from a variety of sources, such as news articles, that document the anticipated and actual path of hurricanes.

[14] Unemployment data are obtained from the Bureau of Labor Statistics.

[15] In modeling participation, I follow Kimmel and Kniesner (1998).

where the coefficients on the explanatory variables include the subscript p to distinguish them from the coefficients in equation (1).[16]

The estimated coefficient on hourly earnings in equation (1), $\hat{\delta}_h$, measures the Frisch wage elasticity of daily hours worked. The estimated elasticity of a wage change on the probability of participation, derived from equation (2), is given by $\hat{\delta}_p \phi(\hat{F}_{pi} + \hat{\delta}_p \ln W_{it} + \mathbf{Z}_{it}\hat{\gamma}_p)/\Phi(\hat{F}_{pi} + \hat{\delta}_p \ln W_{it} + \mathbf{Z}_{it}\hat{\gamma}_p)$, where ϕ denotes the standard normal probability distribution function. Both elasticities should be strictly positive if fishermen behave according to the neoclassical model. If effort per hour remains constant, as assumed, then the sum of these elasticities provides an estimate of the intertemporal elasticity of substitution.

Estimation of equations (1) and (2) proceeds in several steps. Given the data, hourly earnings, W_{it}, are necessarily calculated by dividing fisherman i's total daily earnings on day t by total hours worked that day, H_{it}. Anecdotally, fishermen claim that within-day earnings are fairly constant, so this seems a reasonable approach. Furthermore, to the extent that earnings do vary within a day, variation should not be predictable. Nevertheless, because of the way hourly earnings are calculated, hours worked appears in reciprocal form on the right-hand side of equation (1). As a result, any classical measurement error in hours recorded or misspecification of the model will induce a negative correlation between hours worked and hourly earnings. Another potential problem with estimating equation (1) using observed earnings is that hourly earnings and hours worked conditional on hourly earnings may be jointly determined, in part, by the same factors. If these factors are unobserved, such that they remain part of the error term, $_{hit}$, the coefficient on earnings will be biased. Finally, I only observe earnings for days on which fishermen chose to participate. However, in order to analyze daily participation, a measure of earnings for each open-season day, including nonparticipation days, must be available. For these reasons, I impute hourly earnings based on the following specification,

$$\ln W_{it} = \mathbf{X}_{it}\beta + F_{wi} + \epsilon_{wit}, \tag{3}$$

and I use predicted values, $\widehat{\ln W_{it}}$, in place of observed earnings in equations (1) and (2). This equation specifies fisherman i's average hourly

[16] Methods for estimating fixed effects specifications in linear models that do not require explicit estimation of the "nuisance" parameters associated with the fixed effects do not readily generalize to nonlinear models such as the above specification for participation. It is possible to estimate the fixed effects parameters along with the main parameters of interest, but when the length of the panel (T) is small this is not advisable because it introduces an incidental parameters problem. However, I have, on average, more than 300 observations per fisherman, and so the only problem associated with the direct estimation of individual fisherman fixed effects is that it is computationally cumbersome. See Greene (2004) for further discussion.

earnings on open-season day t as a function of a vector of observables determining earnings, X_{it}, a fisherman-specific fixed effect, F_{wi}, and an unobserved, independent, random component, ϵ_{wit}. The inclusion of F_{wi} introduces time-constant, fisherman-specific heterogeneity, such as unobserved components of ability, which allows for permanent differences in earnings across fishermen.

To capture temporal variation in fishing revenues, X_{it} includes a set of year indicator variables and a set of month indicator variables. The vector X_{it} also includes many of the same weather-related variables included in Z_{it}: (i) average daily wind speed and its square, (ii) a 2-day lag of average daily wind speed and its square, (iii) total daily rainfall, and (iv) indicator variables for whether a hurricane is presently ashore and whether a hurricane made landfall in the past 3 days. To capture the effect of the moon cycle on earnings, I include a continuous variable that equals 0 during the new moon, 1 during the full moon, and the appropriate fraction for moon phases in between. Finally, to account for the possibility that lobster prices are affected by regional demand, I include the monthly, seasonally-adjusted unemployment rate for the state of Florida.

Because fishermen choose to participate by comparing earnings with their reservation wage, any shock that affects earnings, but not the reservation wage, will induce correlation between the explanatory variables and the error term in equation (3). For this reason, I estimate a selectivity-corrected version of equation (3) that accounts for nonrandomness in observed earnings due to self-selection. Following the recommendation of Puhani (2000), rather than use the limited information Heckman two-step estimator, I jointly estimate equation (3) and a reduced form probit model for participation via full information maximum likelihood, known as a type 2 Tobit model in the language of Amemiya (1984). All variables that may directly or indirectly affect participation—namely, X_{it}, Z_{it}, and a set of fisherman-specific fixed effects—are included as explanatory variables in the reduced form probit model.

Beyond relying on functional form differences, identification of the model requires that some observables affect participation but not earnings. I assume that Saturday and Sunday, interactions of these variables with the age indicator variable described above, and an indicator for whether a hurricane is anticipated to make landfall within the next 3 days satisfy this requirement.[17] I discuss the assumptions associated with each set of exclusions in turn. For Saturday and Sunday to be valid exclusions, earnings (i.e., prices, landings, and expenses) must not systematically vary by day-of-week. Because lobsters are easily storable and transportable, and because Florida's contri-

[17] To test the validity of these exclusions, I estimate two additional specifications of the earnings equation, which vary the set of excluded variables. Results are discussed in Sec. V.A.

bution to global supply is small, the equilibrium price should be unaffected by any day-of-week variations in aggregate supply or demand.[18] There is also no reason to expect landings to vary by day-of-week. This is particularly true for trap fishermen, who are unlikely to experience daily abundance variation due to contemporaneous or recent aggregate participation.[19] Furthermore, two independent sources suggest that the average length of time each trap is left to soak between pulls is 9–10 days.[20] As a result, inactivity on a Saturday or Sunday should not increase expected landings on Monday, for example. Finally, fishermen do not pay crew higher wages to work on weekends, so there is no reason to expect expenses to vary by day-of-week.

By excluding weekend-age interactions from the earnings equation, I assume that, while day-of-week preferences for fishing may differ by age, any differential in earnings due to age is constant across days of the week. This weaker assumption would be violated if younger fishermen were relatively more (or less) productive on weekends, which seems unlikely.

For the last exclusion to be valid, earnings must not be systemically higher or lower in the days preceding a hurricane. The rationale for this assumption is that, while fishermen are less likely to participate on these days because of the need to secure vessels and possibly move traps, these days exhibit the same characteristics as any other (e.g., weather patterns have not yet changed) and will, therefore, not attract an earnings differential. Implicit in this argument is that fishermen who do choose to fish will have crew at their disposal and that dealers do not adjust prices in response to expectations about the effect of impending hurricanes on the supply of lobster.[21] Fortunately, the majority of the hurricanes in the sample studied here are small, suggesting little evacuation response and thus a negligible effect on crew availability. In addition, while hurricanes reduce lobster abundance if they destroy traps and reefs, they can increase abundance if habitats avoid a direct hit or wind speeds are not too great since moderate wind is actually beneficial. As a result, it is not obvious, a priori, in which direction dealers would adjust prices.

Using the estimates of the selectivity-corrected earnings equation, I construct an uncensored sample of average hourly earnings for each fisherman

[18] I provide a test of this assumption in app. A. Results support this claim.

[19] Unlike in the taxicab and stadium vendor labor markets, e.g., whether or not other fishermen choose to participate (i.e., pull their traps) on a given day should have virtually no effect on one's own landings for that day.

[20] The 2007–8 personal logbook of one full-time commercial lobster trap fisherman indicates a median soak time of 10 days. A 2000–2001 survey of 272 commercial lobster trap fishermen—discussed in Shivlani et al. (2004)—suggests an average soak time of 8.59 days.

[21] I provide a test of this latter assumption in app. A. Here, too, results support this claim.

on each open-sea day they are in the sample. Next, I estimate a selectivity-corrected version of equation (1) that, again, accounts for the fact that fishermen are able to choose when to participate, leading to a nonrandom sample of observed hours. I estimate by maximum likelihood a type 2 Tobit model in which equation (1) and a reduced form probit model for participation are jointly estimated. As above, the latter includes $\boldsymbol{X}_{it}$, $\boldsymbol{Z}_{it}$, and a set of fisherman-specific fixed effects as explanatory variables. Given the use of imputed earnings in equation (1), identification requires that some observables affect earnings but not participation, except through their effect on earnings. I assume that the lunar phase satisfies this requirement. Given that trappers fish during daylight hours and dock vessels in deep waters where they are unaffected by the tide, and given that other primary fisheries are closed during the period studied here, this seems a reasonable assumption.[22]

Finally, I estimate the structural probit model of participation, equation (2), again replacing observed earnings with imputed earnings. Identification is achieved under the same requirements and assumptions as with equation (1).

B. Identifying the Effect of Self-Selection, Measurement Error, and Endogeneity on the Estimated Wage Elasticity of Daily Hours Worked

Camerer et al. (1997) investigate the effect of temporary wage changes on the labor supply of New York City taxi drivers by estimating versions of equation (1). In their first specification, the authors use observed average hourly earnings as their metric for W_{it}, calculated as cab driver *i*'s total fare income on day *t* divided by total hours worked on day *t*, H_{it}. This specification produces substantially negative estimates of δ_h. Noting that measurement error has the potential to generate spurious negative elasticities, the authors attempt to address this issue by using an instrumental variables (IV) approach. They instrument the daily wage using summary statistics of the distribution of wages for all other drivers observed that day. Their overall conclusion is unchanged. However, whether these instruments are uncorrelated with the measurement error in hours such that they properly deal with the bias is unclear. In addition, self-selection and endogeneity are not addressed.[23]

Given the data that I have access to and the industry characteristics of the Florida lobster fishery, I am able to estimate versions of equation (1) that

[22] Although lobster divers' fishing preferences should be similarly unaffected by the moon, the moon phase is not as strong of a predictor for divers' landings. Hence, the use of trap fishermen in this analysis.

[23] Camerer et al. (1997) argue that self-selection should not pose a problem in their study because cab drivers lack the flexibility to choose their shifts. However, they are unable to test this assumption.

address each of these econometric concerns one at a time in order to identify the impact that each has on the ensuing elasticity estimate. I estimate the following five versions of equation (1): *Model 1* uses observed average hourly earnings, calculated as fisherman *i*'s total daily earnings on day *t* divided by total hours worked on day *t*. This is akin to the first specification estimated in Camerer et al. (1997). *Model 2* attempts to remove the bias introduced by measurement error by using the same approach in Camerer et al. (1997). In particular, I instrument the daily wage using the 25th, 50th, and 75th percentiles of the hourly earnings distribution for that day. *Model 3* instead uses the lunar phase to instrument the wage. To the extent that there are calendar date effects in measurement error, this specification better controls for measurement error. Perhaps more important, this approach also provides exogenous variation in daily earnings, thereby removing bias due to endogeneity of the wage. *Model 4* builds on model 3 by also controlling for self-selection in the wage equation. *Model 5* additionally controls for self-selection in the hours equation.

C. Identifying the Effect of Measurement Error and Endogeneity on the Estimated Wage Elasticity of Participation

To investigate the effect of measurement error and endogeneity of the wage on the wage elasticity of participation, I estimate an aggregate model of labor supply. Following Oettinger (1999), I specify the aggregate labor supply model as follows:

$$\ln H_t = \tilde{\delta}_h \ln W_t + \mathbf{Z}_t \tilde{\gamma}_h + \tilde{\epsilon}_{ht}, \tag{4}$$

and

$$\ln W_t = \mathbf{X}_t \tilde{\beta} + \tilde{\epsilon}_{wt}. \tag{5}$$

Equation (4) specifies aggregate hours worked, H_t, as a function of average hourly earnings, W_t, a vector of observables conditioning labor supply, $\mathbf{Z}_t$, and an unobserved, independent, random component, $\tilde{\epsilon}_{ht}$. The tilde (~) is used to distinguish aggregate parameters from the individual parameters in equations (1)–(3). The vector $\mathbf{Z}_t$ includes year indicators, month indicators, indicators for Saturday and Sunday, the unemployment rate, and observation-weighted averages of the same weather variables included in equation (1). Equation (5) specifies average hourly earnings, W_t, as a function of earnings shifters, $\mathbf{X}_t$, and an unobserved, independent, random component, $\tilde{\epsilon}_{wt}$. The vector $\mathbf{X}_t$ includes year indicators, month indicators, the unemployment rate, observation-weighted averages of the same weather variables included in equation (3), and the moon phase variable. If the model is correctly specified, $\hat{\tilde{\delta}}_h$ measures the Frisch wage elasticity of labor supply.

However, average hourly wages may be negatively correlated with aggregate hours worked if, for example, there are calendar date effects in the measurement error in hours. Furthermore, any omitted variable that is correlated with average hourly earnings and aggregate hours worked conditional on earnings will introduce further bias in the estimated elasticity. In such cases, OLS estimation of equation (4) will produce a biased estimate of the elasticity. To determine the extent of the bias, following Oettinger (1999), I reestimate equation (4) by two-stage least squares (2SLS) using the moon phase as an instrument for average hourly earnings. Finally, I estimate versions of (4) for which aggregate participation, and not aggregate hours, is the left-hand side variable. Comparison of elasticity estimates across aggregate hours and aggregate participation models provides additional information on the size of the hours elasticity relative to the participation elasticity.

IV. Data and Descriptive Statistics

Since 1978, dealers have been required to fill out a Marine Fisheries Trip Ticket for each purchase of marine life and to submit this to the Florida Fish and Wildlife Conservation Commission (FWC), the governing regulatory agency. These records provide rich information on daily labor supply and constitute the main data used in this analysis. Information recorded on trip tickets includes (i) the fisherman's unique saltwater products license number, which can be used to track individual behavior across time, (ii) the trip date, (iii) the trip length, (iv) the location of the trip and the location of the sale, which can be used to link geographical variables, like weather, to each trip made, (v) the fishing gear used, and (vi) the composition of species sold, including the price and quantity of each, which provides information on daily earnings. While it is mandatory for dealers to fill out and submit these trip tickets, they are not used for tax purposes, and I am not aware of any reason for dealers or fishermen to intentionally misreport any information recorded on these trip tickets.

The FWC provided me with all trip ticket records between and including the 1996 and 2007 lobster seasons for which any amount of lobsters was recorded as sold. From this set of trip tickets, the FWC compiled a list of fishing licenses and additionally provided any remaining trip tickets that matched on fishing license. As a result, the data constitute a complete panel of all sales made in Florida between the 1996 and 2007 lobster seasons by fishermen that ever sold spiny lobsters. Because it is rare for a commercial fisherman to make a trip but have no catch to sell, it is reasonable to assume that for each fisherman in the sample, I observe each and every day they chose to fish and, importantly, each and every day they chose not to fish. I provide a brief discussion of these trip tickets below, but I leave much of the detail to appendix B of this article (apps. A–D available online).

This large set of trip tickets includes a variety of fishermen and a variety of fishing trips. In order to analyze the labor supply decisions of lobster trap fishermen in the lobster fishery, specifically, this population and their trip tickets must be identified and extracted from the larger data set. To do so, it is necessary to (i) categorize each observed trip containing some amount of lobsters as either participation or nonparticipation in the lobster fishery, (ii) determine the primary gear type used by each fisherman to harvest lobsters, and (iii) classify each fisherman as either a lobster fisherman—in the sense that fishing for lobsters is regularly in their daily choice set—or a non–lobster fisherman. The criteria used to define lobster trips and lobster trap fishermen and the effect of these criteria on the sample size and composition are discussed in appendix B.[24]

Although the lobster season is open from August 6 until March 31, I restrict my analysis to the first 70 days of each season. The reason for this is to simplify identification of the model. Between August 6 and October 14, there is very little fishing activity by lobster fishermen in other fisheries.[25] Indeed, lobster sales constitute 98.4% of the value of all species sold during this period by fishermen in the sample. Focusing on the first 2.5 months of each season makes identifying factors that affect expected earnings in the lobster fishery but that do not affect outside opportunities more straightforward because outside opportunities do not include the somewhat similar option of fishing for other species.

In order to estimate the wage elasticity of daily hours worked, hours spent at sea must be observed. Unfortunately, in some instances this information is not recorded and in others "days" rather than "hours" is recorded as the unit of measurement.[26] To deal with this issue, I construct two different samples. In the first, which I refer to as having "Incomplete Hours Records," I simply drop all invalid trip tickets, where "invalid" refers to trip tickets missing hours information or recording "days" at sea. The assumption maintained is that invalid trip tickets are not systematically different from "valid" trip tickets in such a way that would influence results. The raw data suggest that this is a reasonable assumption. Nevertheless, I also estimate models using only fishermen with Complete Hours Records in the sense that hours fished is always recorded. However, this is not a representative sample of fishermen. The more lobster trips a fisherman makes, the greater the chance that at least one trip ticket will be invalid such that

[24] In app. C, I vary the criteria used to define the relevant population. Estimates are qualitatively similar across specifications. Refer to app. C for results.

[25] This is primarily due to the fact that the stone crab and kingfish fisheries—the two fisheries in which lobster fishermen most frequently participate—are closed during this period.

[26] By and large, trip tickets that record "days" record a single day at sea. Multiday trips are rare.

when fishermen with incomplete hours records are dropped, this disproportionately affects fishermen who have made a large number of trips.

While it is fairly clear on which days each fisherman chose to participate, it is less clear on which days they are able to participate in the sense that fishing for lobsters is justly in their choice set. Because fishermen must drop traps before they can fish and must remove traps from the ocean before the end of the season, and because it is unlikely for a commercial fisherman to make a trip but have no catch to sell, it seems unlikely that fishing for lobsters is a viable daily option during seasons with zero observed trips. For this reason, I drop all fisherman-season pairs for which no lobster trips are observed. Left to determine is when a fisherman enters the fishery each season and (if and) when a fisherman exits. For this, I construct several different participation rules. Because results are robust to variations in these rules, I discuss what I believe to be the most reasonable rule here and leave discussion of the rest to appendix B. Here, I assume all fishermen enter the fishery on the first day of the season. Anecdotally, this is the norm. However, I do apply an exit rule that posits that fishermen exit the fishery immediately after their last observed trip over the full season. This rule assumes that fishermen do, in fact, have catch to sell on their last trip and that once traps are removed from the ocean, fishermen do not consider re-dropping them, which seems quite reasonable.

Table 1 describes sample sizes and presents summary statistics of key variables. Complete summary statistics are provided in appendix B. To generate these statistics, I first calculate participation rates, average daily hours, and average hourly earnings for each open season day in the sample. I then take a weighted average across all days sharing the same characteristic, where daily values are weighted by the number of fishermen participating that day. In the Incomplete Hours Records sample, there are 965 fishermen and 840 open season days. On average, 26% of active fishermen participate on any given day, and fishermen work roughly 8-hour days and earn $165 per hour.[27]

Key identifying assumptions of the model are (i) that preferences for fishing differ by day-of-week and on days preceding hurricane activity, while earnings do not, and (ii) that earnings vary with the lunar phase, while preferences for fishing do not (except through earnings). Table 1 provides evidence for the relevance of these assumptions. Panel A clearly displays

[27] According to a 2001 survey of predominantly full-time lobster fishermen, individuals fish, on average, 4.2 days per week, which corresponds to a participation rate of 60% (Shivlani et al. 2004). Similarly, the personal logbook of one full-time commercial lobster trapper suggests a participation rate of roughly 50% during the first 2.5 months of the 2007–8 lobster season. Given this information, 50%–60%, and not 100%, should be thought of as a typical participation rate for a full-time fisherman. The lower participation rates shown in table 1 reflect the fact that many of the fishermen in the sample are not full-time fishermen.

Table 1
Summary Statistics on Participation, Hours, and Earnings

	Incomplete Hours Records		Complete Hours Records	
Variable	Mean	SD	Mean	SD
	Panel A: Daily Participation Rates			
All days	.261	.114	.236	.104
Weekdays	.287	.109	.255	.100
Saturdays	.244	.100	.232	.097
Sundays	.152	.082	.147	.079
Hurricane (prep)	.079	.058	.067	.055
Week of full moon	.238	.104	.213	.092
Week of new moon	.291	.123	.266	.112
	Panel B: Average Hours at Sea			
All days	8.144	.322	8.079	.421
Weekdays	8.175	.301	8.119	.401
Saturdays	8.040	.316	7.965	.401
Sundays	8.020	.441	7.911	.535
Hurricane (prep)	8.132	.586	8.081	.761
Week of full moon	8.081	.322	8.022	.419
Week of new moon	8.209	.314	8.139	.415
	Panel C: Average Hourly Earnings			
All days	165.27	52.46	161.23	54.58
Weekdays	165.33	51.68	161.20	53.71
Saturdays	160.98	50.82	158.11	55.09
Sundays	171.45	60.93	166.39	60.57
Hurricane (prep)	183.52	77.34	159.63	53.30
Week of full moon	147.33	47.34	144.78	51.55
Week of new moon	185.08	49.99	180.64	51.89
	Panel D: Sample Size			
Fishermen in sample	965		804	
Active fishermen on a given day	365.91	49.48	203.03	21.01
Open season days in sample	840		840	
Total lobster trips made	78,914		39,825	
Total choice occasions	301,924		168,707	

NOTE.—Incomplete and Complete Hours Records samples are described in Sec. IV. For each open season day in the sample, I calculate the participation rate (defined as the number of participating fishermen divided by the number of active fishermen), average hours at sea, and average hourly earnings. Mean"reports weighted averages of these statistics across all days sharing the same characteristic, where daily values are weighted by the number of fishermen participating that day. To illustrate how labor supply and earnings vary with the moon cycle, I classify days as "week of full moon" if they are within 3 days of the full moon and "week of new moon" if they are within 3 days of the new moon.

day-of-week and hurricane activity effects on participation. Roughly 15% and 50% fewer fishermen participate on Saturdays and Sundays, respectively, relative to weekdays, and 70% fewer fishermen participate on days preceding hurricane activity relative to typical days. The pattern for daily hours, shown in panel B, is similar to that of daily participation, but the variation is much less dramatic. Panel C shows a strong effect of the moon phase on earnings. Average hourly earnings are roughly 25% greater on new moon days compared to full moon days. Note that variation in labor supply with the moon phase and variation in observed earnings with day-of-week and hurricane activity is not indicative of failure of the identifying assumptions. Refer to appendix B for a more thorough discussion of these and other relationships between observables and labor supply and earnings.

V. Empirical Results

A. Individual-Level Model of Labor Supply

I estimate the individual-level empirical model of labor supply on 16 different samples.[28] Because results are very similar across samples, in table 2, I present results for the two samples that are created by applying the participation rule described in Section IV to both the Incomplete and Complete Hours Records samples and refer the reader to appendix C for complete results. In addition to the variables listed, all regressions include year indicators and a complete set of fisherman fixed effects. Standard errors are clustered at the calendar date level to allow for random, unobserved daily shocks common to all fishermen. However, standard errors in columns 2, 3, 5, and 6 are not adjusted to account for the fact that equations (1) and (2) include the generated regressor, $\widehat{\ln W_{it}}$ (see Pagan 1984). As in Miles (1997) and Benito (2006), it seems very unlikely that this correction would cause the parameter estimates to become insignificant. Given the similarity of results across the Incomplete and Complete Hours Records samples, I focus my discussion below on the former.

Columns labeled "Equation (3)" present estimates of the selectivity-corrected log hourly earnings equation. Virtually all of the coefficients obtain the predicted sign: earnings decrease as the season progresses; earnings are negatively affected by wind speeds above 8.3 meters/second (or roughly 19 miles per hour), and this effect increases at an increasing rate as wind speeds grow; earnings are higher immediately following strong winds; and earnings significantly decrease as the moon transitions from new to full. Importantly, this last result suggests that the moon phase is, in fact, a relevant instrument for earnings. Panel B reports tests of self-selection bias in observed earnings. The size and significance of the estimated correlation between the errors in the earnings equation and reduced form participation equation, $\hat{\rho}$, and the size of the p-value from a likelihood ratio test of independence between the two equations suggest weak evidence of positive selection.

[28] These samples are created by varying the criteria used to define the relevant population and by varying the participation rule applied. Details are provided in app. B.

Table 2

Estimates of the Selectivity-Corrected Log Earnings Equation (Eq. 3), the Selectivity-Corrected Log Hours Equation (Eq. 1), and the Structural Probit Model of Daily Participation (Eq. 2)

Variable	Incomplete Hours Records			Complete Hours Records		
	Equation (3)	Equation (1)	Equation (2)	Equation (3)	Equation (1)	Equation (2)
	Panel A: Coefficient Estimates and Standard Errors					
$\widehat{\ln(\text{hourly earnings})}$		.063***	.810***		.064***	.835***
		(.011)	(.087)		(.014)	(.091)
September	−.143***	.000	−.059***	−.114***	−.001	−.045**
	(.012)	(.003)	(.021)	(.013)	(.003)	(.021)
October	−.215***	−.016***	−.141***	−.172***	−.013**	−.138***
	(.018)	(.004)	(.031)	(.018)	(.005)	(.031)
Saturday		−.018	−.161***		−.022	−.121**
		(.018)	(.041)		(.030)	(.057)
Sunday		−.067***	−.488***		−.086***	−.360***
		(.023)	(.057)		(.033)	(.064)
Age × Saturday		.016	.035		.019	.061
		(.019)	(.036)		(.030)	(.054)
Age × Sunday		.052**	−.013		.070**	−.054
		(.023)	(.054)		(.034)	(.062)
Wind speed^2	.012	−.006***	.049***	.006	−.005**	.043***
	(.008)	(.002)	(.014)	(.009)	(.002)	(.015)
Wind speed^2	−.001*	.000	−.011***	−.001	.000	−.011***
	(.001)	(.000)	(.001)	(.001)	(.000)	(.001)
Lagged wind speed	.028***	−.000	.014	.034***	−.001	.016
	(.007)	(.001)	(.011)	(.008)	(.002)	(.012)

Lagged wind speed^2	−.000	.000	.000	−.001	.000	.000
	(.001)	(.000)	(.001)	(.001)	(.000)	(.001)
Moon phase	−.308***			−.310***		
	(.017)			(.018)		
Hurricane (prep)		−.034*	−.612***		−.026	−.645***
		(.018)	(.095)		(.022)	(.106)
Hurricane (land)	−.015	−.008	−.814***	−.062	.020	−.770***
	(.074)	(.016)	(.182)	(.073)	(.013)	(.172)
Hurricane (post)	.085	.000	−.311*	.151*	−.012	−.370**
	(.074)	(.011)	(.173)	(.088)	(.014)	(.173)
Precipitation	.026***	−.004	−.045***	.019**	−.007**	−.026
	(.009)	(.003)	(.015)	(.010)	(.003)	(.016)
Unemployment	−.023	−.001	.064	.000	−.013	.047
	(.027)	(.009)	(.041)	(.028)	(.012)	(.042)
	Panel B: Test of Selection into Participation					
ρ	.029	.000		.030	.001	
	(.023)	(.001)		(.028)	(.001)	
Likelihood-ratio test p-value	.203	.818		.278	.431	
	Panel C: Wage Elasticities					
Elasticity[a]		.063***	1.101***		.064***	1.191***
		(.011)	(.118)		(.014)	(.130)
Observations	78,914	78,914	301,916	39,825	39,825	168,698
Log likelihood	−223,790	−146,205	−147,037	−115,920	−76,506	−78,283

NOTE.—All regressions include year indicators and a complete set of fisherman fixed effects, and in all regressions these sets of variables are highly jointly significant. Standard errors are clustered at the day level and are presented in parentheses below the point estimates.

[a] Elasticities are evaluated at covariate sample means.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Estimates of the structural probit model for participation are shown in columns labeled "Equation (2)." Again, essentially all coefficients obtain the predicted sign. Fishermen are less likely to participate as the season progresses and on weekends, particularly on Sunday. The probability of participating decreases once wind speed exceeds 4.5 meters/second (roughly 10 miles per hour), and this effect increases at an increasing rate as wind speeds grow. Fishermen are less likely to participate on days surrounding hurricane activity and on rainy days. Of primary interest is the effect of predicted log hourly earnings on participation, which is identified by the exclusion of the moon phase. The coefficient on earnings is both positive and highly significant in all samples. The elasticity of a wage change on the probability of participating, shown in panel C, is roughly 1.1–1.2 and is always highly significant.[29] Finally, the set of variables excluded from the earnings equation—Saturday, Sunday, weekend-age interactions, and the hurricane preparation indicator—are jointly significant.

Columns labeled "Equation (1)" present estimates of the selectivity-corrected log hours equation. The coefficient on predicted earnings measures the wage elasticity of hours worked and is again identified by the exclusion of the moon phase. While the elasticity is positive and statistically significant, it is much smaller in magnitude than the participation elasticity, suggesting that trappers do not vary their hours worked much in response to changes in expected hourly earnings. The estimated elasticity suggests that a 1% increase in hourly earnings would lead to a 0.063% increase in hours worked. Given mean earnings of $165/hour and mean hours worked of 8.1 hours, this translates to a 4-minute increase in time spent fishing in response to a $20/hour increase in earnings. This contrasts with roughly a 13% increase in the probability of participating in response to the same increase in earnings. In general, hours worked is less influenced by the explanatory variables. While coefficient signs are roughly the same as in the participation model, magnitudes and significance are much smaller. Unlike with observed earnings, self-selection does not appear to be an issue in observed hours. The estimated correlation between errors, $\hat{\rho}$, is extremely small and insignificant and, given the p-value of the likelihood ratio test for independence, the null hypothesis that the reduced form participation equation and the hours worked equation are independent of one another cannot be rejected.

Self-selection bias is identified by the exclusion of weekend indicators, weekend-age interactions, and the hurricane preparation indicator from the earnings equation. To test the validity of these exclusion restrictions, I

[29] Wage elasticities are evaluated at the sample means of the covariates. The sample means of the estimated elasticity for each fisherman are roughly the same and are not presented here.

estimate two additional specifications of the model.[30] In the first, I relax the assumption that earnings are unaffected by the onset of hurricanes and exclude only Saturday, Sunday, and weekend-age interactions from the earnings equation. The coefficient on the hurricane preparation indicator is both small (−.036) and statistically insignificant, yielding a chi-squared statistic of 0.34. In the second, I relax the assumption that earnings are constant across days of the week and exclude only weekend-age interactions and the hurricane preparation indicator from the earnings equation. Saturday and Sunday coefficients are both small (.001 and .005, respectively) and individually and jointly insignificant, yielding a joint chi-squared statistic of 0.06. Furthermore, elasticity estimates are virtually identical across all three specifications. These findings support the validity of the exclusion restrictions.

1. *The Role of Fixed Costs*

The high fixed costs associated with daily participation, which include crew, fuel, and time, mean that it is likely optimal to work fewer long-hour days rather than many short-hour days. If so, this puts a lower bound on the number of hours a fisherman will choose to work. On the other hand, fishermen are only permitted to pull traps during daylight hours. This puts an upper bound on the number of hours a fisherman is able to work. The combination of these forces may be the reason for observing low between-day variation in hours and a small hours elasticity. The fixed costs faced by fishermen on a daily basis are likely larger than the fixed costs faced by a typical worker. If so, it may be the case that in other industries in which the fixed cost component to working is smaller, the hours elasticity may be larger. Still, given that virtually all workers face daily fixed costs, it is reasonable to conjecture that, in industries in which workers can vary both daily participation and daily hours, workers may be more flexible at the extensive margin.

2. *Heterogeneity*

In addition to time-invariant differences in hours worked and the propensity to participate, fishermen may differ in how they respond to variables conditioning labor supply. In particular, Camerer et al. (1997) posits that an individual's level of experience may affect how they respond to temporary variations in the wage. If workers learn over time that working more on high-wage days and less on low-wage days increases both income and leisure, then wage elasticities may become larger with experience. To test this hypothesis, the authors split their sample into high-experience and

[30] The relevance of these instruments is supported by high joint significance in the reduced form probit model for participation (not reported here).

low-experience drivers and reestimate their model separately for each group. In two out of three samples, they find that less experienced drivers have significantly smaller wage elasticities.[31] I conduct a similar analysis (described in app. D), but I find no consistent evidence that fishermen respond differentially to temporary variations in the wage conditional on experience levels. Furthermore, elasticity confidence intervals (CIs) for high-experience and low-experience groups typically overlap, suggesting very little difference between the two groups.

While experience is not the only attribute over which fishermen may differ in their labor supply responses, I have little non–labor supply–related information on fishermen with which to sort them into meaningful groups. However, given the number of fishermen that I observe and the length of time that I observe them, I can permit arbitrary heterogeneity in labor supply responses by estimating versions of equations (1)–(3) separately for each fisherman.[32] This exercise results in 575 individual hours elasticity estimates and 726 individual participation elasticity estimates.[33] To determine the level of heterogeneity present, I construct 95% CIs for each individual estimate and compare these with the 95% CI for the pooled estimate. CIs that do not overlap indicate statistically different elasticities. Using this measure, I find some heterogeneity in hours worked but very little in participation. Of the fishermen for whom I am able to estimate an elasticity, 74% have hours elasticity CIs that overlap with the pooled CI and 90% have participation elasticity CIs that overlap. Still, 17% of hours elasticities (but less than 1% of participation elasticities) are negative and significant. These findings may be indicative of reference dependence for at least a subset of fishermen.[34]

B. Identifying the Effect of Self-Selection, Measurement Error, and Endogeneity on the Estimated Wage Elasticity of Daily Hours Worked

In table 3, I consider how measurement error in the wage, endogeneity of the wage, and self-selection in observed wages and hours affect hours elasticity estimates. I do this by estimating five versions of equation (1) that control for each of these econometric issues one at a time. For details on each specification, refer to Section III.B. The results are clear: measurement

[31] However, this result may hinge on the behavior of a single low-experience driver (Farber 2005).

[32] Models are estimated on the fishermen and observations in the Incomplete Hours Records sample under the participation rule described in Sec. IV. Doran (2013) performs a similar individual-level analysis using data on New York City taxi drivers.

[33] For a variety of reasons, including multicollinearity and nonconvergence, models for some fishermen could not be estimated.

[34] More detail and results are presented in app. D.

Table 3
The Effect of Self-Selection, Measurement Error, and Endogeneity on the Estimated Wage Elasticity of Daily Hours Worked

Coefficient of Variation (cv)	Model 1	Model 2	Model 3	Model 4	Model 5	No. of Fishers	No. of Trips Taken
All	−.010***	.034***	.064***	.062***	.063***	965	78,914
	(.002)	(.006)	(.011)	(.011)	(.011)		
$cv \geq .15$	−.018***	.033***	.077***	.077***	.079***	656	49,842
	(.003)	(.008)	(.017)	(.017)	(.017)		
$cv \geq .25$	−.075***	−.039**	.117**	.114**	.134***	321	12,645
	(.007)	(.018)	(.049)	(.045)	(.045)		
$cv \geq .35$	−.202***	−.178***	.216	.224	.251*	191	3,558
	(.013)	(.025)	(.155)	(.140)	(.135)		

NOTE.—Each cell reports the estimated wage elasticity of hours worked and the associated standard error for a particular version of eq. (1). Additional regressors are discussed in Sec. III. In model 1, observed earnings are used as a metric for W_{it}, which is directly comparable to the first specification presented in Camerer et al. (1997). Model 5 corresponds to the model discussed in Sec. III.A, which controls for self-selection, measurement error, and endogeneity. Refer to Sec. III.B for a complete discussion of these specifications. Standard errors, presented in parentheses, are clustered at the calendar date level.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

error and endogeneity of the wage, which are controlled for in model 3 but not in model 1, pose serious econometric problems in this setting. When these issues are not controlled for, the opposite conclusion is reached, namely, that fishermen work more when earnings are low.

One difference between the lobster fishery studied here and the taxicab industry studied in Camerer et al. (1997) and elsewhere is that fishermen appear to vary their hours less on a day-to-day basis than do taxi drivers. For example, regressing daily hours worked on a set of fisherman-fixed effects yields an R^2 of 0.53, whereas Farber (2005) reports an R^2 of 0.181 for the same regression on taxi drivers. To investigate how models perform on a sample of fishermen with greater variation in hours, for each fisherman, I calculate the coefficient of variation (cv) of hours worked and create subsamples that include only fishermen with cv's greater than some minimum threshold. Elasticity estimates for fishermen for whom $cv \geq 0.15$, $cv \geq 0.25$, and $cv \geq 0.35$ are shown in rows 2, 3, and 4, respectively. The more variation in the left-hand-side variable, the greater the negative bias generated by model 1 and the more disparate models 1 and 5 become in terms of the estimated elasticity.

It is worth noting that, while model 1 does a poor job estimating the wage elasticity of hours worked and leads to the wrong conclusion about labor supply, the negative coefficient shown in row 4 is still roughly a fifth of the size of the estimates reported in Camerer et al. (1997). There are a couple of possible explanations for this. First, the associated "correct" elasticity is still relatively small (0.251) and is of the same magnitude in absolute value as the "incorrect" elasticity (−0.202). It is reasonably possible that in an industry in which workers optimally choose to vary their hours more in response to wage changes, both estimated elasticities would be larger in absolute value. This is supported by the fact that larger positive elasticities are associated with larger negative elasticities in table 3. And, given industry characteristics and summary statistics, it seems likely that cab drivers do vary their hours more than fishermen. Second, given the fact that earnings in the taxi industry are almost certainly affected by aggregate participation, while this is unlikely to be true in the lobster fishery, endogeneity of the wage is likely to play a much larger role in analyses of taxi driver behavior. Had endogeneity been more of an issue in this industry, the estimates for model 1 may well have been much more negative.

C. Identifying the Effect of Measurement Error and Endogeneity on the Estimated Wage Elasticity of Participation

Table 4 summarizes results of the aggregate model of labor supply. The first two columns report results for aggregate participation, while the last two report results for aggregate hours. The coefficient on the log of average hourly earnings provides an estimate of the wage elasticity of participation and the wage elasticity of overall labor supply, respectively. For each specification of labor supply, I estimate equation (4) both by OLS, in which observed average hourly earnings are used, and by 2SLS, in which daily earnings are instrumented with the moon phase (eq. [5]). Comparing elasticity estimates of these two estimators illustrates the extent of the bias introduced by measurement error and endogeneity of the wage in the estimation of the elasticity of participation. The results suggest, again, that ignoring these issues leads to downward biased estimates of labor supply elasticities, the same conclusion drawn in Oettinger (1999).

Comparing elasticity estimates across labor supply specifications (col. 2 vs. col. 4) provides another measure of the relative size of the daily participation and daily hours responses. The difference between the two estimates (0.084) suggests that more than 90% of the labor supply response to earnings is due to movement at the extensive margin.

Table 4
Estimates of the Aggregate Model of Labor Supply

	Aggregate Participation		Aggregate Hours	
Variable	OLS	2SLS	OLS	2SLS
Log of average hourly earnings	.609***	.838***	.662***	.922***
	(.065)	(.138)	(.066)	(.142)
R^2	.78	.78	.78	.77

NOTE.—Number of observations = 836. Here, observations refers to the number of days in the sample on which at least one fisherman participated in the lobster fishery. Refer to Sec. III.C for a list of regressors. Robust standard errors are presented in parentheses below point estimates.
*** Significant at the 1% level.

VI. Conclusion

This paper estimates the wage elasticity of labor supply at both the intensive (daily hours) and extensive (daily participation) margins using daily labor supply data from the Florida spiny lobster trap fishery. I invariably find that fishermen work more when earnings are temporarily high, behavior that is consistent with intertemporal substitution. Specifically, the wage elasticity of participation is quite large and very significant, ranging from 1.05 to 1.26. While positive and significant, the wage elasticity of hours is much smaller, ranging from 0.062 to 0.066. If reference dependence plays a role in fishermen's labor supply decisions, the propensity to set daily hours based on income or hours targets is not strong enough to erode the propensity to intertemporally substitute leisure for labor when the wage is temporarily high. Furthermore, empirical methods that do not control for measurement error and endogeneity of the wage lead to downward biased estimates of labor supply elasticities and, in the case of daily hours, actually produce spurious negative and significant elasticities. These results highlight the importance of controlling for these issues in studies of labor supply.

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