Subsidy reform and fleet capacity management: China's experience

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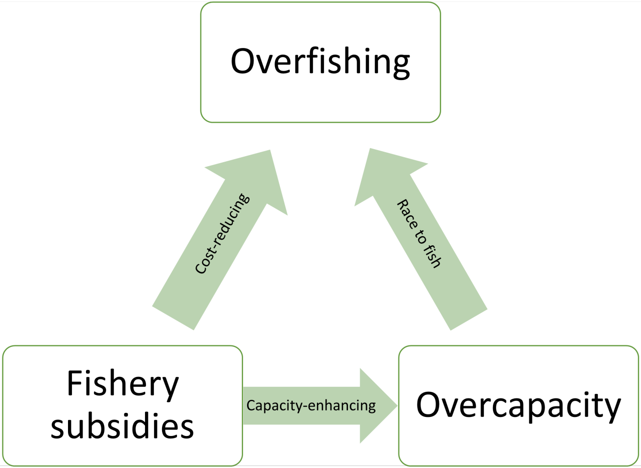
Fleet capacity & fishery subsidies as global issues

- Overcapacity is common for fisheries not rights-based
- Measure of capacity: vessel count/power/tonnage
- Fishery subsidies: cost-reducing / revenue-supporting



Research question

Does China's fuel subsidy reform reduce the fleet capacity?

Motivation

- Fishery subsidy reform
  - Valid social & political costs
  - Unclear benefits to capacity reduction
- China's marine fishery management
  - Largest fleet, few empirical research
  - Changing for sustainability?
- To be the first micro-level empirical study on both fields

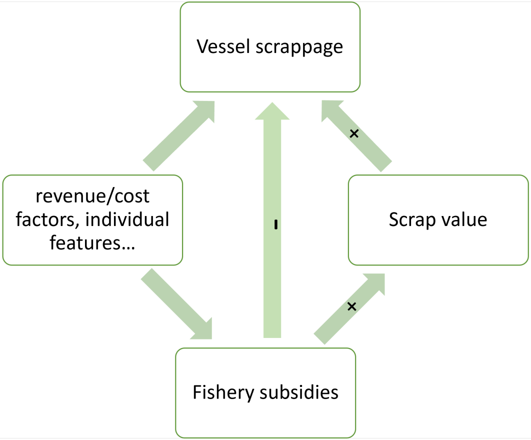
Capacity dynamics: focus on vessel scrappage

$$\Delta Capacity = Constructed - Scrapped$$

- Research focus: Subsidy reform $\Longrightarrow$ Scrappage decision
  - Policy-relevant for existing capacity
  - Lack of tools to manage scrappage
  - More empirically tractable
- Construction change: descriptive evidences

Empirical challenges & our advantage

- Lack of data from policy experiments
  - Unique dataset & large-scale reform
- Endogenous subsidy level & unobserved shocks
  - Quasi-experiment design

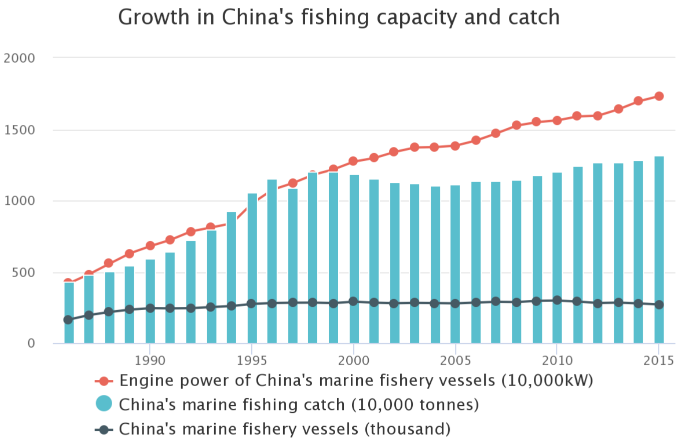


Outline

- Policy background
- Data description
- **Model-free evidence: RDD**
- **Story of more details: Survival model**
- **Heterogeneity: panel FE**

Input control policies: fail till 2015

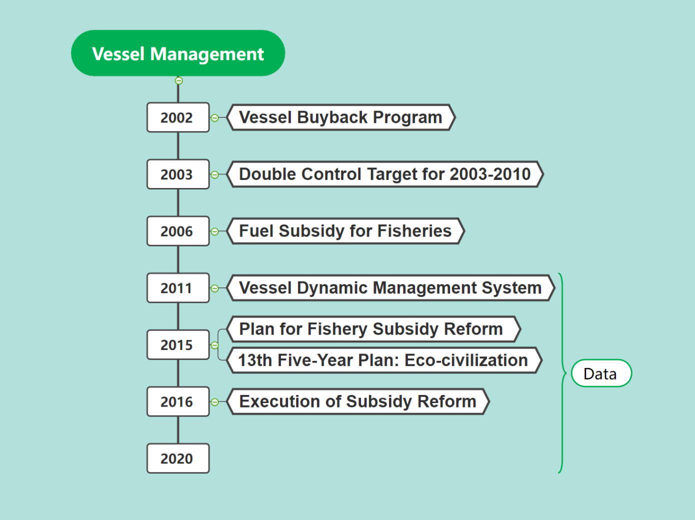
- Double control target
- Power quota & licensing system
- Vessel buyback program



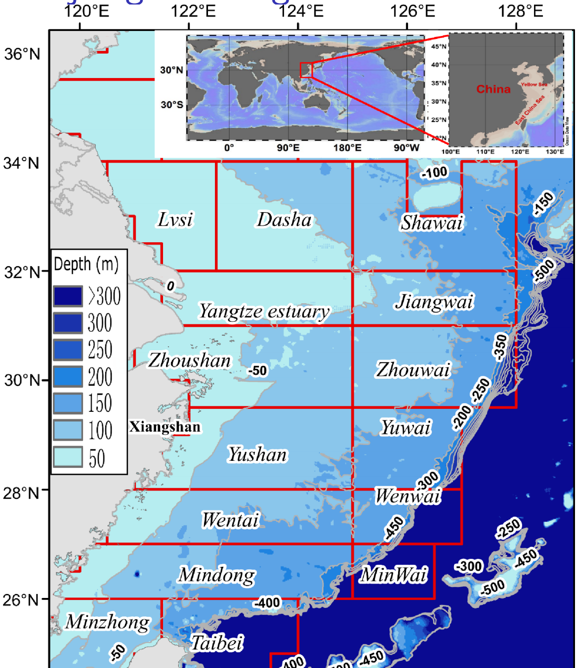
Fuel subsidy program in conflict with input control

- The fuel subsidy program (2006-2015)
  - Aimed to mitigate fuel price deregulation in 2006
  - Based on engine power and yearly fuel price
  - $\Longrightarrow$ a major income support for fishers
  - $\Longrightarrow$ quota price $>$ buyback price $\Longrightarrow$ Few buybacks
- The fuel subsidy reform (2016-2020)
  - Aimed for ocean sustainability
  - Based on vessel length thresholds; reduced annually
  - Put caps on subsidies for new vessels

Policy background: timeline

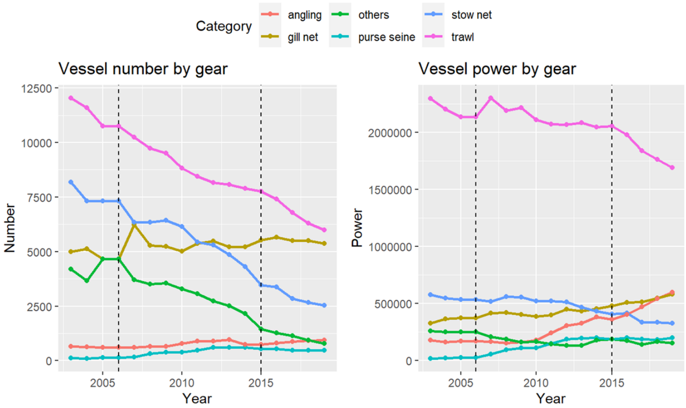


Trawlers in Zhejiang: the largest fleet on East China Sea



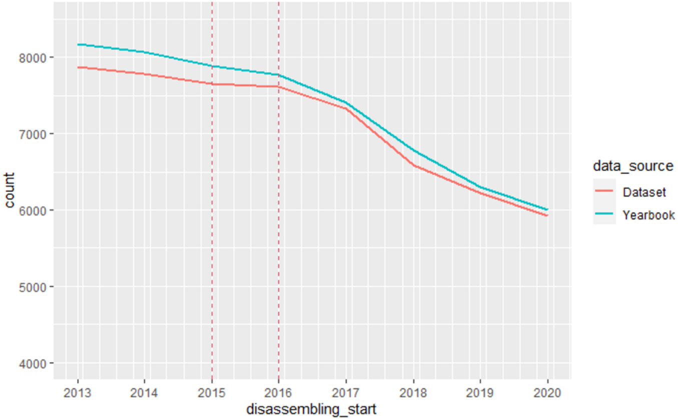
Trawlers' capacity: two-decade change in yearbook

- 2002~2005 (before fuel subsidy): count ↓, power ↓
- 2006~2015 (before subsidy reform): count ↓, power ↑ & →
- 2016~2019 (after subsidy reform): count ↓, power ↓



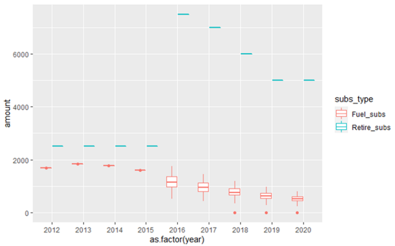
Dataset: from Vessel Dynamic Management System

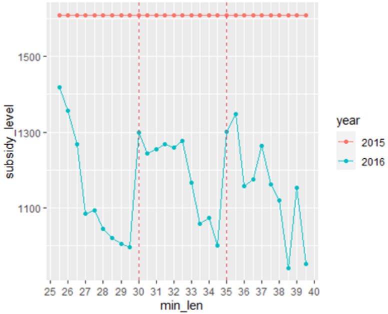
- 9241 trawlers from 2012 to 2019
- ~95% coverage comparing to yearbook



The 2016 reform: exogenous variations in subsidy level

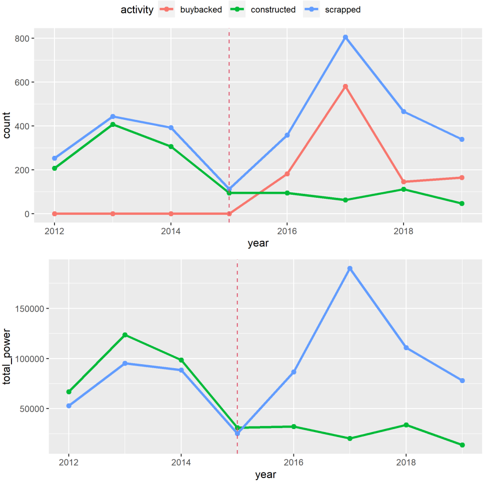
- Temporal: fuel subsidy ↓, buyback price ↑ after reform
- Cross-sectional: ∼30% jump at 30m threshold after reform
- Size: 1000 RMB/kW ≈ 110 $/hp ⇒ ∼$50k for a 300hp trawler in 2015





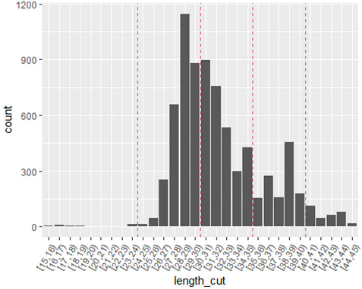
Response to reform: construct, scrap, and buyback

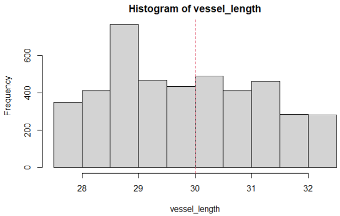
- Construction $\downarrow$, Scrappage $\uparrow$,
- Buyback out of total scrapped: $0 \rightarrow \sim 50\%$



2012 distribution: densiest and balanced around 30m

- Half of trawlers in 2012 fell between 28-30m
- Well-balanced distribution around 30m threshold



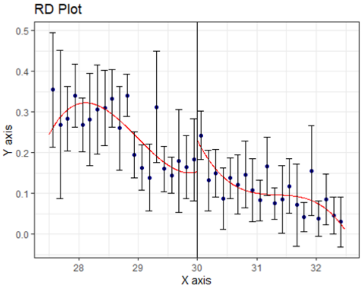


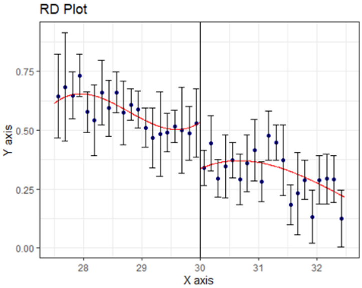
Sharp RDD: cutoff at 30m

- Identification:
  - Local continuity at threshold
  - No anticipation of reform before 2011
- Testing:
  - Local linear polynomial with an optimal bandwidth
- Graphing:
  - Global polynomial of order 3

RD test: scrappage pre and post 2016

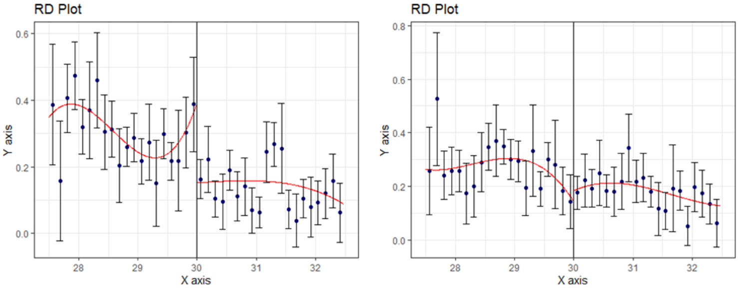
- Before 2016: no discontinuity at cutoff
  - $\tau = 0.06$ ($p = 0.269$)
- After 2016: 20% less scrappage right to cutoff
  - $\tau = -0.199^{**}$ ($p = 0.009$)



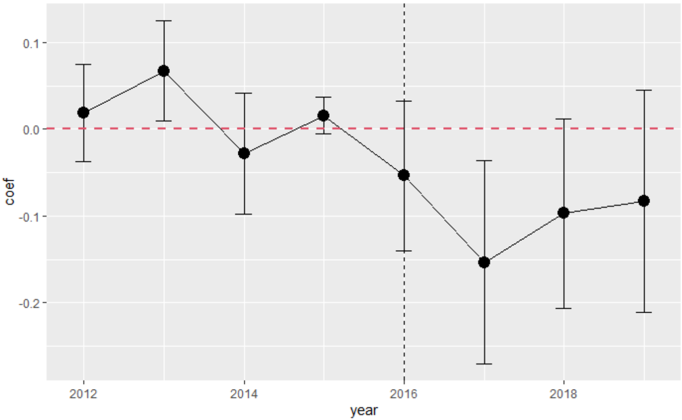


RD test: scrapped for buyback or transaction

- Lower ratio of buyback right to cutoff
  - $\tau = -0.306^{***}$ ($p = 0.000$)
- No discontinuity in scrappage not by buyback
  - $\tau = -0.022$ ($p = 0.597$)



RD test: vessel scrappge by each year



Survival analysis: Discrete proportional hazard model

- h_{it}: scrap hazard, d_{jt}: baseline hazard at age j
- $\theta_t = 1\{t >= 2016\}$, $\lambda_i = 1\{L_i >= \tilde{l}\}$, $D_{it} = \theta_t \lambda_i$
- Regression (1): testing for Treatment

$$\text{clog}\log(h_{it}) = \sum_{J=1}^{J} \alpha_j d_{jt} + \theta_t + \lambda_i + \delta D_{it} + \mathbf{X}_{it}\gamma + \phi L_i + \epsilon_i$$

- Regression (2): testing for Subsidy level

$$\text{clog}\log(h_{it}) = \sum_{J=1}^{J} \alpha_j d_{jt} + \theta_t + \rho \log(FS)_{it} + \mathbf{X}_{it}\gamma + \epsilon_i$$

- Fuel subsidy decreases scrappage $\Leftrightarrow \delta < 0, \rho < 0$

Fuel subsidy decreases scrappage

Threshold 30m; Bandwidth: 29~31m

	(1) matched_t	(2) matched~t	(3) unmatch~t	(4) unmatch~t
1 if failure; ~d				
yr16=1	-0.186	-3.055**	-0.935*	-3.354***
treated=1	0.270		0.179	
yr16=1 # treat~1	-0.636*		-0.478**	
vessel_length	-0.110		-0.101	
engine_power	0.00781***	0.00486**	0.00813***	0.00559***
net_tonnage	-0.0275*	-0.0296**	-0.0199**	-0.0224**
double_otter	1.048***	0.895***	1.018***	0.876***
beam_shrimp	0.401***	0.404***	0.336***	0.338***
log_RS	1.699**	3.307***	2.426***	3.832***
log_FP	3.823***	3.838***	4.400***	4.392***
log_FS		-1.167**		-1.029***
Constant	-45.33***	-51.40***	-57.07***	-62.36***
Observations	6921	6921	10133	10133

Buyback price & Fuel price increase scrappage

- log_RS: Log(Buyback price)
- log_FP: Log(Fuel price)

engine_power	0.00781***	0.00486**	0.00813***	0.00559***
net_tonnage	-0.0275*	-0.0296**	-0.0199**	-0.0224**
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Vessel tonnage & engine power: opposite impacts

- Higher tonnage ⇒ Higher building cost
- Larger power ⇒ More diesel consumption per fishing hour

Threshold 30m; Bandwidth: 29~31m

	(1)	(2)	(3)	(4)
	matched_t	matched~t	unmatch~t	unmatch~t
1 if failure; ~d				
yr16=1	-0.186	-3.055**	-0.935*	-3.354***
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Estimate scrap elasticity to fuel subsidy for full sample

- Panel of scrap rates for model-vintage groups
  - Model m defined by thresholds of vessel characteristics
  - y_{vmt} is the scrappage rate for vintage v and model m group
- Regression (1): year-fixed effect:

$$y_{vmt} = \alpha_{vm} + \alpha_t + \beta_m \log(FS)_{mt} + \varepsilon_{vmt}$$

- Regression (2):year-age fixed effect:

$$y_{vmt} = \alpha_{vm} + \alpha_{vt} + \beta_m \log(FS)_{mt} + \varepsilon_{vmt}$$

Larger shocks of reform for trawlers shorter & older

	(1) scrap_rate	(2) scrap_rate
[24,28) # log_FS	-16.33***	-16.79***
	(1.876)	(2.058)
[28,30) # log_FS	-11.87***	-12.23***
	(1.830)	(1.672)
[30,32) # log_FS	-10.26***	-10.77***
	(1.663)	(0.978)
[32,35) # log_FS	-6.281***	-9.018***
	(1.366)	(1.741)
[35,40) # log_FS	-1.910	-6.217**
	(1.310)	(1.537)
[40,45) # log_FS	-1.426	-6.457**
	(1.330)	(1.490)
Constant	56.38***	74.10***
	(8.786)	(9.672)
Observations	856	856

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

	(1) scrap_rate	(2) scrap_rate
[1990,1995) # log_FS	-18.34***	-20.74***
	(2.015)	(3.903)
[1995,2000) # log_FS	-14.05***	-17.60***
	(1.257)	(1.896)
[2000,2005) # log_FS	-12.34***	-12.42**
	(1.865)	(3.087)
[2005,2010) # log_FS	-5.263**	-3.606*
	(1.551)	(1.214)
[2010,2015] # log_FS	-4.650*	-0.176
	(1.533)	(0.219)
Constant	84.72***	89.28***
	(8.773)	(9.795)
Observations	856	856

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Key findings & concluding remarks

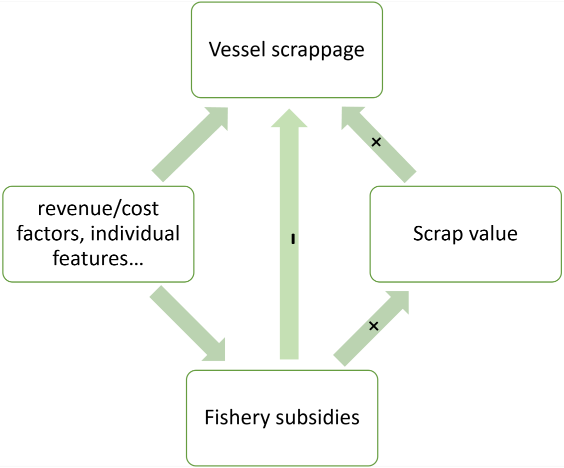
- Fuel subsidy reduction $\Longrightarrow$ higher scrappage
- Older and smaller trawlers: more vulnerable in reform
- Trawlers in 2016 subsidy reform: buyback $\uparrow$, capacity $\downarrow$
- China's fishery management: changes for the better, experiences for the world

Appendix

Contribution

- Related literature
  - Fishery subsidy reform and capacity management
  - Capitalization of subsidies for agriculture & ecosystem service
  - Transitioning marine resource management in developing countries with multiple objectives

Impact of subsidy level on vessel scrappage



Theoretical model: setting up

Consider the economic life T for a vessel with power E

$$\max_{T} \int_{t=0}^{T} e^{-\rho t}[\pi(E) + \alpha E - m(E,t)]dt + e^{-\rho T}\beta(\alpha)E$$

- π: operating profit, $m(E,t)$: maintenance cost at t
- α: Fuel subsidy rate, β: Scrap value
- $\beta = \max\{P^Q, P^B\}$, $e_{\beta|\alpha}$: elasticity of capitalization

Theoretical model: predictions

$$\frac{\partial T^*}{\partial \alpha} = (1 - e_{\beta|\alpha}\frac{\rho\beta}{\alpha})\frac{E}{\dot{m}}$$

- Given same scrap value:

$$e_{\beta|\alpha} = 0 \Rightarrow \frac{\partial T^*}{\partial \alpha} > 0$$

- Given incomplete capitalization:

$$e_{\beta|\alpha} < 1, \frac{\beta}{\alpha/\rho} < 1 \Rightarrow \frac{\partial T^*}{\partial \alpha} > 0$$

- Buyback happens only if $P^B \geq P^Q(\alpha)$

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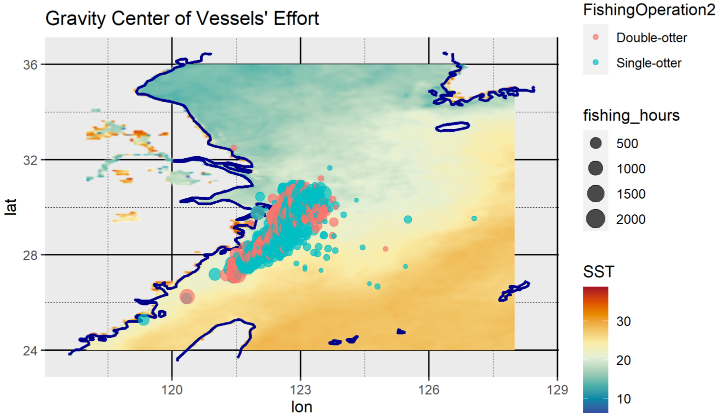
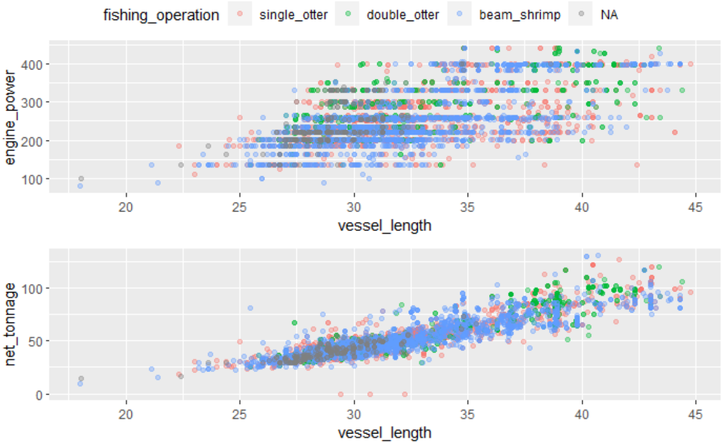


Data description: covariates

- Variation of engine power and net tonnage conditional on vessel length



Survival analysis: identification

- Core assumption
  - For a vessel built before 2011, the subsidy level assignment is strictly exogenous.
- Quasi-experiment design
  - Treatment: $D = 1\{L \geq 30\}$; Scrappage: $h_t = \Pr[T \leq t]$
  - Conditional independence:

$$h_t^1, h_t^0 \perp L, D|X : L - \epsilon < L < L + \epsilon$$

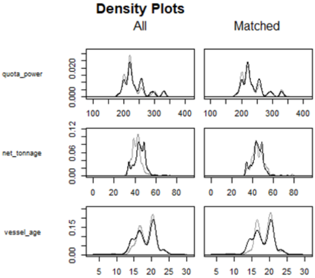
  - Common support: $0 < \Pr[D = 1|X] < 1$

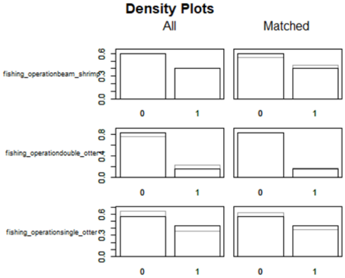
Survival analysis: design

- Testing sample
  - Bandwidth: $\tilde{l} - 1 \leq L < \tilde{l} - 1$
  - Authentic-threshold sample: $\tilde{l}_0 = 30$
  - Pseudo-threshold sample: $\tilde{l}_1 = 29; \tilde{l}_2 = 31$
- Prediction
  - Hypothesis: higher subsidy level reduces scrap rate
  - δ should be negative significant only for $\tilde{l}_0$
  - ρ should be negative significant for any $\tilde{l}$.

Survival analysis: distribution

- PSM using nearest neighbor with replacement
- Balance of distributions for covariates





Survival analysis: falsification

Threshold 31m; Bandwidth: 30~32m

	(1) matched_t	(2) matched~t	(3) unmatch~t	(4) unmatch~t
1 if failure; ~d				
yr16=1	0.145	0.250	-0.0464	-0.461
treated=1	0.0331		0.106	
yr16=1 # treat~1	0.364		0.373*	
vessel_length	-0.480*		-0.424**	
engine_power	0.00535**	0.00490**	0.00644***	0.00547***
net_tonnage	-0.0264*	-0.0285**	-0.0206**	-0.0240***
double_otter	1.518***	1.507***	1.313***	1.299***
beam_shrimp	0.392**	0.363**	0.450***	0.436***
log_RS	0.756	0.854	0.845	1.229
log_FP	2.313***	2.321***	2.436***	2.451***
log_FS		-0.0249		-0.243
Constant	-12.29	-27.68**	-17.38*	-31.28***
Observations	6109	6109	9767	9767

* p<0.05, ** p<0.01, *** p<0.001

Threshold 29m; Bandwidth: 28~30m

	(1) matched_t	(2) matched~t	(3) unmatch~t	(4) unmatch~t
1 if failure; ~d				
yr16=1	-2.728***	-5.008***	-1.485***	-3.301***
treated=1	-0.832***		-0.692***	
yr16=1 # treat~1	0.566**		0.418**	
vessel_length	0.244		0.141	
engine_power	0.00782***	0.00542**	0.00680***	0.00436***
net_tonnage	-0.0216	-0.0187	-0.0326***	-0.0338***
double_otter	0.641***	0.443**	0.733***	0.601***
beam_shrimp	0.254*	0.242*	0.273***	0.261***
log_RS	3.646***	5.170***	2.377***	3.601***
log_FP	4.384***	4.439***	3.789***	3.842***
log_FS		-1.147**		-0.848**
Constant	-75.00***	-71.91***	-57.68***	-56.84***
Observations	10122	10122	10503	10503

* p<0.05, ** p<0.01, *** p<0.001