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Measuring capital value in a commercial fishery: A distance function approach

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ABSTRACT

The term "overcapitalized" is frequently used to describe the condition of various fisheries, and to explain why a fishery is in poor condition from a stock status perspective. Often, the concept of overcapitalization is associated with the number of active vessels in a fishery. Although vessel counts are important, they do not fully capture investment or disinvestment in a fishery, and only serve as a crude proxy for a richer concept of fishing capital. A better measure to judge whether overcapitalization is occurring would be the change in capital value for vessels operating, or permitted in a fishery, relative to a benchmark value. Unfortunately, data do not always exist to measure vessel value and associated changes through time. This study presents a method for calculating vessel capital value using a distance function, publicly available vessel sale price data, and non-parametric programming methods. Estimates of value for vessel attributes returned by the distance function are then used to estimate a total value for currently permitted vessels in the northeast region of the United States, and to construct a capital value index for vessels active in the squid, mackerel and butterfish (SMB) fishery between 1996 and 2016. Findings show that the total value of commercially permitted vessels in the northeast region is estimated to be between \$606.6 and \$769.7 million (\$2016). Based on the constructed capital value index, the SMB fishery has undergone a period of disinvestment marked by both declining vessel numbers and capital value.

1. Introduction

Government intervention and management of activity associated with the harvest of marine fisheries is typically justified based on a well-known triad of interconnected influences – the common pool nature of the resource, "overcapitalization" of fishing fleets, and the depletion of fish stocks. Among these three, the term "overcapitalization" is likely the least understood and is usually equated to the number of vessels in a fishery. While simple vessel counts provide some information about capital in a fishery, a better measure is the total value of all the individual parts of a fishing vessel. A vessel is made up of a hull, engine, electronics and other pieces of equipment, which taken together comprise the capital stock. On a vessel basis, the capital stock value can increase when new pieces of equipment are added to a vessel, or older equipment is replaced by newer equipment. It can also decline as vessels age, and parts deteriorate. In a fishery, overcapitalization occurs when the aggregate level of capital stock is too high relative to what is needed to harvest the resource [1].

A complete accounting of capital stock in a fishery gives managers information about the level of investment in a fishery which is more revealing than simple vessel counts [2]. For example, electronics upgrades increase the level of capital without increasing vessel counts. It also allows capital user cost to be estimated, which is an important component of total cost in an economic analysis. Capital user cost in a time period is simply the capital value times an appropriate interest rate, plus the change in capital value. The first term is also referred to as the opportunity cost of capital, while the second term includes re-investment plus depreciation cost [3]. Without an initial estimate of capital value, user cost cannot be estimated. Economic profit includes capital user cost, and profitability change compared to a benchmark value is an indicator of relative economic well-being for vessels in a fishery. For a complete picture of investment, and to properly account

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for all costs in economic models, it is therefore imperative to calculate a measure of vessel capital value and track changes in this level through time.

Fishing vessels are made up of various pieces of equipment configured to operate together just as land based factories are usually comprised of land, buildings and equipment used on a production line. In order to measure the value of capital in a fishery, dedicated surveys are typically required to inventory the equipment used, value each piece and aggregate the values into a single measure of monetary worth. Usually this effort falls into the realm of fishery agencies because fishing vessels as operating units are generally too small a part of national economies to be broken out separately in terms of accounts used in the calculation of GDP by national statistical agencies. Since the measurement of fish resources usually consumes a large portion of fishery agency budgets, the measurement of vessel capital may not be a priority. Surveys are by nature expensive and time consuming.

Conceptually the measurement of fishing vessel capital is no different than the practices used for land based industries. Specifically, the Perpetual Inventory Method (PIM) has become the most widely accepted standard for valuing capital stocks [4,5]. Although this method has not been used to value fishing capital in the United States, it has been used in Europe [4]. Simply put, the PIM method values each part of the capital stock (vessel, engine, and electronics), and aggregates the individual components into one value, which is considered a benchmark value. Once the benchmark value is established, subsequent year's value is calculated as the benchmark value, plus additional capital investment and any revaluation of capital, minus depreciation [4].[2] Depreciation is usually calculated using established formulas. It should be noted that the work in Europe is based on a much broader concept of capital than simply the value of the fishing vessel, as shore side infrastructure, permit and quota value are also included in the calculation of capital value [4]. This has some advantages in that capital is valued at the firm level rather than the vessel level, recognizing that fishing firms may own more than one vessel, and their assets also include shore side support. It also presents additional challenges when the capital costs are allocated to individual fishing vessels. There are several methods for distributing shore side costs to vessels, and one method needs to be chosen with the recognition that other approaches may be just as valid.

In the northeast United States, data have not been collected to use the PIM method to set an initial capital value, nor to track changes in capital stock. Consequently, this study departs from the PIM approach, and instead adopts a method based on estimates of an input distance function which utilizes vessel sale prices to determine vessel capital value similar to the study by Kirkley and Squires [2], and Daures [7]. It differs in that it uses a distance function to model the transformation of vessel characteristics into vessel value rather than a hedonic approach. The distance function is a multiple input, multiple output representation of technology estimated with parametric or nonparametric methods. This study uses linear programming (LP) methods to estimate the distance function, as opposed to econometric methods used in previous studies [2,7,8].

The distance function model yields shadow prices of vessel attributes which are used to derive an estimate of capital value. Additionally, the value of permits which are often included when vessels are sold are estimated separately from the physical vessel capital value are derived, and a measure of vessel performance in terms of value is provided. Results from the model are then used in two different estimations. First, the total capital and permit value for commercially permitted vessels in the northeastern United States is estimated based on the shadow prices obtained from the model. These values can be considered "benchmark" values for future calculation of capital and permit value. Secondly, shadow prices for the vessel attributes are used to construct a capital quantity index for vessels permitted in the northeast squid, mackerel and butterfish (SMB) fishery which had landings in any year between 1996 and 2015. This allows an examination of trends in the total quantity of capital used in a fishery over a fairly lengthy time period. The Lowe quantity index is chosen for this part of the analysis, and is particularly well-suited because it is a fixed weight index employing constant prices to construct aggregates representing the capital stock value. This avoids having to calculate the shadow prices on a yearly basis, particularly if sale data by year are limited, which is the situation with the data used in this study. Trends in the quantity index are then compared to a simple index of vessel numbers to see if the two indices exhibit similar trends.

Results show that the estimated value of all commercially permitted fishing vessels in the Northeast region in 2016 was between \$606.6 and \$769.7 million, with the capital stock estimated to be worth between \$555.8 and \$700.2 million and the permit value between \$50.8 and \$69.5 million. Fiberglass vessels were the most valuable group in aggregate because they were the largest, while steel hulled vessels were the most valuable vessels on a per vessel basis. Wood hulled vessels were the least valuable vessels. Trends in the capital quantity index for the SMB fishery were similar to those found using a simple vessel count, but the magnitude of change was different between the two indices in individual years.

2. Methods

In order to derive shadow prices for the vessel attributes, parameter values from an input distance function are estimated using linear programming (LP) methods. A full explanation of the distance function derivation can be found in Appendix 1. For each observation in the data, the input distance function efficient value is one, and the LP model seeks to minimize deviations from one subject to non-negativity constraints for the distance function and its partial derivatives with respect to the inputs (attributes) for each observation. The distance function chosen has a translog specification. As an example of what this would look like, the translog distance function equation for a vessel with three attributes (z = 1,2,3) and one value term (v), is:

$$\ln D_i(v, z) = \alpha_o + \alpha_1 \ln v + 1/2\alpha_{11}(\ln v)^2 + \textstyle\sum_{n=1}^{3}\beta_n \ln z_n$$
$$+ 1/2 \textstyle\sum_{n=1}^{3}\sum_{n'=1}^{3}\beta_{nn'}(\ln z_n)(\ln z_{n'}) + \sum_{n=1}^{3}\gamma_n(\ln z_n)(\ln v)$$

This specific form also requires additional constraints be placed on the parameters:

$$\beta_1 + \beta_2 + \beta_3 = 1$$

$$\sum_{n'=1}^{3}\beta_{nn'} = \sum_{n=1}^{3}\gamma_n = 0$$

$$\beta_{nn'} = \beta_{n'n},\ n = 1, 2, 3;\ n' = 1, 2, 3.$$

Empirically, the general empirical approach taken in Färe, Grosskopf, Lovell and Yaisawarng [9] is adopted, which employed a non-parametric programming model developed by Aigner and Chu [10], and allows estimation of the distance function as a (deterministic) non-parametric frontier function. Letting $k = 1, \ldots, K$ index observations, the following LP model is solved:

$$\min \sum_{k=1}^{K} [\ \ln D_i(v^k, z^k)] \tag{1}$$

Subject to:

$$\sum_{n=1}^{N}\beta_n = 1 \tag{2}$$

[2] For further discussion about PIM, see [6] L.R. Christensen, D.W. Jorgenson, The measurement of US real capital input, 1929–1967, Review of Income and Wealth 15(4) (1969) 293–320., and [3] B.M. Balk, Measuring and decomposing capital input cost, ibid.57(3) (2011) 490–512.