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Measuring the economic linkage of Alaska fisheries: A supply-driven social accounting matrix (SDSAM) approach

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ABSTRACT

A supply-driven social accounting matrix (SDSAM) model is developed to examine backward and forward linkage effects of Alaska fisheries. The model includes five harvesting sectors (Trawlers, Longliners, Crabbers, Salmon Netters, and Other Harvesters), two processing sectors (Motherships and Shorebased processors), and a Catcher-processor sector, which both harvests and processes. The study shows that total backward linkage effects of the Other Harvesters sector are strongest, followed by Trawlers and Salmon Netters, while the strongest total forward linkage effects are from Salmon Netters, followed by Other Harvesters and Crabbers. Results of a policy simulation where the effect of a 10% reduction in pollock catch was investigated show that total output will decrease by \$37.1 million via backward linkages while total output in forward-linked sectors falls by \$16.6 million. When the direct impacts on the harvesting sectors (\$73.6 million) are included, total output decreases by \$110.7 million via the combined direct shock and backward linkage effects. Income to Alaska households falls by \$17.6 million due to effects on backward-linked industries, and by \$0.5 million due to forward-linked effects.

1. Introduction

Seafood is an important industry in Alaska. In 2006, about 57%, by weight, of the total U.S. commercial fishing harvest came from Alaska [National Marine Fisheries Service (NMFS, 2007)]. In 2006, about 5.4 billion pounds of fish and shellfish were harvested in waters off Alaska with an ex-vessel value of about \$1342 million (NMFS, 2007). Of this, groundfish accounted for 56% of ex-vessel value, salmon, 20%, halibut, 14%, shellfish, 9% and herring, 1% [North Pacific Fishery Management Council (NPFMC, 2007)]. In 2006, the Alaska seafood industry directly accounted for about 3.0% of total state employment of 314,139 jobs, and about 2.3% of \$13.0 billion total state earnings [Alaska Department of Labor (ADOL, 2007)]. In 2001 Alaska's seafood industry, including both harvesting and processing sectors, accounted for more than 16% of the state's basic sector employment, and more than 47% of private basic sector employment, ahead of oil and gas, mining, forest products, and tourism [Alaska Department of Fish and Game (ADFG, 2001)]. However it should be noted that publicly available data series tend to underestimate employment and earnings in seafood sectors because state unemployment insurance programs do not cover many of the participants due to the informal, seasonal or part-time nature of employment in seafood harvesting and processing industries.

Fishery managers are interested in how fishery management actions, such as rationalization or changes in total allowable catch (TAC), will affect the economy of fishery-dependent regions. Effects of fisheries management actions on participants and their communities are estimated using economic impact models. In the literature, regional economic impacts of fisheries have been studied using demand-driven input–output (IO) models (e.g., Steinback, 1999), supply-driven input–output (SDIO) models (e.g., Leung and Pooley, 2002), and social accounting matrix (SAM) models (e.g., Seung and Waters, 2006a). Recently, Fernandez-Macho et al. (2008) used a supply-driven social accounting matrix (SDSAM) to estimate economic impacts of a more than 50% reduction in hake TAC on fishing sectors and the overall economy of Galicia, Spain. Seung and Waters (2006b) discuss and compare various regional economic models used to assess fisheries impacts.

This study investigates the impact of Alaska fisheries on the Alaskan economy using a SDSAM approach. While IO models are useful in examining the relationship between industries, they cannot examine the distributional impacts of fisheries, such as impacts on value added, households, or state and local government. Some previous studies (such as Leung and Pooley, 2002) argue that it is more appropriate to use a supply-driven model than a

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demand-driven one in situations where the output level (i.e., harvest level or TAC) is altered, since the change in demand is not known. Also for complex production sectors such as Alaska fisheries, it is not necessarily an easy task to derive the changes in final demand that would map to the initial change in output on the supply side. This study follows the approach used by Fernandez-Macho et al. (2008) applied to the Alaska fisheries sectors.

Using the SDSAM we calculate both backward linkage and forward linkage effects of Alaska fisheries, and estimate the impacts of a 10% reduction in pollock catch. The next section discusses the basic SAM modeling approach and describes the SDSAM model used in this study. Section 3 describes the data and procedures used in developing the fishery sector data. Section 4 presents the results including multipliers and the economic impacts resulting from 10% reduction in pollock catch. The final section provides a summary and conclusions.

2. The Alaska SDSAM model

The 2004 Alaska SDSAM model is presented below. For a more detailed discussion of a SAM, see King (1985). First a demand-driven SAM model is shown, which is then converted into a SDSAM model. To develop a demand-driven SAM, we draw on Holland and Wyeth (1993), Adelman and Robinson (1986), and Waters et al. (1999). In the Alaska SAM, there are a total of 55 accounts—52 endogenous and 3 exogenous accounts. The 52 endogenous accounts include 38 industry accounts, 4 value-added accounts (employee compensation, proprietary income, other property income, and indirect business tax), 9 household accounts, and a state and local government account. The three exogenous accounts are federal government, capital (savings and investment), and the rest of the world (ROW) (i.e., imports and exports).

The matrix of direct coefficients in the Alaska SAM model, denoted S, is derived as follows:

$$S = \begin{bmatrix} A & 0 & 0 & C & GD \\ V & 0 & 0 & 0 & 0 \\ IBT & 0 & 0 & 0 & 0 \\ 0 & F & 0 & IHT & STR \\ 0 & SF & BTS & HTX & IGT \end{bmatrix} \tag{1}$$

where S is the matrix of SAM direct coefficients, A is the matrix of technical coefficients, V is the matrix of primary factor payments coefficients, IBT is the matrix of indirect business tax coefficients, F is the matrix of factor payment to household coefficients, SF is the matrix of state and local factor tax coefficients, BTS is the matrix of state and local indirect business tax coefficients, C is the matrix of household consumption coefficients, IHT is the matrix of inter-household transfer coefficients, HTX is the matrix of state and local government direct household tax coefficients, GD is the matrix of state and local government demand coefficients, STR is the matrix of state and local government transfer coefficients, and IGT is the matrix of intergovernmental transfers.

Then the demand-driven SAM model can be represented as

$$\begin{bmatrix} Q \\ V \\ IBT \\ H \\ SG \end{bmatrix} = S \begin{bmatrix} Q \\ V \\ IBT \\ H \\ SG \end{bmatrix} + \begin{bmatrix} eq \\ ev \\ et \\ eh \\ eg \end{bmatrix} \tag{2}$$

or alternatively,

$$\begin{bmatrix} Q \\ V \\ IBT \\ H \\ SG \end{bmatrix} = (I-S)^{-1} \begin{bmatrix} eq \\ ev \\ et \\ eh \\ eg \end{bmatrix}. \tag{2'}$$

where Q is the vector of industry regional output (endogenous), V is the vector of total primary factor payments (endogenous), IBT is indirect business tax payments (endogenous), H is the vector of total household income (endogenous), SG is total state and local government income or revenue (endogenous), eq is the vector of exogenous demand for regional output, ev is the vector of exogenous factor payments, et is indirect business tax payments, eh is the vector of exogenous federal transfers to households, and eg is federal transfers to state and local government. $(I-S)^{-1}$ is called the SAM multiplier matrix or matrix of SAM inverse coefficients.

In Eq. (2), the endogenous variables are Q, V, IBT, H, and SG. The exogenous variables are eq, ev, et, eh, and eg. There are three non-zero exogenous demand vectors—eq, eh and eg. The elements of eq are final demand components including investment demand, federal government demand, and export demand. The elements of eh include federal government transfers to households and financial returns from capital holdings outside Alaska. The components of eg include: (i) federal government transfers to state and local government, (ii) income from leases, trusts, and investments, and (iii) taxes paid by non-residents to Alaska. Injections of income into the region occur through final demand components in eq and extra-regional payment components in eh and eg. Leakages include taxes paid to the federal government, savings, and payments for imported goods, services, labor and capital.

To convert the demand-driven SAM model into an SDSAM model, we bifurcate the output vector, Q, into two sub vectors, Q_1 and Q_2 so that $Q = [Q_1' Q_2']'$ where Q_1 is a vector of output of the *exogenously* determined sectors (in our study the six sectors that harvest fish) and Q_2 is a vector of output of the endogenously determined sectors (i.e., all other sectors). Then, Eq. (2) can be compactly expressed as

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} ex_1 \\ ex_2 \end{bmatrix} \tag{3}$$

where $X_1 = Q_1$, $X_2 = [Q_2' \, V' \, IBT \, H' \, SG]'$, $ex_1 = eq_1$, and $ex_2 = [eq_2' \, ev' \, et \, eh' \, eg]'$.

Solving the linear equations system in Eq. (3) for X_2 assuming that change in ex_2 is equal to zero gives

$$X_2 = (I-S_{22})^{-1} S_{21} X_1 \tag{4}$$

Here $(I-S_{22})^{-1}S_{22}$ is called backward linkage SDSAM multiplier matrix. Each element (i,j) in this matrix measures the change in output or income in endogenous sector i occurring due to change in the output or income of exogenous sector j.

To derive forward linkage multiplier, we use the Ghosh (1958) model. It should be noted that previous studies (e.g., Leung and Pooley, 2002; Cai et al., 2005; Fernandez-Macho et al., 2008) have indicated that the Ghosh methodology suffers from a problematic theoretical interpretation of the model, especially in cases where it is used to explain changes in physical output arising from changes in physical factor inputs. Consequently results from a Ghosh model often should be interpreted with caution. However, it has been argued that if interpreted as a price model, it is possible to make a theoretically correct interpretation of the results, since a change in output due to a change in input prices seems plausible. Oosterhaven (1988, 1989), Dietzenbacher (1997, 2005), and Cai and Leung (2004) discuss some of these issues. In the case presented here, the Ghosh model is being used to assess the impacts on downstream industries of an estimated change in output of exogenous or basic fishing sectors. Consequently the interpretation of results may be relatively more straightforward than other applications of the Ghosh model.

The Ghosh model can be represented as

$$[X_1' X_2'] = [X_1' X_2'] \begin{bmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{bmatrix} + [ew_1 \, ew_2] \tag{5}$$