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Determining the ex-vessel price of landings in the Japanese distant-water longline fishery

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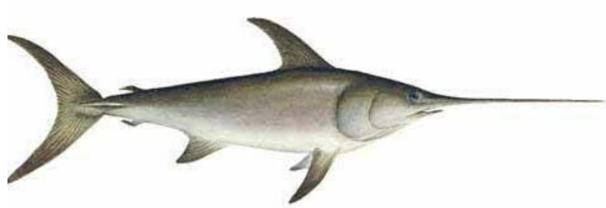

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Abstract

This paper conducts an empirical estimation of the price elasticity of landings of seven fish species by a Japanese off-shore fishing vessel. This estimation is used to quantify the effects of price determinants, freshness of landings (total days per trip), and landing quantities per trip. Results demonstrate that the ex-vessel price of swordfish is statistically affected by both price determinants. The results also demonstrate that freshness dominantly affects the ex-vessel price of swordfish, more than the landing quantity per trip. This study suggests that the fishing strategies of a Japanese off-shore longline fishing vessel, which targets swordfish, should put an emphasis on maintaining freshness of already- harvested fish rather than searching for additional catches.

Introduction

The main purpose of this paper is to empirically identify and quantify the effects of the determinants of landings ex-vessel prices from off-shore longline fishing vessels in *Kesennuma*, Japan. This is done by estimating the price elasticity of five fish species landings, namely swordfish, blue shark, albacore tuna, yellowfin tuna, big eye tuna. The hypothesis is that two variables of landings from off-shore longline fishing vessels, i) the freshness premium of landings which is one of the indicators for quality of landings and ii) the amount of landings per day, uniquely determine the price elasticity of the demand.

The freshness of perishable food commodities, which is defined using the time period from production to delivery to the market or consumers, plays an important role in the determination of the ex-vessel price. When fish markets value freshness by a non-negligible degree, fishers may have an incentive to differentiate their landings by shortening the time between fishing and market delivery. Such incentives would be prominent for fish for direct human consumption markets (e.g., *sashimi*) due to the rapid, perishable nature of seafood commodities.

Changes in the ex-vessel price upon the total landing, price elasticity of demand, is also critical components to determine the ex-vessel price given the market capacity and consumer preference. While the most of tuna species have the global market which has unlimited substitutions, swordfish and blue shark, which account for nearly 80 % of annual revenue of Japanese off-shore longline fishing vessels, forms the unique and only markets in *Kesennuma*, Japan. Moreover, due to the opportunistic nature of fishing activities and limited target species for this vessel type (i.e., swordfish and blue shark), the vessel only allocates effort on either or both swordfish and blue shark seasonally. Therefore, we can assume that off-shore longline fishing vessels are price-takers for swordfish and blue shark. As the result, it is reasonable to assume that the price elasticity of demand for swordfish and blue shark solely define the ex-vessel prices.

Though a few studies present price formulation in fish markets with detailed transaction data, such as Barten and Bettendorf (1989) and Reid et al., (2003), their emphasis was not the premium of freshness. Part of the reason could be the limitation of available data. It is not typically possible to find data on auction price at the individual transaction level and the date of detailed fishing activities due to the confidentiality of operations and business.

The following section describes the longline fishery in *Kesennuma*. Data sources and descriptive statistics are illustrated in the second section. The third section discusses empirical strategies and results. We conclude with the implication of the results.

Data

This study focuses on the off-shore longline fishery ("*Kinkai Maguro Haenawa*") which accounted for about 30% of the 2007 total gross sales of fishery landings in *Kesennuma* City. In 2009, 24 vessels were registered in this category and 19 of them were active. Almost all vessels in this category have 119 MT capacities with 440 horse power engines.

From 2004 to 2007, the total annual gross sales average in this category was 3,064,944 USD. The 2004 to 2007 average gross sales from swordfish and blue shark consisted of 46% and 39% of the total annual gross sales, respectively. The remaining gross revenue came from a variety of tuna species (e.g., big eye tuna, northern blue fin tuna). The sum of the swordfish and blue shark landed values dominates the value of total landings.

This study uses the data of landings at the public fish market of *Kesennuma*. The data include daily auction market records from 2007 through 2009, and fishing trip data. The unit of observation is each vessel's transaction for a certain type of fish on a given auction day. Descriptive statistics of landings (Table 1) shows an overview of landings by the off-shore longline fishing vessel at *Kesennuma*.

This study is based on seven catch species, including swordfish and blue shark, the catches of which make up around 80% of the longline fishery in *Kesennuma* (Table 2). Swordfish landings at *Kesennuma*take supply 80% of share of the Japanese swordfish market, and blue shark landings at *Kesennuma* supply 90% of the share of the Japanese blue shark market (*Kesennuma* City, 2005). While swordfish products are limited to direct human consumption (e.g., sashimi or fillet for steak or other cooking), blue shark products have a variety of uses after processing. Fins go to a high value food market in China. Skins are exported to Italy for leather products. Meats go to *surimi*. Bones are used for raw materials for medicine and cosmetics. Note that direct human consumption of swordfish implies that the ex-vessel price of swordfish would be affected more by a freshness premium than blue shark. Processed uses of blue shark imply that the freshness would not be substantial to determine the ex-vessel price of blue shark. Due to the small market supply in landings of each tuna species, we consider the information from tuna species strictly as supplemental, and simply assume that the price elasticity of demand at the Kesenuma fish market solely defines the ex-vessel price of tuna rather than the global market with substitutions.

Empirical Strategies

This section describes the econometric equations that estimate freshness premium and the effects of the amount of landings per day in the market for seven fish species by a off-shore ongline fishery vessel.

Suppose that vessel *i* leaves a port at date *s* and returns to the market at date *t*. At the market, buyers bid for each single fish, and highest bidders pay their bidding price. Therefore, each single fish (or a box of fish) is auctioned off at different prices. Let P_{ijt} denote the average auction price for fish type *j*, from vessel *i*, at its market transaction date *t*. Buyers determine their bid based on market demand and supply, and their unique valuations on the fish. We consider the following log-linear function for buyers' bidding function for fish *j*:

$$\ln P_{ijt} = \alpha_j + \beta \ln Days_{it} + \gamma \ln Landing_{tj} + \delta_{month} + \delta_{year} + \varepsilon_{ijt}.$$

$Days_{it}$ is the duration of vessel *i*'s trip. At the market, buyers know this information, which determines the freshness of the fish. We also include *Landing*, the total landing of the day for fish type *j*. Buyers may have higher (lower) willingness to pay for fish *j* at auction date *t* when the total landing of the fish is less (more). Under the assumption that fishermen are price takers, γ shows buyers' price elasticity of demand. To control for unobservable effects on the price, we include monthly fixed effects (δ_{month}) and yearly fixed effects (δ_{year}). The identifying assumption is $E[\varepsilon_{ijt} \cdot Days_{it} | \delta_{month}, \delta_{year}] = 0$ and $E[\varepsilon_{ijt} \cdot Landing_{jt} | \delta_{month}, \delta_{year}] = 0$. That is, the error term and the variables of interests are uncorrelated conditional on the month and year fixed effects.

We also consider a model including a vessel fixed effect θ_i:

$$\ln P_{ijt} = \alpha_j + \beta \ln Days_{it} + \gamma \ln Landing_{tj} + \delta_{month} + \delta_{year} + \theta_i + \varepsilon_{ijt}.$$

The identifying assumptions are $E[\varepsilon_{ijt} \cdot Days_{it} | \delta_{month}, \delta_{year}, \theta_i] = 0$ and $E[\varepsilon_{ijt} \cdot Landing_{jt} | \delta_{month}, \delta_{year}, \theta_i] = 0.$ That is, the error term and the variables of interests are uncorrelated conditional on the month, year and vessel fixed effects.

Results

We first show graphical evidence of a freshness premium. Figure 1 plots the auctioned price of swordfish from which the mean price of swordfish on the same day is subtracted. That is, each plot presents a deviation from the mean price of the day. When vessels come back from their trip after less than thirty days at sea, the price is higher than the mean. When their trip days exceed forty five days at sea, the price falls. For example, between a vessel with ten trip days and a vessel with fifty trip days, their price differential is about 0.20 /kg.

The auctioned price of blue shark, however, does not have a clear inverse relationship with trip days. Figure 2 indicates a slight negative relationship, but the 95% confidence interval includes a zero for the most part of trip days.

The downward slopes can be explained by two possible reasons. The negative relationship between trip days and auctioned prices may represent buyers' willingness to pay for freshness of landings. With longer travel days, the freshness premium decreases. At the same time, however, longer trips may allow fishermen to harvest more fish. When supply from a vessel increases the market supply (therefore, increased the total landings) significantly, buyers may devalue the fish depending on their price elasticity of demand. In the following sections, we estimate these two possible determinants of the price in a regression framework. We first estimate each of the determinants separately. Then, we include both variables to explore partial effects of the two variables on auctioned prices. To account for heterogeneity between fish types, we run regressions separately for each fish type.

Table 4 shows estimation results for swordfish. Column 1 and 2 present regression results when we include only ln(*Days*). Without vessel fixed effects, the elasticity estimate is -0.216. That is, when trip days increase by 1%, the auctioned price decreases by 0.216%.

The estimate is statistically different from zero with 1% significance level. As shown in Column 2, including vessel fixed effects does not statistically change the estimate. Column 3 and 4 show regression results when we include only ln(*Landing*). Note that we calculate *Landing* as the total landings of swordfish for the auctioned date and this variable does not include landings of other types of fishes. Under the assumption that each fisherman is a price taker, the estimates can be interpreted as the price elasticity of demand for swordfish. The elasticity estimate is -0.096 without vessel fixed effects and -0.082 with vessel fixed effects. That is, a 1% increase in aggregate supply of swordfish leads a 0.096% decrease in the price. Finally, we include both variables to explore their partial effects. When both variables are included in the regression, both of the freshness premium estimate and the price elasticity estimate slightly decrease. This is because *Days* and *Landing* are positively correlated since longer trips are likely to lead larger quantity of landings. The change in estimates, however, is relatively small. Importantly, the freshness premium has a larger effect on price than the price elasticity of demand.

Table 5 shows results for blue shark. The freshness premium is much smaller than swordfish and is not statistically significant from zero when vessel fixed effects are included. These results imply that the market price for blue shark is less affected by freshness. The evidence is consistent with industrial characteristics in the blue shark industry. Blue shark landed in *Kesennuma* fish port is usually sold as processed products, whereas swordfish is often sold and consumed as raw fish. The point estimates for the price elasticity are also slightly smaller than swordfish, although we cannot reject that these estimates are statistically different from zero. This may represent quasi-vertical structure of the blue shark industry. All processing factories for blue shark are located in *Kesennuma*, and this fact restricts fishing vessels to bring blue shark landings only in *Kesennuma*. Tight integration of supply (fishing vessels) and demand (processing factories) on blue shark would have stabilized the ex-vessel price, and possibly eliminated the effects of price elasticity.

Table 6 shows results for Albacore. Interestingly, the freshness premium is quite large for Albacore. The point estimates are -0.340 without vessel fixed effects and -0.487 with vessel fixed effects. That is, buyers have quite high willingness to pay for fresh Albacore at the *Kesennuma* market. Similar to blue shark, the price elasticity of demand is small and statistically insignificant. Table 7, 8, 9, and 10 also show results for other fish types: yellowfin, big eye, and small big eye. It is difficult to conclude about the estimates for these fish types as standard errors are large due to the lack of variation in the variables. The point estimates are, however, between -0.15 and -0.25 for the freshness premium, and nearly zero for the price elasticity of demand. One interesting finding is that the point estimates of the freshness premium are larger for small big eye (class A) than small big eye (Class B), indicating that buyers may have higher willingness to pay for freshness for higher quality fish categories.

Discussion

In this study, the two determinants of the ex-vessel price on landings by Japanese off-shore fishing vessels are examined. Overall, we observe three findings. First, the freshness premium is significant for most fish types that are purchased as raw fish. For example, the elasticity is -0.487 for Albacore and -0.216 for swordfish. This magnitude is likely to be non-negligible for fishers to consider it. Keeping the effective days of each trip low could enable fishers to keep the market price for their harvested fishes high. Second, compared to this freshness premium, the estimated price elasticity of demand is low and in most cases it is not statistically different from zero. That is, for most fish types, the aggregate landings for the market date do not significantly change the ex-vessel price. Finally, we find considerable heterogeneity in our estimates between fish species. In particular, the magnitude of the freshness premium is substantially different depending on fish species. Moreover, dominate two target species for Japanese off-shore fishing vessel, swordfish and blue shark exhibit explicit heterogeneity in the freshness premium and the price elasticity of demand.

Conclusion

In general, fishermen and policy makers consider potential price decreases due to the demand elasticity more seriously, and do not account for the effect of freshness premium. Our results show that this conventional wisdom may not be consistent with empirical evidence.

The results imply that it may not be beneficial to operate far from shore, or add more days of operations which affect the freshness and subsequent market value of already harvested swordfish, especially when a fisher targets only swordfish. If a fisher targets only blue shark, such considerations would not be significant. In the case the fisher targets swordfish, our estimated freshness premium of swordfish would help decisions about the duration of operations on board. Furthermore, the heterogeneous nature of the freshness premium for swordfish and blue shark would help fishers to decide on the allocation of efforts between swordfish and blue shark toward their optimal fishery operations.

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Table 1

Landings and gross sales in *Kesennuma* in 2006

	Landings (ton)	Gross sales (1000yen)	Ave. Price (yen/kg)
Bonito	27,804	6,173,906	222
Blue shark	11,369	2,220,376	195
Swordfish	5,150	4,211,824	818
Tunas	7,938	4,107,677	517
Others	54,866	4,644,250	85
Total	107,127	21,358,033	199

Note: Tunas includes all types of tuna. Source: City of *Kesennuma* (2007)

Table 2: Annual average accounting of fishing vessels under the category of 119MT off-shore longline fishery in *Kesennuma.*

		2004	**2005**	**2006**	**2007**
Bluefin tuna	Landing(MT)	10.9	7.8	3.7	2.8
	Unit ex-vessel price (1000 USD/MT)	19.2	20.9	17.1	16.8
	Landing value (1000 USD)	209.9	161.7	63.8	47.3
	Species landing share in the value (%)	0.0	0.0	0.0	0.0
Bigeye	Landing(MT)	100.5	59.8	40.6	103.7
	Unit ex-vessel price (USD/MT)	13.4	16.6	18.4	15.4
	Landing value (1000 USD)	1,346.5	989.4	745.4	1,596.1
	Species landing share in the value (%)	0.0	0.0	0.0	0.0
Small bigeye	Landing (MT)	12.6	5.5	2.3	5.6
	Unit ex-vessel price (1000 USD/MT)	5.7	6.6	5.9	8.0
	Landing value (1000 USD)	1,343.2	840.2	282.2	4,152.9
	Species landing share in the value (%)	0.0	0.0	0.0	0.1
Swordfish	Landing (MT)	2,010.5	1,748.2	1,726.4	2,223.3
	Unit ex-vessel price (1000 USD/MT)	7.2	8.5	6.9	8.2
	Landing value (1000 USD)	14,495.0	14,825.0	11,927.3	18,222.7
	Species landing share in the value (%)	**0.47**	**0.46**	**0.49**	**0.49**
Striped marlin	Landing (MT)	58.5	66.3	59.6	48.4
	Unit ex-vessel price (1000 USD/MT)	4.8	5.3	4.0	4.7
	Landing value (1000 USD)	279.9	349.1	237.4	226.7
	Species landing share in the value (%)	0.0	0.0	0.0	0.0
Albacore	Landing (MT)	12.8	13.8	7.3	13.0
	Unit ex-vessel price (1000 USD/MT)	2.9	3.0	2.8	2.3
	Landing value (1000 USD)	510.6	595.2	298.6	319.7
	Species landing share in the value (%)	0.0	0.0	0.0	0.0
Blue shark	Landing (MT)	8,278.6	8,774.2	6,148.8	5,785.2
	Unit ex-vessel price (1000 USD/MT)	1.5	1.7	1.8	2.1
	Landing value (1000 USD)	12,591.4	14,673.8	10,804.3	12,255.5
	Species landing share in the value (%)	**0.41**	**0.45**	**0.44**	**0.33**
Total	Landing (MT)	11,770.7	12,182.5	8,897.1	9,458.0
	Landing value (1000 USD)	32,759.8	35,218.2	25,447.9	35,787.1
Swordfish+Blue shark	Landing value (1000 USD)	27,086.4	29,498.8	22,731.6	30,478.2
	Species landing share in the value (%)	**0.88**	**0.91**	**0.93**	**0.83**

Table 3 Descriptive statistics

	Mean	S.D.	Min	Max	Obs.
Total Landing from a Trip (ton)	46.97	19.39	0.4	111.9	176
Total Revenue from a Trip (10,000 yen)	1818.40	702.04	43	3308	176
Trip Days	38.70	9.56	11	56	176
Operation Days	23.55	6.20	3	46.1	176
Auctioned Price of Swordfish	858.91	160.52	479	1338	171
Auctioned Price of Blue Shark	226.03	46.47	107	335	170
Auctioned Price of Small Bigeye (class B)	1381.24	326.50	250	2440	107
Auctioned Price of Small Bigeye (class A)	427.64	122.50	139	844	99
Auctioned Price of Bigeye	2303.46	795.42	1060	7030	105
Auctioned Price of Albacore	247.54	117.19	20	769	127
Auctioned Price of Yellowfin	1291.53	453.54	273	2450	59

Table 4 Swordfish: Estimated freshness premium and price elasticity of demand

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Days)	-0.216***	-0.218***			-0.188***	-0.197***
	(0.03)	(0.05)			(0.03)	(0.05)
ln(Landing)			-0.0964***	-0.0818*	-0.0744**	-0.0666*
			(0.02)	(0.03)	(0.02)	(0.03)
Vessel Fixed Effect		yes		yes		yes
Year Fixed Effect	yes	yes	yes	yes	yes	yes
Month Fixed Effect	yes	yes	yes	yes	yes	yes
Obs.	171	171	171	171	171	171
R-sq	0.546	0.554	0.51	0.523	0.581	0.58

Note: Dependent variable is the log of the auction price/kg by vessel i at landing date t. Days is the number of trip days for the vessel i. Landing is the total quantity of landing of the fish in the market on the auctioned date. Robust standard errors are in parentheses. Statistical significance: 1% ***, 5% **, and 10% *.

Table 5 Blueshark: Estimated freshness premium and price elasticity of demand

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Days)	-0.103**	-0.0764			-0.0878*	-0.0555
	(0.04)	(0.05)			(0.04)	(0.05)
ln(Landing)			-0.0569	-0.0691	-0.0416	-0.0615
			(0.03)	(0.05)	(0.03)	(0.05)
Vessel Fixed Effect		yes		yes		yes
Year Fixed Effect	yes	yes	yes	yes	yes	yes
Month Fixed Effect	yes	yes	yes	yes	yes	yes
Obs.	170	170	170	170	170	170
R-sq	0.609	0.637	0.602	0.645	0.615	0.648

Note: Dependent variable is the log of the auction price/kg by vessel i at landing date t. Days is the number of trip days for the vessel i. Landing is the total quantity of landing of the fish in the market on the auctioned date. Robust standard errors are in parentheses. Statistical significance: 1% ***, 5% **, and 10% *.

Table 6 Albacore: Estimated freshness premium and price elasticity of demand

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Days)	-0.335**	-0.455*			-0.340**	-0.487*
	(0.12)	(0.18)			(0.13)	(0.21)
ln(Landing)			-0.0233	-0.00809	0.00399	0.0248
			(0.04)	(0.06)	(0.04)	(0.07)
Vessel Fixed Effect		yes		yes		yes
Year Fixed Effect	yes	yes	yes	yes	yes	yes
Month Fixed Effect	yes	yes	yes	yes	yes	yes
Obs.	127	127	127	127	127	127
R-sq	0.605	0.645	0.581	0.605	0.605	0.647

Note: Dependent variable is the log of the auction price/kg by vessel i at landing date t. Days is the number of trip days for the vessel i. Landing is the total quantity of landing of the fish in the market on the auctioned date. Robust standard errors are in parentheses. Statistical significance: 1% ***, 5% **, and 10% *.

Table 7 Yellowfin: Estimated freshness premium and price elasticity of demand

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Days)	-0.0602	0.0265			-0.035	0.142
	(0.15)	(0.33)			(0.16)	(0.31)
ln(Landing)			-0.0286	-0.222	-0.0246	-0.233
			(0.07)	(0.21)	(0.08)	(0.20)
Vessel Fixed Effect		yes		yes		yes
Year Fixed Effect	yes	yes	yes	yes	yes	yes
Month Fixed Effect	yes	yes	yes	yes	yes	yes
Obs.	59	59	59	59	59	59
R-sq	0.364	0.468	0.365	0.501	0.365	0.503

Note: Dependent variable is the log of the auction price/kg by vessel i at landing date t. Days is the number of trip days for the vessel i. Landing is the total quantity of landing of the fish in the market on the auctioned date. Robust standard errors are in parentheses. Statistical significance: 1% ***, 5% **, and 10% *.

Table 8 Big eye tuna: Estimated freshness premium and price elasticity of demand

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Days)	-0.218	-0.24			-0.217	-0.242
	(0.14)	(0.18)			(0.14)	(0.19)
ln(Landing)			-0.0137	-0.00737	-0.00193	0.00507
			(0.03)	(0.06)	(0.03)	(0.07)
Vessel Fixed Effect		yes		yes		yes
Year Fixed Effect	yes	yes	yes	yes	yes	yes
Month Fixed Effect	yes	yes	yes	yes	yes	yes
Obs.	105	105	105	105	105	105
R-sq	0.491	0.614	0.467	0.593	0.491	0.614

Note: Dependent variable is the log of the auction price/kg by vessel i at landing date t. Days is the number of trip days for the vessel i. Landing is the total quantity of landing of the fish in the market on the auctioned date. Robust standard errors are in parentheses. Statistical significance: 1% ***, 5% **, and 10% *.

Table 9 Small big eye (Class A): Estimated freshness premium and price elasticity of demand

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Days)	-0.258	0.0862			-0.258	0.0855
	(0.15)	(0.39)			(0.15)	(0.40)
ln(Landing)			0.0118	-0.01	0.0116	-0.00998
			(0.03)	(0.06)	(0.03)	(0.06)
Vessel Fixed Effect		yes		yes		yes
Year Fixed Effect	yes	yes	yes	yes	yes	yes
Month Fixed Effect	yes	yes	yes	yes	yes	yes
Obs.	99	99	99	99	99	99
R-sq	0.251	0.288	0.231	0.288	0.252	0.289

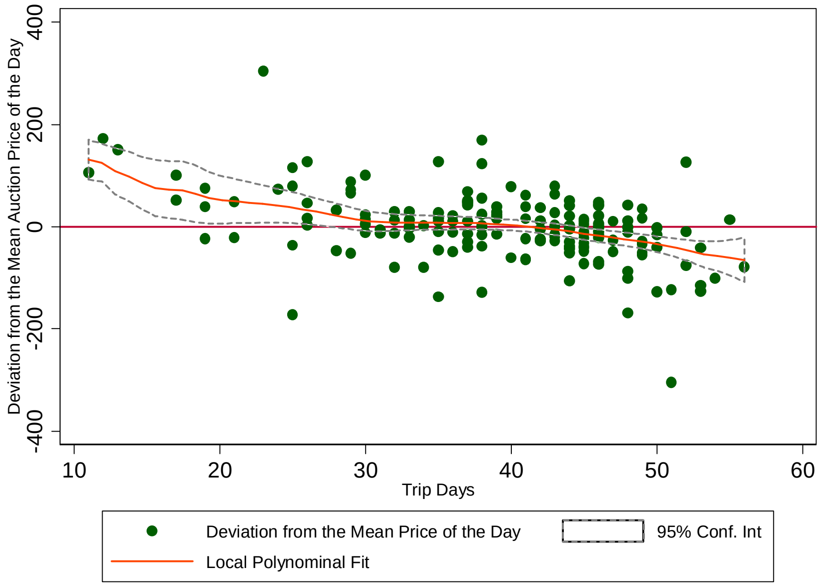
Note: Dependent variable is the log of the auction price/kg by vessel i at landing date t. Days is the number of trip days for the vessel i. Landing is the total quantity of landing of the fish in the market on the auctioned date. Robust standard errors are in parentheses. Statistical significance: 1% ***, 5% **, and 10% *.

Table 10 Small big eye (Class B): Estimated freshness premium and price elasticity of demand

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Days)	-0.185	-0.172			-0.183	-0.134
	(0.09)	(0.11)			(0.10)	(0.12)
ln(Landing)			-0.017	-0.0561	-0.014	-0.0482
			(0.03)	(0.03)	(0.03)	(0.03)
Vessel Fixed Effect		yes		yes		yes
Year Fixed Effect	yes	yes	yes	yes	yes	yes
Month Fixed Effect	yes	yes	yes	yes	yes	yes
Obs.	97	97	97	97	97	97
R-sq	0.199	0.222	0.165	0.233	0.201	0.249

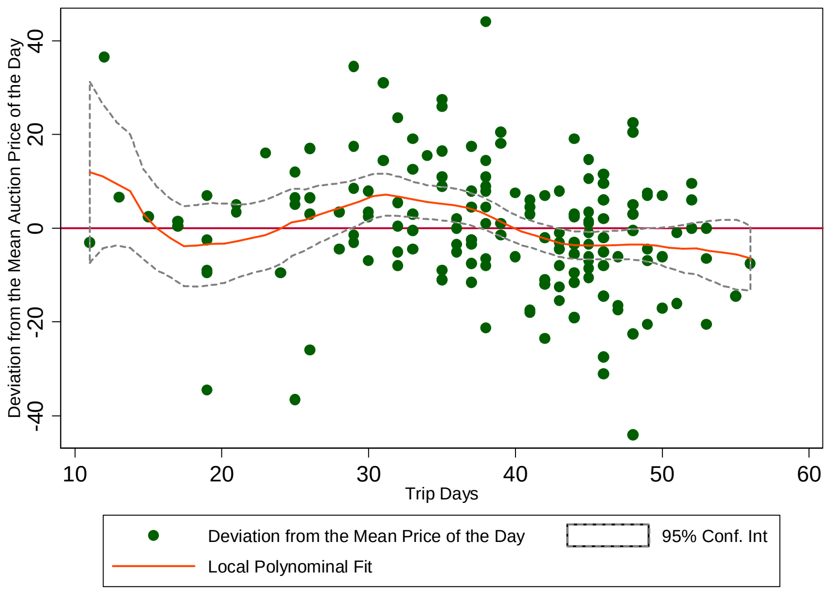
Note: Dependent variable is the log of the auction price/kg by vessel i at landing date t. Days is the number of trip days for the vessel i. Landing is the total quantity of landing of the fish in the market on the auctioned date. Robust standard errors are in parentheses. Statistical significance: 1% ***, 5% **, and 10% *.

Figure 1: Deviations from Mean Auction Price of the Day (Swordfish)



Note: The figure plots auctioned prices of swordfish from which the mean auctioned price of swordfish on the day is subtracted. The figure also includes its local polynomial fit and 95% confidence interval.

Figure 2: Deviations from Mean Auction Price of the Day (Blue Shark)



Note: The figure plots auctioned prices of blue shark from which the mean auctioned price of blue shark on the day is subtracted. The figure also includes its local polynomial fit and 95% confidence interval.