Lobbying over a dynamic resource: Evidence from a shared Fishery[*]

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Abstract

We evaluate how a regulator corrects a dynamic externality under the presence of lobbying. Our application concerns commercial lobbying in New Zealand's most valuable public fishery. While a regulator wishes to limit the commercial harvest to maximize the discounted stream of firm profits and public utility. We show future utility drives a wedge so the profit-maximizing commercial harvest exceeds the welfare-maximizing harvest. The commercial sector responds to this incentive by lobbying to block the regulator from reducing the commercial harvest. We interpret this action as imposing a lobbying constraint. We quantify the misallocation from lobbying by developing and estimating a dynamic model. We use the estimated model to calculate that removing the lobbying constraint increases welfare by between 4.2%-6.4%. We find a large redistribution: removing the lobbying constraint would lower profits by between 12%-21% and increase utility by between 24%-43%.

1 Introduction

Many economic activities earn profits today but impose future costs on the public. In principal, regulation solves this dynamic externality by limiting firm activity so the current marginal profit equals the future cost. For example, a regulator may levy a carbon tax, to dissuade particularly low

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value greenhouse gas emissions. In practice, because regulation reduces firm profits. Firms are likely to generate a misallocation by lobbying for weaker regulation.

In this paper, we develop an empirical framework to assess how lobbying distorts a regulator's ability to correct a dynamic externality. Our empirical application concerns commercial lobbying in New Zealand's most valuable public fishery. Public fishers harvest fish to earn utility and share the fishery with commercial firms who harvest fish to earn profits. A regulator manages the fishery by limiting the commercial harvest to face the following trade-off. On the one hand, reducing the commercial harvest lowers current profits. On the other hand, reducing the commercial harvest increases future profits and utility. This is because reducing the harvest increases the future biomass. More abundant biomass firstly increase profits by decreasing fishing costs and secondly increases utility by making public fishing easier.

We are inspired by a discrete lobbying event in which the commercial sector successfully blocked the regulator from reducing the commercial harvest. We rationalize commercial lobbying by showing the profit-maximizing commercial harvest exceeds the welfare maximizing harvest. The mechanism is as follows. While the profit-maximizing harvest occurs when the current marginal profit equals the future profit from leaving a fish in the ocean. The welfare-maximizing harvest occurs when the current marginal profit equals the future profit and additionally utility from leaving a fish in the ocean. Future utility therefore increases the payoff from leaving a fish in the ocean, and consequently, drives a wedge so the profit-maximizing payoffs exceeds the welfare-maximizing payoff.

Our framework to assess the welfare cost of lobbying starts from the regulator's problem of selecting the yearly commercial harvest. The regulator's objective is to maximize the discounted stream of profits and utility. In selecting the yearly commercial harvest, the regulator considers the biomass equation of motion, which explains how fishing today affects the fish biomass tomorrow. We interpret the commercial sector's lobbying action of blocking the regulator as introducing a lobbying constraint. The lobbying constraint requires the yearly commercial harvest to exceed a lobbied value. A binding constraint causes a misallocation by forcing the regulator to set a higher commercial harvest than would maximize welfare.

Our framework allows us to quantify the lobbying misallocation. As the fishery earns a perpetual stream of utility and profits. We apply a discount rate to capitalize the stream of profits and utility into a present value. We calculate the lobbying misallocation as the present value increase from removing lobbying constraint. Removing the constraint means the regulator may reduce the commercial harvest to maximize welfare. In particular, welfare increases as increase in future public utility outweighs the current decrease in profits.

Our dynamic model requires a model of commercial and public fishing to generate yearly profits and utility. A regulator divides the commercial harvest into tradable quota. The commercial model consists of heterogenous firms who vary by average cost. A firm purchases quota to enter if profitable. This occurs if revenue per caught snapper, which equals the Snapper price minus quota price exceeds the firm's average cost. The quota market clears so the marginal firm earns zero profits. Increasing the commercial harvest requires the quota market to clear with a lower quota price so as to permit a higher average cost firm to enter. Yearly public utility equals a utility value per kilogram multiplied by the public harvest. The regulator does not limit the public harvest and instead the biomass determines the public harvest. More abundant biomass makes public fishing easier. Easier public fishing increases the public harvest and in turn public utility. A biomass equation of motion, which describes how fishing affects the biomass, closes the dynamic model.

We assemble a number of rich datasets to estimate parameters entering into firm profit, public utility, and the discount rate. We specify a Cobb-Douglas public harvest equation, in which technology and the biomass determine the public harvest. We estimate a biomass elasticity of 0.51, which means a 10% increase in the biomass increases the yearly public harvest by 5.1%. We further estimate improving technology increases the harvest by 2% per year. Because we estimate our model using the estimated rather than true biomass. We believe our estimates may suffer from an error-in-variables bias, which bias the biomass elasticity towards zero and the technology parameter away from zero. As the literature typically assumes the biomass elasticity equals one, e.g., (Bentley et al., 2012). We re-estimate the public harvest but constrain the biomass elasticity to equal one. Consistent with expectations, the technology parameter in the constrained model falls to 1%. The regulator estimates marginal utility equals $9.50 per kilogram, which is nearly double the average marginal profit of $5.60. The marginal utility and biomass elasticity combine to drive a wedge between the profit-maximizing and welfare maximizing commercial harvest.

We specify a Cobb-Douglas commercial harvest equation, in which a firm effect, technology, and the biomass determine the firm harvest. We estimate a biomass elasticity of 0.31. This estimate means a 10% increase in the biomass increases each firm's yearly harvest by 3.1%. We estimate technology improves each firm's harvest by 2.1% or 3.3% per year depending on the gear type. Again we are concerned about a possible error-in-variables bias so re-estimate the model but constrain the biomass elasticity to equal one. Consistent with expectations, the technology parameter in the constrained model falls to 2% or 2.1% depending on gear type.

We next use firm entry decisions to estimate the firm entry cost. Because firms become more efficient over time. The quota price increases relative to the snapper price to force higher average cost firms to enter. To illustrate this variation, in 1989, the first year in our data. The Snapper price minus the quota price equals $11.4. We observe 257 firms enter who catch 339 kilograms on an average trip. By 2012, the final year in our data, the Snapper price minus the quota price equals \$5.4. In 2012, we observe 70 firms enter who catch 778 kilograms on an average trip. Last, as the dynamic model discounts future payoffs. We estimate a discount rate of between 3%-4% using data on long-term government borrowing rates.

Using the dynamic model we quantify the lobbying misallocation ranges between 4.2%-6.4%. We unpack the misallocation into a large redistribution: Removing the lobbying constraint would lower profits by between 12.4%-20.8% but increase utility by between 23.9%-42.6%. The lower bound uses the unconstrained parameter estimates and the upper bound uses the parameter estimates when we constrain biomass elasticity to equal one. We conclude that while commercial lobbying generates a small welfare cost. Lobbying significantly redistributes welfare away from the public towards firms.

Contribution to Literature

Our paper provides new insights on regulating dynamic externalities and lobbying distortions. Beginning with Pigou (1920), Coase (1960), and Hardin (1968), an extensive theoretical literature studies how regulation solves an externality. We contribute relative to this literature by firstly developing an empirical framework and secondly allowing for lobbying to cause distortions. Most similar to our paper is Hagerty (2019), who empirically estimates the extent to which efficient trading would increase welfare in the Californian water market. While Hagerty estimates the distortions resulting from vague regulatory transaction costs. Our model firstly pinpoints a specific lobbying distortion and secondly derives the incentive underpinning this distortion.

A second point of departure is to empirically model how a regulator solves a dynamic externality. Our approach is most similar to the climate change literature, which estimates dynamic models to calculate the costs from climate regulation e.g., (Deschênes and Greenstone, 2012; Meerburg et al., 2009; Mendelsohn, Nordhaus and Shaw, 1994). Because we fix attention on a simpler setting with a clean trade-off. Our setting allows us to solve for optimal policy and consider a counterfactual which is typically not feasible in many other applications.

Our paper further relates to the cost of commercial lobbying to weaken regulation. While a previous literature explores how lobbying affects different economic variables. For example, Joskow, Schmalensee and Bailey (1998) show US states with many polluting firms delayed the 1990 Clean Air Act to hold out for a better allocation; and Oehmke (1987) show how high polluting firms lobbied for more credits in the European Emissions Trading Scheme. We contribute relative to these papers by combining a formal model with a concrete lobbying event to calculate the counterfactual outcome without lobbying.

The literature on fishing quota typically analyzes specific outcomes. For example, Birkenbach, Kaczan and Smith (2017) show fishing quota extend the fishing seasons by ending the incentive to race to fish; Birkenbach et al. (2017) show fishing quota cause firms to earn higher revenues by substituting away from low-value frozen fish to higher-value fresh fish; and Grainger and Costello (2014) show fishing quota significantly reduce the risk that the fish biomass collapses. Our paper compliments this literature by translating these mechanisms into a welfare measure.

A set of papers study New Zealand fisheries. Batstone and Sharp (1999), Lock and Leslie (2007), and Hale and Rude (2017) provide extensive surveys. A further set of papers analyzes data on market structure, price formation, and fishing decisions to find rich links between economic fundamentals and quota prices (Newell, Sanchirico and Kerr, 2005; Newell, Papps and Sanchirico, 2007; Stewart and Leaver, 2015; Stewart and Moriarity, 2018). Most relevant to our paper, Batstone and Sharp (2003) show how a regulator may use quota and catch-share prices to solve for the profit-maximizing commercial harvest.

The paper unfolds as follows: Section 2 provides background. Section 3 presents the lobbying incentive and sets up the regulator's problem to quantify the lobbying misallocation. Section 4 introduces the data and links key statistics to the model. Section 5 covers estimation, calibration, and identification. Section 6 presents and discusses the parameter estimates. Section 7 uses the estimated parameters to quantify the lobbying misallocation. A last section concludes.

2 Background

Snapper – *Pagrus auratus* – is a prized eating fish found in coastal waters in New Zealand. Snapper is the most valuable fish species for public fishers and an important commercial species.

A public fisher uses a boat, kayak, or fishes from the shore to catch a small number of snapper for private consumption. Fishing is a popular recreational activity in New Zealand. Surveys estimate between 10% - 15% of the population fish at least once per year (Gray et al., 2019). A regulator does not limit the total public harvest but limits the number of fish a person may catch per day to outlaw egregious harvests. The daily limit is generous so this limit binds for fewer than 10% of public fishers in my data.

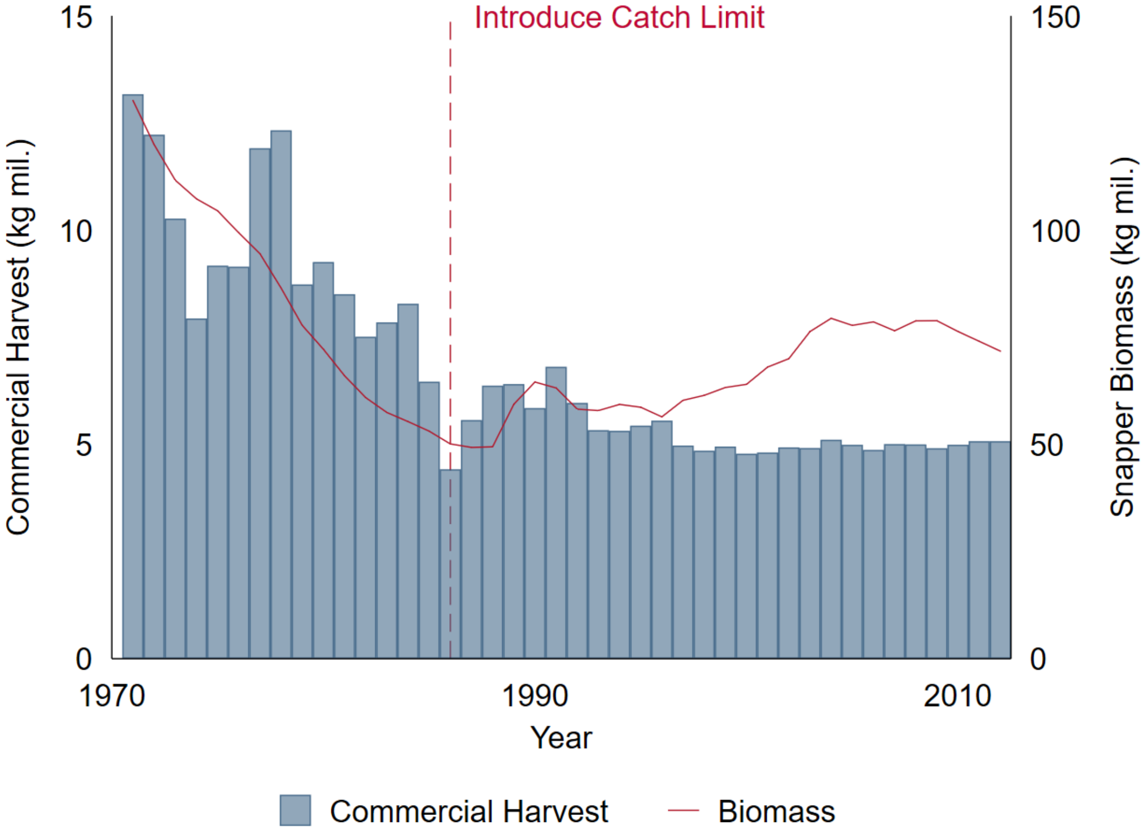
The commercial sector consist of many firms. Each firm catches many fish to sell to supermarkets, restaurants, and to export. Only firms may legally sell fish, which distinguishes firms from public fishers. Firms use a variety of techniques including trawl netting, seining, and Bottom longlining to catch Snapper. Snapper is the premium inshore fish species so firms use specific techniques and equipment to maximize catching Snapper and minimize catching other species. For example, firms will fish at particular times of the day and use specific hooks sizes to maximize snapper catches and minimize catches of other species.

The regulator delineates New Zealand into separate species-region management areas. We focus on Snapper One, which is the management area for Snapper located on New Zealand's north-east coast (map). Snapper One is New Zealand's most valuable public fishery and additionally New Zealand's most valuable inshore commercial fishery.

We now show how commercial fishing affects the biomass and therefore flows onto the public harvest. Figure 1 plots the Snapper biomass and commercial harvest from 1970-2012. Before 1986, the regulator did not limit the commercial harvest. The commercial harvest averaged around 10 million kg per year, which exceeded Snappers spawning rate to cause the biomass to continuously decline from around 120 million kg in 1970 to around 50 million kg by the mid-1980s.

The regulator introduced a commercial catch limit in 1986. Since 1986 the commercial harvest has averaged around 5 million kg, which is below Snapper's spawning rate causing the Snapper biomass to increase from around 50 million kg in 1986 to nearly 80 million kg in 2012.

Figure 1: Snapper One Biomass and Commercial Harvest 1970-2012



A number of factors meant the regulator was not explicit about the trade-off between the commercial harvest and public fishing outcome until 1995. In particular, from 1986 to 1995, the regulator needed time to collect sufficient data to satisfactorily model the Snapper biomass, settle indigenous and commercial allocation disputes; and to revise legislation. In 1995, the regulator decided to significantly reduce the commercial harvest by more than 40% from over 5 million kg to 3 million kg. In making its decision, the regulator explicitly expressed the purpose was to increase the Snapper biomass to benefit public fishers:

> *"I consider the current recreational catch per trip to be inadequate and that it is reasonable to obtain a modest increase in this catch rate"*
> – Doug Kidd, Minister of Fisheries (regulator), 1995 catch limit decision

The commercial sector perceived the harvest reduction would significantly reduce profits so responded by suing the regulator. For legal reasons, the courts ruled the legislation did not allow the regulator to reallocate away from firms to the public. In response to the court case, the regulator cooperated with commercial firms to reach a compromise. The regulator would reduce the commercial catch limit by only 9% rather than the initial 40%. In setting this commercial harvest, the regulator went to great lengths to outline the legal basis for the more modest reduction. We therefore interpret the court decision as an act of commercial lobbying to constrain the regulator to guarantee a minimum commercial catch limit. We find the minimum commercial catch constraint interpretation to be reasonable for the following two reasons. First, the regulator has never changed the commercial harvest limit since the court decision. This suggests the lobbied harvest is binding. Second, we compile numerous documents and statements from the regulator, commercial firms, courts and other parties, which acknowledge litigation risk constrains the regulator from further reducing the commercial harvest.

3 Model

This section introduces the model. Commercial firms and the public catch fish each year to earn profits and utility. Commercial fishing generates the following trade-off. On the one hand, catching a fish earns profits today. On the other hand, leaving the same fish in the ocean means the fish can grow into a larger fish. The larger fish earns higher profits and utility tomorrow.

Subsection 3.1 clarifes the commercial lobby incentive. The primary insight is that future utility drives a wedge so the profit-maximizing harvest exceeds the welfare-maximizing harvest. As a result, public fishing incentivizes the commercial sector to lobby for a larger harvest. In practice, the commercial sector may not perfectly lobby the regulator and instead may only constrain the regulator to ensure a minimum yearly commercial harvest. Subsection 3.2 formalizes the regulator's dynamic problem. The regulator limits the commercial harvest to maximize welfare. In maximizing welfare, the regulator first considers the biomass equation of motion, which describes how fishing affects the biomass. Further, the regulator faces the lobbying constraint, which applies a minimum yearly commercial harvest. We use this framework to quantify the lobbying misallocationby removing the lobbying constraint.

Last, subsection 3.3 fills in necessary detail needed for the dynamic model and estimation. In particular, we explain how heterogenous cost firms and the quota market combine so that the marginal cost increases in the commercial harvest.

3.1 Dynamic trade-off

We show future utility drives a wedge so the profit-maximizing harvest exceeds the welfare-maximizing harvest. Intuitively, while the regulator values both the future profits and utility from leaving a fish in the ocean. The commercial sector only values the future profits. As a consequence, the commercial sector perceive a lower benefit to reducing their harvest to leave more fish in the ocean.

We communicate this reasoning explicitly using the necessary conditions for the optimal commercial harvest path. A regulator limits the commercial harvest to maximize welfare. Where welfare equals the discounted stream of profits and utility. A necessary condition of maximizing welfare is the regulator cannot increase welfare via a deviation. We consider the case in which the regulator deviates by reducing the commercial harvest by one fish today. The cost of this deviation is to reduce current profits. The benefit of this deviation is to leave a fish in the ocean to increase profits and utility in the following year. The welfare maximizing commercial harvest implies the current marginal profit equals the future payoff:

$$\pi'_t = \frac{1+g}{1+r} \cdot \left(\left(1 - \frac{\partial Q_{p,t+1}}{\partial B_{t+1}} \right) \cdot \pi'_{t+1} + \frac{\partial Q_{p,t+1}}{\partial B_{t+1}} \cdot u \right). \tag{1}$$

The left hand side is the marginal profit, π'_t, to catching an additional fish today. The fish growth rate is g so one fish grows into $(1 + g)$ fish the following year. The discount rate is r so one-dollar today is worth $\frac{1}{1+r}$ dollars tomorrow. $Q_{p,t+1}$ is the public harvest in the following year so $\frac{\partial Q_{p_1 t+1}}{\partial B_{t+1}}$ denotes how a larger biomass increases the public harvest. Last, u denotes the public utility per caught kilogram. The right hand side quantifies the future profits plus utility from leaving a fish in the ocean. The public harvest is unrestricted so increases by $(1+g) \cdot \frac{\partial Q_{p_1 t+1}}{\partial B_{t+1}}$. Because the deviation must return back to the equilibrium path. The commercial harvest may only increase by $(1+g) \cdot (1 - \frac{\partial Q_{p_1 t+1}}{\partial B_{t+1}})$.

The commercial sector does not value utility and wants to limit the commercial harvest to maximize the discounted stream of profits. A necessary condition of maximizing the present value of profits is that it is not possible to increase the present value of profits via a deviation. We again consider the deviation to reduce the commercial harvest by one fish today. The cost of this deviation is to reduce current profits. The benefit of this deviation to commercial firms is to leave a fish in the ocean to increase profits in the following year. The profit-maximizing commercial harvest means the marginal cost equals the marginal benefit:

$$\pi_t' = \frac{1+g}{1+r} \cdot \left(\left(1 - \frac{\partial Q_{p,t+1}}{\partial B_{t+1}} \right) \cdot \pi_{t+1}' \right). \tag{2}$$

The profit-maximizing trade-off (2) only differs from the welfare-maximizing trade-off (1) by missing the future utility value, $\frac{\partial Q_{p,t+1}}{\partial B_{t+1}} \cdot u$. By implication, the future utility drives a wedge between the profit-maximizing and welfare-maximizing commercial harvest. The key intuition is the regulator values public fishing so future utility enters the regulator's trade-off. The commercial sector, however, does not value public fishing so perceives the public harvest increase as a tax. To clarify the tax interpretation. Leaving a fish in the ocean increases the biomass, which increases the public harvest. The public harvest increase means the commercial sector may only consume the residual biomass increase. This is most transparent in the corner case, in which $\frac{\partial Q_{p,t+1}}{\partial B_{t+1}} = 1$ so the public harvest increases one-for-one with the biomass. Inserting $\frac{\partial Q_{p,t+1}}{\partial B_{t+1}} = 1$ into (2) clarifies that the commercial sector now has no incentive to leave a fish in the ocean.

The second informative corner case is when the public harvest does not respond to the biomass so $\frac{\partial Q_{p,t+1}}{\partial B_{t+1}} = 0$. This is true, for example, in deep-sea fishing, in which there are no public fishers. In this case, both the regulator's and commercial sector's trade-off collapses to $\pi_t' = \frac{1+g}{1+r} \cdot \pi_{t+1}'$.

The fundamental takeaway is future utility drives a wedge so the profit-maximizing harvest exceeds the welfare-maximizing harvest. This wedge occurs because the commercial sector only receive a fraction of the payoff to leaving a fish in the ocean. In response, the commercial sector increases profits by lobbying the regulator for a greater commercial harvest. While the commercial sector would ideally lobby to maximize profits. In practice, the commercial sector may only feasibly lobby to enforce a minimum yearly commercial harvest.

3.2 Regulator's problem

We now specify the regulator's problem. The regulator selects the commercial harvest path to maximize the discounted stream of profits and utility. Because fishing reduces the biomass, the regulator must account for a biomass equation of motion. Further, the regulator faces a lobbying constraint enforcing a minimum yearly commercial harvest. We write the regulator's problem:

$$\begin{gathered}\max_{\{Q_{ct}\}} V_t=\sum_{t=0}^{\infty}\frac{\pi_t(B_t,Q_{ct})+u_p\cdot Q_{pt}(B_t)}{(1+r)^t}\\ B_{t+1}=B_t+G\left(B_t\right)-Q_{ct}-Q_{pt}\left(B_t\right)\\ Q_{ct}\geq\underline{Q_{ct}}\end{gathered}\tag{3}$$

The yearly profit is $\pi_t\left(B_t, Q_{ct}\right) = p_t \cdot Q_{ct} - C_t(B_t, Q_{ct})$. Where p_t is the world snapper price in year *t* and Q_{ct} is the commercial harvest in year *t* so $p_t \cdot Q_{ct}$ is the yearly revenue. The commercial harvest cost is $C_t(B_t, Q_{ct})$, where B_t is the biomass in year *t*. The marginal profit is again $\pi_t' = p_t - C'\left(B_t, Q_{ct}\right)$. The marginal profit decreases in the commercial harvest because a larger harvest requires increasingly higher cost firms to enter. The marginal profit increases in the biomass as more abundant biomass lowers fishing costs.

The yearly utility is $u_p \cdot Q_{pt}\left(B_t\right)$, which is the utility per kilogram, u_p multiplied by the yearly public harvest, $Q_{pt}(B_t)$. More abundant biomass makes public fishing easier so increases the public harvest. Increasing the public harvest is the only mechanism to increase public utility.

The discount rate, *r* discounts yearly profits and utility to reflect society's preference for current consumption over future consumption. The infinite sum reflects the regulator seeks to maximize the discounted stream of profits and utility.

The second line is the biomass equation of motion. This equation updates next year's biomass as this year's biomass plus the spawning biomass, $G\left(B_t\right)$, minus the yearly harvest. The third and last line is the lobbying constraint. This constraint states the regulator cannot reduce the yearly commercial harvest below $\underline{Q_{ct}}$. A binding lobbying constraint implies the commercial harvest exceeds the welfare-maximizing commercial harvest. A lobbying misallocation arises because the payoff from leaving an additional fish in the ocean exceeds the current marginal profit.

We now explain how we use the regulator's dynamic problem (3) to calculate the lobbying misallocation. We calculate the lobbying misallocation by comparing the present value with and without the lobbying constraint. In practice, this means we solve for optimal commercial harvest path from regulator's problem. We first solve with the lobbying constraint and second solve without the lobbying constraint. Solving the regulator's problem with and without the lobbying constraint recovers two paths of the commercial and public harvest and therefore two streams of profits and utility. We discount each stream to compute the present value. The lobbying misallocation equals the increase in present value from removing the lobbying constraint.

3.3 Commercial Model

This section rationalizes the increasing marginal cost curve through a firm entry and quota market model. The regulator divides a yearly commercial harvest limit into tradeable quota. Firm average cost is heterogenous. A firm enters by purchasing quota. Firms compete for scarce quota leading to an equilibrium quota price to clear the quota market.

3.3.1 Firm Profit

A firm *i* earns the following profit in year *t*:

$$\pi_{it} = (p_t - \theta_t^*) \cdot Q_{it}\left(B_t\right) - f_{it} \tag{4}$$

Where p_t is the yearly world snapper price and θ_t^* is the equilibrium quota price so each firm earns equivalent revenue of $p_t - \theta_t^*$ per kilogram of caught snapper. Each firm harvests $q_{it}(B_t)$ kilogram of Snapper. Last, f_{it} is a yearly firm entry cost, which reflects operating costs such as petrol, wages, and equipment.

3.3.2 Firm Entry

A firm purchases quota to enter if the firm earns positive profits. We rearrange the profit function (4) into an entry condition stating a firm enters if the Snapper price minus the firm average cost exceeds the equilibrium quota price.

$$p_t - \frac{f_{it}}{Q_{it}\left(B_t\right)} \geq \theta_t^* \tag{5}$$

Recognizing $\frac{f_{it}}{Q_{it}}$ is the yearly cost divided by yearly harvest so equals the average cost for firm *i*.

3.3.3 Quota Market

A quota market clearing condition pins down the equilibrium quota price to determine firm entry. The quota market clearing condition says the total commercial harvest cannot exceed the regulator's catch limit, Q_{ct}:

$$\sum_I Q_{it}\left(B_t\right) \leq Q_{ct} \tag{6}$$

The quota market clears so the marginal firm earns zero profits. The equilibrium quota price therefore equals the snapper price minus the marginal firm's average cost so $p_t - \frac{f_{mt}}{Q_{mt}(B_t)} = \theta_t^*$, where *m* represents the marginal firm. For this reason, we may interpret the quota price as marginal commercial profit so $\pi_t' = \theta_t^*$.

4 Data

The data section first describes the data and level of aggregation. We next provide summary and descriptive statistics.

4.1 Data description and aggregation

We compile a variety of administrative, transactions, and survey data from the Ministry of Primary Industries (Regulator), Statistics NZ, Reserve Bank of New Zealand, and the National Institute of Weather and Atmosphere. This section provides a general description of the datasets we use in our analysis. The appendix provides further detail about data construction.

The regulator collects data on commercial and public fishing. Commercial firms complete a logbook for every fishing trip. A logbook records data on the trip harvest, fishing location, and other relevant variables. We use the logbook data for two purposes. First, we use the trip harvest to estimate a harvest equation. Second, we identify firm entry and exit, which we use to estimate the firm entry cost. Commercial firms are further required to lodge all catch-share and quota transactions with the regulator. We use these data to estimate the catch-share and quota price.

The regulator estimates both the public harvest and public utility per caught kilogram. The regulator estimates the public harvest based on a number of data sources. For example, the regulator surveys public fishers at boat ramps; conducts a national panel survey; and uses webcams and a helicopter flyover to count fishing vessels. The regulator estimates the public value per kilogram using a contingent value survey (Wheeler, 1999; Wheeler and Damania, 2001). The contingent value survey interviews public fishers returning from a fishing trip. The survey first asks each fisher about his trip expenditure on consumables (e.g., bait, fuel, ice, etc.). Next, the surveyors ask:

> *"If the fishing trip cost you an extra $X on these items, would you still have gone fishing today?*"

Two sources of variation identify the public willingness to pay per kilogram. First, the surveyors randomly vary the dollar amount, $X, for each fisher. Second, each fisher catches a different number of Snapper. Holding fixed the monetary value $X: The regulator identifies a positive willingness to pay because fishers with a larger harvest are more likely to report a 'yes' response. The appendix and summary statistics provides further analysis and context but we note here the public willingness to pay estimate is intuitively plausible and aligns well with market values.

Statistics New Zealand collects data on fish export values and quantities, retail fish prices, and input prices. We calculate the Snapper price per kg by dividing the yearly export value by the yearly export quantity. The retail price data provides useful context to frame the public value per kg. Input price data includes wages, petrol prices, and the producer price index, which influence the firm entry cost.

The Reserve Bank of New Zealand releases data on the long-term real interest rate. We use these real interest rate data to discount future payoffs. For robustness, we additionally collect data on the social discount rate. The government healthcare provider discounts using the social discount rate when making funding decisions (Grocott and Metcalfe, 2007).

The National Institute of Weather and Atmosphere collects various data to model the Snapper biomass. We first use the biomass estimates from this model. We second calibrate a simplified biomass model to match key moments to the official model. We use a simplified model because the official model uses simulations, which we cannot easily embed in the dynamic problem.

We analyze data covering 1989-2012. We start in 1989 as firms first started collecting logbook data in 1989. We end in 2012 as the biomass estimates data finishes in 2012. We aggregate all data to the yearly level. As the fundamental trade-off is between public and commercial fishing and we only observe public data at the yearly level. It is not clear how using less aggregated data, for example, in the commercial model, would add useful detail. Last, we deflate all dollar values to 2010 NZ dollars.

4.2 Summary and Descriptive Statistics

Table 1 provides context by summarizing the main variables between 1989-2012. The total yearly harvest averages 7.7 million kg representing approximately 12% of the yearly biomass, which averages 68 million kg. The Snapper retail price averages $14/kg but varies between $13 and $15. We calculate the retail value of the yearly harvest averages around $100 million by multiplying the yearly harvest by the retail price. The average discount rate averages 3.7% and varies from 1.1% to 5.5%. We divide the average yearly retail value by the average discount rate to approximate the capitalized value. We approximate the capitalized value to be slightly above $3 billion.

Table 2 contrasts relevant commercial and public data. The first row summarizes the average marginal value by sector. The average quota price summarizes the marginal profit, π_t' (see the quota market clearing condition 6). The quota price averages $5.60, which is slightly less than half the average export price. The difference between the export price and quota price consists of fishing costs as well as processing, shipping, and marketing costs.

The marginal utility is the u_p term entering the yearly utility in equation (3). The regulator estimates the marginal utility equals $9.50/kg. The estimated value is less than the average retail price to suggest the regulator conservatively estimates the marginal utility. The marginal utility is

Table 1: Snapper One Summary Statistics 1989 - 2012

	Mean	Std. Dev.	Min	Max
Harvest (kg mil.)	7.8	0.5	7.1	8.8
Biomass (kg mil.)	68.1	8.3	56.4	79.4
Snapper Price ($)	14.02	0.73	13.06	15.11
Real Interest rate	3.7%	1.3%	1.1%	5.5%
Yearly Value ($ mil.)	116	10	100	126
Capitalized Value ($ mil.)			3134	

Data covers years 1989-2012. Yearly value = harvest x Snapper retail price. Capitalized value = (average yearly value)/(average real interest rate). Values in 2010 NZ$

$4/kg greater than the average marginal profit so a Snapper caught by the public generates more value than Snapper caught by a commercial firm.

The next block of rows breaks down the harvest by sector. While the average yearly public harvest is roughly half the yearly commercial harvest. There are more than 2,000 times more public fisher than commercial firms. These differences clarify why the commercial sector has a much greater lobbying incentive than the public. While, the public consists of a large number of fishers who each catch a small harvest. The commercial sector consists of a small number of firms who each catch a significantly larger harvest.

The last block of rows use the marginal values to approximate the yearly and capitalized fishery values. Although the marginal utility is almost double the marginal profit. The yearly and capitalized commercial and public values are similar because the commercial sector catch significantly more Snapper than do public fishers.

Table 3 presents trends in the main variables to highlight important variation. We focus attention on broad trends by summarizing averages for three eight-year periods. The first row shows the average biomass is 35% greater in the final period as compared to the initial period.

The second block of rows communicates commercial fishing trends. The headline trend is the snapper price minus the quota price, which our model interprets as the average cost of the marginal firm, halves from $10.4 to $5.2. The next two rows shows the number of firms decreases by a factor of three and the commercial harvest per trip more than doubles. These trends combine to tell a consistent story. More abundant biomass and improving technology combine to first lower firm costs. Further, as fewer firms are required to harvest the same quantity of fish. The highest average cost firms exit to reallocate the harvest to lower average cost firms. The final two rows in this block

Table 2: Commercial and Public Summary Statistics for Snapper One 1989 - 2012

	Commercial	Public
Price ($/kg)	13.00[a]	14.02[b]
Marginal Value ($)	5.59[c]	9.50[d]
Yearly Harvest (kg mil.)	5.25	2.55
Firms/Fishers	152	269,000
Catch (kg/trip)	560	2.02
Yearly value[e] ($ mil.)	29	24
Capitalized value[f] ($ mil.)	794	657

Data covers years 1995-2012. Values in 2010 NZ$.

a = export price b = retail price.

c = average quota price d = contingent value survey estimate.

f = marginal value x harvest g = (yearly value)/(real interest rate), where real interest rate is 3.5%, which is the average real interest rate from table 1

provide evidence to corroborate this intuition. We find the the average catch per trip of a firm who exits within a period is 50% lower than the average catch per trip of a firm who survives to the next period. One explanation is larger firms have lower costs so survive, while smaller firms have higher costs so exit. The last row show the public harvest almost doubles.

Table 3: Snapper One trends 1989 - 2012

	1989-1996	1997-2004	2005-2012
Biomass (kg mil.)	57	64	77
Average Cost of marginal firm	10.4	6.7	5.2
Firms	249	124	81
Harvest/trip	353	536	789
Surviving Firm Harvest/trip	402	552	820
Exiting Firm Harvest/trip	231	436	604
Public harvest (kg mil.)	1.7	2.4	3.0

Data covers years 1989-2012. Values in 2010 NZ$. All metrics per kg unless stated as per mil kg.

5 Empirical Model and Estimation

This section introduces the empirical model, explains estimation and calibration, and discusses how the data identify parameters. We estimate two sets of parameters. First, the commercial harvest and cost parameters determining yearly profit $(Q_{it}(B_t), f_{it})$. Second, the public harvest parameters, $Q_{pt}(B_t)$. Last, I introduce the spawning biomass model and parameters.

5.0.1 Commercial

We estimate the commercial harvest and cost parameters $(Q_{it}(B_t), f_{it})$. We specify the yearly firm harvest:

$$Q_{it}(B) = v_i \cdot n \cdot Q_{ijt}\left(B_t\right) \tag{7}$$

Where v_i is the number of vessels operated by firm *i*, n is the yearly number of trips per vessel, and $Q_{ijt}(B_t)$ is the harvest per fishing trip. The snapper harvest increases in the biomass as more abundant Snapper makes harvesting Snapper easier. The number of vessels per firm is fixed over years. Further, the number of yearly trips per vessel is constant over firms and years.

5.0.2 Harvest per Trip

The harvest per trip for firm *i* on a trip *j* in year *t* is Cobb-Douglas:

$$Q_{ijt} = \Omega_i \cdot \Lambda_t \cdot B_t^{\alpha_c} \cdot \exp\left(x_{jt} \cdot \gamma + u_{ijt}\right) \tag{8}$$

Where, Ω_i represents firm catchability; Λ_t represents technology; B_t is the biomass in year *t*; and α_c is the commercial biomass elasticity. The term $x_{jt} \cdot \gamma$ represents the effect of observable harvest shifters such as fishing method, location, and weather. Last, u_{ijt} is a random error term. Taking the logarithm of the commercial harvest equation (7) – denoting logs in lower case – generates the following harvest equation to estimate:

$$q_{ijt} = \omega_i + \lambda \cdot t + \alpha_c \cdot b_t + x_{jt} \cdot \gamma + u_{ijt} \tag{9}$$

Where firm catchability, ω_i enters as a firm fixed effect and technology enters as a linear time trend. We estimate the commercial harvest parameters via OLS regression. Because we use the estimated biomass rather than the true biomass. An error-in-variables bias arises. The error-in-variables bias firstly negatively biases the biomass elasticity towards zero and secondly positively biases the technology trend away from zero. Absent a valid instrument, we pragmatically confront the error-in-variables bias by treating biomass elasticity estimate as a lower bound. We next estimate a model constraining the biomass elasticity to one, which we treat as an upper bound.

5.0.3 Vessels per firm and yearly trips per vessel

Recovering yearly firm harvest requires estimating two additional parameters. First, the number of vessels per firm, v_i, and second the yearly trips per vessel, n. We estimate these parameters in two steps. A first step estimates the trips per vessel for firms we infer operate a single vessel. A second step backs out the vessels per firm for firms we infer operate multiple vessels.

We assume a firm completing fewer than 150 yearly trips operates one vessel. We estimate the number of yearly trips per vessel, *n*, by averaging the number of yearly trips for these single vessel firms. We next estimate the number of vessels per firm, v_i by dividing the observed yearly trips per firm by the estimated trips per vessel, *n*, and round to the nearest integer. We find our simple approach matches the observed aggregate harvest well implying more sophisticated methods would only marginally influence the results.

5.0.4 Firm entry cost

The entry model states a firm only enters if profitable. We rearrange entry equation (5) plus assume an error term to recover to following entry conditions to estimate:

$$\begin{aligned} (p_t - \theta_t^*) \cdot \widehat{q_{it}} &\geq f_{it} + \varepsilon_{ijt} \\ (p_t - \theta_t^*) \cdot \widehat{q_{it}} &< f_{it} + \varepsilon_{ijt} \end{aligned} \tag{10}$$

Where, the snapper price minus the equilibrium quota price, $(p_t - \theta_t^*)$ is data; $\widehat{q_{it}}$ is a fitted value from the estimated harvest equation. We use the fitted harvest values because we do not observe the harvest of a firm who exits. f_{it} is the entry cost for firm *i* in year *t*. Last, the ε_{ijt} is an additive and normally distributed error term. The normal error structure allows for point estimation through a probit regression in the spirit of Bresnahan and Reiss (1991). The alternative is to dispenses altogether with an error structure to calculate fixed cost bounds as in Ciliberto and Tamer (2009) or Eizenberg (2014). We avoid this approach as it would complicate the dynamics.

We express the yearly firm entry cost as the product of a firm component and a year shifter:

$$f_{it} = f_i \cdot \mu_t \tag{11}$$

Where f_i is the entry cost for firm *i* and μ_t is the yearly shifter reflecting input prices. The appendix rationalizes this specification through a Leontief harvest technology. To provide brief explanation, a firm requires a fixed quantity of a fixed bundle of inputs, such as petrol and wages. Increasing input prices, for example, the petrol price, increases the price of the fixed input bundle to increase the yearly entry cost for all firms. We estimate the time shifter, μ_t using data on expenditure shares and input price data for the two primary expenses: labor and petrol. The estimated time shifter $\hat{\mu_t}$ enters into the fixed cost estimation (10).

Two minor estimation issues arise. First, we cannot identify the entry cost for a minority of firms who never exit ($\approx 5\%$). We pragmatically solve this non-identification issue by applying the highest entry cost so the entry equation (10) always holds. Second, some firms enter midway through the panel. We assume these firms have infinite entry cost before entering.

5.1 Public

Yearly public utility equals a constant utility value per caught kilogram multiplied by the public harvest. We specify the public harvest in year *t* as Cob-Douglas:

$$Q_{pt} = \Lambda_t \cdot B_t^{\alpha_p} \cdot \exp\left(u_{pt}\right), \tag{12}$$

Where, Λ_t is technology; B_t is the biomass in year *t*; and α_p is the public biomass elasticity. Last u_{pt} is a random error term. Taking the logarithm of the public harvest equation (12) – denoting logs in lower case – generates the following public harvest equation to estimate:

$$q_{pt} = \lambda_0 + \lambda \cdot t + \alpha_p \cdot b_t + u_{pt}, \tag{13}$$

Where technology enters as a linear time trend. We estimate the public harvest parameters through OLS regression. Again, we observe biomass estimates rather than the true biomass leading to error-in-variables bias. We follow the same approach of treating the estimates as a lower bound. We re-estimate constraining the biomass elasticity to equal to one for an upper bound.

5.1.1 Discount Rate

The long-term real interest rate proxies for society's preference for consumption today as compared to consumption next year. We estimate the discount rate as the average real interest rate between 1995-2012.

5.2 Biomass

The biomass equation of motion updates next year's biomass as this year's biomass minus the total harvest plus the spawning biomass. The spawning biomass follows an inverse u-shape profile as the outcome of two competing biological channels. On the one hand, more abundant biomass increases the number of mating-pairs so increases the spawning biomass. On the other hand, more abundant biomass leads to scarcer food supplies and other crowding consequences so reduces the spawning biomass. At a low biomass, the mating-pair channel dominates so increasing the biomass increases the spawning biomass. Eventually, the crowding channel dominates so increasing the biomass decreases the spawning biomass. The inverse u-profile to spawning biomass has two relevant implications. First, there exists a maximum spawning biomass. Second, the spawning eventually reaches zero so there exists a maximum biomass.

We specify a biomass model to recover the inverse u-profile of spawning biomass profile, while remaining parsimonious enough to calibrate and insert into our dynamic model. Our biomass model follows from Lindner (2010), who specifies a hybrid between the Richards and Ricker biomass model (Richards, 1959; Ricker, 1954). The spawning biomass follows:

$$G\left(B_t\right) = a \cdot B_{t-3} \cdot \left[\exp\left(r \cdot \left(1 - \left(\frac{B_{t-3}}{B_0}\right)^d\right) - 1\right)\right]. \tag{14}$$

Where, *a*, *d*, and *r* are calibrating parameters. B_{t-3} enters rather than B_t as Snapper require three years to reach sexual maturity. Last, B_0 represents the maximum biomass when spawning is zero (as $G(B_t) = 0$ when $B_{t-3} = B_t$). Lindner (2010) provides parameters so spawning biomass matches output from regulator's simulation model.

6 Estimates

This section presents parameter estimates.

6.1 Commercial

6.1.1 Harvest per trip

Table 4 presents estimates from four versions of the commercial harvest model. We present estimates from four models to makes three points. First, both biomass and technology positively affect the commercial harvest. Second, an error-in-variables bias means we likely overestimate technology and underestimate the biomass elasticity. Third, the quota market reallocates the harvest away from low harvest firms towards high harvest firms.

Column (1) uses only log biomass as an explanatory variable. This model estimates the biomass coefficient equals 1.7, which means the commercial harvest increases more than proportionality with the biomass. Column (2) introduces a technology time trend to cause the biomass elasticity to roughly quarter to 0.422. This decreasing occurs because the both commercial harvest and biomass are increasing over time.

Column (3) and (4) are our preferred specifications so enter the counterfactual. Column (3) and (4) additionally add firm fixed effects. Column (3) estimates the biomass elasticity and column (4) constrains the biomass elasticity to equal one. Adding firm fixed effects causes the biomass elasticity estimate to fall from 0.422 to 0.31. the This reduction likely reflects a reallocation away from exiting low harvest per trip firms (see table 3). In our preferred specification, a 10% increase in biomass increases a firm's harvest by 3.3%. We estimate technology improves the harvest by 2.1% to 3.3% per year depending on the fishing method. Constraining the biomass elasticity to one lowers the technology time-trend consistent with an error-in-variables problem.

Table 4: Commercial Harvest Estimates

	(1)	(2)	(3)	(4)
Log Biomass	1.690	0.422	0.306	1.000
	(0.017)	(0.022)	(0.020)	(.)
Technology x Trawl		0.049	0.033	0.021
		(0.001)	(0.001)	(0.001)
Technology x Longline		0.039	0.021	0.020
		(0.001)	(0.001)	(0.000)
R^2	0.166	0.190	0.591	
Firm Fixed Effect	No	No	Yes	Yes

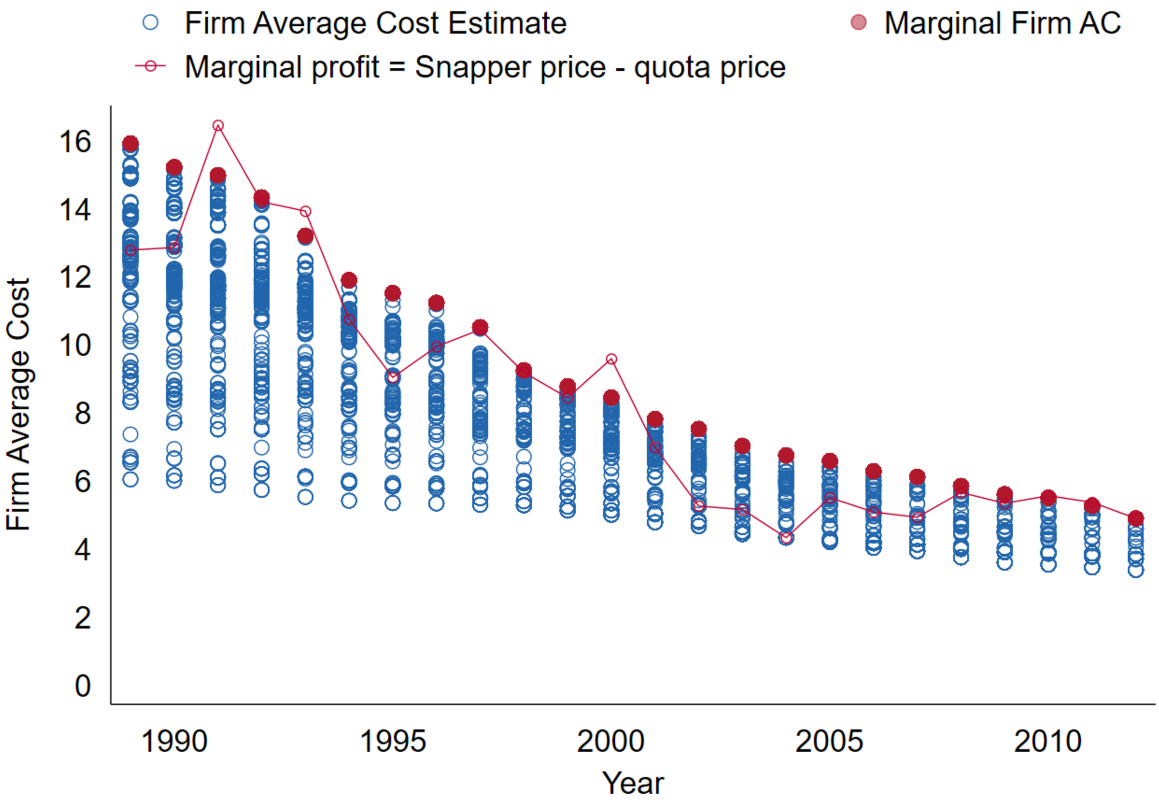
Robust standard errors in parentheses. Data are from commercial logbooks and biomass estimates. All regression use 245,996 observations and span 1989 - 2012. All regressions include a region fixed effect, month of year fixed effect, and control for fishing method. Regression (4) constrains the biomass elasticity coefficient to one.

6.1.2 Entry Cost

We present estimates of the average cost rather than the entry cost. The average cost is the relevant value because a firm enter if firm average cost is less than the snapper price minus the quota price. Figure 2 presents the estimates of firm average against time. The blue dots represent the average cost of an entering firm. The filled red dots represent the average cost of the marginal firm. The marginal firm is the entering firm with the highest average cost. The connected red dots represent the Snapper price minus the yearly quota price, which closely tracks the estimate for the average cost of the marginal firm.

Figure 2 reveals two patterns. First, we estimate the average cost varies widely between firms in a given year. For example, using data for 1995, we estimate the the average cost of the most efficient firm equals \$6. This equals half the average cost of the marginal firm, which we estimate equals \$12. Second, we estimate the average cost of the marginal firm continuously declines. Declining average cost arises from a combination of increasing biomass, improving technology, and reallocating the harvest away from exiting higher average cost firms to surviving lower average cost firms.

Figure 2: Estimates of Firm Average Cost vs. Year 1989-2012



6.2 Yearly trips per vessel and vessels per firm

We estimate a vessel to complete 80 trips in a year. The typical firm operates one vessel. To illustrate, 95% of firms operate a single vessel. A minority of firms operate many vessels. The largest firm operates 48 vessels.

6.3 Discount Rate

We estimate the discount rate equals 3.7%, which closely agrees with the social discount rate of 3.5%.

6.4 Public

Table 5 presents estimates from three versions of the public harvest model. Our results report both biomass and technology positively affect the public harvest. Again an error-in-variables bias means we may overestimate technology and underestimate the biomass elasticity.

Column (1) does not include a time trend and indicates the biomass elasticity is almost one. Column (2) and (3) are our preferred specifications to enter the counterfactual. Column (2) estimates the biomass elasticity, while column (3) constrains the biomass elasticity to one. We estimate the biomass elasticity to equal 0.526 meaning a 10% increase in biomass increases the public harvest by 5.26%. We estimate technology increases the public harvest by about 3.7% per year. Constraining the biomass elasticity to one lowers the technology time-trend to 1.2% consistent with the errors-in-variables problem.

Table 5: Public Harvest Estimates

	(1)	(2)	(3)
Log Biomass	0.991	0.526	1.000
	(0.041)	(0.069)	(.)
Technology		0.037	0.012
		(0.005)	(0.006)
Observations	107	107	107
R^2	0.980	0.990	

Standard errors in parentheses

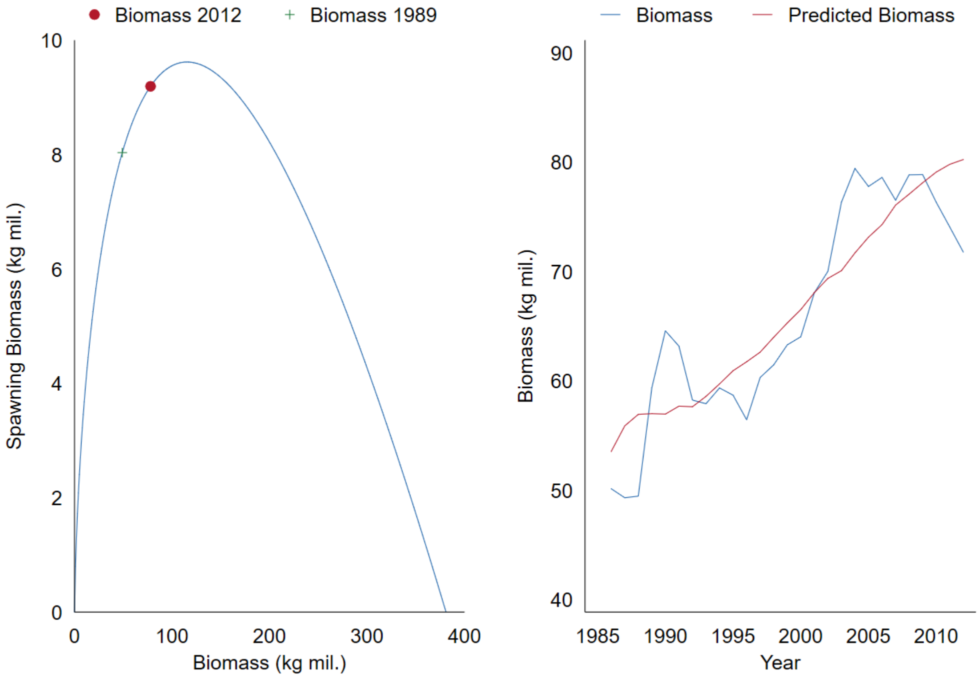
6.5 Biomass

We do not estimate the spawning biomass model. Instead, we use parameters from Lindner (2010), who calibrates parameters to match key moments from the regulator's simulation based model.

Figure 3 consists of two panels. The left-hand panel plots the spawning biomass against the biomass. The right-hand panel plots the calibrated biomass predictions and the biomass estimates against time. The left-hand panel shows the spawning biomass follows an inverse U-shape profile with respect to the biomass. The inverse U-shape profile occurs because of counteracting mating-pair and crowding channels. The mating-pair channel initially increases faster than the crowding-channel so a larger biomass increases the spawning biomass. At 110 million kg, the mating-pair and crowding channel increase at the same rate resulting in the maximum spawning biomass, which equals 10.05 million kg. After 110 million kg, the crowding channel increases at a faster rate than the mating-pair channel so a larger biomass decreases the spawning biomass. Eventually, the two channels exactly offset and the spawning biomass reaches zero at the maximum biomass of 345 million kg. Contrasting the spawning biomass with the commercial harvest from figure 1 is informative. The commercial harvest averaged around 10 million kg from 1970 to 1986, which exceeded the maximum spawning biomass to cause the biomass to continuously decline. Following 1986, the commercial harvest averaged around 5 million kg, which is less than the spawning biomass to cause the biomass to increase.

The right-hand panel plots the calibrated biomass predictions and the observed biomass against time yields two points. First, the calibrated model successfully tracks the main biomass trend. Second, discrepancies arise, in which the biomass estimates are higher or lower than the biomass model predictions. These discrepancies reflect spawning events leading to greater or less than expected spawning biomass. For example, a year with warmer than average water temperatures increases spawning. Although relevant for year-to-year management, our model abstracts from this level of detail as we focus attention on analyzing the between-sector allocation over the long term. We report the parameters values in the appendix.

Figure 3: Spawning Biomass vs. Biomass (left),
Biomass Estimates and Predicted Biomass 1985-2012 (right)



7 Results

This section uses the parameter estimates to quantify the lobbying misallocation. We first explain the necessary practical details to recover the lobbying misallocation. We follow by presenting our results.

7.1 Quantify the Lobbying Misallocation

Solving the dynamic model requires defining a starting year, clarifying the regulator's information, and explaining a solution concept. We select 1995 as the starting year. We choose 1995 because this year most transparently reflects commercial lobbying. To be concrete, in 1995, the commercial sector uses the court system to block the regulator from reducing the commercial harvest by 40%.

We assume the regulator has full information. This assumption means the regulator knows the following sets of parameters: $(G(B_t), C_t(B_t, Q_{ct}), Q_{pt}(B_t), r, u_p, p_t)$ entering the dynamic model. Where $G(B_t)$ is the spawning biomass, $C_t(B_t, Q_{ct})$ is the commercial harvest cost, $Q_{pt}(B_t)$ is the public harvest, *r* is the discount rate, u_p is the public utility, and p_t is the Snapper price path.

We additionally assume the parameter values are stable over time. Combining this assumption with full information implies we best estimate the model parameters using the full dataset. One plausible alternative assumption is the regulator may only use data up to the current year to learn about parameter values, which we plan to address in future work. A second plausible alternative is to relax full information by assuming prices follow a random walk and the regulator forms rational expectations. Again we plan this extension in future work.

Our current solution concept underestimates the lobbying misallocation. To be specific, we solve the dynamic model via fixing a commercial harvest and iterating for one hundred years. After one hundred years we calculate a continuation value. The fix-and-iterate approach calculates the correct present value for the regulator's problem when the lobbying constraint applies. This is because the constraint always binds so. The fix-and-iterate approach, however, underestimates the present value when we remove the lobbying constraint. Intuitively the regulator likely maximizes welfare by changing the commercial harvest each year. Our fix-and-iterate approach misses these adjustment margins so therefore underestimates the lobbying misallocation. We are currently implementing a langrangian solution concept to allow the regulator to optimize by changing the yearly commercial harvest. These estimates are currently in progress.

7.2 Results

Table 6 reports the lobbying misallocation. The first column presents the aggregate lobbying misallocation. The second and third column decompose the aggregate lobbying misallocation into the profit increase and utility decreases. We present a lower and upper bound. The lower bound calculates the welfare effects using the estimated parameters. The upper bound calculates the welfare effects using parameters estimates when we constrain the biomass elasticity to equal one. We present three rows. The first row reports the change in present value from removing the lobbying constraint. The second row provides context by calculating the present value subject to the lobbying constraint. The third row divides the first row by the second row to translate the dollar value into a percentage change.

Table 6: Lobbying Misallocation

	Total	Commercial	Public
Misallocation $ mil.	[73.3, 107]	[-130, -246]	[203, 353]
Value $ mil.	[1753, 1680]	[903, 851]	[850, 829]
Misallocation %	[4.2, 6.4]	[-12.4, -20.8]	[23.9, 42.6]

Lobbying misallocation is the increase in present value from removing the lobbying constraint. [denotes the lower bound from using estimated parameters.] denotes the upper bound from using estimates when we constrain the biomass elasticity to equal one. Value is the fishery value when the lobbying constraint applies. Standard errors in progress. We find the optimal commercial harvest equals 3.5 mil kg using estimated parameters and 3 mil kg when we constrain the biomass elasticity to equal one.

Our first conclusion is the lobbying constraint lowers welfare by between 4.2%-6.4%. We find the lobbying constraint causes a large redistribution. Removing the lobbying constraint would lower profits by between 12.4%-20.8% and increase utility by between 23.9%-42.6%.

We are in the process of decomposing these results into an informative picture. For example, plotting the time path of profits, utilities, and the biomass. We may also use our model to calculate the welfare effects of completely dispensing with a commercial harvest limit. We are further in the process of compiling roubustness checks. For example, how these results change using different estimates of the discount rate.

8 Conclusion

This paper analyzes the welfare cost of commercial lobbying in New Zealand's most valuable public fishery. By contrasting the commercial sector's objective of maximizing profits to the regulator's objective to maximize welfare. We first show public fishing drives a wedge so the profit-maximimizing commercial harvest exceeds the welfare maximizing harvest. This finding matches a discrete lobbying event in which the commercial sector successfully blocked the regulator from reducing the commercial harvest.

Motivated by this lobbying event, we develop and estimate a dynamic model to quantify the welfare cost from commercial lobbying. The regulator's objective is to maximize the discounted stream of profits and utility. In selecting the yearly commercial harvest, the regulator firstly considers the biomass equation of motion, which explains how fishing today affects the biomass tomorrow. The regulator secondly faces the lobbying constraint, which requires the yearly commercial harvest to exceed a lobbied value. Removing this lobbying constraint quantifies the welfare cost to commercial lobbying.

We combine novel data sources to estimate static models of commercial and public fishing and a discount rate. Our estimated commercial model permits rich patterns of cost heterogeneity. Cost heterogeneity means the marginal profit to catching an additional fish today varies with the commercial harvest. Our estimated public model specifies first that the marginal utility exceeds the marginal profit and second that the public harvest increases with the biomass. Taken collectively, there exists a trade-off between current commercial fishing and future public fishing.

Using the dynamic model we quantify the lobbying misallocation ranges between 4.2%-6.4%. We unpack the misallocation into a large redistribution: Removing the lobbying constraint would lower profits by between 12.4%-20.8% and increase utility by between 23.9%-42.6%. We conclude that while commercial lobbying generates a trivial welfare cost. Lobbying significantly redistributes welfare away from the public towards firms.

As our fix-and-iterate solution concepts underestimates the lobbying misallocation. We are currently re-solving using dynamic programming techniques. These techniques allow the regulator to optimize in each period instead of committing to a single commercial harvest. We are further looking at ways to decompose our results into the time paths of profits, utility, and biomass. Additionally, we are testing our results for robustness of key parameters, such as the estimated marginal utility and discount rate.

In terms of other future extensions. It would be interesting to collect additional survey estimates on the public fishing value to increase credibility. Additionally, one could extend the scope of the analysis by attempting to value wider ecological benefits from a tighter catch limit. Alternatively, it may prove interesting to further incorporate lobbying costs in the form of direct lobbying expenses, court costs, and commercially sponsored research.

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We are updating the appendix and data appendix, which should be available shortly. These appendices are quite detailed and were not ready in time for the June 7 deadline for the NZAE conference.