Measuring Benefits from a Marketing Cooperative in the Copper River Fishery

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The degradation of product quality is one form of rent dissipation resulting from incomplete property rights in fisheries. Industry structure and information asymmetries can also lead to underinvestment in product quality, even when property rights are well defined. In this article, we empirically examine whether the voluntary formation of a marketing cooperative was able to mitigate market failures that led to the production of inferior-quality fish. Specifically, we use a difference-in-differences estimation strategy to measure the impact that the Copper River Fishermen's Cooperative, an Alaskan salmon marketing cooperative, had on ex-vessel salmon prices and salmon quality measures. We find that the cooperative was able to improve product quality, as well as attract and sustain a higher price for its salmon. Our findings provide empirical support for many of the key tenets of cooperative theory. Specifically, we find evidence that marketing cooperatives can address existing market failures; that marketing cooperatives can have advantages in high-quality product markets; and that over time, as a result of their success, marketing cooperatives may lead to lasting producer benefits even though they become obsolete due to nonmember free riding.

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In the past decade, there has been a rapid increase in the demand for high-quality food from both land-based agriculture and wild-caught commercial fisheries (Grunert 2005). A major stumbling block that commercial fishermen face in meeting the increasing demand from these niche markets, however, is the presence of market failures that lead to the production of inferior-quality fish. By increasing transaction costs, market failures inhibit commercial fishermen from participating in these revenue-increasing trends.

One well-studied market failure stems from the absence of well-defined property rights in fisheries, which creates incentives for fishermen to engage in a race to fish and neglect product quality. As a number of studies have shown, the allocation of property rights has changed the nature of the race to fish from a competition over quantity to a competition over quality (e.g. Arnason 1993; Gauvin et al. 1994; Geen et al. 1989).[1]

A less studied, but perhaps equally important, aspect of the commercial fishing enterprise is how the production process and resulting industry structure can also cause underinvestment in product quality. In many fisheries, getting fish from the ocean to the market is a two-stage process. Fishermen harvest fish in the first stage and deliver the fish to processors, who process fish in the second stage. The two-stage production process can create obstacles to entry into markets for high-quality food products. For example, when fishermen have more information about the quality of their harvest than processors, the two-stage structure leads to information asymmetries that prevent the optimal investment in quality, even with perfect property rights. Hennessy (1996) demonstrates that when observing product quality is costly for agricultural processors, a two-stage production process leads to suboptimal investments in quality.

Vertical integration is a means to address the information asymmetries in multistage production chains. In this article, we empirically examine whether the voluntary formation of a marketing cooperative, which is by nature a vertically integrated firm, was able to mitigate market failures that led to the production of suboptimal quality in a salmon fishery.[2]

Our article makes two contributions. First, we contribute to the cooperative literature in agricultural economics by being, to our knowledge, the first to empirically measure whether a marketing cooperative was able to generate a price premium and improvements in product quality. Given that a primary objective of a marketing cooperative is to increase the prices paid to members (Sexton and Iskow 1988), it seems important to assess the performance of cooperatives along this dimension. However, most empirical work on marketing cooperatives has focused on various financial ratios (Soboh et al. 2009).[3] We also build on the cooperative literature in agricultural economics by contributing to the debate over whether marketing cooperatives can be successful in markets for high-quality food products.

Our second contribution is that, to our knowledge, we are the first to evaluate the performance of a fishing marketing cooperative. Marketing cooperatives have been largely ignored in the fishery economics literature but can potentially generate benefits for fishermen in today's changing commodity markets. Prior research on fishing cooperatives has focused on harvesting cooperatives, where members are granted rights to harvest a share of the resource each year (e.g. Deacon et al. 2010, 2013; Evans and Weninger 2010; Kaffine and Costello 2011; Wilen and Richardson 2008). Marketing cooperatives are different from harvesting cooperatives, however, because their members do not necessarily have property rights over the resource and because they are vertically integrated. For example, fishermen in the Copper River Fishermen's Cooperative (CRFC) integrated a downstream part of the production process by purchasing and operating a processing plant. Relative to harvesting cooperatives, the gains from fishing marketing cooperatives are less clear. Our estimates of the impacts of the CRFC therefore are an important piece of information for fishermen and producers who are considering ways to take advantage of changing markets for quality food products.

Our empirical strategy uses a natural experiment to construct a counterfactual, permitting us to employ a difference-in-differences (DiD) estimation strategy to identify the causal impact of a marketing cooperative on prices and quality. Specifically, we estimate the impacts of the CRFC, an Alaskan salmon marketing cooperative, on prices paid to fishermen and measures of salmon quality using a neighboring salmon fishery (Upper Cook Inlet) without a marketing cooperative as our control. We define our treatment group as all fishermen in the Cooper River fishery (members and nonmembers), because the CRFC is cited as having widespread and lasting impacts on all producers in the Copper River fishery (Prince William Sound Fisheries Science Center 2012; Bonino 1996; Sell 1997) and because a rich literature exists on cooperative benefit spillovers (Nourse 1922; LeVay 1983; Cook 1995).

We find that the CRFC had a positive impact on salmon prices: sockeye prices increased by about \$0.64–\$0.73 per pound (or 21.0%–24.0% in relative terms), and Chinook salmon prices increased by about \$1.37–\$2.03 per pound (or 38.0%–56.6% in relative terms). We also find empirical evidence of improvements in salmon quality. Based on a back-of the-envelope calculation, we find that the CRFC led to welfare gains on the order of 13.01%–24.92% of average sockeye and Chinook fishery value before 1981. These gains occurred even though the CRFC imposed conditions on members that increased the costs of fishing.

The remainder of the article is organized as follows. We first describe the institutional setting, the empirical approach, and the data. We then estimate the impact of the cooperative on salmon prices and measures of fish quality. To check the robustness of our results, we subject them to two types of placebo tests. Next, we develop a measure of the welfare changes for the salmon fishermen. We then discuss the mechanisms through which the cooperative was able to increase product quality and generate lasting producer benefits. We end with a conclusion and discussion of future research.

Description of the Empirical Setting

The Copper River (CR) and Upper Cook Inlet (UCI) fisheries are two small commercial salmon fisheries in the central region of Alaska (figure 1). Over the period from 1971 to 2001, these fisheries together averaged approximately 14% of the total annual wild-caught salmon in Alaska. In contrast, the Bristol Bay fishery produced, on average, roughly 55% of the statewide sockeye harvest and roughly 40% of the world sockeye harvest. Production in Bristol Bay is, however, highly variable from year to year, as salmon run sizes are affected by climatic and other environmental factors (Groot and Margolis 1991). Because the Bristol Bay fishery is a large supplier on the market, ex-vessel salmon prices in the CR and UCI fisheries are affected by its production (Knapp et al. 2007). As we describe below, the linkage between Bristol Bay and the CR and UCI fisheries indirectly contributed to the formation of a marketing cooperative in the CR fishery.[4]

In 1980, a historically large salmon run for Bristol Bay led to depressed ex-vessel salmon prices throughout the state of Alaska. Fishermen in the CR fishery experienced another shock that year, as sockeye returns were weak and harvest amounted to only 3% of its historical average (Alaska Department of Fish and Game 1981a). According to our interviews with key CRFC personnel and archival research, these conditions motivated fishermen in both the CR and UCI fisheries to organize strikes, with those in the CR fishery striking over coho prices and those in the UCI fishery striking over sockeye prices. Although the reasons for the strikes were similar, the strikes led to two very different outcomes: the majority of processors in the UCI fishery agreed to raise ex-vessel prices to satisfy fishermen (Alaska Department of Fish and Game 1981b), whereas processors in the CR fishery did not.

According to former CRFC board members, failed negotiations in the CR fishery motivated a group of fishermen to take matters into their own hands and ship their coho harvest to Anchorage, Alaska, for custom processing and sale into the commodity market. The fishermen agreed to share the shipping and processing costs evenly. The venture proved profitable, and the following year, the fishermen were elected as board members to direct a newly-formed cooperative, the Copper River Fishermen's Cooperative (CRFC). In 1983 the CRFC purchased a processing plant, which was owned and operated by member fishermen (the interested reader can find more details in a supplementary appendix online).

In order to increase ex-vessel prices for members, the CRFC invested in marketing and product quality improvements. Investments in marketing included commissioning the design of a logo for fish from the CR region, still in use today; marketing directly to Seattle restaurants; and contracting a marketing firm to gain access to Japanese consumers.

To improve product quality, the CRFC mandated that picking hooks be used to remove the fish from the nets, that fish be bled immediately after harvest and put into an ice bags designed to hold 200 pounds of fish, and that fish be delivered on ice up to six hours after they were caught. In addition to implementing restrictions on fishermen's harvesting practices, the CRFC adopted new quality standards at the processing plant and worked with Japanese buyers to develop a grading system to sort fish by quality (see the supplementary appendix online for more details).

Investments in marketing and product quality improvements were costly (e.g., they potentially reduced the rate of production for fishermen), but the cooperative was still successful in attracting new members. The CRFC grew quickly to a membership of 150 out of approximately 500 permit holders by 1985, processing roughly 33% of sockeye harvested in the CR fishery.

The benefits created by the CRFC were not limited to the cooperative's members for two reasons. First, if existing processors were not offering competitive prices due to either market power or opportunistic behavior (as described by Klein, Crawford, and Alchian 1978), then the CRFC would have had a pro-competitive effect, introducing competition into the market and forcing existing processors to raise prices paid to nonmembers (Nourse 1922). The CRFC grew rapidly and within four years captured roughly one-third of the market share for CR sockeye, suggesting that it was a significant competitor for other processors in the CR fishery and was able to have a pro-competitive effect on its competitors (see the supplementary appendix online for more details).

The second reason the cooperative was able to achieve widespread and lasting benefits is that the CRFC's investments in marketing and branding salmon from the Copper River produced benefits for nonmembers and competing processors, enabling other firms in the fishery to enter the newly created markets for high-quality salmon despite the need for costly quality inspections. If, before the CRFC, the cost of observing product quality was high (see, e.g., Hennessy 1996), then the cooperative's regional branding initiative would have increased benefits for *all* high-quality salmon coming from the CR region, reducing the relative costs of observing product quality for all other processors in the fishery (see the supplementary appendix online for more details).

The inability of marketing cooperatives to capture all of the economic benefits they generate is well established in the agricultural economics literature, as is the corresponding result that this can lead to instability when nonmembers free ride (Cook 1995; LeVay 1983; Nourse 1922). In 1991, the CRFC filed for bankruptcy as a result of a number of factors, including depressed prices for wild salmon due to increased aquaculture salmon production, the disruption in production in the CR fishery because of the Exxon *Valdez* oil spill of 1989, and the increased competition in the market caused by the CRFC.

Since the CRFC dissolved in 1991, the cooperative has received recognition for its widespread and lasting changes to the CR fishery. For example, in 2012, the Prince William Sound Fisheries Science Center awarded a Fisheries Achievement Award to the CRFC to honor the cooperative for its "innovations in branding, international marketing and fleet-wide quality control," for implementing "the first fish-hold inspection program in the State of Alaska," and for laying "the cornerstone of quality practices on a fleet-wide basis" (Prince William Sound Fisheries Science Center 2012). Thus, there is evidence that the CRFC impacted fishery-wide outcomes. In what follows, we examine the empirical evidence for this claim.

Identification Strategy

In order to estimate the impact of the CRFC on our outcome variables of interest, it is necessary to construct a counterfactual to examine what would have happened in the CR fishery if the CRFC had not formed. In this analysis, we seek to quantify the impact of the CRFC on ex-vessel salmon prices and measures of salmon quality using a difference-in-differences (DiD) estimation strategy and the UCI fishery as a control fishery. Our hypothesis is that the CRFC improved ex-vessel prices and product quality.

The impact of a treatment that has been obtained voluntarily is known in the program evaluation literature as the effect of the "treatment on the treated." In order to measure the effect of the treatment on the treated, the researcher needs to randomly select those individuals who have voluntarily selected treatment and compare them with those that have been denied treatment (Heckman and Vytlacil 2001). In our case, the treatment group includes all fishermen in the CR fishery who were participating in the same market as the CRFC because of evidence that the impacts of the CRFC transcended its membership. Therefore, we use measures from the entire population of individuals impacted by the CRFC, precluding the need for random selection of individuals.

We use a DiD estimation strategy to estimate the effect of the treatment on the treated. Several conditions are required in order for the DiD estimator to be unbiased. First, the treatment must be exogenous to unobserved drivers of the outcome variables of interest (Besley and Case 2000).[5] In our case, the formation of the CRFC was a function of an exogenous shock to salmon production in the Bristol Bay, leading to low ex-vessel coho prices; an exogenous shock to sockeye production in the CR fishery, which increased the importance of revenue from coho to CR fishermen; and the inability of processors and fishermen to reach an agreement on coho prices.

We need to control for each of these factors in our analysis, because they potentially independently impact ex-vessel sockeye and Chinook prices and quality measures. We directly control for the two exogenous shocks contributing to the CRFC's formation (the impact of production in Bristol Bay and the impact of weak sockeye returns to the CR fishery in 1980) by including relevant explanatory variables. In addition, the DiD framework indirectly controls for any time-invariant features of the CR fishery contributing to the CRFC's formation.

However, unobserved factors not controlled for by the DiD model or explanatory variables could possibly explain the failed price negotiations over coho prices. For example, if fishermen were unable to negotiate prices because they lacked sufficient bargaining power (negatively correlated with ex-vessel prices), and differences in bargaining power between the two fisheries varied over time, then our results will be downward biased and therefore conservative; that is, we will understate the true impact of the CRFC on ex-vessel sockeye and Chinook prices.[6]

A second condition for the DiD estimator to be unbiased is that the treatment must not indirectly impact the control group in any way. For example, if processors in the UCI fishery increased prices to UCI fishermen because of a pro-competitive effect of the CRFC, our results would be biased downward. In our setting, however, there is very little reason to believe that the UCI was impacted by the CRFC, because Alaskan salmon fisheries are limited-entry fisheries (limited-entry regulations were implemented in 1974), meaning that entry into each fishery can occur only through purchase of a permit, and the number of permits is fixed. The limited-entry program, therefore, effectively separates the participants in the two markets.

Third, the treatment and control groups should be as similar as possible in order to control for as many market-wide shocks and trends as possible. The UCI fishery is very similar to the CR fishery. Both are small salmon fisheries (table 1), they neighbor one other and even share a county border (figure 1), they target the same species using identical gear types (gill nets), and both fisheries export their harvest through the Anchorage airport (Babcock and Weninger 2004). Therefore, they are subject to similar unobserved determinants of equilibrium ex-vessel prices including ocean conditions, input prices, and transportation shocks.

Finally, Blundell and MaCurdy (1999) discuss selection bias that can occur if individuals select themselves in or out of the treatment group because of the treatment. For example, our estimates will be biased upward if the formation of the CRFC caused fishermen receiving high ex-vessel prices to leave the UCI fishery for the CR fishery, caused fishermen receiving low ex-vessel prices to leave the CR fishery for the UCI fishery, or both.

Selection bias is not likely to be a problem in our data for several reasons. First, there is limited variation in ex-vessel prices across individuals. Second, the limited-entry program reduces the potential for fishermen to switch without cost between fisheries. Moreover, there is no reason to believe that fishermen receiving low ex-vessel prices would sort out of the CR fishery and those receiving high ex-vessel prices would sort into the CR fishery simply because of the existence of a cooperative in the CR fishery.

Description of the Data

We use data from the Alaska Department of Fish and Game (ADF&G) annual management reports (AMRs) on average annual ex-vessel salmon prices, salmon harvest, and average weight of salmon. The data are supplemented with monthly Commercial Fisheries Entry Commission (CFEC) data on pounds landed, the number of active permit holders, and the number of delivery trips.

To conduct a price analysis, we use ADF&G AMR price data in both the CR and UCI fisheries from 1971 to 2001. All prices are in 2012 USD.[7] ADF&G AMR data are missing in 1976 for the CR fishery. Therefore, the price analysis uses data on two fisheries over a time period of 31 years, with one missing observation, for a total of 61 observations.

To conduct an analysis on salmon quality measures, we use monthly CFEC data from 1975 to 2001 on the number of salmon deliveries, pounds of salmon landed, and active permit holders in the CR and UCI fisheries. There are 220 observations in the monthly data from 1975 to 2001.

Control variables are obtained from a variety of sources. Measures of variance in harvest are taken from the ADF&G AMRs. Weather data, which include the number of days with precipitation over 0.5 inch and the minimum temperature, are from the National Climatic Data Center (NCDC). We use NCDC data from the Cordova MK Smith and Kenai Municipal Airport stations to represent weather conditions in the CR and UCI fisheries, respectively. Both weather variables impact the rate of harvest through their impact on water levels and river width, which are positively correlated with the rate at which salmon migrate through the fishery (Alaska Department of Fish and Game 1983, 2013). The data are summarized in table 2.

Results: Price Analysis

In what follows, we divide up the analysis of our hypothesis into two parts: a graphical analysis to illustrate the patterns over time; and the differences in differences regression analysis that statistically tests the hypothesis.

Graphical Analysis

A graphical analysis of the ex-vessel prices in the two fisheries over time and the price differential provides support for our hypothesis (figure 2). Ideally, the price graphs would show parallel trends in prices (yielding a constant price differential) before the CRFC formed, and to be consistent with our hypothesis, the trends in the prices would diverge after the CRFC's formation. However, the data are somewhat noisy, and we find fluctuations in the salmon price differentials before the cooperative formed and some years where the sockeye price differential is negative after the CRFC formed. Fortunately, as we illustrate in the regression analysis, our control variables have explanatory power over these fluctuations. For example, in 1997, the year with the largest negative sockeye price differential (figure 2), sockeye harvest in the CR fishery reached a historical high (314% of the 1971–2001 mean), potentially putting downward pressure on ex-vessel prices. Therefore, we proceed to control for quantity and other observables to test whether there is empirical evidence supporting the hypothesis that the cooperative increased salmon prices for their targeted species, sockeye and Chinook.

Difference-in-Differences Estimates

While the graphical analysis is illustrative, to control for confounding factors we use a difference-in-differences (DiD) approach that will difference away market-wide shocks to salmon prices that affect the treatment and control fisheries equally *and* difference away preexisting differences in salmon prices between the treatment and control fisheries. The DiD estimator is the difference in mean ex-vessel salmon prices between the CR and UCI fisheries after the CRFC formed less the preexisting difference in mean ex-vessel salmon prices and the impact of our control variables. A positive DiD estimator supports the hypothesis that the price of salmon in CR increased relative to the price of salmon in UCI after the CRFC. The econometric model is as follows:

(1) $$y_{f,t}^{sp} = \beta_0 + \beta_1 T_f + \beta_2 A_t + \beta_3 TA_{f,t} + \mathbf{X}'^{sp}_{f,t}\delta + \tau_t + \epsilon_{f,t}^{sp},$$

where *sp* indexes the salmon species, *f* indexes a fishery, and *t* indexes a year; $y_{f,t}^{sp}$ is a per-pound ex-vessel price for salmon species *sp* in fishery *f* in year *t*; T_f is a dummy variable that equals one for observations in the CR fishery; A_t is a dummy variable that equals one for observations in years after 1981; $TA_{f,t}$ is the interaction of T and A, otherwise known as the policy variable;

$\mathbf{X}_{f,t}^{sp}$ is a vector of control variables; τ_t is a year fixed effect; and $\epsilon_{f,t}^{sp}$ an error term with an assumed normal distribution and a mean of zero.

Note that T_f controls for time-invariant fishery-specific differences in $y_{f,t}^{sp}$, including factors that led to the formation of the CRFC, and A_t and τ_t control for time-varying components of ex-vessel prices that impact both fisheries equally, such as the impact of production in Bristol Bay and the Exxon *Valdez* oil spill. The vector $\mathbf{X}_{f,t}^{sp}$ controls for time-varying fishery-specific factors believed to influence the ex-vessel prices paid to fishermen, including quantity harvested,[8] a five-year lagged coefficient of variation (CV) in harvest, a three-year lagged variance in harvest, a dummy variable to control for weak salmon returns to the CR fishery in 1980, and a dummy variable to control for an oil spill in 1987 (not Exxon *Valdez*) that affected the UCI fishery and not the CR fishery (Alaska Department of Fish and Game 1988). The measures of variation account for the impact that a variable supply has on capital investments in the fishery as well as consumer demand. For example, capital investments may depend on the long-term variation in harvest relative to its mean, and consumer demand may adjust more quickly and be determined by shorter-term levels of variance in fishery supply.[9]

Our DiD estimates are summarized in table 3: in specification (1), we present the uncontrolled DiD estimates; in specification (2), we include common time-varying controls; and in specification (3), we include common time-varying controls and fishery-specific controls. Heteroskedasticity-robust standard errors are reported. Full regression results are available in the supplementary appendix online. The DiD estimates for sockeye salmon range from \$0.64 to \$0.73 per pound, or an increase of 21.0%–24.0% in relative terms, as a result of the formation of the CRFC. Overall, the sockeye salmon DiD estimates are robust to specification. The DiD estimates for Chinook salmon range from \$1.35 to \$2.03 per pound, or an increase of 38.0%–

56.6% in relative terms. The magnitude of the DiD estimate increases after controlling for quantity, but overall the Chinook salmon DiD estimates are robust to specification. For the remainder of the analysis, we use specification (3) for both sockeye and Chinook as our central estimates.

Results: Quality Measure Analysis

In this section, we investigate whether the CRFC was able to improve the quality of the fish delivered to the processor. Although there are no data that directly measure salmon quality, we use monthly salmon deliveries and monthly salmon deliveries per permit holder as proxies for quality. Our hypothesis is that the cooperative's quality standards led to an increase in the number of monthly salmon deliveries for a given quantity of salmon delivered, by restricting the rate of harvest as well as trip time.[10] In other words, more frequent delivery trips are an indication of the salmon freshness upon delivery. We define a delivery trip as a trip where a positive amount of either sockeye or Chinook was delivered, or both.

The choice of our quality proxies and their merit are based on harvesting practices employed in the two fisheries before the CRFC. Both fisheries are gill-net fisheries. A gill net is a long rectangular net that hangs into the ocean, suspended from buoys at the top. The net intercepts salmon swimming to the mouth of the river, and the fish are entangled in the net by their gills. The quickest way for a gill-net fisherman to harvest and deliver salmon, and the way it was being done at the time, is to grab the salmon by the tail and pull it through the net, throw the salmon into a boat hold, fill the boat hold to capacity, and take the fish either to a processor or to a tender, where they are put into the tender's boat hold and then delivered to the processor. However, these practices yield poor-quality salmon. Doyle (1995) describes how pulling salmon through the net can result in a broken spine and internal bruising of the salmon flesh; how filling a boat hold to capacity puts pressure on fish at the bottom of the boat hold, causing fish quality to further deteriorate; and how delaying delivery to a processor until reaching boat-hold capacity compromises freshness.

The CRFC's quality standards addressed each of these issues: using picking hooks to remove fish from the nets maintains the integrity of the fish spine; bleeding the fish reduces bacterial contamination and improves the flavor of the fish; using ice bags designed to hold 200 pounds of fish prevents crushing the fish; and delivering the fish on ice up to six hours after harvest ensures that processors receive a fresh product. However, adopting the CRFC's standards for fish handling required a reduction in the rate of harvest, thereby indirectly reducing the volume of salmon delivered in a single trip, holding trip time constant. Additionally, delivering the fish within six hours of harvest directly reduced the length of a fishing trip and therefore the number of fish that could be delivered, holding the rate of harvest constant.

Graphical Analysis

The data show seasonal peaks in target species deliveries and deliveries per permit over time (figure 3). Clearly, seasonality in salmon availability drives the patterns in this data. As such, it is difficult to assess evidence for or against our hypothesis, so in the next section we move to a DiD analysis where we can control for seasonality and monthly weather conditions.

Difference-in-Differences Estimates

Table 4 summarizes the regression results from the estimation of equation (1) using proxies for salmon quality as dependent variables: in specification (4), we control for common time-varying effects; in specification (5), we control for time-varying and fishery-specific effects; and in specification (6), we use instrumental variables (IVs) for quantity. Heteroskedasticity-robust standard errors are reported. Full regression results are in the supplementary appendix online. We estimate model specifications (4)–(6) using both target species deliveries and deliveries per permit holder as dependent variables. Deliveries per permit holder accounts for the possibility that the price premium generated by the cooperative led to increased effort (participation), thereby increasing the number of delivery trips for a given quantity of salmon without any product quality improvements.

Controls for common time trends in the regressions include a year trend, month fixed effects, and fishing month fixed effects. Fishing months, as defined here, are different from calendar months and are counted starting with the first month that fish are available in a fishery, instead of starting with the first month of the year. This allows the model to capture how salmon fisheries evolve over the fishing season, even with differences in salmon run timing between the two fisheries.[11] Exogenous fishery-specific controls include monthly weather variables (rain days and minimum temperature), a dummy variable to control for weak salmon returns to the CR fishery in 1980 (Alaska Department of Fish and Game 1981a), a dummy variable to control for an oil spill in 1987 that affected the UCI fishery and not the CR fishery (Alaska Department of Fish and Game 1988), and a dummy variable to control for the 1989 Exxon *Valdez* oil spill that affected both fisheries. Weather variables impact the width of glacial-fed rivers in both fisheries, which impacts the rate of harvest and escapement in the fisheries, thus potentially impacting the number of monthly delivery trips. Weak returns and oil spills impact participation rates and harvest levels, and therefore the number of delivery trips taken.

Salmon quantity, measured in total pounds of sockeye and Chinook, is also an important control in this model but is potentially endogenous to salmon deliveries. For example, quantity and the number of delivery trips both may be determined by unobserved climatic conditions. Therefore, we use sockeye and Chinook quantities from the same month in the previous year and total salmon quantity (total pounds of all species) from the same month in the previous year as instrumental variables in the IV estimation. Lagged harvest (from the same month in the previous year) is a good predictor of monthly harvest, because harvest is determined by salmon availability, and the seasonal distribution of salmon migrating into the fishery is fairly stable from year to year (Groot and Margolis 1991). Wu-Hausman tests for endogeneity suggest that IVs should be used in the target species deliveries models but are not necessary in the models of salmon deliveries per permit holder. Therefore, specification (6) is our central estimate for salmon deliveries, and specification (5) is our central estimate for salmon landings per permit holder.

We find that deliveries in the treatment fishery went up by approximately 995 deliveries per month after the formation of the CRFC, or an increase of 52.58% in relative terms (see table 4). Our central estimate for the deliveries model uses IVs to control for the quantity harvested. We find that the first-stage F-statistic is above 10. We fail to reject the joint null hypothesis that the instruments are valid instruments using Hansen's J test of overidentifying restrictions (Hansen 1982). That is, we are unable to reject the hypothesis that the instruments are uncorrelated with the error term and that the excluded instruments are correctly excluded from the estimated equation. Table 4 also shows that the CRFC led to an increase of 1.10 monthly delivery trips per permit holder, or a 21.1% increase in relative terms.

Together, the results suggest that fishery participation increased in the after period, but that overall the fishery was making more delivery trips per unit of salmon (the increase in deliveries per permit holder is less than the increase in total deliveries).[12] Thus, there is evidence that the CRFC's quality standards had an impact on aggregate and individual fishing practices; in other words, given the level of salmon harvested, more delivery trips were made in total and for each active permit.

Robustness Checks

We develop two placebo tests to examine the robustness of our results. The placebo tests examine evidence for the potential existence of preexisting trends in the data, of exogenous and unobservable shocks in the after period, and of serial correlation in the data.[13] We subject results from both the price and quality analyses to each of two placebo tests: a placebo treatment year test and a placebo treatment species test. If we do not find significant treatment effects where there has been no treatment, then this means that our results are robust to our tests.

Placebo Treatment Years

The placebo treatment year test looks for evidence of preexisting trends or serial correlation in the pre-period data. Each pre-period year for which there is at least one year before and at least one year after that year becomes a placebo treatment year in our test. There are eight placebo treatment years in the ex-vessel price data and four placebo treatment years in the quality measure data. For each placebo treatment year, we create a variable for a placebo after period (PA) and a variable that interacts with T in the placebo after period (TPA). The PA variable differs from the variable A in that the dummy variable is set equal to one for years after the placebo treatment year rather than years after the CRFC formed. We estimate DiD models using the pre-period data (1971–1980 in the ex-vessel price data and 1975–1980 in the quality measure data) and check whether there are statistically significant differences in trends in our outcome variables of interest before the CRFC formed. The test model is as follows:

(2) $$y_{f,t}^{sp} = \xi_0 + \xi_1 T_f + \xi_2 PA_t + \xi_3 TPA_{f,t} + \mathbf{X'}_{f,t}^{sp}\lambda + \tau_t + \mu_{f,t}^{sp},$$

where all of the variables included in the placebo tests are identical to the variables used in our central specifications of equation (1) (specification (3) in table 3 for ex-vessel price models, specification (5) in table 4 for deliveries per permit holder, and specification (6) in table 4 for deliveries), with the exceptions that the after-period dummy variable A is replaced with PA and the policy dummy variable TA is replaced with TPA.

Figure 4 shows the estimated coefficients on the ex-vessel price TPA variables and the confidence interval around the estimates. Figure 5 shows the estimated coefficients on target species deliveries and deliveries per permit holder TPA variables and their confidence intervals. Given the confidence intervals around coefficients on each TPA_t include zero, we conclude our estimates are robust to the placebo treatment year tests.[14] In other words, the placebo tests do not find false positives, and the tests suggest that fluctuations in the outcome differentials in the pre-period years are either statistical noise or attributable to observable factors included as control variables in our model.

Placebo Treatment Species

Assuming there were no spillovers to other species, one would expect the CRFC to have no impact on nontargeted salmon species (chum and pink salmon). Finding an impact of the CRFC on nontargeted species may suggest the presence of a confounding factor, that is, some unobserved factor that was driving a difference in trends for all salmon prices. To check for this, we conduct placebo-species tests, where we estimate our central specifications of equation (1) with outcomes for nontargeted salmon species as dependent variables instead of outcomes for the targeted species, sockeye and Chinook.

Figures 6 and 7 summarize our placebo species test results for ex-vessel price and quality specifications. In each figure we show the point estimates and associated confidence intervals. None of the placebo species DiD estimates for ex-vessel prices or our two quality measures are statistically significant at the 5% level.

In summary, our DiD estimates along with our robustness checks support the hypothesis that the CRFC generated a price premium for its targeted salmon species and had a positive and significant impact on our proxy measures for salmon quality.

Fishery Net Benefits

We find robust empirical evidence in support of the hypothesis that the CRFC affected the prices and quality of targeted salmon species. A natural question to ask, however, is: did acting collectively enable fishermen to generate positive net benefits in their fishery, even though product quality improvements were costly?[15]

Using our DiD estimates of the price premiums generated by the CRFC (specification (3) for sockeye and Chinook) and holding harvest constant at pretreatment means, we find that sockeye and Chinook revenue in the CR fishery would have increased by $1.684 million and $1.152 million per year on average, respectively, or $2.836 million per year in total.

How much of the increase in revenue benefited fishermen, and how much was absorbed in added costs of producing a quality salmon product? To address this question, we develop a back-of-the envelope measure of net benefits using data collected in a 2001 CFEC survey on the operating cost of commercial drift gill-net salmon fishing in the Bristol Bay fishery (Carlson 2002).[16]

To our knowledge, the CFEC survey data is the only cost data that exists for an Alaskan drift gill-net salmon fishery during the time period of our analysis. For our back-of-the-envelope calculation, we need to assume that fishing trip expenditures in the Bristol Bay sockeye salmon fishery are representative of fishing trip expenditures in the CR salmon fishery.[17] There are, however, reasons why fishing trip expenditures may be different between the Bristol Bay and CR fisheries. For example, Hilborn (2006) summarizes several factors that drive up fishing costs in Bristol Bay relative to the other salmon fisheries in Alaska. These factors include short fishing seasons, high volumes of fish, distance from markets, and high tides, which create unfavorable delivery conditions. Based on Hilborn's (2006) analysis, the data from Bristol Bay may in fact provide more conservative cost estimates for our calculations.

The estimate for annual fuel expenditures for Bristol Bay is $1,758 per fisherman, and annual expenditures on fuel, maintenance, and nets totaled $6,198. The CFEC deliveries data indicate that Bristol Bay fishermen made an annual average of 21.26 trips in 2001, implying a trip cost of about $83 (or $291 when considering maintenance and nets as variable trip cost). Together with our estimated increase of 945 trips per month for target species in the CR fishery, this suggests that the annual cost of improving salmon quality was roughly $0.454 million (or roughly $1.592 million with maintenance and nets cost) for a 5.5-month fishing season. Thus, the cooperative led to an estimated net gain of $1.244 to $2.382 million per year (e.g., with our high-cost estimate, net gains are $2.836 million – $1.592 million=$1.244 million).[18] The estimated gains represent 13.01%–24.92% of average sockeye and Chinook fishery value before 1981.

These estimates suggest that the costs of product quality improvements were not an insignificant part of the picture. Holding harvest constant at pretreatment means, we estimate that the cost of producing high-quality salmon ranged from 16.01% to 56.15% of the increased revenue attributable to the CRFC.

Discussion

We have demonstrated that the CRFC was able to improve product quality and increase ex-vessel prices for fishermen. However, several important questions remain. How much did the CRFC's institutional structure matter? Could the same outcomes have been achieved with the formation of a firm that was not organized as a cooperative? What do our findings imply about the conditions under which marketing cooperatives can achieve product quality improvements? And how were the price premiums and product quality improvements sustained beyond the life of the CRFC? Here we discuss these questions and identify areas for future work.

Whether marketing cooperatives have advantages in markets for high-quality products is a subject of some debate (see Mérel, Saitone, and Sexton (2009) for a discussion of the subject).[19] While several institutional features may disadvantage cooperatives from operating in markets for high-quality food products, vertical integration can work as an advantage, allowing cooperatives to coordinate quality control measures across different stages in the production process (Sexton and Iskow 1988). Therefore, marketing cooperatives represent a departure from the traditional two-stage production process, a process that can potentially lead to market failures and an underinvestment in product quality.

While the CRFC was less than perfectly vertically integrated, fishermen did own and operate the processing plant. Therefore, the CRFC's organizational structure created a greater degree of communication along the supply chain and with buyers, which likely facilitated the development and adoption of coordinated product quality improvements. In this scenario, the CRFC's institutional structure was critical to what it accomplished. Persistence of the price premiums generated by the CRFC may be evidence that other processors learned and adopted the new production practices that the CRFC was able to develop at low cost (through vertical integration), effectively reducing their costs of observing product quality.

Another potential explanation is that, at the time of the CRFC's formation, markets for high-quality salmon were newly emerging, and existing processors faced uncertainty over the profitability of entering into these markets. Product quality must be preserved from the moment of harvest until the moment of consumption (requiring investments at both stages in production), meaning that fishermen cannot unilaterally enter into high-quality markets. Therefore, uncertain returns may have prevented fish from the CR fishery from being channeled into high-quality markets.

Differences in expected profitability in high-quality markets or risk preferences may explain why the CRFC was willing to enter quality markets when existing processors were not. However, the CRFC's investments in marketing high-quality salmon from the CR region may have reduced uncertainty for other processors on the returns to improving product quality. In doing so, the CRFC would have created lasting benefit spillovers for nonmembers. In this scenario, however, the CRFC's institutional structure may be less fundamental to what the CRFC accomplished.

Information asymmetries and uncertain returns to quality investments to second-stage producers (owing to market structure) are both likely causal mechanisms for what is observed here. However, neither of these can be tested in the data. Future work is needed to more completely understand the mechanisms at work and the potential gains from vertical integration and marketing cooperatives in the fishing industry.

Conclusion

Our work has taken a first step in examining the role of fishing marketing cooperatives in promoting product quality and realizing economic gains for resource users. The work contributes to the literature on marketing cooperatives by providing an impact evaluation of a cooperative and also contributes to the fisheries literature by providing an analysis of a marketing cooperative in a fisheries context.

We find that the CRFC led to an increase in the per-pound prices for sockeye and Chinook salmon of approximately \$0.64–\$0.73 per pound (or 21.0%–24.0% in relative terms) and \$1.37–\$2.03 per pound (or 38.0%–56.6% in relative terms), respectively. Additionally, the number of monthly delivery trips for a given quantity of salmon increased by about 995, or 52.6%, in the CR fishery after the CRFC's formation, and monthly salmon deliveries per permit holder increased by about 1.10 trips per month, or 21.1%. The results are robust to placebo tests; in other words, we do not find significant treatment effects where there has been no treatment. In particular, we tested pre-period data for significant placebo treatment events, and we looked for treatment effects in salmon species that were not targeted by the cooperative.

Although we are unable to provide more than a back-of-the-envelope calculation of fishery net benefits, even the high end of our trip cost estimates suggests that the gains from quality investments outweighed the costs. It is not clear, however, whether one might expect these gains to persist in a limited-entry fishery with incomplete property rights. Future work is needed to better and more precisely understand the mechanisms through which the CRFC actualized the changes found and obtain further insights into the potential welfare gains from vertical integration and marketing cooperatives in fisheries.

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Notes

[1] See Homans and Wilen (2005) for theory on property rights and product quality in fisheries.

[2] See Feng and Hendrikse (2008) and Soboh et al. (2009) for a description of the various conceptualizations of marketing cooperatives in the literature. Our analysis follows from the view of the CRFC as a vertically integrated firm with the objective of maximizing member benefits.

[3] See Soboh et al. (2009) for a review of the different marketing cooperative types, respective objectives, and related empirical work.

[4] Over 1971–2001, aquaculture salmon production was rising, and is a close substitute for wild salmon (Asche et al. 1999; Asche et al. 2005; Valderrama and Anderson 2010). Therefore, the impact of Bristol Bay on ex-vessel wild salmon prices was falling over this period.

[5] However, because our purpose is to examine the effect of the treatment on the treated, we do not need the formation of the CRFC in the CR fishery to "be as good as randomly assigned." A random treatment would be needed if we wished to examine the hypothetical impact of the treatment on any one of the several Alaskan salmon fisheries, which is not the purpose of this analysis. The purpose of our analysis is to estimate the impacts of the CRFC on prices paid to fishermen and measures of salmon quality in the CR fishery.

[6] Given theory from the cooperative literature, we are unable to construct a plausible example of why our results would be upward biased. Specifically, the agricultural marketing cooperative literature states that cooperatives "must be born from necessity" (e.g. Cook 1995; Sexton and

Iskow 1988). That is, cooperatives are costly to form and thus will attract members only when the cooperative can benefit members. Hence, it is unlikely that the CRFC formed as a result of unobserved factors driving upward trends in outcome variables in the CR fishery.

[7] Prices were adjusted to 2012 USD using the Bureau of Labor Statistics consumer price index series No. CUUR0000AA0.

[8] Fishery supply is often assumed to be exogenous to prices, but given the fact that fishermen in the CR and UCI fishery organized strikes, we test for a supply response with Wu-Hausman tests for endogeneity (Hausman 1978; Wu 1973). We find no evidence of endogeneity in quantity for either species. A detailed description of the Wu-Hausman tests and test results are in the supplementary appendix online.

[9] Our estimates are robust to varying the window of time considered in the CV and variance controls.

[10] The analysis includes only those months with nonzero sockeye deliveries.

[11] For example, the fishing season in the CR fishery begins approximately one month before the fishing season in the UCI fishery, meaning that when the CR fishery is in its second fishing month, the UCI fishery is in its first fishing month.

[12] It is possible that the price premium generated by the CRFC would have resulted in increased participation in the fishery if the limited-entry restrictions were not binding. Higher participation rates could also have potentially increased the number of delivery trips per quantity of salmon, confounding our analysis of delivery trips made. Therefore, we also consider the number of delivery trips per permit holder. Additionally, we find that the DiD estimate of the impact of the CRFC on the number of active permit holders is not significant at the 5% level, which suggests our product quality results are not being driven by increased participation.

[13] Serial correlation is a known problem with this class of estimates. See Bertrand, Duflo, and Mullainathan (2004) for an in-depth discussion of the issue.

[14] As suggested in Bertrand, Duflo, and Mullainathan (2004), we provide the average coefficients on the placebo policy variables from the placebo years tests for comparison with our central DiD estimates. The average coefficients on the placebo policy variables are –0.143 (min. –0.785, max. 0.212) and –0.207 (min. –0.968, max. 0.773) in the sockeye and Chinook salmon ex-vessel price placebo years tests, respectively. The average coefficients on the placebo policy variables are –417.780 (min. –492.616, max. –349.048) and 0.358 (min. –0.141, max. 1.345) in the salmon deliveries and deliveries per permit holder placebo years tests, respectively.

[15] In this section, we consider surplus to fishermen. Available price data are ex-vessel prices, which are an input price and not the same as the consumer price. To our knowledge, consumer prices are not available for the two fisheries, and therefore, we are unable to make statements about consumer surplus.

[16] Detailed cost information was gathered from 213 permit holders, vessel owners, or skippers. Of the 12 cost categories in the survey, we use data from the expenditure items believed to represent variable trip costs.

[17] In addition, we do not consider changes in congestion costs (we do not find statistical evidence of increased participation due to the CRFC), and we do not consider the opportunity cost of time. While the opportunity cost of time is not zero in practice, these opportunity costs are not likely to be significant because of the short duration of the salmon season (about four months), the CRFC's restriction of trip length to six hours, the nonpecuniary benefits associated with salmon fishing (Karpoff 1984), and the labor markets in remote fishing communities in Alaska.

[18] Permit prices are another measure of welfare gains in a limited-entry fishery (Stefanou and Wilen 1992). Unfortunately, permit price data in the CR and UCI fisheries were not collected until 1978 and are not long enough to construct a defensible pre-period counterfactual. However, on the suggestion of a reviewer, we conducted a DiD analysis on salmon permit prices, finding that the CRFC led to a $79,666.28 increase in permit prices and the gain is significant at the 1% level. Assuming the high estimate from our back-of-the-envelope calculation of net benefits ($2.382 million per year) is divided equally over the 526 permit holders in the CR fishery and paid out in perpetuity, we find that a 5.68% discount rate equalizes the estimated increase in permit prices and the estimated return from our back-of-the-envelope calculation. The implication is that while we are using cost data from a different fishery in our calculation, our estimate of the potential gains from the CRFC appear reasonable.

[19] Other papers weighing in on the debate include Saitone and Sexton (2009), Pennerstorfer and Weiss (2013), and Deng and Hendrikse (2013). All of these papers consider the case where privately owned firms can perfectly and without cost observe product quality and pay quality-differentiated prices.

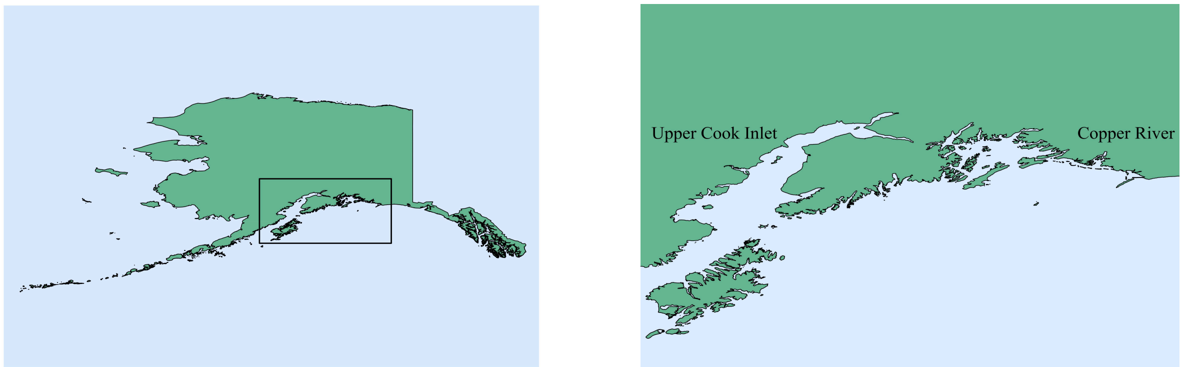

Figure 1. Maps of Alaska and the treatment and control fisheries

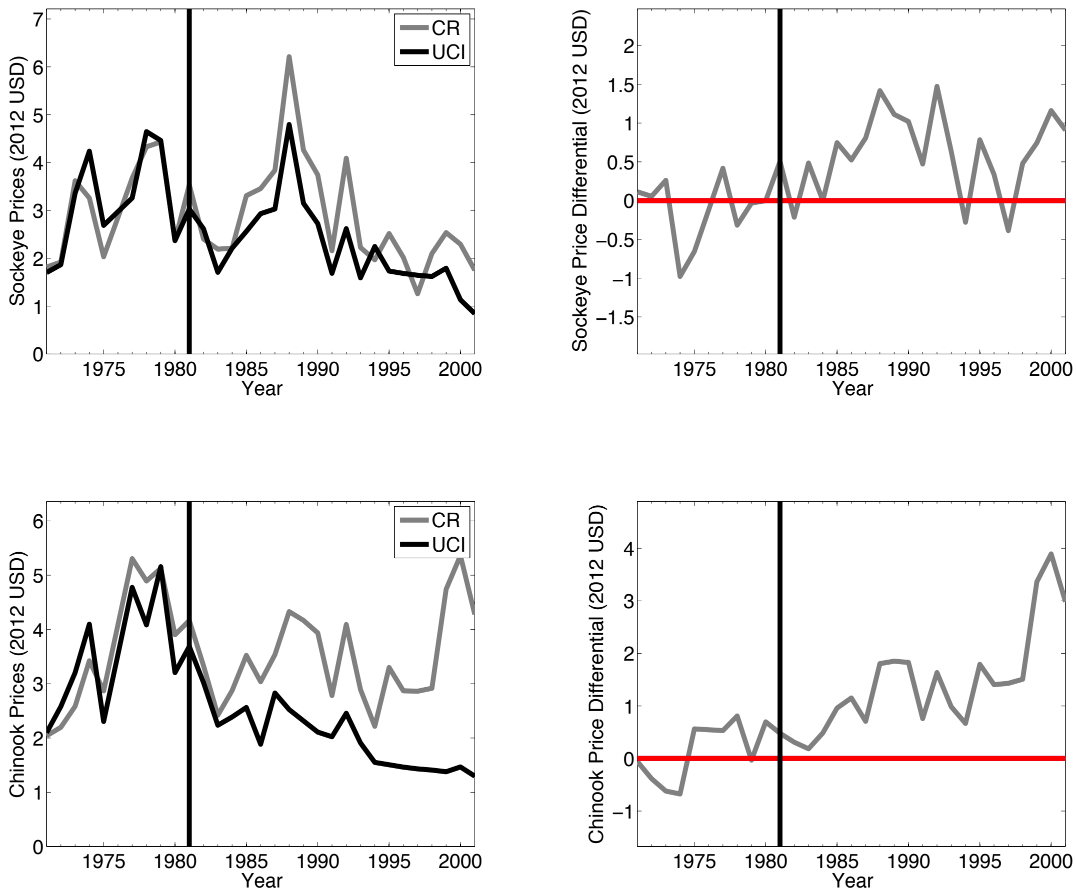

Figure 2. Sockeye (top row) and Chinook (bottom row) prices and price differential

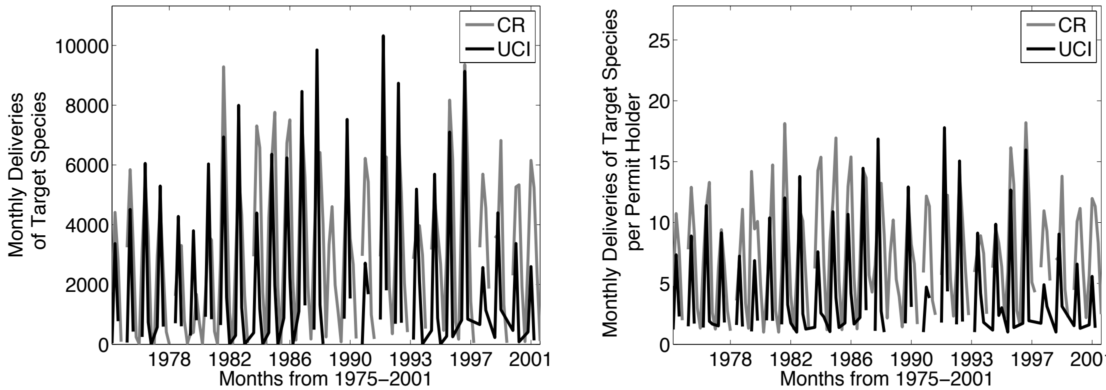

Figure 3. Monthly deliveries of target species (left) and monthly deliveries of target species per permit holder (right) in the treatment and control fisheries

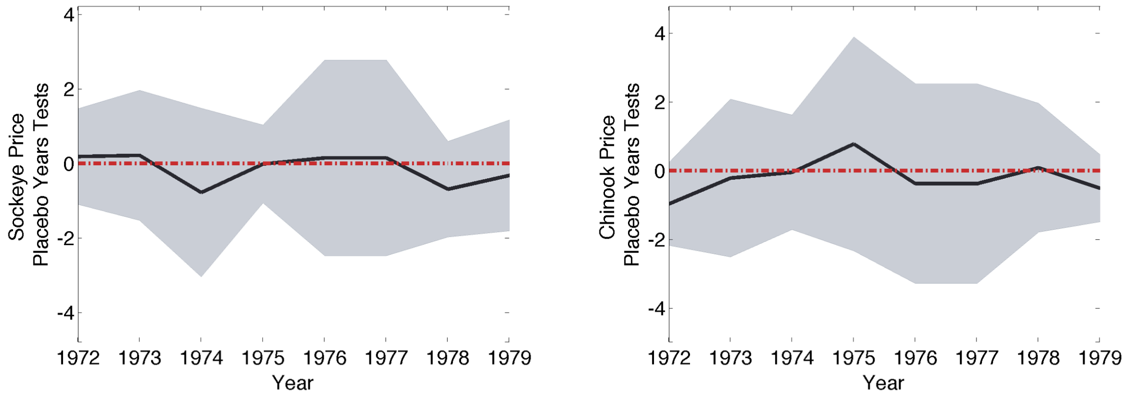

Figure 4. Sockeye price (left) and Chinook price (right) placebo years test results

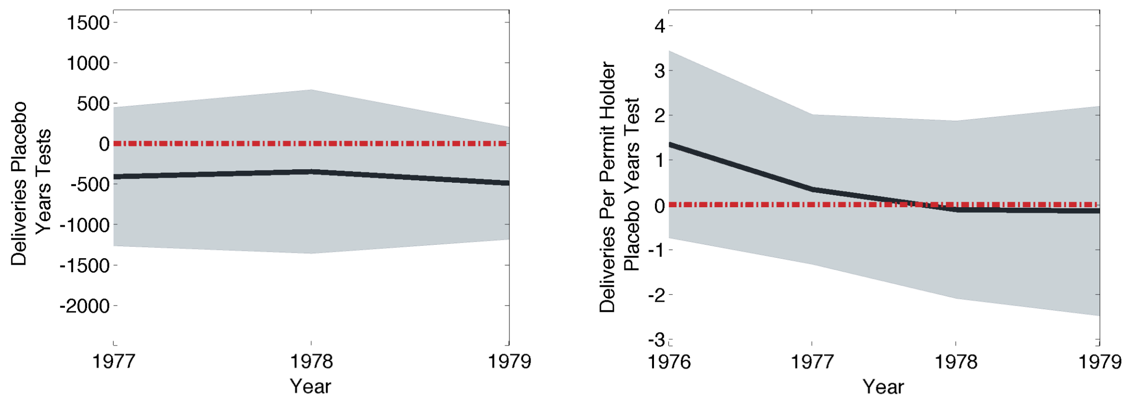

Figure 5. Target species deliveries (left) and target species deliveries per permit holder (right) placebo years test results

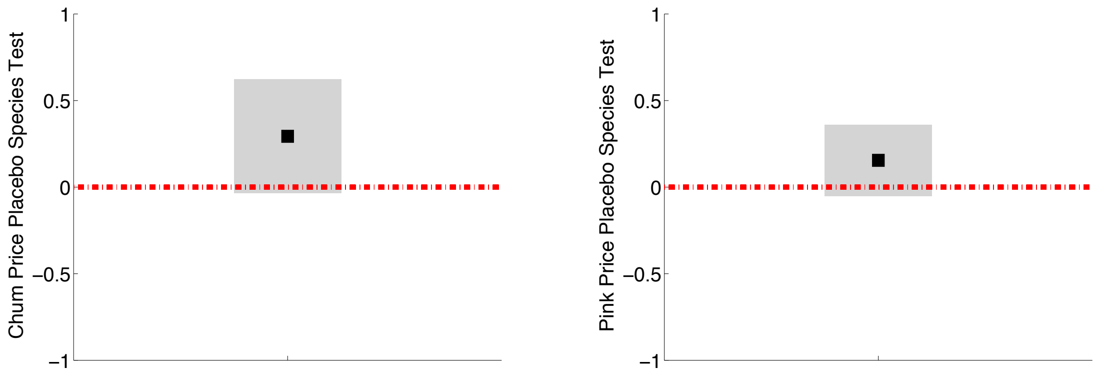

Figure 6. Chum ex-vessel prices (left) and pink ex-vessel prices (right) placebo species test results

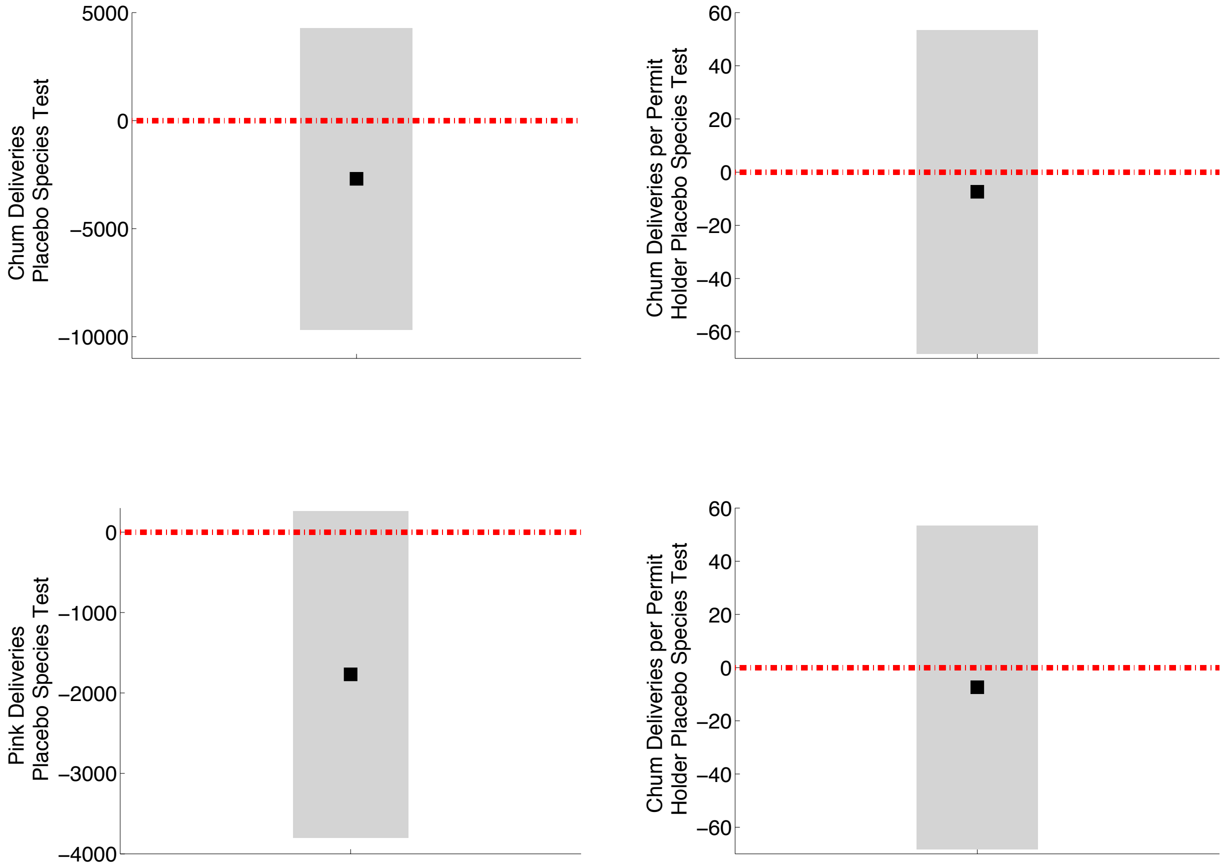

Figure 7. Chum (top) and pink (bottom) deliveries (left) and deliveries per permit holder (right) placebo species test results

Table 1. Size and Variability of Treatment and Control Fisheries, 1971–2001

	Average harvest (thousands of fish)	Average fraction of statewide harvest	Variance in harvest (thousands of fish)
Sockeye			
Treatment	953.2	0.04	3.71E+05
	(612.6)	(0.03)	
Control	3,234.50	0.1	5.34E+06
	(2,383.5)	(0.06)	
Chinook			
Treatment	35.6	0.06	240.879
	(15.8)	(0.03)	
Control	17.7	0.03	71.579
	(9.0)	(0.01)	

Note: Standard deviations are in parentheses.

Table 2. Summary Statistics for Control Variables

	Mean	Std. dev.	Source
<u>Fishery-specific controls: treatment</u>			
Sockeye harvest (million pounds)	5.928	3.837	ADF&G FMRs
Chinook harvest (million pounds)	0.902	0.356	ADF&G FMRs
Sockeye 5-year coefficient of variation	0.440	0.263	ADF&G FMRs
Chinook 5-year coefficient of variation	0.274	0.139	ADF&G FMRs
Sockeye 3-year variance (fish squared)	1.48e+11	2.10e+11	ADF&G FMRs
Chinook 3-year variance (fish squared)	8.36E+07	1.14E+08	ADF&G FMRs
Minimum temperature (TD)	365.71	19.997	NCDC
Rain days	10.323	3.156	NCDC
<u>Fishery-specific controls: control</u>			
Sockeye quantity (million pounds)	19.597	15.247	ADF&G FMRs
Chinook quantity (million pounds)	0.453	0.242	ADF&G FMRs
Sockeye 5-year coefficient of variation	0.437	0.143	ADF&G FMRs
Chinook 5-year coefficient of variation	0.350	0.148	ADF&G FMRs
Sockeye 3-year variance (fish squared)	2.54e+12	3.59e+12	ADF&G FMRs
Chinook 3-year variance (fish squared)	2.92E+07	3.97E+07	ADF&G FMRs
Minimum temperature (TD)	387.194	28.866	NCDC
Rain days	2.516	1.029	NCDC

Note: Coefficient of variation and variance calculations use lagged rolling 5-year and 3-year windows of time, respectively.

Table 3. Summary Price Analysis Regression Results

	Dependent variable					
	Sockeye price			Chinook price		
	(1)	(2)	**(3)**	(1)	(2)	**(3)**
CR fishery	–0.115	–0.126	**–0.222**	0.0714	0.0925	**–1.091***
	(0.467)	(0.147)	**(0.163)**	(0.523)	(0.189)	**(0.406)**
After the CRFC	–0.911*	–0.827**	**–0.646**	–1.453**	0.0459	**–0.944**
	(0.377)	(0.222)	**(0.325)**	(0.349)	(0.823)	**(0.726)**
*CR fishery**	0.721	0.732**	**0.640***	1.366*	1.345**	**2.032****
After the CRFC	(0.564)	(0.186)	**(0.272)**	(0.571)	(0.290)	**(0.394)**
Fishery-specific controls	NO	NO	**YES**	NO	NO	**YES**
Year fixed effects	NO	YES	**YES**	NO	YES	**YES**
Observations	61	61	**61**	61	61	**61**
R-squared	0.117	0.949	**0.962**	0.401	0.849	**0.922**

Note: Asterisk (*) and double asterisk (**) denote variables significant at 5% and 1% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses. Our central estimates are in bold font. Full regression results are available in the supplementary appendix online.

Table 4. Summary Quality Analysis Regression Results

	Dependent variable					
	Target species deliveries			Target species deliveries per permit holder		
	(4)	(5)	**(6)**	(4)	**(5)**	(6)
CR fishery	47,064	41,875	**46,828***	70.37	**67.75**	59.29
	(29,980)	(22,271)	**(20,940)**	(53.49)	**(43.73)**	(39.76)
After the CRFC	1,091**	496.2*	**49.05**	1.566**	**0.642**	0.231
	(290.7)	(207.7)	**(480.0)**	(0.504)	**(0.390)**	(0.603)
*CR fishery**	670.9	840.3**	**994.9***	0.143	**1.103***	1.178*
After the CRFC	(351.3)	(231.2)	**(386.9)**	(0.628)	**(0.481)**	(0.564)
Time fixed effects	YES	YES	**YES**	YES	**YES**	YES
Fishery-specific controls	NO	YES	**YES**	NO	**YES**	YES
Instrument for quantity	NO	NO	**YES**	NO	**NO**	YES
Observations	220	220	**212**	220	**220**	212
First-stage F statistic			**17.30**			17.30
Hansen's J p-value			**0.556**			0.603
R-squared	0.906	0.950		0.928	0.954	

Note: Asterisk (*) and double asterisk (**) denote variables significant at 5% and 1% levels, respectively. Heteroskedasticity-robust standard errors are in parentheses. Our central estimates are in bold font. Full regression results are available in the supplementary appendix online.