At the Mercy of the Sea or Rational Profit-speculators: Offshore Fishermen in Taiwan

Xiaozi Liu[1*], Mikko Heino[2,3], Daigee Shaw [1]

[1]Institute of Economics, Academia Sinica
[2]Institute of Oceanography, National Taiwan University
[3]Department of Biology, University of Bergen

*xzliu@econ.sinica.edu.tw

NAAFE Forum 2017, La Paz, Mexico 2017 年 3 月 23 日

Motivation

Global trends on seafood consumption and supply

- Per capita food fish consumption in the industrialized world has saturated (26.8 kg/capita/year), the growth in developing nations has been rising from 5.2 kg in 1961 to 18.8 kg in 2013.
- The production of the capture fisheries has been stagnating since late 1980s.
- The FAO food price index for wild fish has been increasing since 2002.
- Countries in the Latin America, the Caribbean, Oceania and Asia have become net exporters of food fish.
- Many of these fisheries are only minimumlly controlled: e.g., license control, would the expansion of international seafood trade impose risk on the local marine resources?

Motivation

- How would small-scaled fishermen respond to price change of fish in minimum license-controlled fisheries (essentially open-access)?
- We focus our analysis on the offshore fisheries in Ziguan, southwestern Taiwan.
  - Ziguan is an important 'fresh fish' landing and auction market in Taiwan; it opens almost daily from 11am–3pm.
  - A major fishing ground for trawl fisheries.
  - Two vessel types: most are local vessels, some are also transport vessels that bring catches neighboring ports.
  - Most of the fishermen are in small scale (crew size 3-5) and engage in daily fishing trip.


Main findings

- Small-scaled offshore trawl fishermen are price elastic, and they respond to price changes by adjusting their catch profiles accordingly. We found such evidence on the 17 of 20 species.
- Fishermen become more price elastic during the months when catch levels are high.
- Weather conditions such as wave height (wind speed and wind direction), and fuel price have limited or no effect on fishermen's targeting decisions for many 20 species, but they do affect fishermen's exit decision, i.e., going fishing or not.

Fisheries in Taiwan

- Catches of the coastal fisheries ($\leq$ 200 nautical miles) peaked in 1980s.
- The distant-water fisheries start to dominate the catch portfolio (40% $\rightarrow$ 80%).
- Offshore fisheries characteristics: (1) essentially open-access; (2) multiple species; (3) mostly small-scaled fishermen.

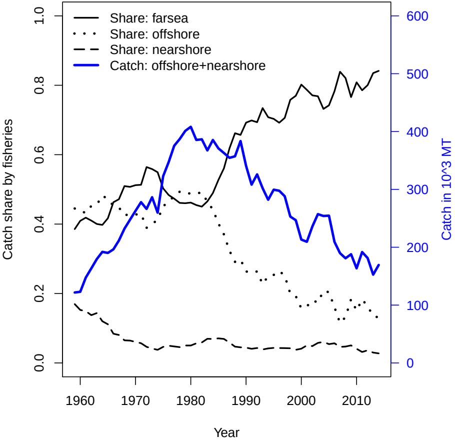


图 1: **Catch by fishery type in Taiwan**.

Theoretical framework

Formulation of price expectations

- Fishermen face price uncertainty: there is a natural lag between the time harvest decisions are made and the time their catches are sold by auction.
- The market is cleared daily through "Dutch Auction", no endogeneity issue.

$$P^e_{i,t} = \begin{cases} p_{i,t-1} & \text{Naive expectations (Naive)} \\ \sum_{k=1}^{k^*} \alpha_k p_{i,t-k} & \text{Linear backward-looking exp.(LBE)} \\ \widehat{p_{i,t}} & \text{Quasi-rational exp. (QRE)} \end{cases}$$

$$p_{i,t} = \theta_1 p_{i,t-1} + \cdots + \theta_k p_{i,t-k} + \varepsilon_t + \gamma_1 \varepsilon_{t-1} + \cdots + \gamma_n \varepsilon_{t-n}$$

Empirical models

Full model

$$\underbrace{\log(q_{i,t})}_{\text{catch}} = \alpha_0 + \underbrace{\alpha_i \log(P^e_{i,t})}_{\text{own exp. price}} + \underbrace{\alpha_j \log(P^e_{j,t})}_{\text{cross exp. price}} + \underbrace{\beta_1 \log(\mathbf{w_t})}_{\text{weather var.}} + \underbrace{\beta_2 \log(f_t)}_{\text{fuel}} + \underbrace{\beta_3 \log(\mathbf{V}_i)}_{\text{time-invariant var.}} + \mu_0, \quad (1)$$

First-difference model

$$\log(\Delta q_{t,t-1}) = \alpha_0' + \alpha_i \log(\Delta P^e_{t,t-1}) + \alpha_j \log(\Delta P^e_{t,t-1}) + \beta_1 \log(\Delta \mathbf{w}_{t,t-1}) + \beta_2 \log(\Delta f_{t,t-1}) + \mu_0' \quad (2)$$

where $\log \Delta q_{i,t} = \log(q_{i,t}) - \log(q_{i,t-1})$

Empirical models

- Estimate point elasticity in a log-log model. We allow non-linearity by analyzing subset data by weekday, month and year.
- First-difference estimator: non-stationarity (KPSS test).
- Using GLS estimator to allow for serial auto-correlation (AR(1)).
- Base model: $\Delta \log(q_{t,t-1}) = \alpha_0 + \alpha \Delta \log(P^e_{t,t-1}) + \mu_0$;
  Extension: +wave, +wave*P^e,+fuel price, normalized q_t.
- The Akaike Information Criterion (AIC): nested and non-nested models .

20 selected species

		
2. Neritic squid	**3 Japanese butterfish**	**4. Spanish mackerel**
		
5. Grouper	**6. Red bulleye**	**7. Alfonsino**
		
8. Silver croacker	**9. Threadfin**	**10. Beared croacker**
		
11. Large heard hairtail	**12. Jarbua terapon**	

Data

表 1: Summary statistics: species disaggregated, but vessel aggregated daily ex-vessel prices and landing during 2000–2015

			Real price (NTD/kg)			Landing (kg/day)		
ID	Species	N	Mean	sd	CV	Mean	sd	CV
1	Mixed	5109	135	33	0.25	3228	2958	0.92
2	Neritic squid	5118	143	43	0.31	1196	2921	2.44
3	Japanese butterfish	5042	213	97	0.46	544	523	0.96
4	Spanish mackerel	3689	261	113	0.43	408	538	1.32
5	Red bulleye	4942	370	131	0.36	195	303	1.55
6	Alfonsino	5088	184	63	0.34	315	239	0.76
7	Silver croaker	5039	122	60	0.49	296	324	1.09
8	Bearded croaker	4107	247	145	0.59	177	276	1.56
9	Largehead hairtail	4987	102	53	0.51	266	310	1.17
10	Thornfish	4763	311	100	0.32	92	95	1.03
11	Shrimp scad	5014	166	66	0.40	132	150	1.14
12	White pomfret	4123	374	230	0.61	75	112	1.50
13	Gloden cuttlefish	5056	117	35	0.30	125	144	1.15
14	Redtail scad	4956	50	29	0.57	314	304	0.97
15	Black pomfret	4107	247	145	0.59	177	276	1.56
16	Black snoek	5023	119	47	0.39	90	88	0.97
17	Snapper kob	3601	255	140	0.55	48	85	1.77
18	Lizardfishes	5019	52	17	0.34	139	118	0.85
19	Flatfishes	3205	244	73	0.30	39	43	1.09
20	Threadfin porgy	4061	207	129	0.62	45	63	1.42

Fishermen's price expectations

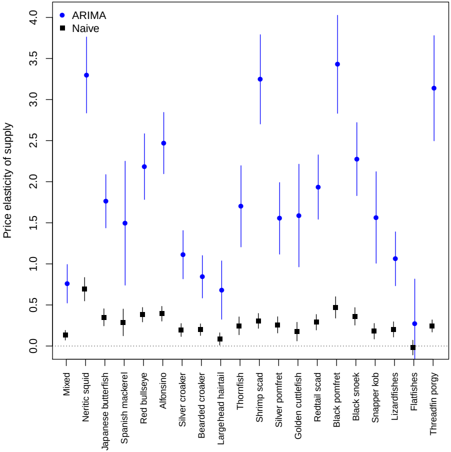
- Linear backward looking expectations (LBE) and ARIMA model slightly outperform the naive expectations model.
- Fishermen in Ziguan are rational and they tend to make use of the best available information to inform decision making.

表 2: Compare AIC values: base model

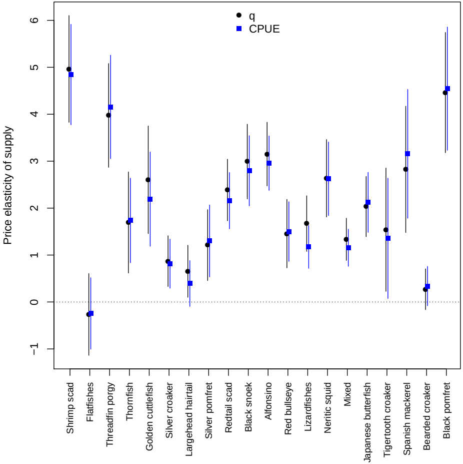
Species	AIC (lag=1)	AIC (lag=K)	AIC (ARIMA)
Mixed	6822.9	6794.5	**6789.1**
Neritic squid	10988.7	**10980.7**	11017.2
Japanese butterfish	12773.5	**12756.7**	12767.1
Spanish mackerel	12197.7	12160.5	**12153.0**
Red bulleye	13081.4	13053.8	**13037.5**
Alfonsino	11886	**11879.9**	11924.3
Silver croaker	14285	**14276.7**	14287.8
Bearded croaker	12533.3	12498.9	**12487.2**
Largehead hairtail	14045.7	14001.8	**13989.8**
Thornfish	13050.6	13041.7	**13041.4**
Shrimp scad	14836.6	**14827.4**	14863.4
Silver pomfret	13996	**13991.3**	14005.5
Golden Cuttlefish	12240.4	12214.9	**12206.1**
Redtail scad	14578.5	**14570.3**	14622.0
Black pomfret	13316.8	**13311.5**	13314.4
Black snoek	13766.8	**13757.8**	13793.0
Snapper kob	10790.5	10757.1	**10742.3**
Lizardfishes	11485.5	**11463.6**	11468.0
Flatfishes	7706.8	7676.3	**7671.5**
Threadfin porgy	13027.9	13001.8	**12986.7**

Own-price elasticity of supply (PES)

- The own-PES of the 20 main species is positive and statistically significant, except for Flatfishes.
- The size of PES is highly dependent on the choice of expectation, but the relative PES of a species is similar.
- i.e., the most elastic species are neritic squid,black pomfret, the least elastic are mixed-species, hairtail, bearded croaker .



Robustness check: q vs CPUE $= \frac{q}{N_{\text{vessel}}}$

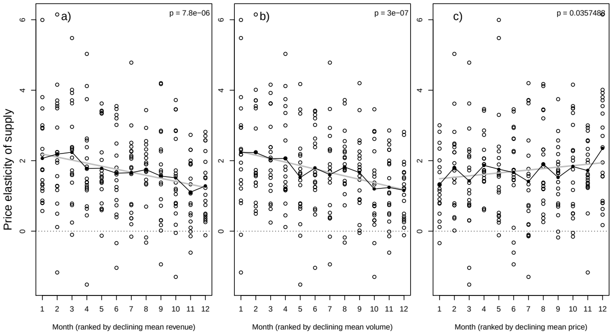


- After controlling for # of vessel per day, the two least elastic species, namely largehead hairtail and bearded croaker , become inelastic, the PES of other species remains robust.

Own-PES: Examples

- Most elastic species tend to be transport species or fast growing species.
- Least elastic species tend to have low stock (target species) or by-catch species, or gear suitability.
- Two factors may explain variation in PES: (a) fisherman's incentive to target a species, and (b) his ability to target a species.

Correlation analysis: cross-species effect

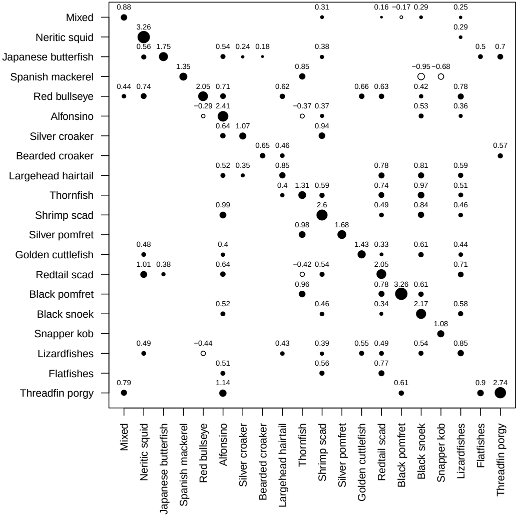


- We estimated monthly PES for each species and treated species as random variable in a mixed-effect model: i.e.,$lmer(PES_m \sim rank_m + (1|species))$.
- On average, fishermen become more price responsive during the months with higher catch/revenue, and less responsive during the month with higher price.

Cross-PES

Adding an additional species into own-PES model $\rightarrow$ 20$\times$20 ;

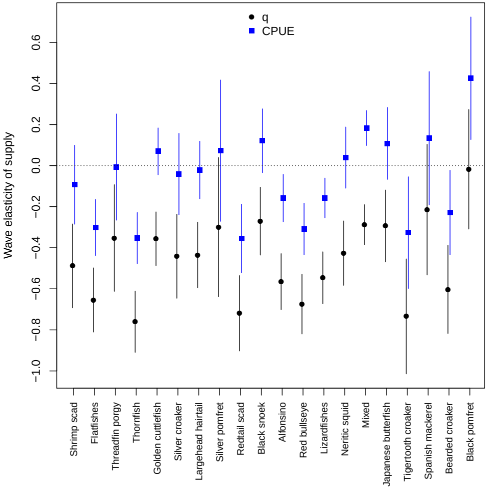
- 80% cross-PES is insignificant;
- Own-PES > cross-PES
- By-catch effect ($p_i \uparrow \rightarrow Q_i \uparrow, Q_j \uparrow$) dominates the input substitution effect ($p_i \uparrow \rightarrow Q_i \uparrow, Q_j \downarrow$).



Wave elasticity

- We found that wave height negatively affects catch except for the three transport species: black pomfret, Spanish mackerel and silver pomfret.
- Typically, a 100% increase of wave height reduces catches by about 30–90%, depending on the species; red bulleye and redtail scad showed the strongest wave effect.
- It is possible that fishing these reef-associated species is more sensitive to weather than fishing species in more open habitats.
- The supply elasticity of neritic squid, Japanese butterfish, silver pomfret and golden cuttlefish are negatively associated with wave height (i.e., the price-wave interaction is significant and negative).

Wave elasticity: robustness check



- If we control for the effort level (i.e., average catch/vessel), the negative association of wave height and catch disappears for 7 species. The effect remains for the rest 10 species.

Fuel elasticity

- Our model does not suggest that fuel prices affect total daily landings or the price elasticity of the offshore trawl fisheries in Ziguan.
- Controlling for vessel number (active vessels per day) would not alter this result.
- We would expect a fuel effect to occur if there is possibility for fishermen to switch from more fuel intensive fishing gears (e.g., bottom trawl) to less intensive gears (e.g., long line or gillnet). Apparently, the switch does not happen easily.

Robustness check: exit decision

表 3: Robustness check: Exit decision—the influence of weather and fuel price on the number of active producers per day (2013–2015).

	Local vessel			Transport vessel		
Model 1: GLS model						
	Estimate	SE	t-value	Estimate	SE	t-value
(Intercept)	52.2***	1.91	27.4	36.8***	1.65	22.3
wave	-0.093***	0.006	-14.7	-0.077***	0.005	-16.6
fuel	0.000 ***	0.000	-5.02	0.000	0.000	1.40
Model 2: Normalized						
(Intercept)	35.5***	0.417	85.1	32.7***	0.361	90.7
normalize(wave)	-4.12***	0.403	-10.2	-3.77***	0.294	-12.8
normalize(fuel)	-2.65***	0.429	-6.17	0.134	0.367	0.365
normalize(wind.speed)	-1.95***	0.365	-5.33	-0.811**	0.248	-3.27

Discussion and conclusion

- Our main finding is that offshore fishermen are price elastic. The effect of fuel price and weather conditions on catch or PES are limited or negligible.
- In a sharp contrast: trawling a relatively indiscriminate fishing method; fishermen are price takers, operating in small scale and facing narrow reaction windows (short fishing trip)
  1. The comparison of price expectation models suggests that fishermen in Ziguan are capable of making use of the best available information.
  2. Market actors (e.g., transport vessels) that source catches from a wider area would make catch less susceptible to local shocks such as weather or local resource availability;
  3. The selected 20 species are mostly valuable commercial species, the less valuable species, especially the by-catch species, are less price elastic or inelastic (e.g., flatfishes);
  4. Experienced fishermen who are assisted by technologies such as sonar and GPS that help them to detect and record the location of fish concentrations.