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Title:

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

Short running title:

Assessing economic impacts of quotas

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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.

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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).

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; Ossterhaven, 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 y 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 at al., 2011) and to assess the socioeconomic effects of changes in transport costs (Mansen 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, 2018b) 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[1]

Within the context of I–O models, the methodological proposal of Surís-Regueiro and Santiago (2018a, 2018b) is developed in an economy in which the value of the total output of the first k sectors is determined exogenously ($\mathbf{x}'^{ex} = [x_1,\dots,x_k]$) and its final demand endogenously ($\mathbf{f}'^{en}= [f_1,\dots,f_k]$). For the rest of the sectors (n-k), the traditional situation of exogenous final demand ($\mathbf{f}'^{ex} = [f_{k+1},\dots,f_n]$) and the endogenous output determined ($\mathbf{x}'^{en}= [x_{k+1},\dots,x_n]$) 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 ($\mathbf{q}_i^0= [q_1^0,\dots, q_k^0]$) will cause a supply shock (positive or negative) that will determine the production possibilities in the first period ($\mathbf{q}_i^1= [q_1^1,\dots, q_k^1]$).

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:

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

[1] For those unfamiliar with terminology, the Table B1 in the Appendix clarifies the economic terms used and the related notation for the I-O analysis.

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 ($\tilde{\boldsymbol{p}}'^{ex} = [\tilde{p}_{1,\dots,}\ \tilde{p}_k]$) for the fishing sectors. For the remaining sectors of the economy, the value added ratio per unit of output will be exogenous variables ($\mathbf{v_c}'^{ex} = [v_{ck+1},\dots,v_{cn}]$). Partitioning the matrix of input coefficients (**A**), we can obtain:

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

Matrix $\mathbf{A_{11}}$ includes the elements from the first k rows and columns from **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 **A**. The same notation criterion can be used for partitioned matrices of identity matrix (**I**) and Leontief's Inverse Matrix (**L**).

Operating from (2), we have:

$$\begin{bmatrix}\mathbf{v_c}^{en}\\ \tilde{\boldsymbol{p}}^{en}\end{bmatrix} = \begin{bmatrix}(\mathbf{I}_{11} - \mathbf{A}'_{11}) - \mathbf{A}'_{21}\,\mathbf{L}'_{22}\,\mathbf{A}'_{12} & -\mathbf{A}'_{21}\,\mathbf{L}'_{22}\\ \mathbf{L}'_{22}\,\mathbf{A}'_{12} & \mathbf{L}'_{22}\end{bmatrix}\begin{bmatrix}\tilde{\boldsymbol{p}}^{ex}\\ \mathbf{v_c}^{ex}\end{bmatrix} \qquad (3)$$

where $\mathbf{L'_{22}} = (\mathbf{I_{22}}\text{-}\mathbf{A'_{22}})^{-1}$.

Given variation in the prices of exogenous outputs in the first period ($\tilde{\boldsymbol{p}}^{ex1}$ known), and assuming that $\mathbf{v_c}^{ex1}=\mathbf{v_c}^{ex0}$, the system (3) would allow $\mathbf{v_c}^{en1}$ and $\tilde{\boldsymbol{p}}^{en1}$ to be calculated. Therefore, this model would allow estimation of the price changes of the non-fishing n-k outputs derived from the exogenous supply shocks in the fishing sectors.

Variation in the prices of non-fishery outputs will imply changes in their production levels (q_i) and final demands (d_i). The variations of the final demand will depend on the price elasticity for these products $[\mathrm{Ed_i} = (\Delta d_i/d_i)/(\Delta p_i/p_i)]$, a stronger relationship will lead to more impact on the final demand. This information is exogenous to the IO model, which is the reason to assume that these final demands are determined exogenously. Thus:

$$\Delta d_i^1 \,/\, d_i^0 \;=\; \mathrm{Ed_i}\;(\Delta p_i^1 \,/\, p_i^0) \quad ; \quad k < i \le n \qquad (4)$$

In the case of the fishing sectors, it is assumed that, at least in the short- and medium-term, an attempt will be made to maintain the supply of intermediate inputs demanded by the other sectors of the economy. Consequently, the impact on the quantity destined to supply the final domestic demand for fishery products will depend both on the size of the supply shock suffered and on the evolution of the final demand of the other sectors.

If we operate with prices of the initial period (period 0), the expected relative variations would be transferred directly to their monetary values for both the supplied quantity of exogenous k fishery outputs ($\Delta q_i^1 \,/\, q_i^0$) and the quantities demanded of endogenous n-k outputs

(Δd_i^1 / d_i^0). If we denote the value of exogenous outputs (those of the fishing sectors) by $x_i^{ex\,1(0)}$ and the value of the exogenous demands (those corresponding to the rest of sectors) by $f_i^{ex\,1(0)}$), both expressed in monetary units of period 0, we would have:

$$x_i^{ex\,1(0)} = x_i^{ex\,0}\,[1 + (\Delta q_i^1 / q_i^0)]\ ; \qquad 1 \le i \le k \tag{5}$$

$$f_i^{ex\,1(0)} = f_i^{ex\,0}\,[1 + (\Delta d_i^1 / d_i^0)]\ ; \qquad k < i \le n \tag{6}$$

After the initial supply shock, we assume that there are no domestic or international (via imports) possibilities for technical substitution of inputs at short-term. Therefore, there is stability in the elements of the regional input coefficient matrix ($\mathbf{A}^{\mathbf{RR}}$). By knowing the expected values for the exogenous variables valued at initial period prices ($x_i^{ex\,1(0)}$ y $f_i^{ex\,1(0)}$), the mixed I–O model can be used to estimate the endogenous variables in the final period; that is, the final demand for the k fishing outputs ($f_i^{en\,1(0)}$) and the values of the n-k outputs of the rest of the sectors ($x_i^{en\,1(0)}$), also valued at the prices of the initial period.

$$\begin{bmatrix} (\mathbf{I}_{11} - \mathbf{A}_{11}^{\mathbf{RR}}) & (\mathbf{I}_{12} - \mathbf{A}_{12}^{\mathbf{RR}}) \\ (\mathbf{I}_{21} - \mathbf{A}_{21}^{\mathbf{RR}}) & (\mathbf{I}_{22} - \mathbf{A}_{22}^{\mathbf{RR}}) \end{bmatrix} \begin{bmatrix} \mathbf{x}^{\mathbf{ex}\,\mathbf{1(0)}} \\ \mathbf{x}^{\mathbf{en}\,\mathbf{1(0)}} \end{bmatrix} = \begin{bmatrix} \mathbf{f}^{\mathbf{en}\,\mathbf{1(0)}} \\ \mathbf{f}^{\mathbf{ex}\,\mathbf{1(0)}} \end{bmatrix} \tag{7}$$

From (7) we will have:

$$\begin{bmatrix} \mathbf{f}^{\mathbf{en}\,\mathbf{1(0)}} \\ \mathbf{x}^{\mathbf{en}\,\mathbf{1(0)}} \end{bmatrix} = \begin{bmatrix} (\mathbf{I}_{11} - \mathbf{A}_{11}^{\mathbf{RR}}) - \mathbf{A}_{12}^{\mathbf{RR}}\,\mathbf{L}_{22}^{\mathbf{RR}}\,\mathbf{A}_{21}^{\mathbf{RR}} & -\mathbf{A}_{12}^{\mathbf{RR}}\,\mathbf{L}_{22}^{\mathbf{RR}} \\ \mathbf{L}_{22}^{\mathbf{RR}}\,\mathbf{A}_{21}^{\mathbf{RR}} & \mathbf{L}_{22}^{\mathbf{RR}} \end{bmatrix} \begin{bmatrix} \mathbf{x}^{\mathbf{ex}\,\mathbf{1(0)}} \\ \mathbf{f}^{\mathbf{ex}\,\mathbf{1(0)}} \end{bmatrix} \tag{8}$$

where $\mathbf{L}_{22}^{\mathbf{RR}} = (\mathbf{I}_{22} - \mathbf{A}_{22}^{\mathbf{RR}})^{-1}$.

The difference between the value of the sectoral output in period 1 and that in 0 ($\Delta x_i^{1(0)} = x_i^{1(0)} - x_i^{0(0)}$) quantifies the direct and indirect effects on the output of each of the sectors of the regional economy associated with the initial supply shock in the fishing sectors (valued at period-0 prices). If we multiply the row vector of impacts on the output ($\Delta\mathbf{x}'^{\,1(0)} = [\Delta x_1^{1(0)}, \dots, \Delta x_n^{1(0)}]$) by the vector column of the value-added ratio per unit of output ($\mathbf{v_c}'$ = [v_{c1},…,v_{cn}]) and by the column vector of the ratio of full-time jobs per unit of output ($\mathbf{fte_c}'$ = [fte_{c1},…,fte_{cn}]) we would obtain, respectively, direct and indirect impacts on value added ($\Delta\mathbf{v}'^{\,1(0)} = [\Delta v_1^{1(0)}, \dots, \Delta v_n^{1(0)}]$ and on employment in every sector of our economy ($\Delta\mathbf{fte}'^{\,1(0)} = [\Delta fte_1^{1(0)}, \dots, \Delta fte_n^{1(0)}]$).

Through the known price changes for the n sectoral outputs ($\tilde{\boldsymbol{p}}'$ = [$\tilde{p}_1, \dots, \tilde{p}_n$]), we can express these impacts on the value of output and value added in monetary units of period 1 with a simple operation:

$$\Delta\mathbf{x}^{\,1(1)} = \tilde{\boldsymbol{p}}'\,\Delta\mathbf{x}^{\,1(0)} \tag{9}$$

$$\Delta\mathbf{v}^{\,1(1)} = \tilde{\boldsymbol{p}}'\,\Delta\mathbf{v}^{\,1(0)} \tag{10}$$

2.2. Data of the economy of Galicia (NW Spain)

Galicia is a region of Spain with approximately 2.7 million inhabitants and almost 1,500 km of coastline and where a wide range of fishing activities linked to the manufacture and trading of marine products are developed. In 2015, the official institute of statistics of the regional government (IGE) published the I–O framework of Galicia for 2011 (IGE, 2015a). The IGE distinguishes 71 sectors in the Symmetric Matrix of Galicia (fishing is one of them). We simplified Galicia's economy to facilitate the understanding and the dissemination of results. In the first phase, all economic activities were grouped into only 15 sectors according to the criteria listed in Table 1. In a second phase, it was decided to differentiate five types of fishing activity, disaggregating the fishing sector into five subsectors according to the major fishing activities in the region: shell-fishing on foot (R01A), artisanal fishing (R01B), coastal fishing (R01C), distant water fishing (R01D), and long-distant fishing (R01E).

It was possible to reconstruct the Symmetric Tables (Total and Regional) of the Economy of Galicia 2011 with 19 sectors, 5 fishing and 14 non-fishing **f**rom the information provided in IGE (2015a and 2015b), Xunta de Galicia (2016), García Negro (2003), and Gobierno de España (2012a and 2012b). The final results of this process are given in the Appendix. The fishing sector of Galicia (R01 sector) requires intermediate inputs from other sectors for around the 40% of the total value of its production. On the other hand, approximately the 56% of its production value is to satisfy the intermediate demand of other sectors of the economy. Fig. 1 details the main suppliers of intermediate inputs to the fishing sector (backward linkages). They are the sectors of R.06. "Manufacture of petroleum, chemical, plastic and other non-metallic products", R.11. "Transportation and storage" and R.13. "Services to companies and individuals". The main clients of their intermediate outputs (forward linkages) are the sectors of R.04 "Manufacture of food products" and R.12. "Accommodation and food service activities".

Figure 1

Given the sectoral division that we develop for the Galician economy, we do not have precise information about the price elasticity of the outputs of the 19 differentiated sectors. For this reason, we decided to establish 5 categories of goods based on their price elasticity in absolute terms: 0.25 for very low elasticity; 0.50 for low elasticity; 0.75 for average elasticity, 1.00 for high elasticity and 1.25 for the very high elasticity. We attribute low elasticity to the products of the coastal and distant water segments because they are highly perishable fresh food products and given the consumption habits in Galicia, with little possibility of replacement by other goods. The products of shellfish and artisanal fishing, although equally perishable, are perceived as more luxury goods (their main species are crustaceans and high-value seafood), and therefore they are given an average price elasticity. The products of the long-distant fishing are frozen (less perishable) and have high possibilities of substitution either by other alimentary goods or by goods coming from import, so we assign them with high price elasticity. For the rest of the non-fishing goods, after consulting various sources (Castillo-Manzano et al., 2013; BBVA Research, 2014; Arce et al., 2013; González and Urtasun, 2015), we assign them elasticity in function of the average characteristics of each output. The values of the price elasticity assumed for each sector are detailed in Table 2.

Table 1

2.3. The coastal and distant water fishing segments

The segments of the fleet are composed of productive units that operate with a wide range of fishing gears and target species and are distributed along the coast heterogeneously. In particular, the fishing segments of coastal fishing (R01C) and distant water fishing (R01D) have as their common denominator that their main target species supply the Spanish market of fresh fish and are managed through total allowable catches (TACs). In 2013 and according to the Common Fisheries Policy, the Government of Spain passed a law to distribute the TACs in individual quotas for the major fisheries. This allows identification of fishing opportunities at vessel level for these two fishing segments since 2014.

From various censuses and records of fishing vessels, we obtained detailed information on the fishing fleet that has Galicia as its home port. A synthesis of the basic information of these segments by fishing modalities is listed in Table 2. The Galician coastal fishing comprises that fleet that develops its main activity in the Atlantic coastal waters of the Iberian Peninsula using various fishing modalities, such as bottom trawlers, longliners, and purse seiners, although there is a small group that uses gill nets. The distant water fleet operates in the area of the Celtic Sea (mainly in ICES area VI, VII, and VIII) and the most commonly used fishing gear is bottom trawls and longlines.

Table 2

For the main species, the distribution of the fishing opportunities (restrictive quotas) between the different gears is published in 2013 (BOE-A-2013-7605, 2013) and has remained constant (BOE-A-2014-2907, 2014; BOE-A-2015-12992, 2015). Crossing the data of the fishing fleet censuses of Galicia with the individual quotas allocated by fishing modality for a sample of sex species by segment in 2015 and 2016 (Table 3). The Spanish and thereof, the Galicia fishing fleets, use to finish their annual quotas (Vardakoulias and Bernick, 2017). Thus, a variation in their volume (positive or negative) influence the fishing production directly. According to these National regulations, these 7 species are the target for the coastal fishing segment as well as the long distant segment, comprising the sample under analysis. In particular for 2016, the fishing quotas of coastal fishing segment have increased by 7.20% compared to the previous year. This increase was mainly due to the quota of horse mackerel. In addition, these trends are similar for the distant segment, which receive an expansion of their fishing opportunities by 14.37%, in which the growth of the hake quota stands out.

Table 3

We link, individually, the home port of each vessel with its fishing opportunities by species. In this way, it is possible to know the quantities of fishing at municipal level and by Galician coastal area. For the delimitation of the coastal areas of Galicia, we use the criterion of Surís-Regueiro and Santiago (2014), who consider all coastal municipalities disaggregated in 9 maritime areas with geographical continuity and similar socioeconomic characteristics (Fig. 2). Then, we add the data of fishing opportunities of the sample and link vessels to the defined maritime zones. This distribution is based on the assumption that production, income and employment generated by fishing are directly linked to the sea areas where the economic agents are found. The adequacy of this assumption, presented in Surís-Regueiro and Santiago (2014), was reinforced in the report of the Galician Institute of Statistics (IGE, 2015b), where it was defined as "the criterion of the home port".

Figure 2

The result of this process is summarized in Table 4. The uneven distribution of quotas by species and fishing modalities can be aggregated for the Galician coastal fishing fleet implying an increase of 7.20% in fishing opportunities to this segment which will have a positive effect ($\Delta Q>0$) only to 5 out of the 9 defined coastal zones. In the case of long distance segment, the increase is 14.37% in the quotas available for 2016, and this will positively affect 7 out of the 9 coastal areas of Galicia. The relative distribution of inter-annual quota variations can be used as an accurate approximation of the geographical distribution of socioeconomic impacts derived from supply shocks linked to increased fishing opportunities for both fleet segments.

Table 4

3. Results

Before we applied the methodological procedure, we made two assumptions. Our first assumption is that the evolution of the fishing quotas of these 7 species in the sample is representative of the total output of each segment, so that the supply shocks for coastal and distant water fishing in 2016 would be 7.20% and 14.37%, respectively. This fact is confirmed by the Spanish Ministry when defining the target species for each fishing segment (Orden AAA/2534/2015). Our second assumption is that there is no other supply shock in the rest of the sectors initially and that, in recent years, there have been no significant changes in the intersectoral technical requirements, so we can use the last available matrices of input coefficients available for the economy of Galicia (referred to 2011).

The estimated direct and indirect impacts linked to the variation of the fishing opportunities (i.e., supply shocks) on the Galician economy are summarized in Table 5. They are expressed in terms of output, Gross Value Added (GVA), and employment (expressed in full-time equivalent jobs). The impacts in terms of output and GVA can be expressed both in monetary units of the initial year (at 2015 prices) and in units of the final year (at 2016 prices). The new price vector resulting from fishing supply shocks, ($\tilde{\boldsymbol{p}}^1$), offers relevant information on the behavior of the prices of all the outputs by branches of activity, so, *céteris páribus*, it can be used as a deflator if we want to express the impact in € at the end of the period after the shock.

Table 5

The increase in fishing quotas in 2016 could lead to an increase in the level of output and GVA equivalent to €110.6 million and €47.8 million, respectively, (both measured at 2016 prices). Moreover, this increase in fishing activity could mean the net creation of almost 880 full-time jobs.

3.1. The sectoral distribution of impacts

The direct and indirect impacts will affect all the sectors of the Galician economy, but mainly those that have greater linkages (backward and forward) with the fishing sectors, the origin of the supply shock (Table 6). The sectors most affected by socioeconomic impacts would be the fishing sectors that are directly affected by the supply shock (sectors R01C and R01D). The sectors most affected indirectly would be those of accommodation and food service activities (R12) and manufacture of food products (R04), both with strong forward linkages with the fishing sectors (they demand fish as a raw material for their productive activities). Other activities with high impacts on their level of output, GVA, and employment would be those that supply intermediate outputs to the fishing sectors, such as services to companies and individuals (R13), repair and supplies (R08), transportation and storage (R11), and manufacture of petroleum, chemical, plastic and other non-metallic products (R06). These results reinforce the idea behind the distribution of impact through the related economic sectors.

Table 6

3.2. The spatial distribution of impacts

According to the distribution criteria of the impacts shown in Table 4, we distribute the direct and indirect impacts along the 9 coastal areas of Galicia (Table 7). Despite the total net increase in fishing opportunities for 2016, only 6 out of the 9 coastal areas in Galicia would have direct and indirect positive impacts on their economies. The unequal distribution of fishing quotas between different species and different fishing gears would have negative effects on areas III (Arousa), VI (Costa da Morte), and VIII (Cedeira). The areas with the greatest positive impact would be IX (A Mariña), VII (Coruña-Ferrol), and I (Vigo). Mariña and Vigo would benefit from the increase in fishing opportunities in both the coastal and distant water segments. However, Coruña-Ferrol would compensate for the losses of quotas of its distant water fleet with an important increase of the fishing opportunities of its coastal fleet.

Table 7

4. Discussion

The distribution of fishing opportunities both between Member States of the EU and among different fishing sectors or coastal regions is not without conflict. In the case of Spain, the allocation system is relatively new, being approved on July 2013 and setting fixed ratios to allocate the fishing possibilities among the different fishing gear, species, and fleets. Subsequently, a relative stability key was established for all the regions of Spain (similar to the Council Regulation COM(83) 740). The proportionality of the allocation was distributed according to historical catches between 2002–2011 and taking into account socioeconomic aspects as the dependency of fishing segments to the allocated species (Orden AAA/1307/2013). Galicia was clearly affected by this allocation specially for key species relevant to the Spanish market as it is one the most important fishing regions in Spain. For instance, in 2016, the Galician proportion of the total national TAC for hake represents 45%, for megrim 71%, for monkfish 41%, for Norway lobster 78% and for blue whiting 44% of the Spanish TAC (BOE-A-2016-1559, 2016; BOE-A-2016-1666, 2016; BOE-A-2016-1667, 2016; BOE-A-2016-3421, 2016; BOE-A-2016-1561, 2016; BOE-A-2016-1560, 2016).

The paper applies a methodology that aims to improve decision making of fisheries managers by providing socioeconomic information on the effects of the quotas' allocation on both the fisheries sector and the related industrial fabrics and their ripple socioeconomic effects at regional level. Specifically, it is difficult to assume price stability when there is a significant supply shock in fish production (i.e. catches). It should not be forgotten that, in many regions, fish is part of the basic diet of the population. The demand for these products is usually stable and, given a decrease/increase in the volume offered in the markets, prices will react accordingly. There are no disaggregated data on landings and prices of the species regulated by TAC for the coastal, distant and long-distant fleets. The official statistics aggregate by species instead than fishing fleet. However, the landings of fresh fish in Galicia shows an increase of 2.17% in tons and 3.52% in value (Xunta de Galicia, 2016), both of which figures are compatible with the results of the analyses.

In addition, it is common that fish processing industries (e.g. canning, frozen products, etc.) have been developed, or service companies (e.g. restaurants) established, where fish is a fundamental element of the productive activity. Obviously, the availability of these raw materials will have an impact on their production costs and, consequently, on the final price of the outputs offered by these industries. In our case study, the fisheries' sector contributes to the economy with an output of €600 million and provides employment to 9,000 full-time equivalent (FTE) workers (IGE, 2015a). The turnover of the processing sector in Galicia is much higher, achieving an output of €3,000 million and 15,500 FTE workers. Finally, the accommodation and food service activities sector has an output of €5,600 million and 50,000 employees at FTE, most of the jobs related to seafood. The increase in the supply of fish from coastal and distant water fishing would imply a significant decrease in the price levels of their outputs and slight decreases in the average prices of the outputs of almost all the other sectors of activity of the economy of Galicia.

The technical coefficients in physical terms remain stable and prices change according to the elasticity of each output and the dimension of the supply shock. When we operate with prices of the initial period, we will obtain monetary valuations of the monetary unit impacts of that period (in our case € in 2015), which can be expressed in monetary units of the final period (€ in 2016) using the variation in prices after the supply shock. As seen from Table 5 the values of the direct and indirect impacts expressed in monetary units of the final period (year 2016) are numerically lower in relation to those same values expressed in prices of the initial period (year 2015). This is due to the compensating effect that market mechanisms produce.

Another important element of the results obtained is related to the high socioeconomic impact of the supply shocks analyzed. An increase in the catch possibilities of 7.20% and 14.37% for the Galician coastal and distant water fishing fleets, respectively, could mean increases in the value of their outputs of around €11 and €18 million (at 2015 prices). In the extreme case that all this additional production volume (€29 million) was destined for final demand (e.g., final consumption or exports), the direct and indirect impact on the whole of the economy, calculated with the traditional I–O multipliers of the demand model, would reach approximately €44 million in terms of output, €23 million in GVA, and approximately 370 jobs. That is, through traditional multipliers, we would be estimating direct and indirect impacts that barely cover 40% of the total impacts estimated. The difference is that traditional methods for estimating impacts only consider backward linkages (with sectors providing intermediate outputs to fisheries) and the strong linkages that the fishing sector has forward with other sectors of the economy (e.g., food industry and catering). That is to say, with the applied methodology, it is possible to simultaneously capture both the effects derived from the backward links (traditional ones in the I–O models) and the derivatives of the forward linkages, without falling into double counting of the impacts.

In relation to the spatial distribution of the impacts, we observe that the distribution of the fishing opportunities by species and fishing modality can affect the various areas of the coast of Galicia in different ways. Fleets and fishing methods are not evenly distributed along the coast. In the case of zones III, VI, and VIII, the greater presence of coastal fishing modalities (specialized in target species that suffered quota reductions) would have negative impacts on their local economies, in contrast to the positive net effects achieved in the whole economy of Galicia. That is to say, the decision of the regulator on the distribution of the annual quota of a species between the different fishing modalities is not economically neutral from a spatial point of view. Knowing the potential impacts on local coastal economies, the decision on modal share could be used as an instrument to address balancing policies towards areas that are most dependent on fisheries and with few alternative economic activities. In our case, the decisions of the Government of Spain on the internal distribution of quotas would have the greatest positive socioeconomic impact on A Mariña, an area highly dependent on fisheries, since more than 5% of the income and employment there depend directly on fishing activities (Surís-Regueiro and Santiago, 2014). However, the next most-favored coastal areas would be those of Coruña-Ferrol and Vigo, the most urban and industrialized areas of Galicia. In contrast, coastal areas that would suffer the greatest negative impacts would be Cedeira and Arousa, areas considered to be highly dependent on fishing.

In conclusion, the applied analysis allows us to obtain results that can be used for the evaluation of the socioeconomic impacts of fisheries management being a proper tool for *ex-ante* assessment of stock recommendations, improving the effectiveness of marine resources' management, and, finally, attaining the ambitious goal of addressing environmental, governance, and socioeconomics aspects in decision-making. In particular, decisions taken within the Common Fisheries Policy on the Total Allowable Catches by species for 2016 and their distribution between countries, together with the decisions of the Government of Spain on the distribution of quotas by fishing and vessel modalities, could imply direct and indirect impacts equivalent to an increase of the GVA in the economy of Galicia of almost €48 million and the creation of approximately 880 full-time jobs. The methodology used captures simultaneously forward and backward sectoral effects. In addition to the fishing segments involved (coastal fishing and distant water fishing), all other sectors of the Galician economy would be affected by these impacts, particularly those sectors with which fishing has strong forward linkages (the food industry and the hotel and catering industry together would absorb just over 30% of the impacts in terms of output, GVA, and employment). Finally, the spatial distribution of impacts is unequal, depending on the degree of specialization of the fleets in certain fishing modalities. We estimate that negative impacts would be concentrated in two areas that are highly dependent on fishing, so that the consequent effects on their local economies would be relatively greater.

The empirical results are influenced by the price elasticity values of both the fishing outputs and the outputs of the other sectors. In addition, accurate estimates of supply elasticity for all the sectors of an economy are not often available. This fact limits the use of the method and a sensitivity analysis would be advocated to understand the robustness of the results against the price elasticities assumed. However, further applications of this innovative framework could focus on translating different combinations of stock assessment [e.g., Maximum Economic Yield (MEY), Maximum Sustainable Yield (MSY), or Multi-species (MSY)], institutional changes (e.g., the distribution of the marine resources among fleets and regions affected) and market effects (e.g., supply-elasticity, demand, supply and/or price trends) to socioeconomic effects. This will enable the establishment of robust scenarios for supporting decision-making through accurate estimations of the socioeconomic consequences linked to the current quota-based management existing in Europe.

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Figures

Figure 1. Backward and forward sectoral linkages of the fishing sector in Galicia.

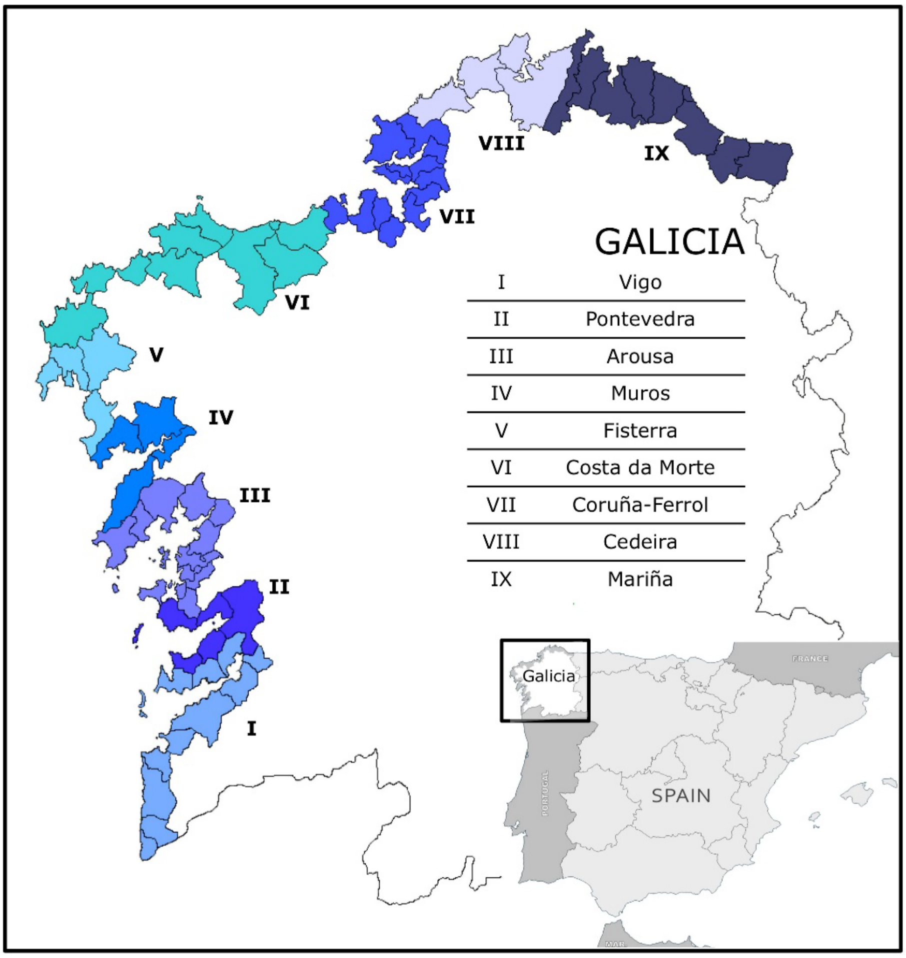
BACKWARD LINKAGES		FORWARD LINKAGES
8,4%	FISHING	4,3%
0,6%	AQUACULTURE	2,5%
0,5%	AGRICULTURE, FORESTRY AND MINING	0,0%
2,8%	MANUFACTURE OF FOOD PRODUCTS	72,9%
2,3%	MANUFACTURE OF TEXTILES, WEARING, WOOD AND PAPER	0,0%
33,3%	MANUFACTURE OF PETROLEUM, CHEMICAL, PLASTIC AND OTHER NON-METALLIC PRODUCTS	0,6%
2,1%	OTHER MANUFACTURES	0,0%
10,9%	REPAIR AND SUPPLIES	0,6%
0,1%	CONSTRUCTION	0,0%
8,2%	WHOLESALE AND RETAIL TRADE	0,0%
16,0%	TRANSPORTATION AND STORAGE	0,0%
0,0%	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	18,6%
13,1%	SERVICES TO COMPANIES AND INDIVIDUALS	0,0%
0,0%	ADMINISTRATION AND PUBLIC SERVICES	0,2%
1,9%	OTHER SERVICES	0,3%

Backward linkages: % of the intermediate consumptions of fishing sector

Forward linkages: % of the intermediate output by fishing sector

Source: Own elaboration based on IGE (2015a).

Figure 2. Delimitation of the 9 marine fishing areas of Galicia.



Source: Surís-Regueiro and Santiago (2014).

Tables

Table 1. The sectors of activity considered, their location and price elasticity

Code	Denomination	NACE Rev.2 codes * and place of fishery	Price elasticity by sector **
R01A	Fishing: Shell-fishing on foot	Part of A 03.1: Intertidal sandbanks areas	-0.75
R01B	Fishing: Artisanal fishing	Part of A 03.1: Inner maritime waters	-0.75
R01C	Fishing: Coastal fishing	Part of A 03.1: Iberian littoral waters, ICES VIIIc and IXa	-0.5
R01D	Fishing: Distant water fishing	Part of A 03.1: Celtic Sea, ICES Vb, VI, VII, VIIIabd	-0.5
R01E	Fishing: Long-distant water	Part of A 03.1: NAFO 3L, 3NO y 3M, NEAFC international waters	-1.0
R02	Aquaculture	A 03.2	-0.75
R03	Agriculture, forestry and mining	A 01; A 02; B 05-09	-0.50
R04	Manufacture of food products	C 10-12	-0.50
R05	Manufacture of textiles, wearing, wood and paper	C 13-18	-0.75
R06	Manufacture of petroleum, chemical, plastic, and other non-metallic products	C 19-24	-0.25
R07	Other manufactures	C 25-32	-0.75
R08	Repair and supplies	C 33; D 35-39	-0.50
R09	Construction	F 41-43	-0.75
R10	Wholesale and retail trade	G 45-47	-0.75
R11	Transportation and storage	H 49-53	-0.50
R12	Accommodation and food service activities	I 55-56	-1.25
R13	Services to companies and individuals	J 58-63; K 64-66; L 68; M 69-75; N 77-82	-0.75
R14	Administration and public services	O 84; O 85-88; R 90-93 non market	-1.00
R15	Other services	O 85-88; R 90-93 market; S 94-96; T 97	-1.25

* Common statistical classification of economic activities in the European Community. Official Journal of the European Union, Regulation (EC) No 1893/2006 of the European Parliament and the Council of 20 December 2006, establishing the statistical classification on economic activities NACE Revision 2.
** Es for fishing segments an Ed for the other segments.
Source: Own compilation

Table 2. Basic characteristics of the coastal and distant water fishing fleets of Galicia, 2015.

Fishing gears and segments	Vessels (nº)	Average Length (m/v)	Average tonnage Gt/v
Coastal fishing	**281**	**20,53**	**93,30**
Bottom trawlers	70	28,40	228,17
Purse seiners	147	17,57	40,13
Longliners	28	17,74	53,10
Gillnets	32	18,24	59,67
Trawlers in Portugal	4	29,37	237,48
Distant water fishing	**72**	**32,07**	**290,31**
Bottom trawlers	29	33,87	323,14
Longliners	43	30,86	268,17

Source: Own compilation from the Fishing Vessel Register of the Autonomous Community of Galicia (http://www.pescadegalicia.gal/rexbuque.html), from the Operational Fleet Census of the Spanish Ministry of Agriculture (http://www.magrama.gob.es/gl/pesca/temas/flota-pesquera-espanola/censo.asp) from the Community Fishing Fleet Register (http://ec.europa.eu/fisheries/fleet/index.cfm).

Table 3. Quotas for seven main species of coastal and distant water fishing in Galicia, 2015 and 2016

Species and fishing segment	Quota 2015 (t)	Quota 2016 (t)	Inter-annual Variation
Coastal fishing	**62.050,4**	**66.515,8**	**7,20%**
Hake (*Merluccius merluccius*)	5.646,4	4.401,0	-22,06%
Mackerel (*Scomber Scombrus*)	11.935,8	11.515,8	-3,52%
Horse Mackerel (*Trachurus spp*)	20.508,4	28.072,1	36,88%
Blue whiting (*Micromesistius poutassou*)	21.692,4	20.405,5	-5,93%
Monkfish (*Lophiidae spp*)	1.153,9	1.005,4	-12,86%
Megrim (*Lepidorhombus spp*)	1.024,9	1.025,8	0,09%
Norway lobster (*Nephrops norvegicus*)	88,7	90,1	1,62%
Distant water fishing	**39.611,6**	**45.303,7**	**14,37%**
Hake (*Merluccius merluccius*)	18.002,5	21.826,2	21,24%
Blue whiting (*Micromesistius poutassou*)	11.058,7	12.238,9	10,67%
Monkfish (*Lophiidae spp*)	1.839,3	1.913,9	4,06%
Megrim (*Lepidorhombus spp*)	5.383,4	5.800,8	7,75%
Norway lobster (*Nephrops norvegicus*)	1.579,2	1.380,3	-12,59%
Pollack (*Pollachius pollachius*)	131,2	137,0	4,39%
Ling (*Molva molva*)	1.617,3	2.006,6	24,08%

Source: Own compilation from several orders of the Spanish Ministry of Agriculture (BOE-A-2013-7605, 2013; BOE-A-2016-1871, 2016; BOE-A-2016-4601, 2016; BOE-A-2015-1099, 2015; BOE-A-2015-2025, 2015; BOE-A-2015-3299, 2015; BOE-A-2014-2907, 2014; BOE-A-2015-1195, 2015; BOE-A-2015-12992, 2015; BOE-A-2015-2378, 2015; BOE-A-2015-3873, 2015; BOE-A-2015-3874, 2015; BOE-A-2015-5050, 2015; BOE-A-2016-1559, 2016; BOE-A-2016-1666, 2016; BOE-A-2016-1667, 2016; BOE-A-2016-3421, 2016; BOE-A-2016-1561, 2016; BOE-A-2016-1560, 2016).

Table 4. Quotas by areas for the coastal and distant water fisheries in Galicia, 2015 and 2016

Coastal area and fishing segment	Quota 2015 (t)	Quota 2016 (t)	ΔQ (t)	Distribution criteria (%)
Coastal fishing	**62.050,4**	**66.515,8**	**4.465,4**	**100,00%**
Area I - Vigo	2.228,1	2.447,8	219,7	4,92%
Area II - Pontevedra	4.534,5	4.909,6	375,1	8,40%
Area III - Arousa	23.475,0	22.956,2	-518,8	-11,62%
Area IV - Muros	7.583,2	7.823,3	240,1	5,38%
Area V - Fisterra	97,5	81,8	-15,8	-0,35%
Area VI - Costa da Morte	3.563,8	3.537,2	-26,6	-0,60%
Area VII - Coruña-Ferrol	5.448,1	8.866,9	3.418,9	76,56%
Area VIII - Cedeira	840,7	694,3	-146,4	-3,28%
Area IX - Mariña	14.279,5	15.198,7	919,2	20,59%
Distant water fishing	**39.611,6**	**45.303,7**	**5.692,1**	**100,00%**
Area I - Vigo	10.052,2	11.996,7	1.944,5	34,16%
Area II - Pontevedra	0,0	0,0	0,0	0,00%
Area III - Arousa	1.549,9	1.791,4	241,5	4,24%
Area IV - Muros	0,0	0,0	0,0	0,00%
Area V - Fisterra	269,3	320,1	50,9	0,89%
Area VI - Costa da Morte	0,0	0,0	0,0	0,00%
Area VII - Coruña-Ferrol	2.052,9	1.695,4	-357,5	-6,28%
Area VIII - Cedeira	1.344,8	1.239,1	-105,7	-1,86%
Area IX – A Mariña	24.342,4	28.261,0	3.918,6	68,84%

Source: Own compilation from several orders of the Ministerio de Agricultura del Gobierno de España (BOE-A-2016-1871, BOE-A-2016-4601, BOE-A-2015-1099, BOE-A-2015-2025, BOE-A-2015-3299, BOE-A-2014-2907, BOE-A-2015-1195, BOE-A-2015-12992, BOE-A-2013-7605, BOE-A-2015-2378, BOE-A-2015-3873, BOE-A-2015-3874, BOE-A-2015-5050, BOE-A-2016-1559, BOE-A-2016-1666, BOE-A-2016-1667, BOE-A-2016-3421, BOE-A-2016-1561, BOE-A-2016-1560).

Table 5. Estimate of direct and indirect impacts on the economy of Galicia.

	Coastal fishing	Distant water fishing	TOTAL
Output (thousands € in 2015)	42,955	74,619	**117,574**
GVA (thousands € in 2015)	20,112	31,462	**51,574**
Output (thousands € in 2016)	41,316	69,354	**110,670**
GVA (thousands € in 2016)	19,015	28,810	**47,825**
Employment (employment FTE)	345.7	534.0	**879.8**

Source: Own compilation.

Table 6. Sectoral distribution of impacts at 2016 prices, Galicia 2016

		Impacts on Output	Impacts on GVA	Impacts on Employment
	Sectors	**(thousands € 2016)**	**(thousands € 2016)**	**(nº FTE)**
R01A	Fishing: Shell-fishing on foot	0	0	0,0
R01B	Fishing: Artisanal fishing	0	0	0,0
R01C	Fishing: Coastal fishing	9,253	6,376	117.2
R01D	Fishing: Distant water fishing	12,709	6,477	131.1
R01E	Fishing: Long-distant water	0	0	0,0
R02	Aquaculture	986	436	15.8
R03	Agriculture, forestry and mining	6,078	2,948	0,0
R04	Manufacture of food products	22,911	3,970	113.2
R05	Manufacture of textiles, wearing, wood and paper	1,270	370	10.3
R06	Manufacture of petroleum, chemical, plastic, and other non-metallic products	5,567	888	14.4
R07	Other manufactures	3,566	806	15.2
R08	Repair and supplies	5,456	2,135	17.9
R09	Construction	2,672	947	20.7
R10	Wholesale and retail trade	4,616	2,519	76.5
R11	Transportation and storage	5,057	2,026	46.7
R12	Accommodation and food service activities	20,616	10,976	190.6
R13	Services to companies and individuals	7,345	5,136	59.6
R14	Administration and public services	801	618	12.6
R15	Other services	1,767	1,199	38.1
	TOTAL GALICIA	**110,670**	**47,825**	**879.8**

Source: Own compilation.

Table 7. Spatial distribution of direct and indirect impacts on the output and GVA (in thousands € 2016) and on Employment (in FTE)

Areas	**Coastal f.**			**Distant water f.**			**Total**		
	Output	**GVA**	**FTE**	**Output**	**GVA**	**FTE**	**Output**	**GVA**	**FTE**
Area I - Vigo	2,033	936	17.0	23,692	9,842	182.4	25,725	10,777	199.4
Area II - Pontevedra	3,471	1,597	29.0	0	0	0.0	3,471	1,597	29.0
Area III - Arousa	-4,801	-2,209	-40.2	2,942	1,222	22.7	-1,858	-987	-17.5
Area IV - Muros	2,221	1,022	18.6	0	0	0.0	2,221	1,022	18.6
Area V - Fisterra	-146	-67	-1.2	620	257	4.8	474	190	3.6
Area VI - Costa da Morte	-246	-113	-2.1	0	0	0.0	-246	-113	-2.1
Area VII - Coruña-Ferrol	31,633	14,559	264.7	-4,356	-1,810	-33.5	27,277	12,749	231.2
Area VIII - Cedeira	-1,354	-623	-11.3	-1,288	-535	-9.9	-2,643	-1,158	-21.3
Area IX – A Mariña	8,505	3,914	71.2	47,745	19,833	367.7	56,250	23,747	438.8
Total Galicia	**41,316**	**19,015**	**345.7**	**69,354**	**28,810**	**534.0**	**110,670**	**47,825**	**879.8**

Source: Own compilation.

Appendix

Table B.1. Definition of the economic terms used and the related notation for the I–O analysis

Variable	Notation	Brief definition
Total output	x_i	Value of the total annual production of the sector i of an economy (thousands of €)
Final demand	f_i	Part of the annual production of the sector i intended for final consumption, investment, or international trade (thousands of €)
Physical production	q_i	Total annual production of sector i measured in physical units (tons)
Price	p_i	Annual average price of an output of the sector i in the market (at € per tons)
Price elasticity of supply	Es_i	Variation of the output average prices of the sector i due to margin variation of the supplied quantity q_i in the market (%)
Price elasticity of demand	Ed_i	Variation of the output average prices of the sector i due to margin variation of the demanded quantity q_i in the market (%)
Value Added	v_i	Value of the total output of the sector i minus the intermediate consumption of goods and services required to produce that output (thousands of €). The value added consists of the income to be distributed among the compensation of employees and the operating surplus.
Value Added per unit of output	v_{ci}	Ratio between the generated value added of the sector i and its total output ($v_{ci}=v_i/x_i$)
Input coefficients	a_{ii}	Proportion of the products from the sector i used for the sector j (z_{ij}) to generate a unit of output of sector j ($a_{ij} = z_{ij} / x_j$)
Input Coefficients Matrix	A	Square matrix of n rows and n columns (n=nº of productive sectors of the economy) composed by the coefficients of the input a_{ii}
Regional Input Coefficients Matrix	A^{RR}	Square matrix of n rows and n columns composed by the regional coefficients of the input (without imports from other economies)
Full-time equivalent jobs	fte_i	Number of persons employed in the sector i in equivalent units of full time dedication
Full-time equivalent jobs per unit of output	fte_{ci}	Number of persons employed in the sector i per unit of output ($fte_{ci}=fte_i /x_i$)
Matrix	In bold	The matrixes are in bold type: **x**, **f**, **q**, $\mathbf{v_c}$, **A**, …
Transposed matrix	´	Transposed matrix symbol: **x´**, **f´**, $\mathbf{v_c}$**´**, **A´**, …

Table B.2. Total Input–Output Transactions Table of Galicia 2011 at basis prices with 19 sectors (in thousands of €)

	R01A	R01B	R01C	R01D	R01E	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	Oi	FC	GCF	Exp	FD	R
R01A	122	526	559	0	0	714	0	20663	0	158	0	160	0	2	0	5278	1	65	97	28345	11331	0	10890	22222	50567
R01B	0	789	1001	519	0	1365	0	39520	0	302	0	307	0	3	0	10094	1	125	185	54213	21672	0	20829	42502	96715
R01C	0	0	2341	1515	1087	2923	0	84597	1	647	0	657	0	6	1	21607	3	267	397	116050	46393	0	44588	90981	207030
R01D	0	0	0	3052	1035	2416	0	69934	0	535	0	543	0	5	1	17862	2	221	328	95935	38352	0	36860	75211	171147
R01E	0	0	0	0	6701	3962	0	114672	1	877	0	890	0	9	1	29289	4	362	538	157306	62886	0	60439	123325	280630
R02	9	95	282	368	639	2365	0	65680	3	5640	0	834	1	29	97	76981	10	5979	3037	162049	73115	0	86856	159971	322020
R03	7	72	213	278	482	1300	515999	1810133	217568	2008668	8488	715349	111828	186335	4	49155	11698	4656	2427	5644660	550589	147331	1128044	1825964	7470624
R04	42	446	1325	1727	2997	23746	817546	1948660	409	16534	60	10231	142	30610	1732	1352715	4387	29692	53940	4296941	2866356	95312	4184950	7146618	11443559
R05	33	356	1056	1377	2388	6999	771	222690	1155728	67826	199799	33616	108683	78465	14871	45133	184879	61573	72513	2258756	958910	38559	2256677	3254146	5512902
R06	487	5233	15529	20246	35119	17967	199968	293783	255925	2200630	2687183	498359	994017	356674	687403	103588	102061	80021	129165	8683358	1540532	73108	4612652	6226292	14909650
R07	30	327	970	1264	2193	1363	97090	291269	75530	397391	4506472	387145	588037	263903	43308	43377	266100	90282	203152	7259203	1108463	1805373	8748226	11662062	18921265
R08	160	1721	5108	6660	11553	34208	60926	190714	135342	891493	510899	1530418	131111	369401	147968	166697	227707	216154	130921	4769162	1198479	0	1504383	2702862	7472024
R09	1	8	24	32	55	272	19022	26464	6174	24702	75835	288179	4528810	126632	88781	34199	471989	76751	46013	5813943	488477	5870037	0	6358514	12172457
R10	120	1290	3827	4989	8655	14147	139325	316198	160243	172681	255263	58320	319915	408545	200369	301004	118789	351550	98455	2933685	5867670	300401	1341515	7509586	10443271
R11	234	2516	7465	9733	16883	14781	80635	321675	107427	295306	178732	119050	128249	861063	1580781	21257	295737	95398	35092	4172014	911854	4139	1079417	1995410	6167424
R12	0	0	0	0	0	0	324	7885	1755	12398	32627	42851	16146	57714	41365	26279	128703	50021	35571	453639	5915328	0	0	5915328	6368967
R13	192	2060	6114	7972	13828	25919	114224	544943	178803	281525	614066	584852	858291	1802481	364701	486480	3306326	873209	587691	10653678	7617210	1584413	1718253	10919876	21573554
R14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10221267	0	0	10221267	10221267
R15	27	292	868	1131	1962	6254	4363	14668	26430	15195	31071	41523	20408	74810	18459	57300	148347	125141	374620	962870	4878798	5474	75110	4959382	5922252
Ci	1466	15731	46683	60864	105578	160701	2050193	6384148	2321339	6392509	9100495	4313284	7805639	4616687	3189843	2848294	5266744	2061467	1774142	58515807	44377682	9924147	26909689	81211518	139727325
GVA	35205	54404	103451	63249	97929	128313	1927490	1493906	952355	1384844	2722476	2811654	4366818	5632257	2267210	3366769	12720372	8159800	4013035	52301537					
X	36670	70135	150134	124112	203508	289014	3977683	7878054	3273694	7777353	11822971	7124938	12172457	10248944	5457053	6215063	17987116	10221267	5787177	110817344					
Imp	13897	26579	56896	47034	77123	33006	3492941	3565505	2239208	7132297	7098294	347086	0	194327	710371	153904	3586438	0	135075	28909981					
R	50567	96715	207030	171147	280630	322020	7470624	11443559	5512902	14909650	18921265	7472024	12172457	10443271	6167424	6368967	21573554	10221267	5922252	139727325					
E	2001	3394	1628	912	955	4606	62821	38695	26585	20057	50219	23343	94454	169792	50383	57310	145929	160092	124665	1037840					

R01A: Shell-fishing on foot; R01B: Artisanal fishing; R01C: Coastal fishing; R01D: Distant water fishing; R01E: Long-distant water; R02: Aquaculture; R03: Agriculture, forestry, and mining; R04: Manufacture of food products; R05: Manufacture of textiles, wearing, wood and paper; R06: Manufacture of petroleum, chemical, plastic ,and other non-metallic products; R07: Other manufactures; R08: Repair and supplies; R09: Construction; R10: Wholesale and retail trade; R11: Transportation and storage; R12: Accommodation and food service activities; R13: Services to companies and individuals; R14: Administration and public services; R15: Other services.
Oi: Intermediate Outputs; FC: Final Consumption; GCF: Gross Capital Formation, Exp: Exports; FD: Final Demand; R: Total Resources; Ci: Intermediate Consumption; GVA: Gross Value Added; X: Regional production; Imp: Imports CIF; E: Employment in number of Full Time Equivalents (FTE)
Source: Own elaboration based on IGE (2015).

Table B.3. Regional Input–Output Transactions Table of Galicia 2011 at basis prices with 19 sectors (in thousands of €)

	R01A	R01B	R01C	R01D	R01E	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13	R14	R15	Oi	FC	GCF	Exp	FD	X
R01A	122	526	559	0	0	714	0	14805	0	16	0	116	0	2	0	3306	1	0	97	20264	5516	0	10890	16406	36670
R01B	0	789	1001	519	0	1365	0	28317	0	30	0	222	0	3	0	6323	1	0	185	38757	10550	0	20829	31379	70135
R01C	0	0	2341	1515	1087	2923	0	60615	1	64	0	475	0	6	1	13536	2	1	397	82964	22583	0	44588	67171	150134
R01D	0	0	0	3052	1035	2416	0	50109	0	53	0	392	0	5	1	11190	2	0	328	68584	18669	0	36860	55528	124112
R01E	0	0	0	0	6701	3962	0	82164	1	87	0	643	0	9	1	18348	3	1	538	112458	30611	0	60439	91050	203508
R02	9	95	282	368	639	2365	0	49530	3	559	0	684	1	29	97	69442	9	5559	3037	132708	69450	0	86856	156306	289014
R03	7	71	210	274	475	1292	510272	1251877	172690	116624	5087	17897	103018	81495	0	29703	8601	4541	2240	2306374	429691	147331	1128044	1671309	3977683
R04	41	437	1296	1690	2931	7696	721426	666023	116	688	59	2955	97	23483	71	699749	3145	14056	25888	2171846	1426682	95312	4184950	5706208	7878054
R05	30	322	956	1246	2162	2628	370	48223	233828	30826	75802	14267	91393	32009	2275	9341	120994	15506	48628	730806	249522	38559	2256677	2542888	3273694
R06	356	3821	11339	14783	25643	10011	84223	57205	99777	442129	559525	352916	513460	56358	416196	16368	21894	18343	10233	2714579	393463	73108	4612652	5062774	7777353
R07	4	39	115	150	259	476	48081	84706	20184	153219	1553438	176090	332883	36789	4819	15992	34863	11631	53001	2526738	116896	1805373	8748226	9296233	11822971
R08	160	1721	5108	6660	11553	34208	60365	189704	133186	737396	453138	1456161	128094	366097	147324	165171	222397	184090	119542	4422076	1198479	0	1504383	2702862	7124938
R09	1	8	24	32	55	272	19022	26464	6174	24702	75835	288179	4528810	126632	88781	34199	471989	76751	46013	5813943	488477	5870037	0	6358514	12172457
R10	115	1234	3662	4774	8281	13607	130575	299773	154648	165963	245868	56110	304141	389368	131792	285697	112547	336568	94635	2739358	5867670	300401	1341515	7509586	10248944
R11	221	2369	7031	9166	15900	13637	72375	290912	97788	272028	165412	110395	117392	807697	1183807	19412	252215	77770	29721	3545248	828290	4139	1079417	1911805	5457053
R12	0	0	0	0	0	0	315	4018	1006	8667	18206	26683	9244	33654	39105	24240	60263	45635	28699	299735	5915328	0	0	5915328	6215063
R13	164	1756	5211	6794	11785	21624	105582	330196	146160	194723	454582	441644	671309	1512631	306555	443695	2127666	816506	483674	8082257	7332606	1584413	1718253	9904859	17987116
R14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10221267	0	0	10221267	10221267
R15	27	292	868	1131	1962	6254	4363	14067	20824	14600	30030	39046	19327	74162	18343	54523	144261	107100	337155	888336	4821072	5474	75110	4898841	5787177
Ci	1256	13480	40003	52154	90470	125450	1756969	3548709	1086386	2162373	3636982	2984875	6819170	3540429	2339168	1920235	3580852	1714058	1284011	36697030	39446821	9924147	26909689	74120314	110817344

R01A: Shell-fishing on foot; R01B: Artisanal fishing; R01C: Coastal fishing; R01D: Distant water fishing; R01E: Long-distant water; R02: Aquaculture; R03: Agriculture, forestry and mining; R04: Manufacture of food products; R05: Manufacture of textiles, wearing, wood and paper; R06: Manufacture of petroleum, chemical, plastic, and other non-metallic products; R07: Other manufactures; R08: Repair and supplies; R09: Construction; R10: Wholesale and retail trade; R11: Transportation and storage; R12: Accommodation and food service activities; R13: Services to companies and individuals; R14: Administration and public services; R15: Other services.

Oi: Intermediate Outputs; FC: Final Consumption; GCF: Gross Capital Formation, Exp: Exports; FD: Final Demand; X: Regional production; Ci: Intermediate Consumption

Source: Own elaboration based on IGE (2015).