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An applied method for assessing socioeconomic impacts of European fisheries quota-based management

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ABSTRACT

Fishing activity is conditioned by diverse factors that determine and limit the capacity of fishermen to decide on their level of production (i.e., the fisheries output is determined exogenously). In the context of the input-output analysis, models have been developed that permit the assessment of socioeconomic impacts of an activity, but almost always from a perspective where demand is the driving force of the economy. Procedures have recently been developed to measure impacts in which both the existence of sectors subject to exogenous supply shocks and the existence of forward linkages with other sectors of the same economy are considered. The objective of this study is the application of this new methodology for the analysis of a specific case: fishing activity in Galicia (NW Spain). The socioeconomic impacts linked to the determination of annual fishing quotas by species for major fleet segments managed by European Union are quantified. This procedure is should be potentially be very useful as a fishing management tool. It provides more accurate estimations of the possible socioeconomic impacts of catch limitations and gives detailed information on the sectoral and spatial distribution of these impacts on the economy.

1. Introduction

In most economic activities, the producers make decisions about what and how much to produce based on available resources (material and/or human) as well as the market demands. However, fisheries have limited ability to decide the level of their production. This is mainly due to two reasons. On one hand, fishing activity is strongly influenced by the characteristics of the environment in which production is developed, and is often subject to biological, environmental, or climatic phenomena that are difficult to predict (Allison et al., 2009; Ho et al., 2016; Koenigstein et al., 2016; Wernberg et al., 2016). On the other hand, the inherent characteristics of the marine environment have fostered a lower development in the delimitation of property rights (Townsend, 1998; Jentoft, 2000; Allison et al., 2012; Abbott, 2015), which has led to a high level of either intervention or regulation of activity by public bodies (either governments or international institutions). The combination of all these elements leads to a high level of uncertainty for the fishermen and influences their fishing possibilities. When unexpected changes occur in fishing opportunities from one season to the next, we say that there is a supply shock. This can be either positive or negative for the fishing sector (the supply), i.e., resulting in an increase or a decrease, respectively, of fishing possibilities. Therefore, fishermen are forced to adapt their activity due to circumstances beyond their individual control that are linked to the natural resource and not to market demand. These supply shocks may be linked to either natural causes (e.g., weather conditions restrict the fishing activities or climatic events cause (un)expected declines in biomass status of fishery resources) or human causes (e.g., a spill or spillage of oil at sea or public regulations based on fishing quotas). In this context, for both producers and policy makers, the assessment and quantification of potential impacts of these supply shocks are fundamental to support their decision-making.

The Input–Output (IO) analysis has traditionally developed a powerful conceptual and methodological framework (Dietzenbacher et al., 2013) that can be applied to evaluate the socioeconomic impacts either associated with environmental elements (Lenzen et al., 2003; Suh, 2004; Suh and Kagawa, 2005; Hertwich, 2011) or, for example, linked to the occurrence of either disasters or attacks (Santos and Haimes, 2004; Andrijcic and Horowitz, 2006; Okuyama, 2007; Okuyama and Santos, 2014).

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Most of the theoretical developments and I-O applications have followed the classical perspective, where the final demand is the conductive or driving force of the economy. In accordance with this, the demand for seafood (either for household consumption or for supplying the processing sector) should guide the establishment of the quantities to produce (fish) by producers (fishermen). However, fishing activity is influenced by factors beyond the market and the individual control of fishermen. Therefore, we also need to use the economic perspective based on the supply side (Dietzenbacher, 2002; Miller and Blair, 2009; Oosterhaven, 2017).

Some authors have used the Ghosh model in empirical analysis of the effects on output from the supply perspective (Dietzenbacher, 2002). However, other authors have questioned this solution, considering it implausible (Oosterhaven, 1988, 1989). The Ghosh model has subsequently been reinterpreted (Dietzenbacher, 1997; Guerra and Sancho, 2011), but its validity and theoretical consistency are still questioned (Oosterhaven, 2012). Thereby, I–O supply models are useful in carrying out descriptive analyses of the sectoral relationships of the fishing sector as a supplier of inputs to other sectors of an economy [e.g., to the fish canning industry or Hotel, Restaurant and Catering, HORECA, sector], but any causal interpretation is likely to lead to results with a weak economic rationale.

In order to simultaneously consider possible forward and backward effects, Rose and Wei (2013) developed the Oosterhaven (1988) idea for the estimation of the total economic consequences of a seaport disruption. These authors used the demand-driven I–O model to capture impacts on suppliers up the supply chain (in our case, the sectors that provide inputs used by the fishing sector, for instance, fuel, nets, ice, and packaging) and a modified version of the supply-driven I–O model to capture impacts on customers down the supply chain (the sectors that use fishing catches either for their production or for providing their services). The modified version of the supply-driven I–O model managed to avoid some of the criticism regarding the use of this type of models. However, as Oosterhaven (1989, p. 465) had already concluded, markets and prices need to be introduced into I–O models to integrate demand and supply effects in a satisfactory way.

Changes in prices, supply constraints, and possibilities of replacement of inputs can be studied through computable general equilibrium (CGE) models. These models have also been used either for the analysis of disaster-related impacts (Rose and Liao, 2005; Rose et al., 2011) and to assess the socioeconomic effects of changes in transport costs (Madsen and Jensen-Butler, 2004). Within the I–O modeling framework, Hallegate (2008) created a model incorporating some price dynamics as a response to the sub-production that can be generated after a disaster such as Hurricane Katrina. Recently, Surís-Regueiro and Santiago (2018a, 2018b) proposed a methodological procedure that, by introducing the possibility of price changes in the outputs with supply changes, captures not only the traditional backward effects of I–O models on the demand side, but also the impacts derived from the existence of forward links with other sectors of the same economy.

I–O analysis applied to the assessment of socioeconomic impacts derived from fishing activities is relatively scarce (Papadas and Dahl, 1999; Leung and Pooley, 2002; Fernández-Macho et al., 2008; Dyck and Sumaila, 2010; Seung and Waters, 2013; Vega et al., 2014; García-de-la-Fuente et al., 2016; Garza-Gil et al., 2017). In these studies, an attempt has been made to collect the special circumstance of this activity, in which fishermen's production levels are determined by a set of exogenous factors that for the most part are beyond their control. The recent proposal of Surís-Regueiro and Santiago (2018a, 2018b) makes it possible to approach the analysis and quantify the sectoral impacts in an economy that, like fishing, are frequently subject to these type of supply shocks.

The objective of this study is to carry out the first adaptation of the methodological proposal of Surís-Regueiro and Santiago (2018a,b) for the analysis of an applied case. The case study consists of the quantification of the socioeconomic impacts linked to the annual variation of the physical production possibilities (restrictive quotas) of the coastal and deep-sea fishing segments of Galicia (Spain). This region is the most important region in Europe for fishing and aquaculture (Surís-Regueiro and Santiago, 2014). Socioeconomic effects are quantified (in terms of output, Gross Value Added and Employment), linked to the inter-annual variations of the Total Allowable Catches for these fleets using the available information for the years 2015 and 2016. This valuation of the direct and indirect impacts considers the forward and backward linkages of fishing within the rest of the sectors of the Galician economy. In addition, it estimates the sectoral and geographical distribution of these impacts.

To accomplish these objectives, after this introduction section, the information available to carry out the applied analysis and the I–O methodology is outlined in a second section. Then, the results obtained are presented in the third section, highlighting the spatial and distribution of the socioeconomic impacts. Finally, a discussion of these results is presented via a summary of the main conclusions.

2. Materials and methods

2.1. Methodology[3]

Within the context of I–O models, the methodological proposal of Surís-Regueiro and Santiago (2018a,b) is developed in an economy in which the value of the total output of the first k sectors is determined exogenously ($\mathbf{x}'^{ex} = [x_1,\ldots,xk]$) and its final demand endogenously ($\mathbf{f}'^{en} = [f_1,\ldots,fk]$). For the rest of the sectors (n-k), the traditional situation of exogenous final demand ($\mathbf{f}'^{ex} = [fk_{+1},\ldots,f_n]$) and the endogenous output determined ($\mathbf{x}'^{en} = [xk_{+1},\ldots,x_n]$) are maintained. We can assume that these k sectors correspond to fishing activities, whose production possibilities are conditioned by the establishment of annual catch quotas by the fisheries' administration. Therefore, the physical quantity of product of each fishing segment at the initial moment ($\mathbf{q_i}^{\circ} = [q_1{}^{\circ},\ldots, qk^{\circ}]$) will cause a supply shock (positive or negative) that will determine the production possibilities in the first period ($\mathbf{q_i}^1 = [q_1{}^1,\ldots, qk^1]$).

This variation in the quantity of fish supplied ($\Delta q_i^1 = q_i^1 - q_i^0$) may alter the price of the fish products (p_i). The sensitivity of these price variations before changes in the quantity offered is given by the inverse of the Price Elasticity of products linked to the supply shock [$Es_i^{-1} = (\Delta p_i/p_i)/(\Delta q_i/q_i)$]. That is:

$$\Delta p_i^1 = Es_1^{-1} p_1^0 (\Delta q_1^1 / q_1^0) \quad (1)$$

The change in the price of fishery outputs may affect the prices of other outputs, especially in those sectors that use fish as consumables, i.e., an intermediate input. Assuming stability of the input coefficients, we can quantify this process through a mixed input–output model of prices. In an economy with n branches of activity, we assume that the prices of fishery outputs are determined exogenously as a consequence of the supply shock, so that we can construct the corresponding vector of price indices ($\tilde{\boldsymbol{p}}'^{ex} = [\tilde{p}_{1,\ldots,} \tilde{p}\ k]$) for the fishing sectors. For the remaining sectors of the economy, the value added ratio per unit of output will be exogenous variables ($\mathbf{v_c}'^{ex} = [v_{ck+1},\ldots,v_{cn}]$). Partitioning the matrix of input coefficients ($\mathbf{A}$), we can obtain:

$$\begin{bmatrix} \tilde{\boldsymbol{p}}^{ex} \\ \tilde{\boldsymbol{p}}^{en} \end{bmatrix} = \begin{bmatrix} \mathbf{A}'_{11} & \mathbf{A}'_{21} \\ \mathbf{A}'_{12} & \mathbf{A}'_{22} \end{bmatrix} \begin{bmatrix} \tilde{\boldsymbol{p}}^{ex} \\ \tilde{\boldsymbol{p}}^{en} \end{bmatrix} + \begin{bmatrix} \mathbf{v_c}^{en} \\ \mathbf{v_c}^{ex} \end{bmatrix} \quad (2)$$

Matrix $\mathbf{A_{11}}$ includes the elements from the first k rows and columns from $\mathbf{A}$, the elements of the matrix $\mathbf{A_{12}}$ are the first k rows and the last n-k columns, the elements of the matrix $\mathbf{A_{21}}$ are the last n-k rows and the first k columns, and the elements of the matrix $\mathbf{A_{22}}$ are the last n-k rows and columns from $\mathbf{A}$. The same notation criterion can be used for

[3] For those unfamiliar with terminology, the Table A1 in the Appendix A clarifies the economic terms used and the related notation for the I-O analysis