Economic impacts of TAC regulation: A supply-driven SAM approach

Javier Fernández-Macho ∗, Carmen Gallastegui, Pilar González

Institute for Public Economics, University of the Basque Country, E48015 Bilbao, Spain

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Abstract

The Galician fishing fleet is one of the most important of all the European fleets that fish in European Union waters and hake is its vital species. The aim of this article is to estimate some of the economic impacts that a reduction in the TAC of hake during the period 1999–2003 have on the entire Galician economy. We use a “supply-driven” Social Accounting Matrix (SDSAM) model for the Galician fishing sector that takes hake production as exogenously given. In this respect, the present work constitutes a first attempt at applying a SDSAM model to fisheries. It also presents both the traditional backward linkage effects as well as the lesser known forward linkage effects. The SDSAM model allows us not only to compute impacts on production but also to estimate the impact distribution on household incomes and production factors. Impacts on employment have also been calculated. These results may be useful to policy makers as they provide some perceptions into the consequences of one of the measures of the Common Fisheries Policy (CFP) and may help to design policy initiatives.

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1. Introduction

Acting on the warning given by the International Council for the Exploitation of the Sea (ICES) regarding the imminent collapse of cod and hake stocks in European Union (EU) waters, and at the request of all fisheries ministers in December 2000, the European Commission drew up a proposal for the long-term recovery of fish stocks. The measures included a more stringent Total Allowable Catch (TAC) on these species. Of all the regional fleets that fish in EU waters, the fishing fleet of the Autonomous Community of Galicia is doubtless the most important by far, and hake is its vital species. According to figures covering the period 1994–2001 it represents approximately 30% of the total value of the fish catch and 12% of the total quantity fished. Since 1999, hake catches have been declining both in terms of tonnage and value. The deteriorating situation of the stock and the consequent regulatory measures undertaken affect not only the fishing activities but also the entire Galician economy. The Social Accounting Matrix (SAM) drawn up for the Galician fishing sector (Fernández-Macho et al., 2004b) constitutes an ideal starting point for the evaluation of the economic effects of TAC reductions. Input–output (IO) tables and SAMs provide a basis for useful models with which to evaluate, through calculation of impact multipliers, the changes in the distribution of production, income and employment due to varying government policies that affect the final demand (Leontief, 1941; Stone, 1961, etc.). However, a reduction in the TAC of hake means a reduction in the total output of this commodity, not just of its final demand. To estimate its impact by calculating demand-oriented multipliers when the actual “driver” is the total output is totally inadequate and it would lead to an overestimation of the results (see, e.g. Groenewold et al., 1987; Leat and Chalmers, 1991; Midmore, 1993; or Sharma et al., 1999). In order to be able to correctly calculate the impacts induced by a change in a supply variable, it becomes necessary to change the method of solving the models in the sense that the production of some of the goods is treated as exogenous. When these changes have been implemented, both the IO or SAM models as well as their cor-

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* Corresponding author.
E-mail addresses: javier.fernandezmacho@ehu.es (J. Fernández-Macho), jepgazuc@bs.ehu.es (C. Gallastegui), etpgocap@bs.ehu.es (P. González).

1 A Spanish legal term to refer to any of the 17 regions that make up the state of Spain.
responding multipliers are called “supply-driven” IO or SAM (SDSAM) models and multipliers.\textsuperscript{2}Johnson and Kulshreshtah (1982) were among the first to consider the use of supply-driven IO multipliers in the resource management literature. More recently Roberts (1994) also made use of supply-driven multipliers in a study of the impact of milk quotas on the UK economy. Her paper distinguishes between backward and forward linkages pointing out that traditional multipliers cannot capture impacts due to the latter. She then proposes that forward impacts be estimated from the value-added driven Ghosh (1958) model. Papadas and Dahl (1999) in a study of US agriculture discussed the effects of exogenous changes in sectoral total outputs rather than final demands within an IO framework, differentiating explicitly between activities and commodities (Stone, 1962). The paper by Leung and Pooley (2002) again raises the point of supply-driven vs. final-demand-driven multipliers in a study on the economic importance of longline fisheries in Hawaii and also compares backward and forward linkages. The present article constitutes, to the best of our knowledge, a first attempt at applying a SDSAM model to fisheries (see the review by Seung and Waters, 2005). Specifically, its purpose is to estimate some of the economic impacts that a reduction in the hake TAC established by the European Commission during the period 1999–2003 may have had on the Galician economy using a SDSAM model for the Galician fishing sector, which takes hake production as exogenously given. We note that an industry-based technology assumption is well justified in the case of a traditional fishing sector like the Galician one where boats fish all they can, so it is not unreasonable to assume that primary and secondary production share the same input coefficients (see Miller and Blair, 1985 for the implications of alternative technology assumptions). The SDSAM model allows us to compute not only impacts on production but also the impact distribution upon household incomes, as it makes available a value-added account that distinguishes labour, capital and mixed incomes on the one hand, as well as fishermen and non-fishermen on the other. At the same time, the impacts caused by such measures on the employment of both fishermen and non-fishermen can also be quantified. Lastly, impacts due to both backward and forward linkages will also be considered.

The paper is structured as follows. Section 2 gives a stylised description of the Galician fishing sector. Section 3 presents the methodology used to obtain the SDSAM multipliers. Section 4 shows the structure of the Galician SAM. Finally, Section 5 gives an account of the main results obtained and Section 6 sums up the conclusions.

2. The Galician fishery

The Galician fishing sector is made up of four types of activity: extractive fishing, aquaculture, shellfish gathering and the fish processing industry. Table 1 sums up the general characteristics of the sector. It can be observed that the Galician fishing sector represents almost 15\% of the total value of EU landings. Table 2 shows the weight of the fishing sector in terms of employment and value added. The EU provides some indexes (MegaPesca Lda. Portugal and Centre for Agricultural Strategy, UK, 2000) that measure the level of dependence on the fishing and fish processing sectors of the European regions: one in terms of employment (rate of employment in fishing with respect to total employment in the area) and a second one in terms of value added (share of fishing in the total value added of the area). The results obtained in this study, using 1996 data, confirm that the index of dependence on fishing of Galician employment is 19.42, the highest value in the EU. When the rate of dependence is calculated in terms of value added, the indicator for Galicia reaches 11.22 points.

The division of the Galician fleet into segments,\textsuperscript{3} according to data supplied by the Fisheries Department of the Autonomous Galician Government, shows that around 85\% of the boats belong to the smallest segment dedicated to inshore fishing. As for the rest, 8\% of the boats are involved in coastal fishing, about 5\% in deep-sea fishing and 1\% operate in the industrial or high-sea fishing segment. The portion of the fleet that fishes outside the 12 m zone thus represents a very small percentage in terms of the number of boats but nevertheless provides employment to 25\% of the extractive fishing sector.

Within the extractive fishing sector, the Galician deep-sea fleet operates in EU waters (mostly in the ICES fishing sub-areas VII and VIII: see Fig. 1) capturing basically hake (more than 50\% of the landings), megrim and anglerfish. This activity is highly regulated in Europe through CFP measures that have a great deal of influence on the fishing activity and in turn, via sectoral interrelationships, on the regional economies. Hake has been subjected to regulation for almost three decades now but

\begin{table}[h]
\centering
\begin{tabular}{lccc}
\hline
 & Galicia & \% Spain & \% EU-15 \\
\hline
Number of vessels & 8,811 & 54.47 & 9.51 \\
Total tonnage (tonnes) & 254,279 & 48.33 & 12.73 \\
Total power (KW) & 895,748 & 67.20 & 12.03 \\
Landings (thousand tonnes) & 475 & 51.13 & 10.65 \\
Landings (million euros) & 801 & 43.51 & 12.88 \\
Aquaculture (thousand tonnes) & 253 & 80.92 & 19.51 \\
Aquaculture (million euros) & 143 & 32.18 & 4.78 \\
\hline
\end{tabular}
\caption{Galician fishing sector, 2001}
\end{table}

\textsuperscript{3} The four extractive segments considered are: Inshore fishing: fleet made up of small boats of less than 30 tonnes of GRT that operate mostly in the estuaries and near the coast. Coastal fishing: fleet made up of boats of less than 150 tonnes of GRT that fish in coastal waters from the coast of Portugal up to the waters of the Bay of Biscay (ICES fishing sub-area VIII). Deep-sea fishing: this subsector consists of two fleets, one that fishes in the Irish Box and the other in the Canary-Sahara bank. High-sea fishing: basically made up of large freezer ships that operate in different banks in all continents and whose products are frozen.

\textsuperscript{2} The use of this terminology in the present context is quite obvious (Papadas and Dahl, 1999; Leung and Pooley, 2002). However, it should not be confused with Ghoshian value-added multipliers (Ghosh, 1958) sometimes also referred as “supply-driven” in the literature.
Table 2
Employment and value added in the fishing and fish processing sector

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Fishing</td>
<td>31,494</td>
<td>30,607</td>
<td>29,184</td>
<td>29,569</td>
<td>30,134</td>
<td>32,416</td>
<td>32,158</td>
</tr>
<tr>
<td>Fish processing</td>
<td>7,896</td>
<td>7,971</td>
<td>7,808</td>
<td>8,073</td>
<td>8,148</td>
<td>8,487</td>
<td>10,404</td>
</tr>
<tr>
<td>Total</td>
<td>39,390</td>
<td>38,578</td>
<td>36,992</td>
<td>37,642</td>
<td>38,282</td>
<td>40,903</td>
<td>42,562</td>
</tr>
<tr>
<td>% Galician emp.</td>
<td>4.20</td>
<td>4.12</td>
<td>3.91</td>
<td>3.91</td>
<td>3.86</td>
<td>4.04</td>
<td>4.11</td>
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</thead>
<tbody>
<tr>
<td>Fishing</td>
<td>572.32</td>
<td>602.36</td>
<td>658.08</td>
<td>660.41</td>
<td>657.88</td>
<td>640.74</td>
<td>722.31</td>
</tr>
<tr>
<td>Fish processing</td>
<td>189.08</td>
<td>182.26</td>
<td>174.55</td>
<td>201.88</td>
<td>209.76</td>
<td>231.29</td>
<td>257.66</td>
</tr>
<tr>
<td>Total</td>
<td>761.40</td>
<td>784.63</td>
<td>832.63</td>
<td>862.29</td>
<td>867.63</td>
<td>872.04</td>
<td>979.97</td>
</tr>
<tr>
<td>% Galician VA</td>
<td>3.50</td>
<td>3.41</td>
<td>3.40</td>
<td>3.31</td>
<td>3.10</td>
<td>2.89</td>
<td>3.02</td>
</tr>
</tbody>
</table>

Source: Instituto Galego de Estadística (Galician Government).

3. Methodology: supply-driven SAM multipliers

A Social Accounting Matrix (SAM) (Stone, 1961, 1962) is a tool of twofold interest from the point of view of regional economic analysis: it provides a consistent database that allows a detailed analysis of the economic structure of a region, taking into account not only the patterns of production and demand but also their relationships with the institutions; and it is also a useful tool for gauging the impacts of both demand and supply, of economic policies on the economy as a whole.

A SAM is represented as a square matrix $T$ whose $t_{ij}$ element shows the transaction value where the income obtained by account $i$ originates from the expenditure by account $j$. In contrast with an IO table, a SAM is able to illustrate the complete circular flow of funds within the economy from demand of commodities leading to production leading to demand of factors leading to income distribution among institutions (such as different socio-economic household groups) and back to demand of commodities. Within the production side it is also customary to differentiate between activities and commodities, which allows the establishment of a secondary flow between productive sectors and commodities and vice versa. It also usually incorporates different kinds of households (e.g. depending on their income level, origin, etc.), as well as other institutions such as firms (e.g. depending on their size), the foreign sector (e.g. depending on the geographical zone) and the government. In this sense, if we want both to describe the economic structure of a region as well as to compute the impacts generated by different economic policies through impact multiplier analysis, the advantage of a SAM, where all economic agents can be treated as endogenous variables, is clear.

Once the SAM has been partitioned into endogenous and exogenous accounts it can be used for modelling purposes (Miller and Blair, 1985). In essence, multiplier analysis provides the means by which the impacts of exogenous injections on the economic system can be calculated. The traditional arrangement sets production activities, commodities, households and factors as endogenous and the rest of accounts as exogenous. The demand-driven multipliers thus obtained estimate the economic impacts originating from the final demand. On the other hand, supply-driven multipliers represent a measure of the interrelationships and economic changes generated starting out from

normalisation of the size of the stock to that considered ideal by biologists has still not been achieved. The establishment of TACs and quotas for the Spanish fishing fleet using the Relative Stability Principle (Gallastegui et al., 2003) started to take effect in 1987. The evolution undergone by the TAC of hake is shown in Fig. 2, illustrating the decrease in the possibilities of fishing this species, whose consequences upon the whole Galician economy will be evaluated in what follows.
production. As it has already been discussed, for our present purposes, it may be more sensible to consider the actual output from one of the fishing commodities (such as hake) as exogenously altered (say, by a change in its present TAC) instead of its final demand, whose change, in turn, will now be endogenous while it will all remain the same as before for the rest of accounts.

Given a balanced economy characterised by an accounting system with \( n \) accounts, a SAM describes the intersectoral relationships in such a way that, for each account \( i \), total income and total expenditure must be the same. The elements of the transactions matrix \( T \) are usually expressed as proportions of total income (column sums), so that the SAM may be written as \( y = Ay \) where \( y \) is the \((n \times 1)\) vector of incomes (or expenditures) and \( A \) is a matrix of average expenditure propensities.

After partitioning the system into \( n \) endogenous accounts, \( n_e \) exogenous commodities (such as hake for instance) and \( n_n - n_e \) other exogenous accounts, it may be written as

\[
\begin{pmatrix}
    y_n \\
    y_c \\
    y_x
\end{pmatrix} =
\begin{bmatrix}
    A_n & A_{nc} & A_n^* \\
    A_{cn} & A_c & A_c^* \\
    A_n^* & A_{xc} & A_x^*
\end{bmatrix}
\begin{pmatrix}
    y_n \\
    y_c \\
    y_x
\end{pmatrix},
\]

where \( A_c = 0 \) since in our SAM there are no direct flows between commodities. This partition implies that for the accounts of interest

\[
y_n = A_n y_n + A_{nc} y_c + x_{c},
\]

\[
y_c = A_{cn} y_n + A_c y_c + x_c,
\]

where \( x_{c} = A_{c}^* y_{c} \) are the exogenous injections and \( x_{c} = A_{c}^* y_{c} \) is a vector of residual balances or transactions from the rest exogenous accounts into the exogenous commodities. Rearranging the matrices we obtain

\[
\begin{pmatrix}
    y_n \\
    y_c
\end{pmatrix} =
\begin{pmatrix}
    (I - A_n)^{-1} & (I - A_n)^{-1} A_{nc} \\
    -A_{cn}(I - A_n)^{-1} & I - A_{cn}(I - A_n)^{-1} A_{nc}
\end{pmatrix}
\begin{pmatrix}
    y_n \\
    y_c
\end{pmatrix},
\]

where \( I \) is the identity matrix. It makes explicit the fact that the mixed vector \((y_n', x_c')\)' is endogenously determined by the system from an exogenous vector made up of injections \( x_{c} \) and commodity outputs \( y_{c} \). Taking derivatives with respect to \( y_{c} \) (assuming that \( x_{c} \) does not change), we have that matrices

\[
\begin{pmatrix}
    B_{y} = (I - A_n)^{-1} A_{nc}, \\
    B_x = I - A_{cn}(I - A_n)^{-1} A_{nc},
\end{pmatrix}
\]

provide supply-driven multipliers. Thus, the \((i, j)\) element of \( B_{y} \) can be interpreted as the change in income of account \( i \) that will be necessary in order to satisfy an exogenous unit increase in the output of good \( j \). We call these the backward linkage SDSAM multipliers of the exogenous commodities, while the elements of \( B_x \) will provide the corresponding changes in their own injections (e.g. final demands).

Conversely (as Ghosh, 1958 did with the Leontief model in an IO context), the transactions matrix \( T \) may be expressed as proportions of total expenditure (row sums), so that the SAM may also be written as \( y = Cy \) where \( C \) is a matrix of average income propensities.

Partitioning this system in a similar manner will provide analogous results from a leakage point of view. In such case we will obtain

\[
\begin{pmatrix}
    y_n \\
    p_c
\end{pmatrix} =
\begin{pmatrix}
    (I - C_n)^{-1} & (I - C_n)^{-1} C_{nc} \\
    -C_{cn}(I - C_n)^{-1} & I - C_{cn}(I - C_n)^{-1} C_{nc}
\end{pmatrix}
\begin{pmatrix}
    n \\
    p_c
\end{pmatrix},
\]

which makes explicit the fact that the mixed vector \((y_{n}', p_c')\)' is endogenously determined by the system from an exogenous vector of leakages \( p_{n}^* \) and commodity outputs \( y_{c} \). Taking derivatives with respect to \( y_{c} \) (assuming now that \( p_{n}^* \) does not change), we have that

\[
D_y = (I - C_n)^{-1} C_{nc}, \\
D_p = I - C_{cn}(I - C_n)^{-1} C_{nc},
\]

will provide supply-driven multipliers which can be interpreted in much the same way as before. Thus, the \((i, j)\) element of \( D_y \) is the change in expenditure of account \( i \) as a consequence of an exogenous unit increase in the output of good \( j \). We call these the forward linkage SDSAM multipliers of the exogenous commodities, while the elements of \( D_p \) will provide the corresponding changes in their own leakages (e.g. primary inputs).4

The fact that we will use these expressions in order to calculate multipliers in a SAM context is important because, in particular, a SAM considers households as just another productive activity. This means that an exogenous change not only generates changes in production but will also generate a change in the disposable income of the families which, in turn, will produce further variations in demand and so on, that is, the analysis implicitly incorporates a sort of Keynesian mechanism that allows for income changes to induce new adjustments in production through their marginal effect on consumption. In this respect, the multipliers corresponding to households will be interpreted as income multipliers. Finally, employment multipliers can also be calculated by multiplying the corresponding output multipliers (contained in \( B \) or \( D \)) by an employment coefficient given by \( \ell_i = L_i/y_i \), where \( L_i \) is the employment occupied in the production of good \( i \). Thus, \( \ell_i b_{ij} \) is the backward change in employment of sector \( i \) that will be required in order to satisfy an exogenous unit increase in the final demand of good \( j \). While \( \ell_i b_{ij} \) can be interpreted as the forward change in employment of sector \( i \) induced by an exogenous unit increase in the primary inputs of sector \( j \).

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4 As noted by Leung and Pooley (2002), the theoretical interpretation of the Ghosh model has been criticised in the literature primarily when it is used to explain physical output changes due to physical changes in primary factor inputs such as labour and capital. However, a theoretical correct interpretation can be made as a price model in that "sectoral output values change due to the price changes, which are caused by price changes for the primary inputs." See Oosterhaven (1988, 1989), Dietzenbacher (1997, 2005), and Cai and Leung (2004), for further details of this discussion. Because of this, the figures obtained for the forward linkages should be used with caution while interpreting the results.
4. The Galician SAM

Fig. 3 summarises the generic structure of the SAM for the Galician fishing sector divided into seven main accounts. The level of disaggregation of these large accounts depends upon the availability of data and the specific aims of the analysis. Since our aim is to construct a sectoral SAM for the fishing sector, the accounts related to production differentiate between fishing and non-fishing sectors, the latter including the rest of the Galician economy. Besides, this SAM differentiates between activities and commodities, allowing any fishing activity to produce more than one output. As a result, the actual Galician SAM for the fishing sector is a $98 \times 98$ square matrix. The data for the production accounts, factor payments and final demand come from the IO tables for the Galician fishing and preserved fish sectors 1999 (IOTGF99) (García Negro et al., 1999), the IO tables for the Galician economy 1998 (IOTG98) (Instituto Galego de Estadística, 1998) and the Galician Economic Accounts (Instituto Galego de Estadística, 1999). The flows from the activities accounts of the Galician SAM have been valued at basic prices, following current international accounting criteria (European Accounting System). A brief description of the main accounts follows.

The Activities account has been disaggregated into 33 subaccounts corresponding to eight fishing activities and 25 non-fishing activities. The disaggregation of the fishing activities has been performed following the IOTGF99 classification: the four extractive fishing fleet segments mentioned in Section 2 plus shellfish gathering, two aquaculture activities (mussel farming and marine fish farming) and the fish processing industry. The disaggregation of the rest of activities into the 25 non-fishing activities has been carried out based upon the importance of the relationships of these activities with the fishing sector.

In the disaggregation of the Commodities account, it has been assumed that each non-fishing activity produces but one single commodity. However, for the fishing activities the most relevant species for each sector in terms of value of landings have been selected as products (with the exception of the processing sector). The degree of coverage of the fleet production as represented by the species selected is different for each segment as there are activities that concentrate on a single product (e.g. marine fish farming, where turbot represents more than 90% of the total output) whereas other fishing segments are multi-species, catching up to 200 different species as in the case of the traditional fishing fleet, so that the species selected represent between 50 and 60% of the total catch.

The Households account can be classified according to either their income or their origin (Thurlow and Wobst, 2003), depending on the aim of the study. In our case, they have been divided into those households that are associated with the fishing sector and those that are not, using the percentage of jobs in the fishing and processing sectors with respect to the total employment in Galicia (Instituto Galego de Estadística, 1999).

The Factors account include payments made to salaried workers, mixed income and capital. Although economic accounts usually include mixed incomes as capital payments, the most recent Galician accounts present payments to factors split into the three categories mentioned above. It is interesting for our analysis to be able to differentiate between mixed incomes and capital, because these kind of incomes include payments made by the owner of a family business to family members and this type of firm constitutes an important part of the Galician fishing sector, especially that of the inshore and coastal fleets, shellfish gathering and mussel farming.

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5 The complete SAM is available from the EU Directorate-General for Fisheries funded project QLRT-2000-02277 (Fernández-Macho et al., 2004a).
Finally, the *Rest-of-the-world* account is split into rest of Spain and rest of the world as is usually done in a regional SAM.

The SAM data in Fig. 3 provide a good description of the economic structure of the fishing sector and its interaction with the rest of the sectors. It can be observed that the expenditure of the fishing activities is equally distributed between commodities and payments to factors. In particular, more than 65% of the expenditure on intermediate consumption is done outside the fishing sector and more than 53% of the total payments to factors are made to capital. Therefore, the productive structure of the fishing sector is typical of an industrial activity where the production of a unit of a fish product requires the assistance of many other sectors. Due to these interactions between the fishing and the non-fishing sectors it is to be expected that any change in the former will have consequences of some relevance on the entire regional economy.

As regards the rest of the world’s account, imports of fish products reach almost 32% of the total production at market prices whereas for the rest of the Galician economy it only amounts to about 22%. This is mostly due to that share of the catches by Galician fishing units in non-EU waters that are not recognised as European products due to EU laws. On the other hand, we may note that more than 67% of total fishing commodities are exported, which is a clear sign of an important outside demand for Galician fish products.

5. Impacts of hake TAC reduction on the Galician economy

In this section we will estimate some of the economic impacts of a change in the TAC of hake assigned by the European Commission. Taking into account the base year (1999) used for constructing the Galician fishing sector SAM, the time period considered for our case study is 1999–2003. The reduction in TAC set over these years has been a considerable 54% (see Fig. 2). These data suggest that a reasonable exercise would be to evaluate the impact that such a reduction in the hake TAC would have on the Galician economy, a value that can be quantified in 107.69 million base-year euros. We have calculated the supply-driven multipliers derived in Section 3 to quantify the impacts, both backward and forward, of a fishing policy characterised by such exogenous change in the hake supply.

Within this supply-driven context, the backward linkages occur because an exogenous reduction in the output affects the economy through a decrease in the demand of the inputs both from the rest of the sectors as well as from the production factors. In turn, this decrease will generate a series of induced effects: decreasing the demand for inputs in certain sectors will reduce the demand for their own inputs. The resulting reduction in payments to the production factors will then reduce the income of endogenous institutions (such as households) who will then have to reduce their expenditure resulting in another series of effects on the economy. On the other hand, the forward linkages are based on the fact that a reduction in the level of hake output will influence the level of activity of the sectors that take hake as an input. This expected reduction of production in other sectors will generate, in turn, a series of induced effects due to the circular flow of the economy, meaning that a reduction in commodity output changes household consumption which then results in their changing their provision of factor services and so on. As an illustration, a reduction on the output of hake will have, for instance, an effect on the number of trucks travelling with fresh fish from Galicia to Madrid (the largest fish market in Spain). The revenues obtained by agents working in the transport sector will then be reduced and this will, in turn, feed back into the production of other sectors of the economy that may experience reductions in demand for its products. Note that there might be a problem of double counting when these two types of linkages are used to quantify the effects of the same exogenous change. If such were the case, the sum of both impacts could still be interpreted as the maximum potential change. On the other hand, taken individually, they should be interpreted as extreme cases: one where only the backward linkages generate impacts and the other where only forward linkage effects are produced (Roberts, 1994).

Table 3 shows the supply-driven multipliers for the activities along with their economic impacts (in euros of 1999). Results are shown separately for the fishing and the non-fishing activities in order to be able to detect how and where the regional economy is affected by a change in the hake supply.

The total backward impact means a reduction of 153.38 million euros, nearly equally divided between fishing and non-fishing activities. Note that almost all of the impact on the fishing sector is the direct impact on the deep-sea fishing sector itself. The backward impact on the rest of the fishing activities is rather small. The reduction in the regional non-fishing activities is rather important. This is a consequence (see Section 4) of the role of the fishing sector as an important demander of inputs from the rest of the Galician economy: in particular, 88% of the intermediate inputs for the deep-sea fishing fleet come from the non-fishing sectors. Consequently, the reduction in the TAC of a species vital for the deep-sea sector has an effect not only on the level of fishing production but also on the rest of the Galician economy.

As regards forward impacts, they add up to almost 113 million. This result provides a fair idea of the potential impacts of a TAC policy on the “users” of hake. Note that although forward economic impacts are in general smaller than the corresponding backward impacts, the contrary occurs for those activities that are expected to be hake demanders. Thus, for sectors such as fish processing, hotel and trade restaurants and boat and naval repair services, the forward multiplier is considerably larger than the backward one. The distribution of the forward impacts between fishing and non-fishing activities is completely different. In the fishing sectors, the impacts due to forward linkages are lesser overall than those due to backward linkages. The biggest part of this decrease originates from the fact that hake is not a fundamental input for the majority of fishing activities except for the fish processing industry. On the other hand, the economic impact on non-fishing activities is bigger via the forward linkages.

Supply-driven commodity multipliers along with their backward and forward economic impacts have also been calculated...
As regards forward impacts on income, they are smaller than 88.82 euros for non-fishermen. Income impacts show, differences between per capita household incomes is a significant 0.77. It has to be taken into account that more than 50% of the value of the hake supply corresponds to value added, so that any change in the level of output should have a considerable effect on income. The distribution of this impact among the different factors is quite unequal. The greatest effects occur on incomes from labour (46.2 million euros), followed by capital incomes (26.3 millions) and mixed incomes (7.3 millions). This result is due to the fact that labour is the main productive factor for the deep-sea fleet, which is the one affected directly by the TAC of hake. The estimated impacts on employment are also shown in Table 4. Concerning the backward linkages, it can be observed that their corresponding multipliers are not too different for fishers and non-fishers. This implies that the total backward impact on employment, a decrease of 2868 equivalent jobs, is more or less equally distributed. Since the

The supply-driven SAM multipliers also allow us to calculate the impacts on income distribution among productive factors. The total multiplier of the payment to factors (equal to that of household incomes) is a significant 0.77. It has to be taken into account that more than 50% of the value of the hake supply corresponds to value added, so that any change in the level of output should have a considerable effect on income. The distribution of this impact among the different factors is quite unequal. The greatest effects occur on incomes from labour (46.2 million euros), followed by capital incomes (26.3 millions) and mixed incomes (7.3 millions). This result is due to the fact that labour is the main productive factor for the deep-sea fleet, which is the one affected directly by the TAC of hake. The estimated impacts on employment are also shown in Table 4. Concerning the backward linkages, it can be observed that their corresponding multipliers are not too different for fishers and non-fishers. This implies that the total backward impact on employment, a decrease of 2868 equivalent jobs, is more or less equally distributed. Since the

Table 3
Impacts on activities

<table>
<thead>
<tr>
<th>Activities</th>
<th>Backward Multipliers</th>
<th>Economic impacts (million euros)</th>
<th>Forward Multipliers</th>
<th>Economic impacts (million euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 In-shore fishing</td>
<td>0.00818</td>
<td>−0.881</td>
<td>0.00205</td>
<td>−0.221</td>
</tr>
<tr>
<td>2.2 Coastal fishing</td>
<td>0.00594</td>
<td>−0.639</td>
<td>0.00135</td>
<td>−0.145</td>
</tr>
<tr>
<td>2.3 Deep-sea fishing</td>
<td>0.68787</td>
<td>−74.078</td>
<td>0.02482</td>
<td>−2.673</td>
</tr>
<tr>
<td>2.4 High-sea fishing</td>
<td>0.00069</td>
<td>−0.075</td>
<td>0.00408</td>
<td>−0.439</td>
</tr>
<tr>
<td>3.1 Mussel farming, etc.</td>
<td>0.00038</td>
<td>−0.041</td>
<td>0.00149</td>
<td>−0.161</td>
</tr>
<tr>
<td>3.2 Marine fish farming</td>
<td>0.00038</td>
<td>−0.041</td>
<td>0.00058</td>
<td>−0.062</td>
</tr>
<tr>
<td>4 Shellfish gathering</td>
<td>0.00057</td>
<td>−0.062</td>
<td>0.00053</td>
<td>−0.057</td>
</tr>
<tr>
<td>5 Fish processing</td>
<td>0.00256</td>
<td>−0.276</td>
<td>0.007203</td>
<td>−7.756</td>
</tr>
<tr>
<td>Non-fishing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Agriculture and live-stock</td>
<td>0.04263</td>
<td>−4.590</td>
<td>0.03247</td>
<td>−3.497</td>
</tr>
<tr>
<td>6 Salt</td>
<td>0.00223</td>
<td>−0.240</td>
<td>0.00455</td>
<td>−0.490</td>
</tr>
<tr>
<td>7 Other extractive industries</td>
<td>0.00677</td>
<td>−0.729</td>
<td>0.00385</td>
<td>−0.414</td>
</tr>
<tr>
<td>8 Fats and oils</td>
<td>0.00206</td>
<td>−0.222</td>
<td>0.00151</td>
<td>−0.162</td>
</tr>
<tr>
<td>9 Food, drinks, etc.</td>
<td>0.06887</td>
<td>−7.417</td>
<td>0.03164</td>
<td>−3.408</td>
</tr>
<tr>
<td>10 Ropes, nets and textiles</td>
<td>0.00075</td>
<td>−0.835</td>
<td>0.00180</td>
<td>−0.194</td>
</tr>
<tr>
<td>11 Clothes and leather</td>
<td>0.02162</td>
<td>−2.232</td>
<td>0.01101</td>
<td>−1.185</td>
</tr>
<tr>
<td>12 Cases and packaging</td>
<td>0.02057</td>
<td>−2.215</td>
<td>0.00780</td>
<td>−2.994</td>
</tr>
<tr>
<td>13 Refinery products</td>
<td>0.03064</td>
<td>−3.299</td>
<td>0.00515</td>
<td>−0.554</td>
</tr>
<tr>
<td>14 Chemical products</td>
<td>0.00766</td>
<td>−0.825</td>
<td>0.00083</td>
<td>−0.843</td>
</tr>
<tr>
<td>15 Plastic containers</td>
<td>0.01560</td>
<td>−1.680</td>
<td>0.01777</td>
<td>−1.914</td>
</tr>
<tr>
<td>16 Metal goods</td>
<td>0.01566</td>
<td>−1.686</td>
<td>0.02372</td>
<td>−2.555</td>
</tr>
<tr>
<td>17 Machinery and equipment</td>
<td>0.03783</td>
<td>−4.074</td>
<td>0.04838</td>
<td>−5.210</td>
</tr>
<tr>
<td>18 Boats and naval repair services</td>
<td>0.06660</td>
<td>−7.172</td>
<td>0.12286</td>
<td>−13.231</td>
</tr>
<tr>
<td>19 Energy and water</td>
<td>0.02131</td>
<td>−2.295</td>
<td>0.02404</td>
<td>−2.589</td>
</tr>
<tr>
<td>20 Service stations and other</td>
<td>0.01772</td>
<td>−0.783</td>
<td>0.01582</td>
<td>−1.704</td>
</tr>
<tr>
<td>21 Wholesale trade services</td>
<td>0.00008</td>
<td>−0.009</td>
<td>0.00120</td>
<td>−2.607</td>
</tr>
<tr>
<td>22 Retail trade services</td>
<td>0.00228</td>
<td>−0.245</td>
<td>0.04327</td>
<td>−4.659</td>
</tr>
<tr>
<td>23 Hotel-trade and restaurants</td>
<td>0.05239</td>
<td>−2.642</td>
<td>0.16259</td>
<td>−17.509</td>
</tr>
<tr>
<td>24 Transport</td>
<td>0.04481</td>
<td>−4.826</td>
<td>0.03993</td>
<td>−4.300</td>
</tr>
<tr>
<td>25 Financial intermediaries</td>
<td>0.04679</td>
<td>−5.039</td>
<td>0.03688</td>
<td>−3.971</td>
</tr>
<tr>
<td>26 Business services</td>
<td>0.12711</td>
<td>−13.689</td>
<td>0.11896</td>
<td>−12.811</td>
</tr>
<tr>
<td>27 Public services</td>
<td>0.04102</td>
<td>−4.418</td>
<td>0.05949</td>
<td>−6.406</td>
</tr>
<tr>
<td>28 Educational services</td>
<td>0.01461</td>
<td>−1.573</td>
<td>0.03778</td>
<td>−4.069</td>
</tr>
<tr>
<td>29 Sanitary, veterinary, other services</td>
<td>0.01353</td>
<td>−1.457</td>
<td>0.03690</td>
<td>−3.974</td>
</tr>
<tr>
<td>All fishing sectors</td>
<td>0.70857</td>
<td>−76.092</td>
<td>0.10692</td>
<td>−11.514</td>
</tr>
<tr>
<td>All non-fishing sectors</td>
<td>0.71769</td>
<td>−77.288</td>
<td>0.94019</td>
<td>−101.249</td>
</tr>
<tr>
<td>Total</td>
<td>1.42426</td>
<td>−153.380</td>
<td>1.04710</td>
<td>−112.764</td>
</tr>
</tbody>
</table>
Table 4
Impacts on income and employment

<table>
<thead>
<tr>
<th></th>
<th>Backward Multipliers</th>
<th>Economic impacts</th>
<th>Forward Multipliers</th>
<th>Economic impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households (million euros)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishers</td>
<td>0.03137</td>
<td>−3.378</td>
<td>0.02359</td>
<td>−2.541</td>
</tr>
<tr>
<td>Non-fishers</td>
<td>0.73374</td>
<td>−79.018</td>
<td>0.55188</td>
<td>−59.433</td>
</tr>
<tr>
<td>Total</td>
<td>0.76511</td>
<td>−82.396</td>
<td>0.57548</td>
<td>−61.974</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households (per capita)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishers</td>
<td>−80.14 €</td>
<td>−60.28 €</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-fishers</td>
<td>−88.82 €</td>
<td>−66.81 €</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factors (million euros)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labour</td>
<td>0.42901</td>
<td>−46.200</td>
<td>0.28231</td>
<td>−30.403</td>
</tr>
<tr>
<td>Mixed income</td>
<td>0.07338</td>
<td>−7.903</td>
<td>0.09902</td>
<td>−10.663</td>
</tr>
<tr>
<td>Capital</td>
<td>0.26272</td>
<td>−28.293</td>
<td>0.19415</td>
<td>−20.908</td>
</tr>
<tr>
<td>Total</td>
<td>0.76511</td>
<td>−82.396</td>
<td>0.57548</td>
<td>−61.974</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment (equiv. jobs)</td>
<td>13.70735</td>
<td>−1476</td>
<td>14.47335</td>
<td>−1559</td>
</tr>
<tr>
<td>Fishers</td>
<td>12.91987</td>
<td>−1391</td>
<td>10.93491</td>
<td>−1178</td>
</tr>
<tr>
<td>Total</td>
<td>−2868</td>
<td>−2736</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final demand (million euros)</td>
<td>0.98905</td>
<td>−106.512</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5
Summary of impacts

<table>
<thead>
<tr>
<th>Economic activities (million euros of 1999)</th>
<th>Backward: −153.38</th>
<th>Forward: −112.76</th>
<th>Most vulnerable sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households (million euros of 1999)</td>
<td>Backward: −82.40</td>
<td>Forward: −61.97</td>
<td>Per capita impacts</td>
</tr>
<tr>
<td>Employment (equiv. jobs)</td>
<td>Backward: −2868</td>
<td>Forward: −2736</td>
<td>Fishing vs. non-fishing impacts</td>
</tr>
</tbody>
</table>

fishing sector accumulates only around 4% of the total regional employment, this result implies that even though in terms of income per capita non-fishermen are marginally more affected, it is the employment in the fishing sector that bears the brunt of the adjustment following a decrease in the TAC of hake. The forward employment impacts, while similar in size to the backward ones, are again more concentrated on fishermen, with a multiplier of 14.5 much higher than that of 10.9 for non-fishing employment. The so called backward final demand multiplier in Table 4 reflects mostly the effect on exports, as public consumption and gross capital formation are negligible. A unit reduction in the hake catch decreases exports by 0.99 which amounts to about 106.5 million euros. This results agrees with the fact that a high percentage of the hake catch is exported outside Galicia.

6. Summary and conclusions

The present study constitutes a first attempt at using a SDSAM as a tool for fisheries management. As is well known, the over-exploitation of the fish stocks demands regulation either via output (catches), via input (effort) or via technology. Regulation has biological and economic implications. Any sensible policy has to take into account all the possible consequences that it originates. In this sense, the work presented allows us to conclude that the effort involved in constructing a SAM and solving the model from a supply point of view is worthwhile. The SDSAM model gives valuable insights into the effects that some instruments of the CFP, in particular a reduction on the TAC of a species, may have on fishing activities as well as on the regional economy as a whole.

Table 5 provides a concise summary of the most relevant empirical results obtained which could be useful to policy makers when implementing a TAC policy. Considering, first of all, the impacts generated on activities, there are important negative effects both on fishing as well as non-fishing sectors. They are concentrated on the deep-sea fishing and fish processing sectors on the one hand, and on business services, hotel and restaurant, and boats and naval repair services on the other.
In general, impacts due to backward linkages are bigger than forward impacts, although with some interesting exceptions. For sectors such as fish processing, hotel trade and restaurants, and boats and naval repair services (direct demanders of hake) the forward impact is considerably bigger than the backward one. Secondly, our results provide a measure of the decrease in household income. The reduction of the TAC has a negative effect of a similar magnitude, as in per capita terms, for families related both to the fishing and non-fishing sectors. Besides, regarding income distribution among factors, the greatest impact is obtained for labour incomes as it nearly doubles that of capital. With respect to employment, it can be seen that even though it diminishes for both fishers and non-fishers, it is the fishing sector the one that suffers the most. Given the high unemployment rate in the region (11.4% in 2002) policy makers should be aware of this non-desired consequence of the policy.

These results serve to bring us closer to understanding a reality which otherwise is hard to express quantitatively. To conclude, it is true that achieving biological sustainability demands the introduction of control measures. Since biological research suggests that there is an over-exploitation of hake in the NE Atlantic fishery where the Galician fleet operates, a reduction in the TAC of this species is a policy that pursues a better management of an important renewable resource. It is also true that when the policy is successful there will be economic benefits, as the fish biomass will eventually increase and catches will be less costly. Our analysis does not question neither the policy nor the good consequences that it may generate over the fishing biomass and the fishing sector in the medium term. It does put the accent on the immediate economic effects that, as shown, are negative and go well beyond the impacts on the fishing sector directly concerned with the policy.

Policy makers should consider both types of consequences, economic and biological, and incorporate the subsequent trade-off in their decision making process. Knowledge of the economic impacts obtained with a SDSAM model provides the information needed to identify not only the sectors and agents that are affected by policy measures but also the amounts by which they are affected. In this way it would be easier to evaluate how strongly the measure introduced will conflict with the short-term interests of households and industries. Movements towards efficient resource management generate net benefits although they may also induce effects that make some sectors or agents net losers. These losers may then oppose measures that are necessary to preserve the biological sustainability of the resource or may demand compensation. The type of analysis that we propose may help policy makers to define policy combinations that will ensure not only efficiency but also political and social acceptability by means of reducing the economic impacts generated by the management measures. The decisions adopted, in this case by means of the CFP, can then be supported by two complementary information sets: the biological information concerning the state of the fish biomass and the economic information that comes via an analysis of the type undertaken in this work.

Acknowledgements

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References


