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Factors Affecting Alaska's Salmon Permit Values: Evidence from Bristol Bay Drift Gillnet Permits

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Abstract: The effects of total earnings, total costs and mining exploration on permit prices in Alaska are investigated using an autoregressive distributed lag (ARDL) approach to co-integration. We take specific account of regional and gear specific salmon fisheries – that is, Bristol Bay drift gillnet permits – in our modelling. We find that there is a stable long-run relationship among permit prices, total earnings, and total costs. It is also found that, in both the short- and long-run, total earnings have a positive and significant relationship with permit prices, while total costs have a negative and significant relationship. Although the mining exploration in the region has a negative and significant effect on permit prices in the short-run, the effect does not seem to last in the long-run.

Keywords: Alaska; ARDL model; Bristol Bay; Drift gillnets; Permit prices

JEL Classifications: C22, D46, L79, Q22

1. Introduction

Commercial salmon fisheries are not only a critical resource to Alaska's economy, but to the U.S. market as well. During the 2013-2014 period, for example, the Alaskan salmon fisheries provided an annual average of 59,539 jobs with total labor income of $1.584 billion and accounted for almost 98% of U.S. salmon harvests with annual harvests averaging around 800 million pounds valued at over $500 million (McDowell, 2015). To prevent economic rent dissipation in the salmon fisheries, the Alaska state legislature thus has adopted the so-called limited entry permit system for commercial salmon fisheries through the passage of the Limited Entry Act since 1975. The system issues tradeable permits for specific salmon fisheries corresponding to different types of gear and geographical areas, and requires the permit holders to be present on the vessel when fish are landed. However, the Alaskan salmon fisheries have been subject to great volatility in permit values over the past four decades. For example, starting in 1978 the value of a permit in 2014 dollars was nearly $152,000. They reached an all-time high of $475,000 in 1989, but fell sharply to a low of $26,000 in 2002. By 2014, the values of the permits had rebounded back to around $150,000. Therefore, it is crucial to examine factors that contribute to the dynamic behavior of permit values appropriately in order to understand Alaska's commercial salmon fisheries accurately.

A number of studies to date have investigated the markets for limited entry permits in the Alaska salmon fisheries. Some examine the implications of the limited entry permits for commercial salmon fisheries in Alaska (Karpoff, 1982) and changes in local ownership of Alaskan salmon entry permits (Knapp, 2010). Others address the economic and non-economic effects of the limited entry permits on the Alaskan salmon fisheries (e.g., Karpoff, 1985; Benshoof and Baek, 2014). Moreover, a couple of studies have analyzed the key factors affecting the prices of limited entry permits (Karpoff, 1984; Huppert *et al*. 1996). They commonly find that (expected) total earnings generated by permit ownership and use are the most significant factor in determining the permit values, confirming asset pricing theory. However, an important point overlooked by the two researchers is that if the selected variables in their models are nonstationary, standard OLS estimation leads to the spurious regression problem, thereby raising doubts about the validity of the results. Further, despite wide variations in permit prices corresponding to gear types and/or fishing areas, the emphasis of the studies has typically been on Alaskan statewide salmon fisheries. In other words, there is no current research or modeling on regional/gear specific salmon fisheries in the State of Alaska.[1]

In this article, therefore, we take one step further and attempt to examine the factors affecting the prices of limited entry permits in the context of regional and gear specific salmon fisheries in Alaska using enhanced methods and an updated dataset. Special attention has been given to the assessment of the short- and long-run effects of such factors as gross earnings and operating costs on the values of Bristol Bay drift gillnet permits. Bristol Bay, located in southwestern Alaska, accounts for nearly one-third of all Alaska's salmon harvest earnings ($156 million in 2016) and produces the largest sockeye salmon fishery in the world.[2] In addition, drift gillnets are used to catch nearly 80% of Bristol Bay sockeye salmon. For the analysis, we employ an autoregressive distributed lag (ARDL) approach to cointegration developed by Pesaran *et al*. (2001). The ARDL approach can be applicable to the level of variables without testing whether they are stationary or nonstationary and uses an error-correction format to estimate both the short- and long-run dynamics with a single step; hence, it is well suited to deal with this line of research. The remaining sections present an overview of Alaska's limited entry permit system, empirical method, data, empirical findings and concluding remarks.

This paper is organized as follows. Section 2 describes the limited entry permit system in Alaska that this research analyzes. Section 3 describes the model and methods used to investigate the factors determining the values of Bristol Bay drift gillnet permits. Section 4 describes the data utilized in the analysis. Section 5 reviews the empirical results. Finally, section 6 presents our conclusions and discusses limitations and policy implications.

[1] In fact, Huppert *et al*. (1996) use two gear types such as purse seine and drift gillnet in their models and conclude that estimating the two gear types separately would be more desirable in order to draw robust conclusions. However, they employ Alaskan statewide salmon fisheries data for the analysis.

[2] As the second most abundant species commercially caught in Alaska, sockeye salmon is known as the most valuable salmon species.

2. Limited Entry Permit System in Alaska

Alaska created the Commercial Fisheries Entry Commission (CFEC) in 1973 and adopted a limited entry management system for commercial salmon fisheries through the passage of the Limited Entry Act in 1975. Eight geographic areas (Southeast, Yakutat, Prince William Sound, Cook Inlet, Kodiak, Chignik, Alaska Peninsula, and Bristol Bay) are fished using five different types of gear (purse seine, beach seine, drift gill net, set gill net, and power troll). These limited entry permits were originally issued for free to individuals based on "(1) the degree of economic dependence upon the fishery, including… the percentage of income derived from the fishery, reliance on alternative occupations, availability of alternative occupations, investment in vessels and gear; (and) (2) extent of past participation in the fishery, including … the number of years of participation in the fishery, and the consistency of participation during each year" (Alaska Statutes, Sec. 16.43.250). Only individuals may own these permits, the owner must be present on the vessel while they are fishing, and permits may not be leased (Knapp, 2010).

The Limited Entry Act allows for two types of permit transfers: permanent and emergency. Permanent transfers occur when there is a change in the holder of the permit, and emergency transfers allow for the permit to be fished by someone other than the holder if the permit holder: "is prevented from fishing due to illness, death, disability, required military or government service, or other unavoidable hardship of a temporary, unexpected and unforeseen nature." In order to permanently transfer a permit to someone else, the permit holder must file a "Notice of Intent to Permanently Transfer" form and wait the 60 day waiting period; the permit holder and the transferee then must complete the "Request for Permanent Transfer of Entry Permit" form (CFEC, 2012b). This 60 day waiting period was created by the legislature so that permit holders would have time to consider their long term needs before permanently transferring their permit. Limited entry permits must be renewed annually once issued, and failure to renew for a period of two years results in forfeiture. Also, the Alaska Legislature has reserved the right to modify or revoke a limited entry permit without providing compensation or through buyback programs (Weiss, 1992). Permits that have been forfeited are removed from the fishery and are not reissued to other fishermen (CFEC, 2012a).

3. The Model and the Method

To investigate the factors determining the values of Bristol Bay drift gillnet permits, following previous studies (i.e., Karpoff, 1984; Huppert *et al*., 1996), we also rely on an asset pricing model developed by Hirschleifer (1980). In its simplest form this model can be stated as:

$$P = f(R, C, Z) \tag{1}$$

where P is the price of a permit; R is the expected total earnings (revenue); C is the expected total costs; and Z is other shift factors affecting the price of a permit. Equation (1) can be specified in a log-level form as follows:

$$\ln P_t = \beta_0 + \beta_1 \ln R_t + \beta_2 \ln C_t + \beta_3 DUM_{2002\text{–}2013} + u_t \tag{2}$$

where $\ln P_t$ is the natural log of the price of permits; $\ln R_t$ is the natural log of the average total earnings; $\ln C_t$ is the natural log of the average gasoline price as a proxy for costs; DUM_t is a dummy variable capturing the effect of the 2002-2013 Pebble Mine exploration on permit prices; and u_t is the error term. Pebble Mine is a mineral exploration project investigating a very large porphyry copper, gold and molybdenum mineral deposit in Bristol Bay. However, since the mine is located in the headwaters of the fishery, many local fisherman have voiced their concern over the mine and the possibility of the negative impacts it has on the fishery in the future. The decision for DUM_t to take on the value of 1 for the years 2002-2013 is decided based upon Northern Dynasty Minerals Ltd. starting exploration in 2002, discovering Pebble East deposit in 2005, forming the Pebble Partnership with Anglo American plc in 2007, developers releasing preliminary assessment and environmental data in 2011, and the Pebble Partnership coming to an end in 2013 leaving Northern Dynasty looking for new investors.

Since an increase in expected total earnings generally leads to an increase in permit prices, it is expected that $\beta_1>0$. To the extent that a rise in expected total costs results in a decrease in permit prices through reduction in fishing activities and hence demand for permits, it is expected that $\beta_2<0$. Finally, if the Pebble Mine exploration has a negative effect on the fishery and permit prices, it is expected that $\beta_3<0$.

Equation (2) is now reformulated as follows to illustrate the ARDL modeling approach:

$$\begin{aligned}\Delta \ln P_t = \beta_0' + \sum_{i=1}^{n} \beta_{i1}' \Delta \ln P_{t-i} + \sum_{i=0}^{n} \beta_{i2}' \Delta \ln R_{t-i} + \sum_{i=0}^{n} \beta_{i3}' \Delta \ln C_{t-i} + \beta_4' DUM_{2002-2013} \\ + \theta_0 \ln P_{t-1} + \theta_1 \ln R_{t-1} + \theta_2 \ln C_{t-1} + \varepsilon_t\end{aligned} \tag{3}$$

All variables here are as previously defined with ε_t being the error term. Unlike a standard error-correction model that includes the lagged error-correction term (ec_{t-1}) from Equation (3), the ARDL model includes the linear combination of lagged level variables ($\ln P_{t-1}$, $\ln R_{t-1}$, and $\ln C_{t-1}$) as the error-correction term. Pesaran *et al*. (2001) recommend using the *F*-test to evaluate whether or not the three lagged level variables in Equation (3) are jointly significant. For this, the upper and lower asymptotic critical values provided by Pesaran *et al*. (2001) can be utilized to test the null hypothesis that there is no cointegration (H_0: $\theta_0= \theta_1= \theta_2=0$) against the alternative that there is (H_1: $\theta_0\neq \theta_1\neq \theta_2\neq 0$). Once the F-test provides a cointegrating relationship, the long-run coefficient estimates are derived by the estimates of θ_1 and θ_2 normalized on θ_0. The short-run dynamic effects are represented by the estimates of coefficients following the sigma symbols.

4. Data

The average price of actual sales transactions for permits are used as a proxy for permit values and are acquired from the Commercial Fisheries Entry Commission (CFEC) via the Alaska Department of Fish and Game (ADF&G). The total average earnings for all permanent permit holders are used as a proxy for the expected total earnings and are collected from the CFEC. Since the rise and fall of fuel prices affects fishing activities, gasoline prices are used as a proxy for the expected operating costs and are taken from the U.S. Energy Information Administration (EIA).[3] All the variables are deflated to 2014 dollars using the Consumer Price Index (CPI) taken from the U.S. Bureau of Labor Statistics (BLS). Finally, since permit values are not recorded until 1978, our dataset is compiled from 1978 to 2014.

[3] It should be admitted that there are a number of inputs that contribute to total costs with wages paid to the deckhands, food prices, maintenance costs, and insurance rates all being examples. Due to unavailability of those data, however, average gas prices are used as a proxy for input costs in our model; thus, our findings should be viewed with caution.

5. Empirical Results

Although the ARDL method does not require the variables in Equation (3) to all be of the same order of integration, it crashes in the cases where $I(2)$ variables are involved. Before estimating the model, therefore, the presence of a unit root in the selected variables is tested using an augmented Dickey Fuller (ADF) test. Table 1 reports the results of the ADF test for a unit root in each of the three variables. Since the test statistics for the levels (first differences) are above (below) -3.5(-3.18) at the 5% (10%) significance level, we cannot (can) reject the null hypothesis of a unit root for any of the three variables. This indicates that each series in Equation (3) is $I(1)$ variable, ensuring that the ARDL method can be safely applied to the current research.

Table 1. Results of ADF unit root tests (period: 1978-2014)

Variable	Level	First difference	Decision
$\ln P_t$	-1.142 (1)	-3.808** (1)	$I(1)$
$\ln R_t$	-2.121 (2)	-4.408** (2)	$I(1)$
$\ln C_t$	-1.461 (1)	-4.928** (1)	$I(1)$

Notes: ** and * indicate rejection of the null hypothesis at the 5% and 10% levels, respectively. The 5% and 10% critical values for the ADF, including a constant and trend, are -3.5 and -3.18, respectively. Numbers inside parentheses are lag lengths, which are selected by the Schwarz Information Criterion (AIC).

In the ARDL approach, the short- and long-run estimated coefficients of the individual series are statistically meaningful only if they are cointegrated. Therefore, the model is tested to determine the existence of cointegration relationship among the three variables using the F-test. For this, after imposing a maximum of two lags, Akaike's Information Criterion (AIC) is used to select the optimum lags in Equation (3). Since the computed F-statistic of 15.703 far exceeds the 5% upper bound critical value of 6.021, we can reject the null hypothesis that the three variables are not cointegrated. Therefore, it is likely that any deviation among the three variables is not expected to continue and will have a tendency to return to its trend path in the long-run.

Table 2. Estimated long-run coefficients of the price permit model of Bristol Bay (period: 1978-2014)

Variable	Coefficient
$\ln R_t$	1.352*** (7.725)
$\ln C_t$	-0.576** (-1.968)
$DUM_{2002\text{-}2013}$	-0.101 (-0.455)
Constant	-2.966 (-1.520)

Notes: ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively. In parentheses are t-statistics.

We now move on to discuss the results of the short- and long-run coefficient estimates of the permit price model of Bristol Bay. Tables 2 and 3 report our key findings, where the permit value is used as the dependent variable. The estimated effect of the earning variable on permit prices is positive and highly significant in both the short-and long-run, suggesting that improved earnings result in higher permit prices. In the long-run (short-run), for example, with a 1% increase in earnings we can expect to see an increase in permit prices by 1.352% (0.516%). The estimated effect of the cost variable on permit prices is negative and significant in the short- and long-run, indicating that as costs increase the profit margin tends to decrease which in turn reduces demand for permits and prices. In the long-run (short-run), for example, with a 1% increase in costs we can expect to see a decrease in permit prices by 0.576% (0.346%). These findings could be viewed as one piece of evidence supporting that traditional asset pricing theory holds for permit values in Bristol Bay in both the short- and long-run: therefore, changes in net earnings, which represent revenues less costs, generally determine the fluctuations in permit values. Finally, the dummy variable representing the Pebble Mine exploration is negative in the short- and long-run - but insignificantly so for the long-run and highly significant for the short-run. Apparently, there is evidence that heavy mining exploration occurred in the region negatively affect permit prices in the short-run, but does not last in the long-run.

Table 3. Estimated short-run coefficients of the price permit model of Bristol Bay (period: 1978-2014)

Variable	Coefficients
$\ln R_t$	0.516^{***} (5.448)
$\ln C_t$	-0.346^{*} (-1.913)
$DUM_{2002\text{-}2013}$	-0.32^{**} (-1.995)
ec_{t-1}	-0.601^{***} (-4.783)
Serial correlation	1.266 [0.261]
RESET	2.195 [0.138]
Normality	0.410 [0.815]
Heteroskedasticity	0.016 [0.901]

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. In parentheses are *t*-statistics. Brackets in diagnostic tests are *p*-values. RESET indicates regression specification error test, which uses Ramsey's RESET test based on the square of the fitted values.

It is important to mention that the error-correction term (ec_{t-1}) obtained from the linear combination of lagged variables in Equation (3) are negative and highly significant, confirming that there is a significant long-run relationship among the variables (Kremers *et al.*, 1992). The significant coefficient on the error-correction term being -0.601 indicates that when permit values in the previous year deviate from the equilibrium, the permit market tends to adjust by approximately 60.1% in the following year.

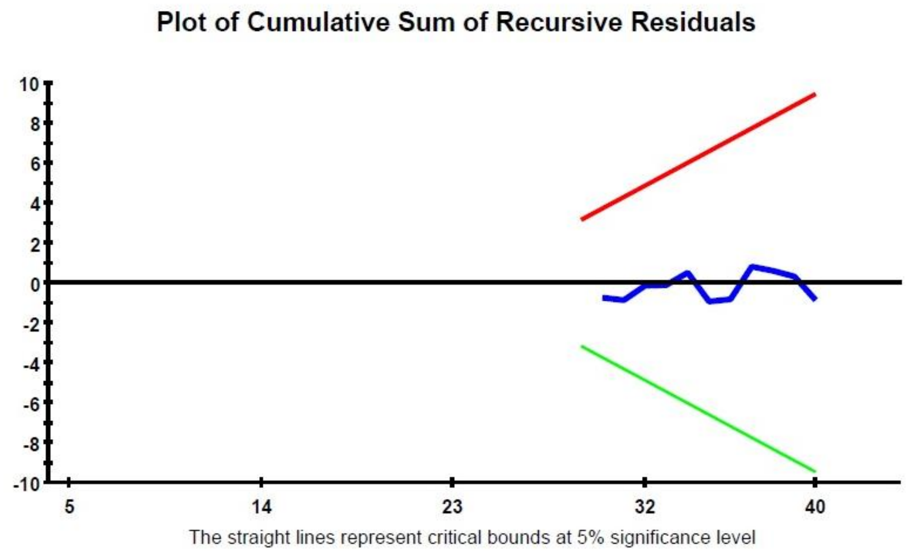

Figure 1. Plots of CUSUM (1978-2014)

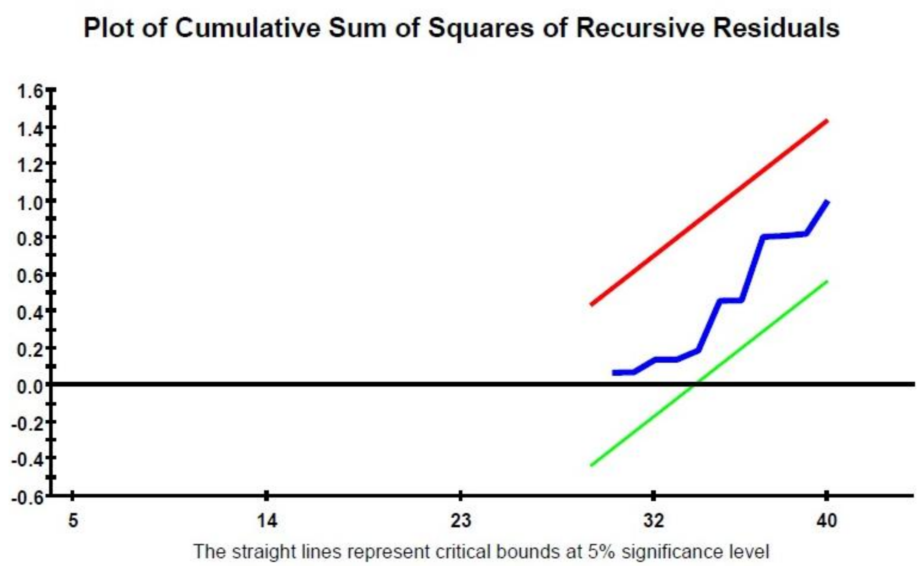

Figure 2. Plots of CUSUMSQ (1978-2014)

Finally, a series of diagnostics tests show that our ARDL model seems to be well-specified, passing such tests as serial correlation, regression specification error test (RESET), heteroscedasticity, and non-normality. In addition, the cumulative sum (CUSUM) and cumulative sum of squares (CUSUM**SQ**) show that the plots lie between the 5% critical bounds at all points, providing the stability of the short- and long-run coefficient estimates for the period 1978-2014 (Figures 1 and 2).

6. Concluding Remarks

Alaska adopted a limited entry permit system for commercial salmon fishing in 1975. These permits have been subject to great volatility in price over the last four decades. In this short paper, therefore, we aim to empirically examine the factors that contribute to the dynamic behavior of the permit values. The primary contribution of the paper is to address the issue in the context of regional and gear specific salmon fisheries in Alaska – that is, Bristol Bay drift gillnet permits - using an enhanced method – that is, an autoregressive distributed lag (ARDL) approach to cointegration. Evidence is found that there is a stable cointegration relationship among the variables of interest which points to a long-run relationship between permit prices, total earnings, and total costs. It is also found that total earnings have a positive and significant relationship with permit prices, and total costs have a negative and significant relationship in both the short- and long-run. Finally, it is found that the mining exploration in the region has no significant long term effect.

As of early May 2017 it has been reported that the US EPA and Northern Dynasty are close to settling litigation over the Pebble Mine. At stake is an Obama-era Proposed Determination that, if finalized, would place restrictions on the mine (Associated Press, 2017). With a new administration and a shift in EPA leadership it is possible the mine will become a high priority again in the near future. If the mining activity does indeed negatively impact permit prices in the short-run like our analysis shows, policy could be introduced in order to compensate the fishermen over a determined period of time in order to offset the negative effect. The cost proxy of gasoline price was found to have a negative and significant effect and policy could be developed in order to subsidize fuel costs when permit prices are above a level determined to be unattainable by historical permit fishermen. Finally with earnings being shown to have a positive relationship with permit prices policy could be introduced in order to help keep salmon prices steady to allow for more constant earnings and permit prices to avoid the dips and peaks we observe in the past.

There are two main caveats to our analysis. First, we used gas prices alone as a proxy for costs to the permit holder while there are other factors at hand such as shares paid to deckhands, food prices, maintenance costs, and insurance costs. With limited cost data our findings must be viewed with caution. Second, our indicator variable representing Pebble Mine exploration covers a vast period including the years 2002-2013. Over this period there is a structural break in the data that may be explained by factors other than Pebble Mine that we have not accounted for. Future research could be done utilizing ADF&G Fish Ticket cost data or an index of costs in order to more accurately estimate costs in the fishery. More research also need to be done on what else occurred in the Pebble Mine indicator time period and what exactly caused the break in the data before we can definitively comment on the impacts of the mine on the permit market.

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