North American Journal of Fisheries Management

ISSN: 0275-5947 (Print) 1548-8675 (Online) Journal homepage: http://www.tandfonline.com/loi/ujfm20

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North American Journal of Fisheries Management 32:1017–1031, 2012
American Fisheries Society 2012
ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1080/02755947.2012.707633

ARTICLE

Examining Bargaining Power in the Northeast Multispecies Days-at-Sea Market

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Abstract
The Northeast U.S. groundfish fishery is economically large and culturally important. Between 2004 and 2009, the primary management control used in this fishery was a tradable input allowance system known as Days at Sea (DAS); however, many regulatory institutions limited trading. These barriers included a set of "conservation equivalency" restrictions based on length and horsepower that were explicitly designed to restrain increases in the fishing power of the fleet. Despite these limitations, trade in the DAS market was fairly robust; by 2008, over 40% of all used DAS were traded. This research uses ordinary least squares and quantile regression to examine the effects of these institutional limitations on the bargaining power of traders in this market. The conservation equivalency restrictions adversely impacted the bargaining power of both small sellers and large buyers of DAS. Despite these bargaining power effects, prices were responsive to changes in aggregate supply and productivity in economically reasonable ways. Finally, the downward intrayear trend in price is consistent with decay in the time value component of financial options.

The Northeast U.S. groundfish fishery is an economically and culturally important fishery in New England; annual revenues have recently fluctuated between US$75 and 85 million. Since 1996, this fishery has been managed using the Days-at-Sea (DAS) input allowance system, and trading of DAS began in 2004. The market for DAS is characterized by large variation in prices and systematic intrayear downward trends in price. Because input allowances cannot perfectly control output, many limitations on permissible trades were implemented in order to avoid overfishing, rebuild depleted stocks of fish, and encourage fleet diversity. This research examines the transactions in the DAS market that occurred from 2004 to 2008 from a bilateral bargaining perspective to determine the impacts of these market institutions on bargaining power. This approach is appropriate when there are few participants in a market and those parties attempt to exert market power over the price of a good. In the bargaining model, the buyer and seller first allocate DAS to maximize the joint gains from trade, then split those gains using price (Blair et al. 1989). Bilateral bargaining models have recently been used in hedonic analyses of house prices; to identify the effects of bargaining power in the presence of a particular type of misspecification, researchers assume that identical parties have equal bargaining power (Harding et al. 2003; Ihlanfeldt and Mayock 2009). Because DAS have a precise legal definition and no unobservable characteristics, the assumption of equal bargaining power made by other researchers is not required and can be examined. Limitations on trade based on vessel length and horsepower were explicitly used by managers to limit increases in fishing power. This research finds evidence that vessel length has asymmetric effects on the bargaining power of buyers and sellers. In addition, there is also weaker evidence that vessel horsepower leads to asymmetric bargaining power; this effect is only seen for trades which occur at relatively high prices.

In the northeastern United States, 13 species and 20 stocks of groundfish are managed jointly by the Northeast Fisheries Management Council (NEFMC) under the Northeast Multispecies Fishery Management Plan. At the end of 2009, 12 of these stocks were classified as overfished and overfishing was occurring in 8 of them (NMFS 2010). The fishing fleet uses a wide variety of fishing gear, including otter trawls, gill nets,

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Received June 21, 2011; accepted June 21, 2012
Published online October 3, 2012

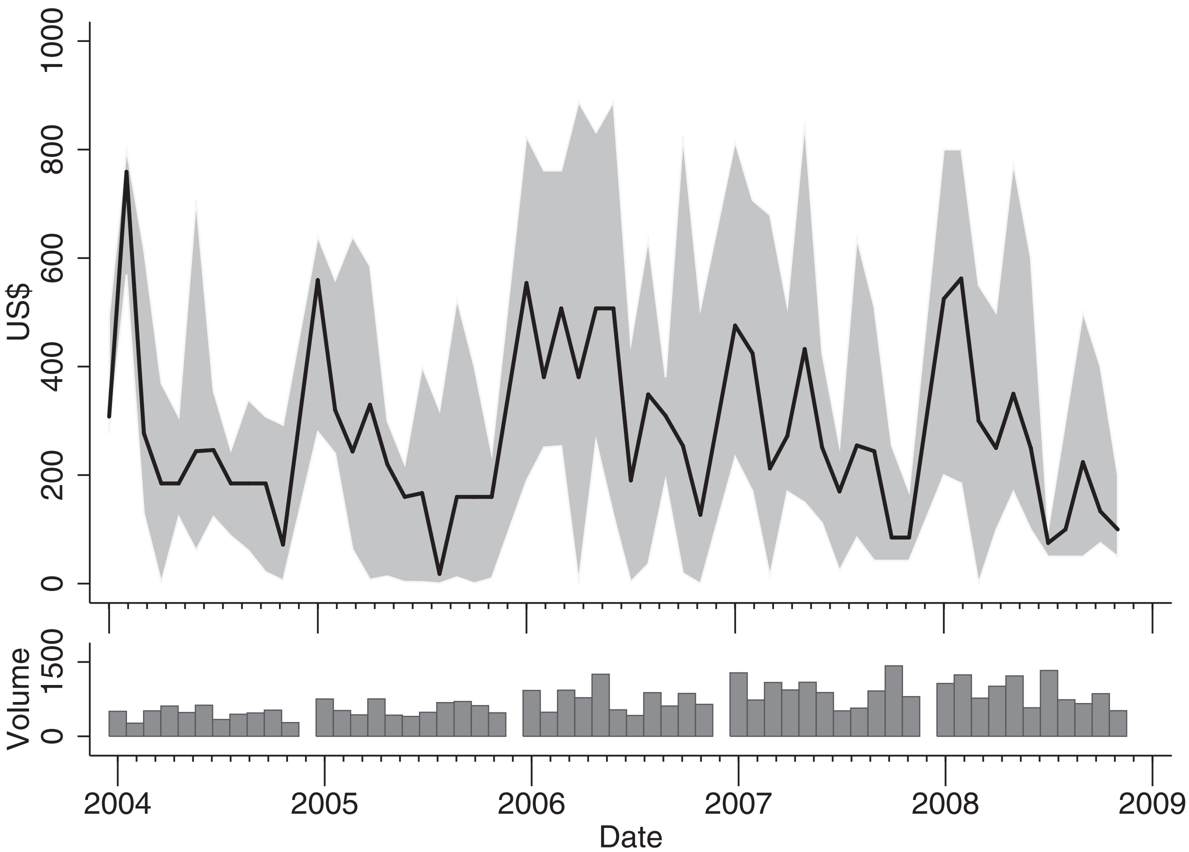

FIGURE 1. Median and interquartile range of real monthly Days-at-Sea price (upper panel) along with the volume of trades (lower panel). The fishing year begins on May 1, and trades are prohibited in the final month of the fishing year. The real price tends to decline during the fishing year, consistent with the decay in the time value component of options.

and hooks. The production technology in this fishery is known to be joint and multiproduct (Squires 1987; Kirkley and Strand 1988). The vessels which participate in the groundfish fishery frequently participate in other fisheries, including the sea scallop *Plactopecten magellanicus*, goosefish *Lophius americanus*, and American lobster *Homarus americanus* fisheries. During 2004–2008, the fishery was also managed with a combination of trip limits, permanent and rolling area closures, minimum mesh sizes, and minimum fish sizes which were designed to achieve a target total allowable catch.

Under the DAS system, fishing vessels are given a yearly allocation of fishing days based on historical patterns of use (for regulatory purposes, the fishing year begins on May 1). Since the DAS program started in 1996, substantial reductions from the initial aggregate allocation of approximately 236,000 DAS have been made. By 2004, when DAS trading began, aggregate DAS available for targeting groundfish had been reduced to approximately 44,000 (U.S. Office of the Federal Register 2004). These trades are technically leases, in which DAS are transferred for a single fishing year. While permanent transfer of DAS is allowed, this occurs infrequently and is not examined in this research. The market for DAS is characterized by large variation in prices and systematic intrayear downward trends in price (Figure 1). Interpretation of this magnitude of price dispersion is difficult; Newell et al. (2005) also found similar levels of price dispersion in the New Zealand individual transferable quota market and noted that this may be driven by unobservable attributes of transactions, such as the exertion of bargaining power or transactions costs. The downward intrayear trend in Figure 1 is consistent with the decay of the time-value component of financial options.

With approximately 1,000 possible participants in the DAS market, the exertion of market power does not seem likely or even possible. However, "conservation equivalency" restrictions and other regulatory limitations are likely to have segmented the DAS market into many smaller markets. The conservation equivalency restrictions state that

> [a] Lessor only may lease DAS to a Lessee vessel with a baseline main engine horsepower rating no greater than 20 percent of the baseline engine horsepower of the Lessor vessel. A Lessor vessel only may lease DAS to a Lessee vessel with a baseline length overall that is no greater than 10 percent of the baseline length overall of the Lessor vessel. (U.S. Office of the Federal Register 2004).

This limitation on trade was designed to prevent effort from shifting to larger, more powerful vessels with higher catch rates and to promote fleet diversity. Because of these trade restrictions, certain vessels may have few feasible trading partners. For example, the largest vessels may purchase DAS from only a small number of counterparties, which is likely to place those vessels at a relative disadvantage in the bargaining process. Similarly, the smallest vessels may purchase DAS from almost any sellers and may be at a relative advantage. The conservation equivalency restriction is one of the drawbacks of using an input-based tradable control instead of an output-based tradable control to manage a heterogeneous fishery: management regulations must be designed to account for increased efficiency and in some cases explicitly prevent efficiency gains.

In addition to the conservation equivalency restrictions, there are at least three other distinctive features of this market. First, there is no a centralized market at which buyers and sellers congregate and trade at publicly posted prices. Although the prices and quantities of trades must be reported to the National Marine Fisheries Service (NMFS), neither are publicly available, potentially limiting the price discovery and market equilibration processes (Anderson 2004). Trading partners are found by word of mouth, by advertisements in trade publications, or through brokers who match buyers with sellers. Second, an upper limit on the total number of DAS that a vessel can hold was imposed. This limit was based on historical allocations; it may also constrain the maximum number of days fished by some vessels. Third, subleasing of DAS is prohibited. This provision reduces the administrative burden of the trading program and limits the ability of vessels to engage in a sequence of trades which successively transfer DAS from smaller to much larger or more powerful vessels. However, this regulation eliminates speculation and some market-making activities, possibly reducing market performance.

As a tradable input allowance with an expiration date at the end of the fishing year, a DAS is similar to a financial call option. A fishing vessel which owns DAS has the right, but not the obligation, to fish for groundfish. The value of this option can be decomposed into a time-value component and an intrinsic-value component (Black and Scholes 1973). The time-value component declines to zero at the end of the fishing year, while the intrinsic component is related to vessel profitability. Beginning with the 2004 fishing year, a limited amount of banking was allowed. Under this provision, a vessel may carry over up to 10 unused DAS to the subsequent fishing year. Additional DAS expire at the end of the fishing year. Fishing vessels must maintain a positive balance of DAS in order to legally fish.

In 2006, there were two changes to fishery policy regarding DAS, one temporary and one permanent. The NEFMC desired lower fishing mortality during the 2006 fishing year. However, the regulatory process necessary to effect this change could not be completed by the beginning of the fishing year. For approximately 6 months, the fishery operated under an Emergency Action and fishing for groundfish required 1.4 DAS for each day spent fishing (except for trips occurring in the US–Canada resource-sharing area, which continued to be charged DAS at a 1:1 ratio). This was a temporary regulation designed to reduce catch while the regulatory process was being fulfilled. Vessels operators had no opportunity to act strategically prior to this regulatory change, and the 1.4:1 ratio was not likely to have been anticipated by fishermen.

The permanent change to groundfish policy was titled Framework Adjustment 42 and was implemented on November 22, 2006. This regulation created differential DAS areas with heterogeneous costs of access. Vessels that used the differential DAS areas were charged at a rate of 2 DAS for each day fished. Fishing in other zones was charged at the normal rate of 1 DAS per day fished. While fishing vessels are mobile and may be able to switch fishing locations, there are limits to this mobility. Vessels may not have the required speed or size required to fish farther offshore, gear may be suitable only in certain fishing areas, and crew many not have the knowledge required to effectively utilize unfamiliar fishing areas. Both of these regulatory actions may be interpreted as negative shocks to the productivity of DAS for a subset of the fishing fleet. The permanent changes to the DAS regulations were subject to extensive public notice and were known by most, if not all, fishermen. However, the timing of the implementation was not known until 1 month before the rule went into effect. While Georgianna and Kirkley (2009) found that a subset of fishing vessels substituted non-DAS activities during the Emergency Action period, aggregate usage suggests that there were minimal differences in fleet-level patterns of DAS usage after the change (Figure 2).

METHODS

Behavioral and Empirical Model

In a perfectly competitive market, firms would adjust their holdings of DAS until the marginal revenue from DAS was exactly equal to the price of DAS. If the price of DAS were always greater than the firm's marginal revenue, the firm would sell its entire allocation of DAS. Conversely, if the price of DAS were always less than the firm's marginal revenue, the firm would purchase as many DAS as possible. By reducing the feasible set of counterparties, the conservation equivalency restrictions may lead to noncompetitive markets in which parties bargain over the price of DAS. Nash (1950) shows that bargaining between optimizing individuals with full information and equal bargaining power will maximize the joint surplus relative to the noncooperative outcome. When the assumption of bargaining power equality is relaxed, bargaining still leads to the allocation which maximizes the joint surplus; however, the surplus is divided according to individual bargaining power (Blair et al. 1989). One type of economic analysis focuses on detecting the exertion of market power, frequently using industry level time series data; examples include Raper et al. (2000), Gervais and Devadoss (2006), and Mouchart and Vandresse (2007). In a fishery application, Matulich et al. (1995) found that the fishing

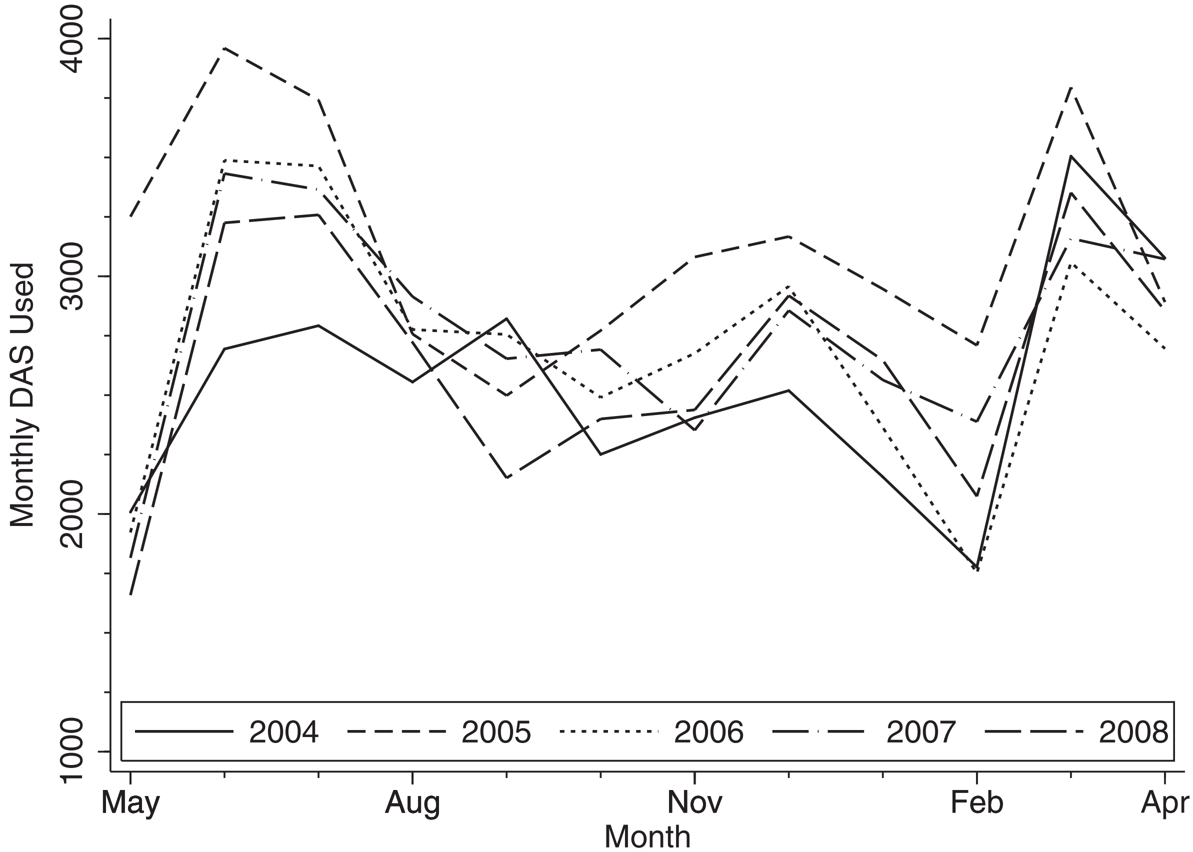

FIGURE 2. Aggregate monthly Days-at-Sea (DAS) usage for 2004–2008. The usage patterns are similar before and after the regulatory changes in 2006.

and processing sectors each attempt to exert market power and behave as monopolists (sole sellers) and monopsonists (sole buyers), respectively, in the Alaska red king crab *Paralithodes camtschaticus* fishery. Fell and Haynie (2011) found that the implementation of an individual fishing quota system increased the bargaining power of the fishing sector relative to that of the processing sector in the northwestern U.S. sablefish *Anoplopoma fimbria* fishery.

An alternative line of research attempts to identify the attributes of individuals which are associated with high or low levels of bargaining power. In models of household decision making, individuals with good alternatives are able to capture a proportionately larger share of household surplus (Manser and Brown 1980; McElroy and Horney 1981; Lundberg et al. 1997). Ayres and Siegelman (1995) and Harless and Hoffer (2002) linked the demographic characteristics of buyers to bargaining power in the automobile markets. Graddy (2006) found that Asian buyers of fish in the Fulton Fish Market paid lower prices than white buyers. Asian buyers may have had better information, more alternatives for fish sourcing, and more elastic demand by the final customer compared to white buyers. Examination of bargaining power has frequently been conducted in the hedonic valuation literature, beginning with Harding et al.'s (2003) bargaining model, which incorporates buyer and seller attributes in a hedonic pricing model for real estate. In the Harding et al. (2003) model, individuals agree to trade and then divide the trade surplus by means of price. The price is based on the relative bargaining strength of each party.

In DAS trading, the two parties in a trade have initial allocations of days at sea, DAS_0^b and DAS_0^s, where the superscripts indicate the buyer and seller, respectively. These initial allocations produce the payoffs $\Pi^b(DAS_0^b)$ and $\Pi^s(DAS_0^s)$, respectively, for the buyer and seller. These can be interpreted as the expected noncooperative payoffs resulting from using the initial allocations of DAS to fish, finding another trading partner, spending time in an alternative fishery, or some combination of those activities. The two parties then allocate DAS to maximize the joint surplus from bargaining for buyer and seller (Nash 1950), namely,

$$\Delta\Pi = \left[\Pi^b\left(DAS_1^b\right) - \Pi^b\left(DAS_0^b\right)\right] + \left[\Pi^s\left(DAS_1^s\right) - \Pi^s\left(DAS_0^s\right)\right]. \tag{1}$$

This trade surplus is divided according to relative bargaining power, which is derived from the next-best alternatives. Consider the prospective purchaser with no initial DAS. If a trade were not completed, this fishing vessel could search for another trading partner, spend time in fishing activities that do not require DAS, or not fish at all. The search process is not formally modeled; however, the ease of finding an alternative counterparty is related to the length and power of the vessel through the conservation equivalency restrictions. A large purchaser may have only a small number of potential counterparties. Similarly, a prospective seller in a transaction could search for another trading partner, fish for groundfish using DAS, spend time in alternative fisheries, or do nothing. A small prospective seller will also have very few feasible trading partners.

Harding et al. (2003) operationalizes the behavioral model for home prices by specifying a hedonic price equation which incorporates demographic characteristics of buyers and sellers, namely,

$$p_i = D_i^b b^b + D_i^s b^s + D_i^b d^b + D_i^s d^s + Z_i\gamma + \varepsilon_i, \tag{2}$$

where p_i is the price of good i; D_i^b and D_i^s are row vectors of the demographic characteristics of buyers and sellers respectively; b^b, b^s, d^b, d^s, and γ are column vectors of estimated coefficients; Z_i is a row vector of the observed characteristics of the traded good; and ε_i is an error term. The b terms capture shifts in prices due to bargaining power differences. In hedonic models, particularly models of real estate, it is likely that some variables have been omitted from the estimating equation. This will cause bias if the omitted variables are correlated with the independent variables. In a model of bargaining, it is likely that there are types of buyers or sellers who systematically prefer some of those unobserved characteristics. This self-selection is captured by the d terms in equation (2); however, equation (2) is underidentified and cannot be estimated without further restrictions. Harding et al. (2003) make two identifying restrictions: identical buyers and sellers have identical bargaining power ($b^b = -b^s = b$) and identical preferences for any omitted characteristics of the traded good ($d^b = d^s = d$). Equation 2 can then be written as

$$p_i = \left(D_i^b - D_i^s\right)b + \left(D_i^b + D_i^s\right)d + Z_i\gamma + \varepsilon_i. \tag{3}$$

Equation (3) augments the traditional hedonic price equation with vectors of sums and differences of demographic characteristics. The coefficient vector associated with the demographic differences (b) captures bargaining power effects. If buyers and sellers in a transaction have similar characteristics in the sample of trades, precise estimation of the b effects will be difficult because the differenced variable will contain little variation. The coefficient vector associated with the demographic sums (d) captures the effects of unobservable-good characteristics that are correlated with the characteristics of buyers and seller. This identification strategy has been frequently used to analyze price formation in real estate (Colwell and Munneke 2006; Ihlanfeldt and Mayock 2009).

An alternative estimation strategy, employed by Cotteleer et al. (2008), simply assumes that $d^b = d^s = 0$ in equation (2). Buyer and seller demographics can enter the estimating equation directly; however, the ability of this approach to estimate relevant structural coefficients hinges on either proper specification of the hedonic part of the estimating equation or the lack of correlation between any omitted characteristics and the included demographic characteristics, both of which are unlikely in the housing market.

While the identification assumptions of bargaining power equality and preference equality may be appropriate in the housing market, these are questionable in the DAS market. The conservation equivalency restrictions introduced asymmetries into the market; buyers and sellers with similar characteristics are not likely to have equal bargaining power because they have a different number of potential trading partners. However, the traded good in this research has a precise legal definition that is consistent across fishing vessels. That definition of DAS has changed slightly over time as regulations have changed, and the marginal product or intrinsic value of DAS certainly varies across vessels. However, there are no unobservable attributes of DAS. With no unobservable attributes, the d vectors in equation (2) must be zero and the price equation can therefore specified as

$$p_i = D_i^b b^b + D_i^s b^s + Z_i\gamma + \varepsilon_i. \tag{4}$$

This formulation allows the demographic characteristics of buyers and sellers to enter the price equation directly. These demographic characteristics include variables that are related to total trade surplus and variables that may alter the bargaining power of buyers and sellers. Variable Z_i includes transaction-specific variables which may shift price, such as the time remaining in the fishing year and policy variables. Equations (3) and (4) are typically estimated using ordinary least squares (OLS). Collecting all of the estimated coefficients into a single row vector, $\beta = (b^b, b^s, \gamma)$ and all independent variables into a column vector, $X_i = (D_i^b, D_i^s, Z_i)'$, the OLS optimization problem of minimizing the sum of squared residuals can be written as

$$\min_{\beta} \sum_{i=1}^{N} (p_i - X_i\beta)^2. \tag{5}$$

The estimated coefficients in this model are typically interpreted as the effects of marginal changes in independent variables on the conditional mean of price and are held constant.

Estimation of equation (4) using quantile regression can provide additional insight into the nature of the relationship between price and the independent variables. While the marginal effects of an independent variable are constant in the OLS model, quantile regression allows the marginal effects of the independent variables to vary across the distribution of the dependent variable (Koenker and Bassett 1978). This technique has become increasing popular in applied economics. Chamberlain (1994) found that union membership raises wages; however, the union wage premium is primarily found for low-wage workers and disappears for workers with wages in the upper quantiles. Manning

TABLE 1. Historical Days-at-Sea (DAS) allocation, usage, and trading patterns for 2004–2008. Carryover, in which up to 10 unused DAS may be utilized in subsequent-year fishing, was authorized in 2004. The values in the last column were normalized to 2008 dollars using the Bureau of Labor Statistics' Producer Price Index for unprocessed finfish.

Year	Allocated	Carryover	Used	Traded	Value of trades ($)
2004	44,635		30,060	6,192	2,590,182
2005	43,903	6,994	32,194	8,068	2,709,263
2006	40,807	7,618	32,399	11,245	3,279,149
2007	40,742	7,050	33,264	13,900	4,815,603
2008	40,931	6,236	31,701	13,996	4,494,270

et al. (1995) examine alcohol consumption and found that low and moderate consumers of alcohol are sensitive to price while heavy consumers are insensitive to price. Eide and Showalter (1998) found heterogeneity in the effects of expenditure and school length on student test scores.

Let $Q_\tau(p|D_i^b, D_i^s, Z_i)$ be the τth quantile of the distribution of the DAS price, which is conditional on the demographic characteristics of buyers and sellers and other price shifters. The conditional quantiles are modeled as

$$Q_\tau\left(p_i|D_i^b, D_i^s, Z_i\right) = b_\tau^b D_i^b + b_\tau^s D_i^s + Z_i\gamma_\tau. \tag{6}$$

For any $\tau \in (0, 1)$, the coefficient vector $\beta_\tau = \{b_\tau^b, b_\tau^s, \gamma_\tau\}$ can be estimated by minimizing an asymmetrically weighted sum of residuals, that is,

$$\min_{\beta_\tau} \frac{1}{N} \sum_{i=1}^{N} \rho_\tau(u_i), \tag{7}$$

where $u_i = p_i - X_i\beta_\tau$ and the function $\rho_\tau(u_i)$ is a residual weighting function defined as

$$\rho_\tau(u_i) = u_i(\tau - I(u_i < 0)).$$

$I(\cdot)$ is the indicator function which takes on the value 1 if $u < 0$ and 0 otherwise. The asymmetric weighting of residuals in $\rho_\tau(u)$ leads to positive residuals being weighted by τ and negative residuals being weighted by $\tau - 1$ in the optimization problem. Quantile regression retains most of the familiar properties of OLS but is more robust to outliers (Koenker 2005). Median regression is a special case of quantile regression in which $\tau = 0.5$ and $\rho_{0.5}(u) = \frac{u}{2}$ for positive u and $\rho_{0.5}(u) = \frac{-u}{2}$ for negative u. For median regression, the minimization problem in equation (7) can be equivalently expressed as

$$\min_{\beta_{0.5}} \frac{1}{n} \sum_{i=1}^{n} |p_i - X_i\beta_{0.5}|, \tag{8}$$

which is the Minimum Absolute Deviation or Least Absolute Error estimator. In the special case of median regression, the parameters can be interpreted as describing the marginal effect of the independent variables on the conditional median of the dependent variable. While OLS coefficients provide insight into the effect of each independent variable on the conditional mean, quantile regression describes the effect of each independent variable on the conditional quantile. In this application, the conservation equivalency restrictions may have segmented the market for DAS into many small markets, each with few participants. The bargaining power effects are likely to be most pronounced at both tails of the price distributions, and quantile regression is able to reveal those effects.

Data Used

The data used in this analysis are drawn from multiple sources maintained by the National Marine Fisheries Service, including DAS transaction reports, permit databases, and trip reports. The unit of observation in this analysis is a reported trade of DAS. For 2004–2008, allocated DAS declined slightly while carryover and used days remained roughly constant (Table 1). Over this period, there were 2,349 trades representing approximately 53,400 DAS worth $17.9 million; however, only 1,788 trades occurred at a nonzero price. The other 561 transactions may represent intracompany trades, protest responses, or profit-sharing arrangements. For all analysis, only the trades which occurred at nonzero prices were included. While aggregate DAS allocations have declined by approximately 8% during this period, both the volume of trade in the DAS market and the aggregate value of exchanged DAS have increased markedly. In 2008, over 40% of all used DAS were traded. Demographic characteristics for buyers and sellers, including length, horsepower, and number of limited-access permits held, was extracted from the NMFS databases of permit holders (Table 2). All economic data (prices and revenues) was deflated using the Bureau of Labor Statistics' Producer Price Index for unprocessed finfish with the base year set to 2008.

In order to verify that the effects of market size on bargaining power are related to the conservation equivalency trading restrictions, two counterparty variables based on length, horsepower, and the conservation equivalency restrictions were constructed. For a vessel of length l and horsepower h, the seller counterparty variable was constructed as the number of vessels with length $\leq 1.1 \cdot l$ and horsepower $\leq 1.2 \cdot h$. The buyer counterparty variable was constructed as the number of

TABLE 2. Summary statistics for transactions in the Days-at-Sea (DAS) leasing market ($N = 1{,}788$). Economic values were normalized to 2008 dollars using the Bureau of Labor Statistics' Producer Price Index for unprocessed finfish. All mean values of buyer and seller demographic variables are statistically different at the 1% confidence level except alternative revenue.

Transaction-level characteristics

Variable	Definition	Mean	SD
Price	Price per DAS ($)	360	521
Time remaining	Days remaining in fishing year	171	95.6

Individual-level characteristics

		Buyer		Seller	
Variable	Definition	Mean	SD	Mean	SD
Length	Vessel length (feet)	60.3	19.1	62.2	18.9
Counterparties	Number of vessels	433	275	626	268
Horsepower	Vessel horsepower	437	191	503	242
Revenue	Revenue per DAS (US$1,000s per day)	3.92	3.13	1.03	2.39
Alternative	Revenue per day fished, non-DAS trips (US$1,000s per day)	1.93	3.20	1.82	4.21
Permits	Number of limited-access permits	2.35	1.59	1.46	1.99
Experience	Number of times a vessel has traded in the DAS market	4.5	4.5	2.5	2.8
Trawl	Dummy variable = 1 if vessel uses trawl gear, = 0 otherwise	0.69	0.46	0.80	0.40
Differential	Fraction of revenues from differential DAS areas	0.458	0.439	0.149	0.332

vessels with length $\geq l/1.1$ and horsepower $\geq h/1.2$. These two counterparty variables are highly correlated with the length and horsepower variables (Table 3). Buyer length and horsepower are highly correlated, as are seller length and horsepower. The attributes of the parties involved in a transaction are also highly correlated; for example, the correlation coefficient for buyer length and seller length is 0.93. The high correlations between buyer and seller length and buyer and seller horsepower are consistent with "matching" in the market for DAS based on these attributes. The high levels of collinearity between some of the attributes leads to lower levels of precision for the estimated coefficients. An alternative formulation of the counterparty variables was also employed. In this formulation, the seller counterparty variable was constructed as the number of *active* sellers with length $\leq 1.1 \cdot l$ and horsepower $\leq 1.2 \cdot h$. The buyer counterparty variable was constructed as the number of *active* buyers with length $\leq l/1.1$ and horsepower $\leq h/1.2$.

Variables which measure the profitability of DAS and alternative fishing activities for buyers and sellers were constructed from trip report data. Fishing vessels in this fishery are required to file these reports, which include location, type of gear, and catch composition data. Vessels make decisions to buy or sell DAS based, in-part, on the marginal expected profitability of using DAS. Therefore, using a measure of marginal profitability in the estimating equation is theoretically preferable; however, cost data are unavailable on a trip-level basis. Revenues may be a reasonable approximation due to the system of labor compensation. In general, labor in this fishery is compensated using

TABLE 3. Selected one-way correlations. Price is positively correlated with buyer length and horsepower and negatively correlated with the number of counterparties. Price is positively correlated with seller length, horsepower, and the number of counterparties. Buyer length and horsepower have large, negative correlations with the number of counterparties, while seller length and horsepower have large, positive correlations with the number of counterparties. The length and horsepower of vessels engaged in a transaction are highly correlated.

		Buyer			Seller		
	Price	Length	Horsepower	Counterparties	Length	Horsepower	Counterparties
Price	1.00						
Buyer length	0.39	1.00					
Buyer horsepower	0.29	0.81	1.00				
Buyer counterparties	−0.36	−0.93	−0.84	1.00			
Seller length	0.35	0.93	0.79	−0.87	1.00		
Seller horsepower	0.25	0.71	0.83	−0.71	0.75	1.00	
Seller counterparties	0.34	0.90	0.79	−0.90	0.93	0.77	1.00

a share system (McConnell and Price 2006); the crew's share is a fraction of revenues minus a fraction of variable costs; the vessel owners, who own the DAS, receive the residual. Average revenue is likely to be a good approximation to marginal expected revenue. To measure the average revenues produced while using DAS, the annual revenues from trips which used DAS were divided by the yearly DAS used at the vessel level. The average revenue per DAS, lagged 1 year, was used as the measure of marginal profitability.

A variable to measure the revenues from alternative fishing activities was constructed using a similar method, that is, annual revenues from non-DAS trips were divided by days fished. It is important to note that these two measures of profitability are not directly comparable; a fishing day and a DAS are not necessarily equivalent. In addition to the revenue variables, the number of limited-access permits is included in this analysis to control for the opportunity costs of using DAS. Vessels with high alternative revenues and many limited-access permits have a relatively high opportunity cost using DAS; they have highly productive alternative fishing activities. Together, these variables are related to the trade surplus over which buyers and sellers bargain.

Because prices are not posted and the opportunities to learn about prices are limited, experience in the market was included as an explanatory variable. For each transaction, the buyer's and seller's experience is constructed as the number of times each party had previously participated in the DAS market. However, the expected effect of this variable is unclear: although frequent participants may have an informational advantage relative to infrequent participants, experience may reflect self-selection into the market due to particularly high or low expected profits from using DAS.

A dummy variable for the use of trawl gear is included in the model. Vessels that use trawl gear are typically larger and more powerful and catch more fish than vessels that use long-line, hand-line, or gill-net gear. This higher level of output is captured in the revenue variables; however, trawl vessels typically have higher operating expenses, mostly due to higher fuel usage. Although detailed variable cost information is not available at the vessel level, inclusion of a dummy variable for trawlers may capture the higher variable operating costs associated with this type of gear.

Two variables are used to capture the possible effects of the technological shock from the differential DAS regulations which were implemented with Framework 42. The fraction of annual revenues derived from trips in the differential DAS areas was constructed using locational data from landings reports and the boundaries of the differential DAS zones. This variable captures the relative importance of the differential DAS areas for each fishing vessel and was constructed for buyers and sellers in all trades, including those which occurred before Framework 42 was implemented. A dummy variable which takes on the value of 1 if the trade occurred after Framework 42 and 0 otherwise was also included. This variable also interacted with the differential DAS importance variable. Utilization of the differential DAS areas is expected to impact price or bargaining power after the adoption of the differential DAS counting regulations. The time-value component of DAS value is incorporated by using a variable which measures the number of days remaining in the fishing year at the time the trade is completed. Yearly dummy variables based on the fishing year are also included in the estimated model. These capture large-scale effects in the fishery, including the effect of the 1.4:1 DAS counting. In general, the vessels of the buyers of DAS were slightly shorter and had less horsepower than those of sellers (Table 2). Buyers also had higher revenues and more experience in the market, and were more likely to fish using trawl gear and in the differential DAS areas than were the sellers.

RESULTS

Three alternative specifications were estimated using OLS (Table 4). The first specification includes length and horsepower variables for the buyer and seller, the second specification adds the counterparty variables, and the third specification replaces the length and horsepower variables with the counterparty variables. Model fit and estimated parameters were nearly identical across specifications. The linear model fit by OLS explains a relatively small proportion of the variation in prices: the R^2 for the three specifications ranges from 0.188 to 0.201. The addition of the counterparty variables does not improve the model fit; this is likely due to the high collinearity between counterparties, length, and horsepower. With the exception of the buyer revenue coefficient, the point estimates and standard errors are very similar for all three specifications. Relatively few of the independent variables can significantly explain prices; this may be a result of high degrees collinearity between these variables. A final group of specifications using the alternative definitions of the counterparty variables produced qualitatively similar results.

The OLS point estimates imply that length increases bargaining power for sellers, the seller's alternative (non-DAS) revenues increase prices, and sellers that primarily use trawl gear receive lower prices. Consistent with the time-value component of DAS, trades which occur early in the year occur at higher prices than trades which occur near the end of the year. Somewhat surprisingly, the dummy variable for Framework 42 and the interactions with differential DAS use for both buyers and sellers do not explain prices; however, this may be a result of the collinearity of the independent variables. However, the 2006–2008 dummy variable coefficients are quite large in magnitude and could indicate a structural change in pricing corresponding to regulatory changes beginning in 2006. Finally, the negative coefficient for buyer counterparties in the third specification is consistent with the positive effect of buyer length in the other two specifications. Buyer length and horsepower are inversely related to the buyer counterparty variable used in the third specification; increases in counterparties should increase the buyer's bargaining power, driving down the price of DAS.

TABLE 4. Ordinary least-squares coefficients for three alternative specifications of equation (4) (see text). Coefficients which are different from zero at the 5% significance level are in bold italics. Standard errors are in parentheses and are robust to arbitrary heteroscedasticity; $N = 1{,}788$.

Independent variable	(1)	(2)	(3)
Buyer length	***10.44***	***9.865***	
	(1.406)	(1.461)	
Seller length	0.0846	1.016	
	(1.474)	(1.607)	
Buyer horsepower	−0.107	−0.153	
	(0.115)	(0.125)	
Seller horsepower	0.0127	0.0391	
	(0.0612)	(0.0666)	
Buyer counterparties		−0.101	***−0.384***
		(0.0918)	(0.0783)
Seller counterparties		−0.117	0.125
		(0.112)	(0.0933)
Buyer revenue	1.350	1.307	8.481
	(4.979)	(5.066)	(4.610)
Seller revenue	6.565	6.810	7.293
	(6.139)	(6.132)	(6.535)
Buyer alternative	2.814	2.960	2.911
	(3.192)	(3.227)	(3.265)
Seller alternative	***8.382***	***8.410***	***8.714***
	(2.008)	(2.036)	(1.966)
Buyer permits	24.67	24.13	26.05
	(14.08)	(13.76)	(13.82)
Seller permits	6.503	6.918	10.19
	(6.893)	(6.965)	(6.926)
Buyer experience	0.451	0.484	2.364
	(3.609)	(3.618)	(3.533)
Seller experience	−4.164	−3.679	−3.574
	(5.733)	(5.885)	(5.966)
Buyer trawl	12.92	14.80	49.34
	(33.70)	(33.66)	(33.81)
Seller trawl	***−88.09***	***−88.01***	−73.67
	(44.39)	(44.81)	(45.84)
Buyer differential	88.27	91.60	58.18
	(54.17)	(55.36)	(56.41)
Seller differential	−9.169	−7.999	−6.090
	(38.86)	(36.88)	(37.53)
Framework 42	11.64	13.14	24.89
	(61.31)	(60.73)	(61.91)
Framework 42 × buyer	−92.13	−91.81	−96.83
differential	(68.01)	(68.04)	(67.70)
Framework 42 × seller	70.82	68.66	68.46
differential	(73.82)	(74.04)	(73.93)
Time remaining	***0.356***	***0.359***	***0.381***
	(0.149)	(0.149)	(0.150)
D2005	−19.96	−22.21	−30.17
	(30.17)	(30.60)	(30.03)
D2006	***204.3***	***203.0***	***210.5***
	(47.06)	(47.03)	(47.96)
D2007	129.5	125.6	***141.3***
	(66.16)	(66.82)	(66.83)
D2008	***183.5***	***179.5***	***184.3***
	(68.65)	(69.91)	(69.95)
Constant	***−469.6***	***−371.6***	127.0
	(50.34)	(111.6)	(85.28)
R^2	0.201	0.201	0.188

The linear quantile regression model is estimated for the 10th through 90th price quantiles, at intervals of 5%, using the `quantreg` package in `R`, and standard errors are computed using 20,000 bootstrap replications (Table 5). The coefficients estimated from a specification using the alternative definition of the counterparty variables are qualitatively similar and for brevity are not presented. The model fit, as measured by Koenker and Machado's (1999) R^1 statistic, is very low at the lowest quantiles (just 0.018 at the 10th percentile) and increases at higher quantiles (0.399 at the 75th percentile). The model has very little explanatory power in the lower quantiles of the price distribution; there is also little variation in prices at these quantiles. While trades with zero-valued prices were removed from the data set, it is possible that the intrafirm transfers remain in the data set at low recorded prices. Visualization is the easiest way to interpret the results of quantile regression; a selection of the estimated coefficients are plotted as a function of τ, along with shaded 90% confidence bands. A dotted line representing the OLS coefficient estimate is also included for comparison. The graphs and associated coefficients can be interpreted as the marginal effect of an independent variable on price at a given quantile. A horizontal line for a set of coefficients implies that the marginal effect of the independent variable is constant; departures from zero slope indicate that the marginal effects are heterogeneous across different price quantiles.

The conservation equivalency restrictions explicitly limit feasible trades based on vessel length and horsepower, resulting in bargaining power differentials based on those attributes. Despite the high correlation between buyer and seller lengths, these variables were found to have a statistically significant impact on prices (Figure 3). Buyer length increases the price of DAS; however, this effect is strongest at the highest prices and nonexistent at the lowest prices. The marginal effect on price of buyer length is \$5.37 at the 25th percentile and nearly \$10 at the 90th percentile of prices. In addition, seller length has a similar effect on prices although this effect is smaller in magnitude. These two results are consistent with a bargaining power effect derived from the trading limitations. With relatively few sources of DAS, the longest buyers are at a relative disadvantage in the bargaining process. Interestingly, horsepower does not have a consistent impact on the bargaining power of buyers or sellers; Buyer horsepower may increase prices at moderate quantiles of price. These results suggest that the length trading limitations are more restrictive in determining feasible trades in this market than the horsepower limitations.

The total surplus from a completed trade is closely related to the buyer's revenues and the seller's alternative revenues. The OLS coefficients (Table 4) for these two variables imply that only the seller's alternative revenues explain prices; an increase of \$1,000 in the seller's alternative revenues results in higher prices for DAS by approximately \$8–9. The quantile regression results suggest a more complex process of pricing and bargaining (Figure 4). There is a fairly large amount of variation in the marginal effects of the revenue and alternative

TABLE 5. Regression coefficients at selected quantiles. Coefficients which are different from zero at the 5% significance level are in bold italics. Standard errors (in parentheses) were computed using 20,000 bootstrap replications; $N = 1{,}788$.

	Quantile				
Independent variable	10	25	50	75	90
Buyer length	0.67	***5.37***	***6.87***	***8.18***	***9.74***
	(0.45)	(0.61)	(0.59)	(0.64)	(0.86)
Seller length	−0.11	***−1.72***	***2.09***	***2.49***	***3.45***
	(0.23)	(0.40)	(0.57)	(0.62)	(0.73)
Buyer horsepower	0.00	−0.03	***0.16***	***0.16***	0.01
	(0.02)	(0.05)	(0.05)	(0.05)	(0.05)
Seller horsepower	−0.01	−0.03	−0.02	0.05	***0.11***
	(0.01)	(0.02)	(0.05)	(0.05)	(0.04)
Buyer revenue	−1.69	−4.03	***5.62***	1.95	−1.97
	(1.47)	(2.14)	(2.34)	(1.75)	(2.82)
Seller revenue	−1.52	6.79	***7.58***	***9.08***	***10.24***
	(4.09)	(4.10)	(0.78)	(1.99)	(3.06)
Buyer alternative	0.31	0.36	1.67	1.34	−1.22
	(0.80)	(1.20)	(1.66)	(1.05)	(1.60)
Seller alternative	5.25	***15.22***	***8.25***	***4.36***	0.23
	(5.61)	(2.05)	(1.08)	(0.64)	(1.68)
Buyer permits	−0.16	−2.96	***−12.23***	−0.78	***11.30***
	(1.26)	(2.55)	(3.11)	(3.50)	(4.69)
Seller permits	9.28	***41.12***	***15.12***	3.79	−8.02
	(6.31)	(3.39)	(2.93)	(2.59)	(4.58)
Buyer experience	−0.57	−2.26	−2.91	−1.13	−2.95
	(0.52)	(0.90)	(1.11)	(1.23)	(1.54)
Seller experience	−0.70	***−3.46***	−0.44	−1.33	−0.27
	(0.73)	(1.40)	(1.41)	(1.61)	(1.89)
Buyer trawl	−9.23	***−55.09***	***−52.51***	***−41.46***	−3.28
	(6.08)	(6.52)	(5.50)	(8.55)	(11.04)
Seller trawl	3.10	7.51	***−34.95***	−9.36	4.16
	(3.86)	(7.20)	(6.35)	(6.91)	(10.07)
Buyer differential	0.63	2.28	15.72	1.96	37.66
	(4.80)	(14.02)	(15.82)	(16.19)	(26.41)
Seller differential	−16.47	22.93	8.36	***32.28***	18.10
	(14.23)	(13.93)	(13.25)	(14.29)	(22.46)
Framework 42	−8.50	−15.27	***78.79***	***155.46***	***147.16***
	(5.84)	(49.28)	(34.36)	(33.84)	(25.99)
Framework 42 × buyer differential	12.30	−8.25	***−122.70***	***−113.81***	***−149.58***
	(9.79)	(21.09)	(18.25)	(19.80)	(30.13)
Framework 42 × seller differential	6.04	***−43.90***	4.37	29.18	20.24
	(13.05)	(15.10)	(17.08)	(16.10)	(26.50)
Time remaining	0.00	***0.26***	***0.47***	***0.42***	***0.50***
	(0.02)	(0.05)	(0.04)	(0.04)	(0.06)
D2005	−4.34	***−31.40***	−21.75	−14.65	−5.06
	(5.81)	(9.13)	(13.46)	(13.58)	(23.39)
D2006	1.40	***71.74***	***156.56***	***181.71***	***237.41***
	(5.02)	(44.72)	(15.54)	(18.80)	(28.96)
D2007	4.36	***95.35***	***98.93***	5.89	33.63
	(7.98)	(46.13)	(32.83)	(35.05)	(32.50)
D2008	10.83	***104.71***	***114.31***	27.72	59.96
	(10.22)	(46.88)	(33.74)	(35.64)	(34.14)
Constant	−15.86	−149.45	−409.36	−447.61	−509.37
	(14.10)	(23.35)	(23.21)	(22.25)	(32.32)
R^2	0.018	0.144	0.309	0.399	0.328

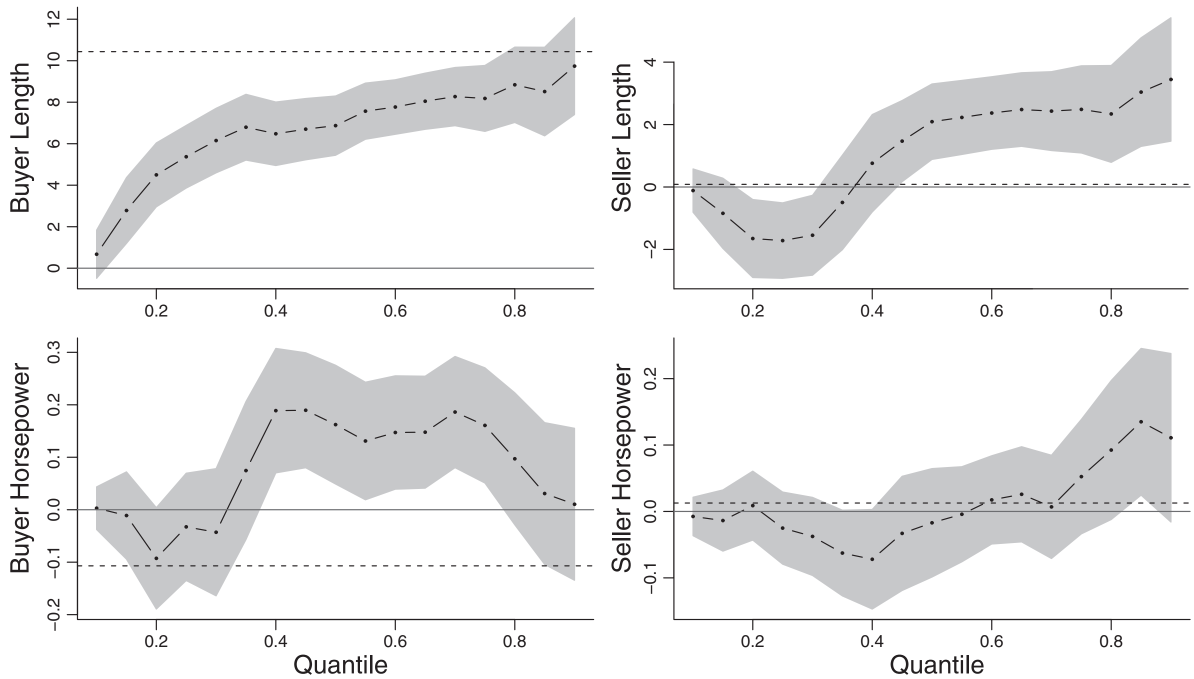

FIGURE 3. Graphical representation of the quantile regression coefficients for the buyer and seller characteristics related to the conservation equivalency restrictions. Increases in buyer length decrease bargaining power and therefore increase prices. Increases in seller length increase bargaining power and therefore increase prices. Neither buyer nor seller horsepower has an impact on price.

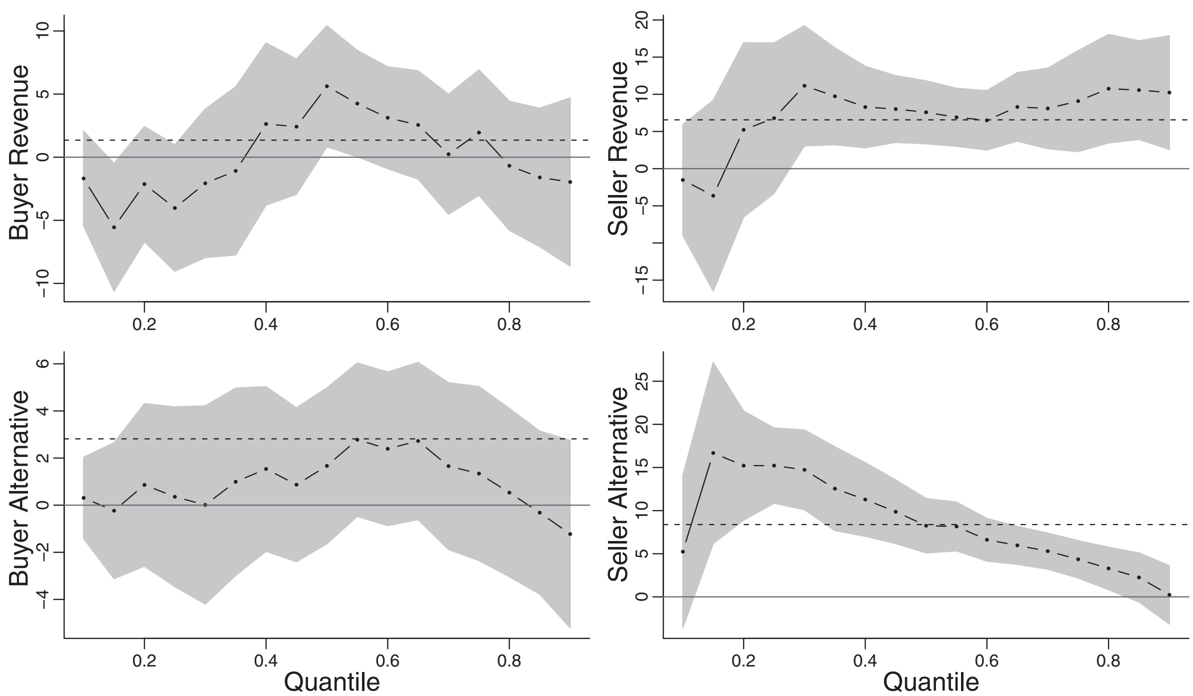

FIGURE 4. Graphical representation of the quantile regression coefficients for buyer and seller revenue and alternative revenue (see text). Increases in buyer revenue and alternative revenue do not have an impact on price; increases in seller revenue and alternative revenue increase prices.

revenue variables. Surprisingly, buyer revenues and buyer alternative revenues have no impact on prices. The seller's revenue has a slight positive impact on prices at the 15–80th percentiles. This effect is consistent across a large portion of the distribution of prices and is close to the marginal effect estimated via OLS. The marginal effect of the seller's alternative revenues is highest at the 15th percentile of prices and steadily declines at higher percentiles.

The value of a DAS decays at the rate of approximately \$0.40–0.50 per day across the middle and upper price quantiles, a finding which is similar to the results of least-squares analysis (Table 5). The yearly price effects estimated by quantile regression are similar to the effects estimated by OLS. Relative to 2004, prices were generally higher in 2006. However, 2007 and 2008 prices were only higher in the middle quantiles of the price distribution. The higher prices in 2006 could reflect some of the regulatory uncertainty regarding the Emergency Action and the timing of the adoption of Framework 42. The large coefficient on the 2006 dummy variable reflects higher prices during the time in which the fishery operated under the 1.4:1 DAS counting ratio.

While the OLS results suggest that Framework 42's differential DAS system had no effect on the prices of DAS, quantile regression reveals an interesting pattern of effects on prices which varied across the distribution of prices. The implementation of differential DAS areas reduced the profitability of DAS and total fishing effort, although the exact reductions would be determined by fishing vessels and not managers. Vessels which used the differential DAS areas experienced decreases in the intrinsic value of their DAS if they continued to use the differential areas. After implementation of Framework 42, the prices in the lower quantiles were unchanged or slightly lower; however, the prices at the middle and higher quantiles increased substantially, by \$78–155. There is also an effect due to the interaction of the Framework 42 and differential DAS variables. Buyers that exclusively used the differential areas saw corresponding declines in prices, while sellers who utilized the differential DAS areas did not see a price change (Table 6). The joint effects of Framework 42's differential DAS regulations are evaluated for different combinations of differential DAS use by buyers and sellers. After the implementation of differential DAS, prices remained constant if the buyer exclusively used the differential DAS areas (first row of each panel). However, if the buyer did not use those areas, the prices for DAS were substantially higher (second row of each panel). These findings reflect lower gains from trade for the buyers who used the differential areas relative to the buyers who did not.

There are also differences between the OLS and quantile regression results for the trawl variables. The buyer trawl dummy variable is not statistically significant in the OLS regression; however, quantile regression reveals that the use of trawl gear by buyers is associated with the lower prices paid in the middle quantiles. This finding is consistent with two interpretations: trawl usage may confer bargaining power on buyers, or trawl

TABLE 6. Partial effects of the differential Days-at-Sea (DAS) regulation on price for combinations of differential DAS users evaluated at select quantiles. After differential DAS regulations were enacted, the price of DAS increased substantially for buyers who did not use the differential DAS areas at the 50th and higher quantiles. For lower quantiles and ordinary least squares, all partial effects were insignificant and are not reported. Combinations which are different from zero at the 5% significance level are in bold italics. Standard errors are in parentheses.

	Seller differential = 1	Seller differential = 0
	50th quantile	
Buyer differential = 1	−39.5	−43.9
	(37.1)	(36.9)
Buyer differential = 0	***83.2***	***78.8***
	(42.3)	(37.1)
	75th quantile	
Buyer differential = 1	12.5	41.6
	(40.0)	(40.2)
Buyer differential = 0	***126.3***	***155.5***
	(44.1)	(39.9)
	90th quantile	
Buyer differential = 1	−22.7	−2.4
	(7.0)	(55.0)
Buyer differential = 0	***126.9***	***147.2***
	(54.3)	(43.8)

users may have higher costs and therefore lower willingness to pay for DAS.

A quantile regression model which uses the counterparty variables in place of the length and horsepower characteristics specifications was also estimated. The qualitative results are unchanged; the model is robust to these specification changes. The marginal effects of the number of buyer counterparties and seller counterparties on price (Figure 5) are consistent with the effects from the preferred specification (Figure 3). An increase in the number counterparties for a buyer is associated with higher levels of bargaining power for buyers and therefore lower prices. An increase in the number counterparties for a seller is also associated with higher levels of bargaining power for sellers and therefore higher prices.

The bargaining power equality assumptions used by Harding et al. (2003) can be examined by computing the sums of paired demographic coefficients using the OLS or quantile regression models (Table 7). Positive sums indicate that increases in the independent variable lead to higher prices and reflect higher levels of bargaining power for the seller. Inversely, negative combinations indicate that increases in the independent variable lead to lower prices and higher levels of bargaining power for the buyer. Based on the OLS results, bargaining power equality is rejected for most of the demographic characteristics, including length, revenue, alternative revenue, and trawl usage. With the exception of the 10th quantile, the quantile regression coefficients tell

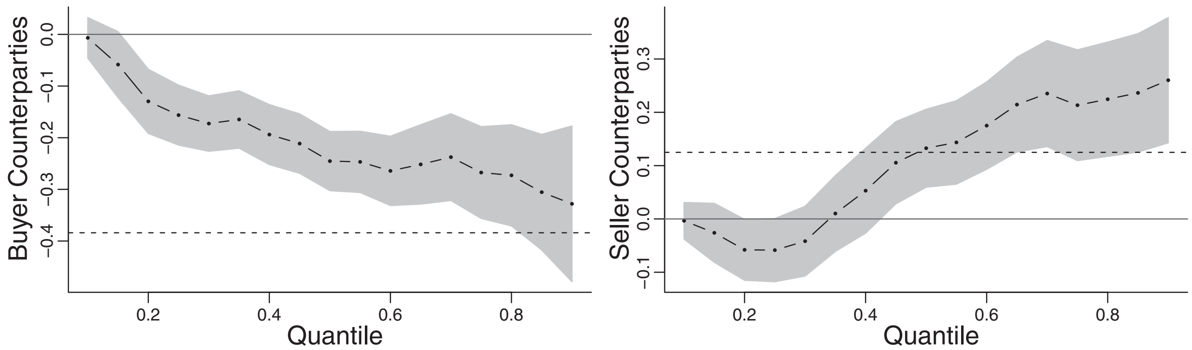

FIGURE 5. Graphical representation of the quantile regression coefficients for the marginal effects of changes in the number of buyer and seller counterparties. Increases in the number of legal counterparties leads to higher bargaining power. For buyer counterparties this translates into lower prices, while for sellers this leads to higher prices.

a similar story. In general, there is substantial heterogeneity in the net effect of buyer and seller characteristics across quantiles. These results provide strong evidence for rejecting the hypothesis that length confers bargaining power equally to buyers and sellers at the 25th percentile and higher; length lowers the bargaining power of buyers relative to sellers, and this effect is largest at the highest price quantiles. The bargaining effects of horsepower are not robust across quantiles; however, there is evidence that horsepower increases the seller's bargaining power at the middle and higher quantiles of price. There is also weak evidence that revenue and alternative revenue confer bargaining power on sellers in the middle price quantiles. Permits have a fairly large positive effect on the seller's bargaining power at the 25th percentile of price, although this result is not consistent across the quantiles.

DISCUSSION

A major finding of this research is that the conservation equivalency restrictions based on size led to unequal bargaining power for buyers and sellers. Essentially, large sellers are at an advantage relative to large buyers because of the relative

TABLE 7. Sums of buyer and seller bargaining power coefficients computed after ordinary least-squares (OLS) and quantile regression. If the coefficients do not sum to zero, the attribute has effects on buyer and seller bargaining power. Positive values indicate that increases in the attribute lead to a higher price and may be interpreted as increasing seller bargaining power. Sums which are different from zero at the 5% significance level are in bold italics. Standard errors are in parentheses.

		Quantile				
	OLS	10	25	50	75	90
Length	***10.521***	0.559	***3.654***	***8.964***	***10.668***	***13.185***
	(1.332)	(0.504)	(0.836)	(0.810)	(0.741)	(1.276)
Horsepower	−0.094	−0.005	−0.058	***0.145***	***0.213***	0.121
	(0.096)	(0.0223)	(0.058)	(0.059)	(0.058)	(0.068)
Revenue	7.916	−3.208	2.762	***13.199***	***11.036***	8.271
	(8.055)	(5.007)	(5.791)	(3.731)	(5.278)	(6.020)
Alternative	***11.197***	5.547	***15.573***	***9.919***	***5.698***	−0.994
	(4.170)	(5.295)	(3.568)	(2.752)	(2.549)	(3.057)
Differential	79.102	−15.835	***25.215***	***24.079***	34.24	55.764
	(45.726)	(32.110)	(36.111)	(25.477)	(28.219)	(36.936)
Experience	−3.713	−1.267	***−5.715***	−3.355	2.464	−3.218
	(5.759)	(1.199)	(2.398)	(2.112)	(2.647)	(2.976)
Trawl	−75.175	−6.131	***−47.584***	***−87.458***	***−50.823***	0.881
	(26.836)	(9.283)	(16.405)	(15.429)	(14.076)	(21.081)
Permits	***31.175***	9.117	***38.160***	2.888	***3.013***	3.279
	(13.470)	(7.424)	(5.806)	(5.415)	(5.406)	(9.838)
Framework 42 × differential	−21.312	18.343	−52.146	***−118.333***	***−142.994***	***−169.824***
	(90.083)	(31.472)	(38.450)	(33.307)	(30.907)	(45.655)

scarcity of trading partners; this enables large sellers to exert some degree of bargaining power. The trading restrictions have segmented this market into many smaller submarkets in which individuals may be exerting market power. Despite these limitations, the price of DAS seems to change in economically reasonable ways. The price of DAS declines within a fishing year, reflecting the decay in the time value of financial options. This effect varies across the price distribution, ranging from no effect at the lowest quantiles to approximately $0.50 per day at the middle and upper quantiles. Relative to the median DAS price of $215, the rate of decay in value is approximately 1.5% per week. Second, the price of DAS and bargaining power is responsive to shocks to aggregate supply and productivity. Implementation of differential DAS areas reduced the profitability of DAS for vessels which used the differential areas. Vessels which fished outside of these areas paid higher prices for DAS after the implementation, while vessels inside did not, reflecting the differential profitability of those inputs.

By examining a good without unobserved characteristics, the assumption of bargaining power equality used for identification can be econometrically tested. Based on analysis using least-squares and quantile regression, bargaining power equality is be rejected for many demographic characteristics, most notably vessel length. It is important to note that the rejection of bargaining power equality in this research does not imply that the assumptions used by Harding et al. (2003) to identify structural parameters are generally inapplicable. This particular market has institutional limitations which are unlikely to be shared by other markets.

This research does not model the search process associated with finding trading partners in the DAS market. Ignoring these costs may bias the estimates of the effects of bargaining power if different types of individuals have different search costs. However, it is reasonable to believe that search frictions are low for most vessels in this market. Trades are facilitated through well-established networks of brokers and middlemen, word of mouth, and advertisements in fishing industry publications. Additionally, NMFS maintains a Web site which facilitates trades by generating contact information of eligible counterparties. While all traders will experience search costs, these costs are not likely to vary systematically by individual.

The productivity of DAS (revenues) was found to have a minimal effect on prices or the bargaining power of either buyers or sellers. This surprising finding may occur because the effects of the conservation equivalency regulations dominate any revenue effects. Alternatively, the revenue variable used may be a weak measure of the firm-level DAS profitability, which should include costs in addition to revenues. However, the lay system of labor compensation is used in this fishery; crews are typically paid a fraction of total revenues minus variable costs and the owner of the fishing vessel receives the remainder of the total revenues. Therefore, the returns to the owner from using DAS should be reasonably correlated to revenues. Anecdotally, the costs of leased DAS were frequently included the variable costs which were subtracted from the crew's share of revenues. When this occurs, vessel owners who buy DAS have lower incentives to bargain for lower prices. Unfortunately, the data on the share system could not be included in this analysis.

Several reviewers raised the issue that a buyer's access to credit could determine the price of DAS; however, there are no data available on access to credit markets. Access to capital is probably tied closely to owner's equity, defined as total assets minus total debts. Total assets such as physical capital, permits, and allocations are positively correlated with revenue. Unfortunately, no data are available about debt and therefore it is difficult to make any claims about buyer's access to capital. However, because these trades are leases, the capital requirements are far lower than the costs of outright purchases: the median and 75th percentile of trade value (for nonzero prices) was $3,500 and $11,272, respectively. These costs are certainly nontrivial; however, they are also not excessively large.

Use of catch shares to solve the public goods problem has become more common in fisheries management; Costello et al. (2008) found that these instruments lead to better ecological outcomes. In contrast, tradable input allowances are less commonly used in the USA, although tradable trap programs have been used in the management of Florida's spiny lobster *Panulirus argus* (Larkin and Milon 2001) and in a portion of the American lobster fishery in New England. Input allowances remain popular with fishermen (Rossiter and Stead 2003); however, these findings illustrate one of the distributional difficulties associated with using tradable input-based controls to manage the fishery. In order to avoid increases in total catch, limitations of feasible trades were required. In the groundfish fishery, this was accomplished by limiting feasible trades based on length and horsepower because smaller vessels are believed to be less efficient than larger vessels. One of the (unintended) consequences of this regulation was a decrease in bargaining power for smaller vessels which sold DAS and for larger vessels which purchased DAS. This inflated the prices paid by the largest buyers and depressed the prices received by smaller vessels.

ACKNOWLEDGMENTS

The author acknowledges helpful comments from Amy Ando, John Braden, Dick Brazee, Eric Micheels, Eric Thunberg, two anonymous referees, and the editors. As always, responsibility for any remaining errors rests solely with the author. Any opinions, findings, conclusions or recommendations expressed in this article are his own and do not necessarily reflect the views of NOAA–Fisheries.

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