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Decomposing productivity and efficiency changes in the Alaska head and gut factory trawl fleet

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ABSTRACT

Fishing fleets are subject to numerous factors that affect economic performance, making identification and attribution of such impacts difficult. This paper separately identifies the effects of changing input and output prices, fishery management, and quota allocations on total factor productivity using a Lowe Index. Indices account for technical change and decompose productivity estimates into its technical, environmental, and scale-mix components. This results in measures that reflect shifts in the production frontier, and movements by vessels toward and around the frontier, to capture economies of scale and mix after a policy shift to a catch share program that includes fishing cooperatives and a limited access fishery. The difference between cooperative and limited access vessels is exploited to compare the changes in economic performance between the groups after the introduction of the shift to catch shares and cooperative management, which allowed the vessels to improve the timing and coordination across multi-species fisheries and to decrease incidental catch of quota-limited bycatch species that had closed the target fisheries prematurely in the past. Results indicate that total factor productivity increased significantly after the move to a catch share program, largely due to increases in technical change that shifted out the production frontier of the fishery.

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1. Introduction

Fishing fleets are subject to numerous factors that affect economic performance, including those under their control (e.g., input and output selection) and those exogenously determined (e.g., market prices, regulations, stock levels, and quota allocations). As such, analysts interested in monitoring the economic performance of fishing fleets, or identifying the impacts of particular policies, have the daunting task of identifying relevant and feasible metrics given available data, and decomposing the metrics to inform the questions of interest. Total factor productivity (TFP), the focus of this study, is a commonly employed metric to evaluate performance. TFP change is the quantity change component of profitability change, and it can be estimated under a wide range of data availability scenarios. For an introduction to the analysis of productivity and firm performance, see Grifell-Tatje and Lovell [1]. However, no fishery TFP studies to date have decomposed estimated TFP change into its components including technical change, environmental efficiency, technical efficiency and scale-mix efficiency. Measuring the specific components can be particularly informative, as effects of fishery management policies are likely to be lumped in with other factors in conventionally produced composite productivity residuals. These measures allow the identification of specific changes due to scale increases from vessel consolidation, changes in relative efficiency after the introduction of fishing cooperatives, and potential cost-saving input reallocation due to ending the race for fish.

This paper analyzes changes in TFP and its components for one of the more prominent fishing fleets operating in the North Pacific: the Alaska head and gut factory trawl fleet, which will be referred to in this paper as the Amendment 80 (A80) fleet. With the implementation of A80 to the Bering Sea and Aleutian Islands (BSAI) Fishery Management Plan (FMP) in 2008, this fleet transitioned from a common-pool fishery in which vessels competed for a share of the allowable catch to a catch share fishery comprised of cooperatives who were given an allocation of fish; there is also a

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limited access fishery for those who do not join cooperatives that operates under slightly different rules. Forming a cooperative has several advantages including having an exclusive harvesting privilege based on the catch history of member vessels, receiving an allocation of incidentally caught prohibited species catch (PSC),[2] and having to meet increasingly restrictive groundfish retention standards at the co-op level rather than at the vessel level. One cooperative formed in 2008 included 16 of the 24 eligible vessels and the remaining 8 vessels fished in the limited access fishery until 2011 when they formed their own cooperative and eliminated the limited access fishery.

The cooperative structure has allowed the vessels to improve the timing and coordination across multi-species fisheries and to decrease incidental catch of quota-limited PSC species that had closed the target fisheries prematurely in the past [2]. In fact, it was the historically high levels of PSC and discards of target species in the past that led the North Pacific Fishery Management Council (Council) to simultaneously implement heighted catch retention standards and the option for a quota-based cooperative structure which was believed to provide the flexibility to meet the new standards [3]. Catch data from the fishery indicate that the program has been a success in improving retention, as nearly all of the vessels exceeded the standard [4]. This paper seeks to investigate whether other improvements in productivity or efficiency resulted from the management change and whether these improvements differed between the fleet as a whole and those who participated in cooperatives.

Changes in economic performance are examined using a Lowe TFP index, described in more detail in a following section, to separately identify the effects of changing input and output prices, catch share program implementation, and quota allocations on TFP. Specifically, Lowe TFP indices can be decomposed into measures of technical change and measures of technical, environmental, and scale-mix efficiency change. This decomposition results in measures that reflect movements in the production frontier, movements by vessels towards the frontier, and movements by vessels around the frontier to capture economies of scale and scope through changes in the catch portfolio after the policy shift to catch shares. Because of the differential adoption of the cooperative structure over time the analysis is able to distinctly evaluate the economic performance of those participating in the limited access fishery from those who are fishing in cooperatives.

The next section provides an overview of the literature on estimating productivity in fisheries, followed by a detailed exposition of the chosen methodological approach. The following section gives details on the fishery under study and data used in the analysis. This is followed by a description of the econometric model and results. The last section includes a discussion of the findings and some conclusions from the analysis.

2. Relevant literature

Productivity in fisheries has a considerable history of interest to both fishery managers and researchers, but there have been varied and somewhat inconsistent approaches for tracking performance by analysts. This is likely in part due to data availability dictating the approach, as fisheries are notoriously data scarce, but also due to competing methodologies with varying degrees of rigor and/or restrictive assumptions.

Numerous studies in the fisheries productivity literature provide context for this analysis. Walden et al. [5] provides an extensive list of such studies, starting with the work by Comitini and Huang [6] which used a parametric approach to estimate a Cobb-Douglas production function representing halibut fishing vessels in the North Pacific. Jones et al. [7] used data from a sample of South Carolina's shrimp trawlers to analyze resource productivity and profitability in the fishery from 1971 to 1975. Norton, Miller and Kenney [8] created an Economic Health Index using data from several U.S. fisheries to estimate productivity across fisheries. These early studies suffered from identification issues because they failed to account for the influence of the resource stock in productivity growth. Squires [9–11] broadened the literature by employing index number and growth accounting theory and using the resource stock to disentangle changes in productivity and resource abundance in the Pacific Coast Trawl Fishery. Weninger [12] generalized the fisheries TFP index by using a non-parametric, directional distance function to examine changes in productivity for surfclam vessels. Jin et al. [13] used a growth accounting approach to conduct a broad total factor productivity study for the entire total New England groundfish fishery covering the years 1964–2003. Hannesson [16] examined different specifications of TFP change in Norwegian fisheries, emphasizing the importance of accounting for resource abundance in productivity growth. Felthoven and Paul [14] reviewed past productivity studies and suggested ways that the methodological approaches commonly employed could be improved to reflect many of the idiosyncrasies of fisheries settings.

Building on this foundational research, empirical fisheries studies routinely employ the productivity framework to examine the state of the industry and relationship between policy and productivity. After a license buyback in Australian fisheries, Fox et al. [15] examined the resulting changes in productivity, capacity, and quota trading. Squires et al. [17] used data envelopment analysis to estimate a Malmquist index to examine productivity growth in the Korean tuna purse seine fishery operating in the Pacific Ocean. Felthoven et al. [18] implemented their 2004 framework in a primal, growth accounting application to the Alaskan pollock fishery covering 1994–2003, incorporating environmental conditions, bycatch and stock effects into their model. Paul et al. [19] subsequently expanded this analysis to examine productivity change in both harvesting and processing using a dual, revenue function approach. Walden et al. [20] updated Weninger's aforementioned 2001 analysis to examine productivity change in the surfclam and ocean quahog ITQ fishery using a Malmquist index. Eggert and Tveterås [21] examined productivity change in Icelandic, Norwegian and Swedish fisheries between 1973 and 2003 using a growth accounting framework. Torres and Felthoven [22] conducted a study similar to their earlier work in the Alaskan pollock fishery using a longer panel (1994–2009) and improved econometric techniques to account for the mixed distribution of the production data within a revenue function specification. Most recently, [5] used the Lowe index to measure multi-factor productivity change for all the U.S. catch share fisheries, including the fishery under study, but did not decompose TFP into the efficiency components, did so for a shorter time series, and accounted for fewer inputs.[3]

The objective of this research is to use a rigorous set of tools grounded in production theory to examine the ways in which the policy change and resulting behavioral adjustments may have affected the economic performance of the fleet. This is accomplished using an approach rooted in [23], and subsequently developed

[2] PSC is a special category of bycatch of Pacific salmon, Pacific halibut, and king and Tanner crab in the groundfish fisheries that cannot be retained or sold by the vessel. See 50 CFR Part 679 available at: http://alaskafisheries.noaa.gov/regs/part679_all.pdf, for more detail.

[3] As part of a national effort to estimate productivity for all U.S. fisheries managed bycatch shares, the authors agreed to utilize the same methodology across fisheries, so data limitations in some fisheries necessitated a simpler approach across all fisheries in that study.

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