



Everything comes at a price: The impact of eliminating harmful subsidies in the Spanish marine resources industry

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ABSTRACT

One of the objectives for the European Horizon 2021–2027 is completely eliminating harmful fishery subsidies. Spain was the country that received the greatest amount of the previous European Marine Fishery Funds framed within EU horizon-2020. We explore the potential impacts of eliminating these harmful subsidies in the sectors related to marine resources in Spain. We address it with the novelty of applying an input–output model, disaggregating marine resource activities into three sectors (fishing, aquaculture and seafood processing sector). Our results show that the subtraction of these harmful subsidies will entail significant reductions in the value-added of the analysed sectors, which will impact their supply and demand of inputs affecting the rest of the sectors of the economy. It will affect the final demand for their outputs and the sectors linked to them. We derive policy recommendations to smooth the transition to a fishery-related industry without harmful subsidies.

1. Introduction

The subsidies for the global fishing sector were estimated to be \$ 35.4 billion in 2018 [41]. China was the nation that allocated the most aid during that period, representing 21% of the total, followed by the EU with 11%, the United States and the Republic of Korea with 10% and 9%, respectively. In the case of the EU member countries, the subsidies represented around \$ 3803 million [41]. More than half of these grants, about \$ 2036 million (53.5%), were allocated to subsidies considered "harmful" [40,41].

Some subsidies are considered "harmful" because they help the fishing fleet to obtain "artificial" benefits by reducing their costs (by subsidising, for example, the diesel consumption of vessels). These subsidies contribute directly or indirectly to keep the fishing capacity of the European fleet above the reproductive capacity of marine resources. This mismatch has accelerated the degradation of marine resources, even leading several fish stocks to overexploitation [14,39].

This perverse effect that subsidies have on natural resources has become a priority problem to be solved on international agendas. One of the main initiatives was taken by the members of the United Nations, who included a specific measure to address this problem within objective 14 (Life below water) in the Sustainable Development Goals (SDG).

Precisely, measure 14.6 proposed eliminating all types of fishing subsidies that favour overfishing, overcapacity and illegal fishing activities by 2020. However, the EU countries did not achieve this objective by the end of the period set. In part because they continued to grant, among others, the modernisation of vessels indirectly related to exploiting marine resources. However, there was some progress towards entirely eliminating these subsidies, like subsidies for the construction of boats. In addition, the percentage of funds for other "beneficial" subsidies also increased, as was the case with those granted to improve data collection, monitoring and increase enforcement measures [38].

It should be noted that the "harmful" subsidy elimination alone would not solve overcapacity and overfishing problems, but it would help to a large extent to reduce them. Among other positive impacts, it would contribute to regenerating the most threatened fish stocks and increase economic benefits in the fishing sector and the sectors related to it in the medium and long term [7,24]. Another positive effect is the release of public funds, which could be used for more beneficial purposes for society (among which, to mitigate the impact of the withdrawal of these subsidies on employment and the incomes that depend on the sectors affected). However, the true scope of the elimination of subsidies will largely depend on the interdependence between the sectors associated with marine resources and the rest of the economy [6].

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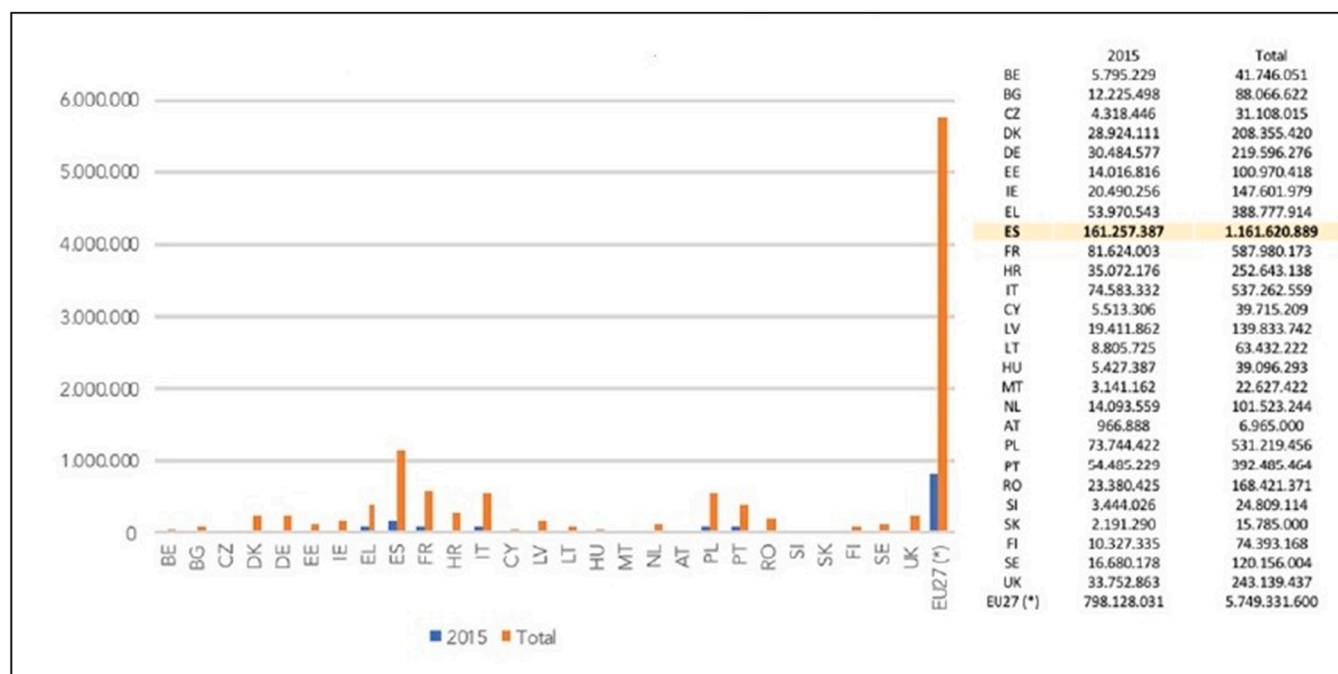


Fig. 1. Total EMFF funds by country for the year 2015.

Source: own elaboration with data from European Commission EC [9]. Units in €. More details in Annex 1 (Table A.1).

The initial effects of its elimination would occur by reducing the gross value added (GVA) of the marine resource sectors because these subsidies are part of it [12]. Likewise, there would be an increase in production costs in the industries where the subsidies are eliminated, which will affect the value of the production of other sectors that require inputs from these sectors [43]. These variations in production, both in the sectors associated with fishery resources and those indirectly affected, will ultimately affect their demand, probably causing significant losses in all these sectors. Therefore, the extension and scope of the effects of eliminating harmful fishery subsidies is a relevant subject of analysis.

Since the objective of Measure 14.6 of the Sustainable Development Goals (SDG) was not achieved, this study investigates the potential impacts of the complete elimination of "harmful" subsidies as a goal of the Horizon 2030 agenda. Thus, we analyse the effects of a complete withdrawal of the funds of the previous European Maritime and Fisheries Fund (EMFF) program (2013–2020) for Spain in the EMFF funds program for 2021–2027. The analysis focuses on three sectors of the Spanish industry of marine resources (fishing, aquaculture and processing of seafood), applying an input–output model based on the year 2015. The research analyses five different scenarios; the initial (baseline) scenario, three scenarios where subsidies are eliminated in each sector and a fifth, where they are subtracted jointly. Comparing each scenario with the initial one, we estimate: (i) the impacts on the GVA of the industries; (ii) the forward and backward linkages of the industries; and (iii) the potential monetary losses that the fall in final demand would cause in each of the three sectors analysed, as well as in the rest of the sectors of the economy, estimated through the price elasticity of demand. We intend that the results of the research serve as a guide to policymakers for the design of policies that help to minimise the negative impacts of the subsidies reform and, thus, facilitate the transition of the Spanish economy towards a model with a more sustainable fishing sector free from "harmful" subsidies.

This article is structured as follows: Section 2 reviews the relevant literature; Section 3 presents the context of the study; Section 4 describes the sources of information and data; Section 5 shows the methods applied; Section 6 presents and discusses the results; Section 7 draws the conclusions of the work and some brief policy recommendations.

2. Literature review

There currently needs to be unanimity to define what a harmful subsidy is. It occurs because each type of subsidy can have different economic, social and environmental impacts, depending on the circumstances [33]. Some authors and organisations have proposed their classification of subsidies according to their effects and how they can be measured [2,23,32,33,35,44–46]. These classifications respond to different criteria, such as their impact on trade and development [46] or the form taken by the subsidies (direct or indirect financial transfers) and the value they bring to the industry [45]. To carry out this study, we have focused on the categorisation made by Sumaila et al. [40], because it is simple and focus precisely on the impacts of subsidies on marine resources. These authors differentiate them into three large groups, according to the impact they have on marine resources: (i) beneficial subsidies, (ii) harmful subsidies and (iii) ambiguous subsidies. In the first group, for example, subsidies for research and management (general services) can be considered since it is understood that they will not negatively affect marine resources. Among the aids that negatively affect the environment are those allocated for subsidising the diesel used by vessels or those allocated for their repair or modernisation. Regarding the subsidies considered ambiguous, it refers to those that a priori may seem to be beneficial for the environment, but whose effects may become adverse for the marine resources, leading them to their over-exploitation [40]. An example of this type of aid is for "license withdrawal" programs. When vessel owners retire their license in one country, they can decide to go to another country where they can continue fishing. It invalidates the program's effectiveness, and the problem moves elsewhere.

Input–output models have been widely used to analyse the economic impacts of the fishing sector in different countries [8,28], including Spain [42]. In the Spanish case, we found an article on the aquaculture industry that analyse subsidies [18]. Likewise, few studies are dedicated to Spain's fish product processing sector. We can cite García-del-Hoyo et al. [15] and, particularly, the work of Fernández-Polanco et al. [13], which has helped us to elaborate our research. Their work analyses the price demand and income demand elasticities of canned fish products in

Table 1

Contribution and co-financing of the EMFF and the Spanish government to the objectives of the EU, technical assistance and other aid, during 2014–2020.

	Measure	EU	National Contribution	TOTAL
Promote fisheries that are environmentally sustainable, resource-efficient, innovative, competitive, and knowledge-based	1 - Articles 33, 34 and 41 (2) (Article 13 (2) of the EMFF)	82,178,128 €	82,178,128 €	164,356,256 €
	2 - Financial allocation for the rest of the priority 1 of the Union (Article 13 (2) of the EMFF)	270,313,132 €	90,104,378 €	360,417,510 €
		352,491,260 €	172,282,506 €	524,773,766,00 €
Encourage aquaculture that is sustainable from the environmental point of view, efficient in the use of resources, innovative, competitive and based on knowledge	-	205,905,843 €	68,635,448 €	274,541,291 €
Favour marketing and transformation	1 - Storage aid (Article 67) (Article 13 (6) of the EMFF)	10,149,073 €		10,149,073 €
	2-Compensation to the outermost regions (article 70) (article 13, paragraph 5, of the EMFF)	60,900,000 €		60,900,000 €
	3 - Financial allocation for the rest of the priority 5 of the Union (Article 13, Financial allocation for the rest of the priority 5 of the Union (Article 13 (2) of the EMFF)	203.360.626 €	67.786.876 €	271.147.502 €
		274.409.699 €	67.786.876 €	342.196.575 €
		832.806.802 €	308.704.830 €	1.141.511.632 €

Source: own elaboration with data from the EC (2018)[10].

the Spanish market.

Extensive literature is focused on different aspects of the Spanish fishing sector using bio-economic analyses [1,31,37]. Among these papers, the objective of analysis of Merayo et al. [33] is closely related to ours. They analyse the design of an income policy for fishers to minimise the impact on well-being after reducing subsidies to the sector. They conclude that if an effective income policy accompanies the elimination of these subsidies, the welfare of the fishers is maintained while the fishing pressure is reduced. Studies for other countries applying general equilibrium models analyse how the fishing sector and the economy are affected after the elimination of fishing subsidies. In this context, Jinji [26] analyses how the elimination of unemployment subsidies and price compensation affects the different actors involved in the fishing sector. He concludes that, depending on the economy's circumstances, eliminating these aids may cause fishers to increase the levels of fishing pressure to compensate for their loss of income. Carvalho et al. [6] focus on removing harmful subsidies in the case of the Azores Islands. They conclude that the economy benefits in a general way after the elimination of these subsidies, while both exports and employment are negatively affected.

This paper contributes to the literature by providing an analysis of the economic impacts of the elimination of harmful subsidies from the fishing-related sectors in Spain. The paper fills this gap in the literature applying an input–output model, which allows us to consider adequately the interdependencies between the different productive sectors of the economy. The findings of this research will help policymakers to design effective policies that avoid unnecessary costs in the transition towards a more sustainable marine resource industry.

3. Study context

Spain stands out for being the major fishing country in the EU. It has around 8000 km of coastline and key geographical points, giving it a comparative advantage over other European countries. This leading position is reflected by its almost one million tonnes of fish caught or raised annually [9]. Of that amount, 882 thousand tons, with a market value of 1982 million euros, were caught by the fishing fleet through its 19,720 vessels, and total employment was estimated at 31,166 full-time equivalents in 2013 [9]. That same year, the aquaculture sector obtained a production value of 501 million euros, employing 27,180 workers, of which 6639 (24.42%) were full-time. In contrast, the seafood processing sector employed 18,391 workers, 17,702 (96.25%) were full-time [9].

The EMFF is a European restructuring and investment program that

finances the Operational Program (OP) "Fisheries and Marine 2014–2020". These European funds prioritise the achievement of objectives set by the country itself and those included in the European strategy "Horizon 2020". In order to achieve these objectives, a total of 5749.33 million euros of European funds were awarded to the EU member states for the period 2014–2020. In this distribution, Spain received the largest sum from the EMFF, € 1161.62 million (Fig. 1). Along with these European funds, the different governments also contributed to co-finance the OP projects in their respective countries. In particular, the Spanish government contributed € 396.65 million to co-finance its OP projects [9]. The Spanish authorities' contribution and that provided by the EU added up to a total budget of € 1558.28 million available to implement the OPs of "Fishing and Marine 2014–2020" in Spain.

In order to carry out the different measures adopted in the OP (Table 1) for the three sectors analysed, 524.49 million were allocated to the fishing sector (352.49 from European funds and 172.28 from the Spanish government); 342.19 million to the processing sector (274.40 from European funds and 67.78 from Spanish funds); and the aquaculture sector received 274.54 million (205.90 million from European funds and 68.63 million from Spanish funds). It represented a total of € 1141.51 million (€ 832.80 million from European funds and 308.70 million € from Spanish funds) (Table 1) [9]. The rest of the funds that complete the total budget of PO "Fishing and Marina 2014–2020", € 416.76 million, were allocated to the rest of the priorities.² It should be noted that for this study, only the subsidies assigned to the three sectors under study (fishing, aquaculture and seafood processing) are considered.

It is estimated that, between 2013 and 2019, the EU countries allocated, including European and national funds, 54% of these funds to "beneficial" subsidies, 6% to ambiguous subsidies, and the remaining 40% to those classified as "harmful" [41]³ (Annex 1, Table A.3). Spain was the only EU country that appears as one of the countries that granted most subsidies during that period worldwide. In addition, it presented percentages very different to the European average (18% of

² They were allocated to the implementation of the Common Fisheries Policy; increase employment and territorial cohesion; favour the development and execution of the Integrated Maritime Policy; and technical assistance. More details in Table A.2 of the Annex ([10], p. 163).

³ \$ 1523 million to "harmful" subsidies; \$ 2036 million to "beneficial" subsidies; and \$ 244 million to those classified as "ambiguous". Estimates calculated from 2013 to 2019, in current \$ 2018 [41].

Table 2

Percentages of total EMFF and national funds by sector over total EMFF and national funds for the three sectors for 2014–2020.

	EMFF	National funds
Fishing	42.33%	55.81%
Aquaculture	24.72%	22.23%
Processing	32.95%	21.96%

Source: Own estimates based on EC data (2016)[9]

funds allocated to "beneficial" subsidies, 1% to ambiguous ones, and 81% to "harmful" subsidies). In the 'harmful' category, three primary items of subsidies stood out: exemption from fees, fishing access and subsidies for fuel, which were the ones that received the most resources (Annex 1, Table A.4).

Approximately 20% of the total funds were allocated to the European aquaculture sector, around 1725 million euros ([11], Regulation (EU) No 508/2014). The Spanish sector was the most subsidised (274.5 million euros), followed by the Polish (269 million), Italian (221 million), French (118.4 million) and Romanian (112.3 million). These five countries received more than 80% of total aid, although they only represented 51% of total production [18]. The principal purpose of these grants was to promote technological development, improve the working conditions of employees and the performance of SMEs, protect and conserve biodiversity, and facilitate knowledge and new skills for workers [18]. However, some subsidies favour the expansion of the sector's production. It implies a more intensive use of marine resources to meet the new requirements of such expansion (for example, increased demand for fish and other foods for fish farms) so that they can ultimately endanger marine resources [3].

Canned fish has established itself as one of the top products in the Spanish diet [30]. The Spanish seafood processing sector was the second most important among the EU member states in 2015, being 15% of the total value of this EU production [9]. The EU allocated 274 million euros in subsidies to this sector in Spain and 67 million provided by the Spanish government [9], representing 17% of the total EMFF funds allocated to this sector. It is estimated that practically all the aid was allocated to "harmful" subsidies during 2014–2020 [38]. An example is subsidies aimed at increasing storage capacity. This type of investment, which promotes the vertical expansion of the sector, can indirectly harm fishery resources since the increase in storage capacity gives more room for an increase in fishing pressure [3].

4. Data description

4.1. Input–output tables

The information in the Spanish input–output tables is collected by the National Institute of Statistics of Spain [25]. The industrial sectors in the input–output table are initially grouped into 68 industries and coded up to 3 NACE digits. For this study, we used this level of disaggregation, but we reduced the number of industries to 38 to adjust to the object of analysis of this article. This reduction in the number of sectors has an effect known in the literature as "aggregation bias" (more details in [20]). We disaggregate the sectors related to marine resources as follows: we divide fish and other fishery products; aquaculture products; fishing support services (NACE 03) into Marine Fisheries (NACE 031), Aquaculture (NACE 032) and processing and conservation of fish, crustaceans and molluscs (NACE 102). The latter includes the sector for processing fish, crustaceans and molluscs (NACE 1021) and the manufacturing of canned fish (NACE 1022).

4.2. Subsidies

Initially, € 1558,280,753 was allocated (€ 1161,620,889 from European funds and € 396,659,864 from national funds) for the 2014–2020

period. Of the total amount of the EMFF, € 832,807,052 were allocated to the three sectors analysed, representing 71.69% of the total. Likewise, of the total national funds, € 308,704,830 were allocated to these sectors, representing 77.83% (Table 1). Regarding funds allocated to finance OPs objectives for 2015, we only know those granted by the EU, €161,257,387, which is 13.88% of the total EMFF for 2014–2020. However, we do not have the exact amount of national funds for 2015. Assuming it was the same percentage (13.88%), the estimate of these funds is € 55,064,723.61.

To calculate the amount allocated to the three sectors during the whole year 2015, the share of the total amount of European funds allocated for the entire period for the three sectors (832,807,052 €) over the total EMFF funds for the same period (€ 1161,620,889) (71.69%) is applied over € 161,257,387.00, obtaining an estimate of € 115,611,871.04. In addition, to calculate the national funds for the three sectors in 2015, we follow the same criteria. In this case, we apply the percentage (77.83%) that represents the amount allocated to the three sectors for 2014–2020 (€ 308,704,830) over the total national funds for this same period (€ 396,659,864) on the amount of total national funds assigned for 2015 (€ 55,064,723.61), which gives a value of € 42,854,716.81. (Table 2).

Finally, according to Sumaila et al. [41], around 81% of subsidies in Spain are considered harmful, and 1% are ambiguous (Annex 1, Table A.3). Based on these percentages, we estimate for Spain a total of 82% of the EMFF budget for 2015, including national co-financing, assuming that ambiguous subsidies can also cause adverse effects (column 5, Table 3).

4.3. Price elasticities of demand

The data to calculate the price elasticity of demand in Spain is extracted from Santiago and Surís-Regueiro [42]. They constructed their data from different sources of information detailed in their article. They differentiate five categories, assigning three different values to the elasticities for each product category in different scenarios (low elasticity, reference, and high). We have taken the value assigned in the reference scenario. Moreover, as data are not available for all the industries (such as Coal mining; Oil and gas extraction; Metallurgy; Machinery; Other Manufacturers; Electricity; Gas manufacturing, Hot water supply; Water purification and distribution; Finance sector; Business services; Education; and Health care sector), we took the missing elasticity values from Ogarenko and Hubacek [36]. For those sectors that did not match in both classifications, we assigned the elasticity value of a closely related sector; that is, the value assigned to a sector classified under the same SIC code.

Table 4 shows the price elasticity of demand for the different sectors considered. We can observe that two out of the three sectors analysed in this research, the fishing and the seafood sectors, show the lowest absolute value in their elasticities among all sectors, 0.5 each, while the aquaculture sector exhibits a slightly higher absolute value, 0.75. These low absolute values of the elasticities are mainly explained because these sectors produce basic consumer goods.

5. Input–output model

Input–output models are considered a stylised form of a general equilibrium model that allows analysing the effects of external shocks within an economy [17]. Leontief's input–output model is a matrix model that allows monitoring of the interactions between industrial sectors after a shock from supply or demand [36]. The Leontief pricing model is an appropriate analysis tool for our analysis. First, the model allows us to analyse the effects of relative changes in the prices of the products demanded due to the variation in the prices of primary inputs. In addition, another great advantage is that it allows knowing the short-term consequences that may come from the political reform of the elimination of subsidies. Consequently, it enables anticipating them and

Table 3

Estimates of harmful subsidies for Spain by sector in 2015.

Sector	Budget	2014–2020	2015 *	82% Harmful [41]	Total HFS per sector	Total HFS
Fishing	EMFF	352,491,260.00 €	48,933,512.26 €	40,125,480.06 €	59,736,954.11 €	129,942,715.87 €
	National	172,282,506 €	23,916,431.78 €	19,611,474.06 €		
Aquaculture	EMFF	205,905,843.00 €	28,584,243.74 €	23,439,079.87 €	31,252,074.58 €	
	National	68,635,448 €	9528,042.33 €	7812,994.71 €		
Processing	EMFF	274,409,949.00 €	38,094,115.03 €	31,237,174.32 €	38,953,687.17 €	
	National	67,787,876 €	9410,381.53 €	7716,512.85 €		

Source: Own estimates based on data from EC (2016) [9] and Sumaila et al. [41]. * The percentage that represents the amount allocated for the three sectors over the total EMFF for 2014–2020, 71.69%, has been applied to estimate the amount that is allocated for European funds for 2015. Making the same approximation, in this case 77.83%, we calculated the amount of national aid for the year 2015.

Table 4

Price elasticity of demand.

Industrial sector	Price elasticity of demand
Agriculture and forestry	-0.50
Fishing	-0.50
Aquaculture	-0.75
Mining and quarrying	-0.50
Manufacture of food products, beverages and tobacco products	-0.50
Seafood processing	-0.50
Manufacture of textiles, wearing apparel, leather and related products	-0.75
Manufacture of wood and paper products, and printing	-0.75
Manufacture of coke, and refined petroleum products	-0.25
Manufacture of chemicals and chemical products	-0.75
Manufacture of pharmaceuticals, medicinal chemical and botanical products	-0.75
Manufacture of rubber and plastics products, and other non-metallic mineral products	-0.75
Manufacture of basic metals and fabricated metal products, except machinery and equipment	-0.75
Manufacture of computer, electronic and optical products	-0.75
Manufacture of electrical equipment	-0.75
Manufacture of machinery and equipment n.e.c.	-0.75
Manufacture of transport equipment	-0.75
Other manufacturing, and repair and installation of machinery and equipment	-0.75
Electricity, gas, steam and air-conditioning supply	-0.50
Water supply, sewerage, waste management and remediation activities	-0.50
Construction	-0.75
Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.75
Transport and storage	-0.50
Accommodation and food service activities	-1.25
Publishing, audiovisual and broadcasting activities	-0.75
Telecommunications	-0.75
IT and other information services	-0.75
Financial and insurance activities	-0.75
Real estate activities	-0.75
Legal, accounting, management, architecture, engineering, technical testing and analysis activities	-0.75
Scientific research and development	-0.75
Other professional, scientific and technical activities	-0.75
Administrative and support service activities	-1.00
Public administration and defence, compulsory social security	-1.00
Education	-1.00
Human health services	-1.00
Residential care and social work activities	-1.00
Arts, entertainment and recreation	-1.00
Other services	-1.25
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	-1.25
Activities of extra-territorial organisations and bodies	-1.25

Source: Elasticities computed based on data from Ogarenko and Hubacek [36], Santiago and Surís-Regueiro [42] and Eurostat [12].

adopting strategies to reduce their impacts [36].

This model shows that a production unit's total price is equal to its production's total cost, including the value of intermediate and primary inputs. We start from the standard algebraic formulation of the price model that is commonly presented in the literature as:

$$\mathbf{p}' = \mathbf{v}' (\mathbf{I} - \mathbf{A})^{-1} = \mathbf{v}' \mathbf{L} \quad (1)$$

Where \mathbf{p}' represents the $1 \times n$ vector of prices of the outputs produced by industries; \mathbf{v}' is the $1 \times n$ vector of the prices of primary inputs; \mathbf{I} is the identity matrix; \mathbf{A} is the $n \times n$ matrix of technical coefficients; $(\mathbf{I} - \mathbf{A})^{-1}$ inverse Leontief matrix, represented as \mathbf{L} , which includes the direct and indirect requirements of inputs produced by industry i for each unit of final output produced by industry j .

Apart from the intermediate inputs necessary for the production process, the industries require primary inputs that have their prices. Therefore, the total GVA of the industries is composed of the workers' wages, business surplus and subsidies net of taxes [12]. Expression (2) is used to capture how the variation of the price of any GVA component affects the sectoral interactions.

$$\Delta \mathbf{p}' = \Delta \mathbf{v}' \mathbf{L} \quad (2)$$

Eq. (2), $\Delta \mathbf{p}'$ refers to the variation in the price vector, while $\Delta \mathbf{v}'$ is the vector that includes the variations in the price of primary inputs. In our study, removing subsidies will modify the GVA vector ($\Delta \mathbf{v}'$), which will change prices ($\Delta \mathbf{p}'$).

As we will see in the results section, the effects of changes in the prices of primary inputs (\mathbf{v}), where subsidies are included, will entail a series of dispersion effects on the value added of the industries. These will involve an increase in costs that will be transferred to the “buyer” sectors via an increase in the price of inputs. Moreover, these same “buyer” sectors will increase the prices of their production to assume these increases in their costs and so forth [34].

5.1. Forward and backward linkages

The variation in the industry's production has two possible effects on the rest of the industries. First, when sector j increases its production, this same sector will demand inputs from other sectors to carry out this increase. It means a causal effect in the demand model known as backward linkages and indicates the connection of a specific sector with others (upstream) from which it acquires inputs. Second, the increase in the sector j 's production also implies that other industries use more product j as input. The relationship between a sector and those it sells its production (downstream) is called forward linkages, the causal direction in the supply model.

Backward linkages measure the degree of dependence of the production of sector j on the inputs that come from other industries i . Estimating the direct and indirect effects throughout the economy is done through the total sums of the columns of the requirements matrix, $\mathbf{L} = [\mathbf{l}_{ij}]$, the measure of total backward linkages.

Table 5

GVA reductions by scenario compared to Scenario 1.

Sector	Sc.2-Sc.1	Sc.3-Sc.1	Sc.4-Sc.1	Sc.5-Sc.1
Fishing	-58.092	-0.097	-0.003	-58.192
Aquaculture	-0.459	-30.336	-0.001	-30.795
Seafood processing	-0.202	-0.032	-37.894	-38.128
Three marine resource sectors	-58.753	-30.466	-37.897	-127.116
Total	-72.777	-32.702	-38.896	-144.374
Indirect *	-14.024	-2.236	-0.998	-17.258

Source: estimates of the authors of this study based on data from INE [25]. * In the GVA of the rest of the industries. Scenario (Sc.) Units: million euros

$$BL(t)_j = \sum_{i=1}^n l_{ij} \quad (3)$$

The forward linkages measure the capacity of each industrial sector to induce the use of its production as input for other industrial sectors [5]. Their estimation used to rely on the sum of coefficients of the rows of **L**, the inverse Leontief matrix. However, this estimate is taken with scepticism for conceptual reasons (to learn more, see [34]), so the coefficients of the Ghosh model⁴ were suggested as a more appropriate alternative [4,27]. Thus, "total" forward linkages are estimated through the sum of the rows of the inverse Ghosh matrix, **G** = [*g*_{ij}], which are represented as:

$$FL(t)_i = \sum_{j=1}^n g_{ij} \quad (4)$$

The interest of this study is to know the effects in the three sectors of the fishing industry that we have disaggregated. Thus, elements in the diagonal in **A** or **L** that correspond to the three sectors were omitted. It allows knowing the 'net' impacts derived from these sectors' forward and backward linkages with the rest of the industries (as suggested in [34]).

5.2. Elasticities

Productive sectors need more time to react and adapt their production in the short term. Despite being one of the limitations of input-output models, this fact is quite in line with reality since the technical adjustments necessary to adapt their techniques of production to new demand usually take more than a year. Consequently, it is the consumers who end up assuming the costs via prices [36].

In order to capture the effect, it has on final household demand, we propose to follow the methodology of Ogarenko and Hubacek [36]. Specifically, they relate the variation obtained in the Leontief price model, and the changes in the quantities demanded:

$$\varepsilon = \frac{\Delta q p}{q \Delta p} \quad (5)$$

In expression (5), ε represents the demand-price elasticity, while Δp and Δq express the variations in prices and quantities, respectively. From this expression, it is possible to estimate the change in quantities, Δq , due to price fluctuations, using:

$$\Delta q = \frac{\varepsilon}{p} \frac{q \Delta p}{p} \quad (6)$$

Adapting (6) in matrix terms, we obtain:

$$\Delta y = \Delta \hat{p} \hat{e} y_0 \quad (7)$$

We use the prices obtained in the price model (2) and diagonalise

⁴ The Ghosh model is a supply-side oriented input-output model which captures the impacts of primary inputs on industry prices downstream the production process [21].

Table 6

Top 10 GVA reduction compared to Scenario 1.

#	Sc. 2 (Fishing)	GVA Reduction	#	Sc. 3 (Aquaculture)	GVA Reduction
1	Manufacture of food products, beverages and tobacco products	-6.5606	1	Manufacture of food products, beverages and tobacco products	-1.0461
2	Accommodation and food service activities	-4.4366	2	Accommodation and food service activities	-0.7074
3	Education	-0.4815	3	Fishing	-0.0973
4	Aquaculture	-0.4585	4	Education	-0.0768
5	Agriculture and forestry	-0.3811	5	Agriculture and forestry	-0.0608
6	Seafood processing	-0.2022	6	Seafood processing	-0.0322
7	Residential care and social work activities	-0.1836	7	Residential care and social work activities	-0.0293
8	Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.1495	8	Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.0238
9	Public administration and defence, compulsory social security	-0.1207	9	Public administration and defence, compulsory social security	-0.0192
10	Arts, entertainment and recreation	-0.1158	10	Arts, entertainment and recreation	-0.0185
#	Sc. 4 (Seafood processing)	GVA Reduction	#	Sc. 5 (all sectors)	GVA Reduction
1	Manufacture of food products, beverages and tobacco products	-0.5123	1	Seafood processing	-38.1282
2	Accommodation and food service activities	-0.1957	2	Aquaculture	-30.7953
3	Agriculture and forestry	-0.0831	3	Manufacture of food products, beverages and tobacco products	-8.1191
4	Manufacture of textiles, apparel, leather and related products	-0.0209	4	Accommodation and food service activities	-5.3398
5	Manufacture of wood and paper products, and printing	-0.0181	5	Education	-0.5761
6	Education	-0.0178	6	Agriculture and forestry	-0.5249
7	Manufacture of chemicals and chemical products	-0.0157	7	Residential care and social work activities	-0.2174
8	Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.0152	8	Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.1886
9	Arts, entertainment and recreation	-0.0080	9	Public administration and defence, compulsory social security	-0.1462
10	Human health services	-0.0072	10	Manufacture of textiles, apparel, leather and related products	-0.1444

Source: authors' estimates based on INE data (2020) [25]. Scenario (Sc.) Units: million euros

Table 7

Total backward linkage and forward linkage multipliers in the Spanish economy (top 10 sectors and marine resource sectors).

#	Backward linkage multipliers	Multiplier	#	Forward linkage multipliers	Multiplier
1	Construction	2.3003	1	Electricity, gas, steam and air-conditioning supply	2.6414
2	Transport and storage	2.1618	2	Manufacture of food products, beverages and tobacco products	2.4168
3	Manufacture of pharmaceuticals, medicinal chemical and botanical products	2.0960	3	Manufacture of basic metals and fabricated metal products, except machinery and equipment	2.2997
4	Accommodation and food service activities	2.0797	4	Manufacture of coke, and refined petroleum products	2.2228
5	IT and other information services	2.0171	5	Construction	2.1786
6	Manufacture of electrical equipment	2.0162	6	Manufacture of wood and paper products, and printing	2.1594
7	Manufacture of chemicals and chemical products	2.0100	7	Manufacture of chemicals and chemical products	2.0759
8	Publishing, audiovisual and broadcasting activities	1.9998	8	Manufacture of rubber and plastics products, and other non-metallic mineral products	2.0524
9	Manufacture of rubber and plastics products, and other non-metallic mineral products	1.9930	9	Publishing, audiovisual and broadcasting activities	2.0440
10	Manufacture of computer, electronic and optical products	1.9793	10	Water supply, sewerage, waste management and remediation	2.0332
19	Seafood processing	1.6720	32	Fishing	1.4759
36	Fishing	1.4032	38	Aquaculture	1.1441
40	Aquaculture	1.1303	39	Seafood processing	1.0435

Source: own estimation based on INE data (2020) [25]. Units: euros.

them, $\Delta \hat{p}$; y_0 represents the final demand vector of households, and \hat{e} is the diagonal vector of the matrix of elasticities obtained from the study of Santiago and Surís-Regueiro [42] (Table 4). Finally, using expression (7), we estimate the change that will suffer the final demand of the sectors of marine resources by households.

6. Results and discussion

6.1. Total GVA and net impacts

As specified in expression (2) in the methodology section, we estimate the total (net) impacts on GVA in the sectors analysed. To do this, we simulate five different scenarios, including an initial reference scenario without modifying the subsidies, Scenario 1. Scenario 2 refers to the elimination of subsidies in the fishing sector. Scenario 3 refers to the elimination of subsidies in the aquaculture sector. Scenario 4 refers to the elimination of subsidies in the seafood processing industry. Finally, Scenario 5 refers to removing subsidies in the three marine resource sectors. These scenarios will allow us to compare the effects of

Table 8

Total backward linkage multipliers by analysed sector (top 10 sectors and marine resource sectors).

#	Fishing sector	Multiplier	#	Aquaculture sector	Multiplier
1	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0525	1	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0162
2	Transport and storage	0.0491	2	Transport and storage	0.0151
3	Electricity, gas, steam and air-conditioning supply	0.0235	3	Fishing	0.0080
4	Other manufacturing, and repair and installation of machinery and equipment	0.0209	4	Electricity, gas, steam and air-conditioning supply	0.0072
5	Administrative and support service activities	0.0203	5	Other manufacturing, and repair and installation of machinery and equipment	0.0064
6	Manufacture of coke, and refined petroleum products	0.0200	6	Administrative and support service activities	0.0062
7	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0192	7	Manufacture of coke, and refined petroleum products	0.0061
8	Manufacture of transport equipment	0.0186	8	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0059
9	Financial and insurance activities	0.0167	9	Manufacture of transport equipment	0.0057
10	Water supply, sewerage, waste management and remediation activities	0.0143	10	Financial and insurance activities	0.0051
28	Aquaculture	0.0032	38	Seafood processing	0.00002
38	Seafood processing	0.0001			
#	Seafood processing				Multiplier
1	Manufacture of food products, beverages and tobacco products				0,0135
2	Agriculture and forestry				0,0081
3	Fishing				0,0035
4	Wholesale and retail trade, repair of motor vehicles and motorcycles				0,0032
5	Transport and storage				0,0019
6	Administrative and support service activities				0,0015
7	Manufacture of wood and paper products, and printing				0,0013
8	Electricity, gas, steam and air-conditioning supply				0,0012
9	Manufacture of chemicals and chemical products				0,0012
10	Aquaculture				0,0011

Source: estimates of the authors of this study based on INE data (2020) [25]. Units: euros

eliminating harmful subsidies in each sector separately and, as a whole, with that of the initial situation (Annex 1, Table A.5).

6.1.1. Scenario 2

When we compare the impacts of each of the scenarios to the initial situation (Scenario 1), we see that Scenario 2 would entail total losses of € 72.77 million (58.75 million in the three sectors analysed and 14.02 million in the other sectors), with the fishing sector being the most affected (€ 58.09 million) (Table 5). The next most affected is the sector of the manufacture of food products, beverages and tobacco products,

Table 9

Total forward linkage multipliers by analysed sector (top 10 sectors and marine resource sectors).

#	Fishing sector	Multiplier	#	Aquaculture sector	Multiplier
1	Transportation and storage	0.0738	1	Transportation and storage	0.0224
2	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0513	2	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0155
3	Manufacture of food products, beverages and tobacco products	0.0382	3	Manufacture of food products, beverages and tobacco products	0.0116
4	Electricity, gas, steam and air-conditioning supply	0.0319	4	Electricity, gas, steam and air-conditioning supply	0.0097
5	Administrative and support service activities	0.0267	5	Administrative and support service activities	0.0081
6	Manufacture of coke, and refined petroleum products	0.0248	6	Manufacture of coke, and refined petroleum products	0.0075
7	Other manufacturing, and repair and installation of machinery and equipment	0.0223	7	Other manufacturing, and repair and installation of machinery and equipment	0.0068
8	Financial and insurance activities	0.0205	8	Financial and insurance activities	0.0062
9	Mining and quarrying	0.0188	9	Mining and quarrying	0.0057
10	Manufacture of transport equipment	0.0180	10	Manufacture of transport equipment	0.0054
28	Aquaculture	0.0025	20	Fishing	0.0025
34	Seafood processing	0.0012	34	Seafood processing	0.0004
#					Multiplier
1	Seafood processing				0.0145
2	Manufacture of food products, beverages and tobacco products				0.0082
3	Agriculture and forestry				0.0031
4	Wholesale and retail trade, repair of motor vehicles and motorcycles				0.0028
5	Transportation and storage				0.0018
6	Administrative and support service activities				0.0017
7	Electricity, gas, steam and air-conditioning supply				0.0012
8	Manufacture of wood and paper products, and printing				0.0011
9	Manufacture of chemicals and chemical products				0.0010
10	Manufacture of rubber and plastics products, and other non-metallic mineral products				0.0009
33	Financial and insurance activities				0.0001
36	Fishing				0.0001
	Aquaculture				0.0001

Source: estimates of the authors of this study based on INE data (2020 [25]). Units: euros

with € 6.56 million. Then the sector related to accommodation and food service activities with a reduction of 4.43 million € (Table 6).

6.1.2. Scenario 3

Scenario 3 simulates the elimination of subsidies in the aquaculture sector. This scenario would imply a reduction in the GVA of all sectors of € 32.70 million (€ 30.46 million would be in the three sectors analysed and € 2.23 million in the GVA of the rest of the industrial sectors). The most significant impact would be in the GVA of the aquaculture sector, € 30.33 million (Table 5), followed by the sector of the manufacture of food products, beverages and tobacco products (€ 0.51 million) and accommodation and food service activities (€ 0.19 million) (Table 6).

6.1.3. Scenario 4

In Scenario 4 the total losses would represent € 38.89 million, most of which would be assumed by the three sectors studied (€ 37.90 million), the seafood processing sector being the most affected (€ 37.89 million),

Table 10

Impacts on demand (absolute values).

#	Sc. 2	Demand reduction	#	Sc. 3	Demand reduction
1	Accommodation and food service activities	4.4690	1	Aquaculture	2.5100
2	Fishing	3.2588	2	Accommodation and food service activities	0.7126
3	Manufacture of food products, beverages and tobacco products	2.3693	3	Manufacture of food products, beverages and tobacco products	0.3778
4	Education	0.0777	4	Education	0.0124
5	Seafood processing	0.0738	5	Seafood processing	0.0118
6	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0669	6	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0107
7	Residential care and social work activities	0.0564	7	Residential care and social work activities	0.0090
8	Real estate activities	0.0486	8	Real estate activities	0.0077
9	Arts, entertainment and recreation	0.0472	9	Arts, entertainment and recreation	0.0075
10	Other services	0.0453	10	Other services	0.0072
#	Sc. 4	Demand reduction	#	Sc. 5	Demand reduction
1	Seafood processing	13.8333	1	Seafood processing	13.9189
2	Accommodation and food service activities	0.1971	2	Accommodation and food service activities	5.3787
3	Manufacture of food products, beverages and tobacco products	0.1850	3	Fishing	3.2644
4	Manufacture of textiles, wearing apparel, leather and related products	0.0078	4	Manufacture of food products, beverages and tobacco products	2.9322
5	Agriculture and forestry	0.0074	5	Aquaculture	2.5480
6	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0068	6	Education	0.0930
7	Arts, entertainment and recreation	0.0033	7	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0844
8	Education	0.0029	8	Residential care and social work activities	0.0667
9	Real estate activities	0.0028	9	Real estate activities	0.0591
10	Other services	0.0024	10	Arts, entertainment and recreation	0.0580

Source: own estimation based on data from Ogarenko and Hubacek [36]; Santiago and Suris-Regueiro [42]; INE [25]. Scenario (Sc.) Units: million euros

Table 11

Impact on the final demands of aggregate and individual sectors by scenario.

Sector	Sc.2	Sc.3	Sc.4	Sc.5
Fishing	3.2588	0.0055	0.0001	3.2644
Aquaculture	0.0379	2.5100	0.0001	2.5480
Seafood processing	0.0738	0.0118	13.8333	13.9189
Marine resource sectors analysed (total)	3.3705	2.5273	13.8335	19.7313
Total impact on economy	10.7576	3.7052	14.2620	28.7248
Indirect *	7.3871	1.1779	0.4285	8.9935

Source: own estimation based on INE data (2020) [25]. * In the demand of the rest of the industries. Scenario (Sc.) Units: million euros

Table 12

Differences between impacts on GVA and amount of subsidies eliminated.

	Sc.2- Sc.1	Sc.3- Sc.1	Sc.4- Sc.1	Sc.5- Sc.1
Three marine resource sectors	-58.753	-30.466	-37.897	-127.116
Subsidies	59.736	31.252	38.953	129.942
Net differences in the three sectors	0.983	0.786	1.056	2.826
By sector	-58.092	-30.336	-37.894	-
Subsidies	59.736	31.252	38.953	-
Net differences	1.644	0.916	1.059	-
Total economy	-72.777	-32.702	-38.896	-144.374
Subsidies	59.736	31.252	38.953	129.942
Net differences	-13.041	-1.45	0.057	-14.432

Source: own estimate based on INE data (2020) [25]. Scenario (Sc.) Units: million euros.

* Sector where subsidies are eliminated

and implying reductions in GVA in the rest of the sectors of € 0.99 million (Table 5). This reduction in the GVA of other sectors is the smallest of the three scenarios analysed so far. It is striking that both the GVA of the fishing sector, in the 33rd position, and that of the aquaculture sector, in the 40th, is not among the most affected by the subtraction of these subsidies. In this scenario, the impacts on GVA are also less significant in those sectors related to the activity of marine resource sectors (Table 6).

6.1.4. Scenario 5

Finally, as expected, Scenario 5 is the one that would have the most impact on the three sectors analysed and the rest of the industries of the economy. In this scenario, total losses in all industries GVA would be quantified in approximately € 144.37 million, of which € 127.11 million would correspond to the sectors related to the fishing industry. Being the GVA of the extractive fishing sector, the most affected (€ 58.19 million), but also significant the reduction in aquaculture (€ 30.79 million) and seafood processing (€ 38.12 million) GVA. In addition to causing a total reduction in the GVA of the rest of the sectors of € 17.25 million (Table 5).

Table A.1

EMFF Program Budgets for 2014–2020.

	2014	2015	2016	2017	2018	2019	2020	Total
BE	5722,130.00	5795,229.00	5848,204.00	5942,991.00	6081,279.00	6122,861.00	6233,357.00	41,746,051.00
BG	12,071,289.00	12,225,498.00	12,337,253.00	12,537,214.00	12,828,942.00	12,916,663.00	13,149,763.00	88,066,622.00
CZ	4263,975.00	4318,446.00	4357,922.00	4428,555.00	4531,602.00	4562,588.00	4644,927.00	31,108,015.00
DK	28,559,270.00	28,924,111.00	29,188,510.00	29,661,596.00	30,351,790.00	30,559,328.00	31,110,815.00	208,355,420.00
DE	30,100,054.00	30,484,577.00	30,763,242.00	31,261,850.00	31,989,281.00	32,208,016.00	32,789,256.00	219,596,276.00
EE	13,840,012.00	14,016,816.00	14,144,946.00	14,374,205.00	14,708,679.00	14,809,253.00	15,076,507.00	100,970,418.00
IE	20,231,798.00	20,490,256.00	20,677,561.00	21,012,701.00	21,501,645.00	21,648,669.00	22,039,349.00	147,601,979.00
EL	53,289,776.00	53,970,543.00	54,463,896.00	55,346,644.00	56,634,503.00	57,021,756.00	58,050,796.00	388,777,914.00
ES	159,223,336.00	161,257,387.00	162,731,468.00	165,369,007.00	169,216,972.00	170,374,037.00	173,448,682.00	1,161,620,889.00
FR	80,594,423.00	81,624,003.00	82,370,140.00	83,705,190.00	85,652,923.00	86,238,597.00	87,794,897.00	587,980,173.00
HR	34,629,786.00	35,072,176.00	35,392,777.00	35,966,420.00	36,803,321.00	37,054,974.00	37,723,684.00	252,643,138.00
IT	73,642,561.00	74,583,332.00	75,265,111.00	76,485,002.00	78,264,728.00	78,799,884.00	80,221,941.00	537,262,559.00
CY	5443,762.00	5513,306.00	5563,703.00	5653,880.00	5785,440.00	5824,999.00	5930,119.00	39,715,209.00
LV	19,167,006.00	19,411,862.00	19,589,309.00	19,906,810.00	20,370,021.00	20,509,307.00	20,879,427.00	139,833,742.00
LT	8694,653.00	8805,725.00	8886,220.00	9030,247.00	9240,371.00	9303,555.00	9471,451.00	63,432,222.00
HU	5358,928.00	5427,387.00	5477,000.00	5565,770.00	5695,280.00	5734,223.00	5837,705.00	39,096,293.00
MT	3101,540.00	3141,162.00	3169,876.00	3221,253.00	3296,208.00	3318,746.00	3378,637.00	22,627,422.00
NL	13,915,788.00	14,093,559.00	14,222,391.00	14,452,906.00	14,789,211.00	14,890,336.00	15,159,053.00	101,523,244.00
AT	954,693.00	966,888.00	975,727.00	991,541.00	1014,613.00	1021,551.00	1039,987.00	6,965,000.00
PL	72,814,233.00	73,744,422.00	74,418,532.00	75,624,702.00	77,384,410.00	77,913,547.00	79,319,610.00	531,219,456.00
PT	53,797,969.00	54,485,229.00	54,983,288.00	55,874,453.00	57,174,593.00	57,565,539.00	58,604,393.00	392,485,464.00
RO	23,085,512.00	23,380,425.00	23,594,150.00	23,976,562.00	24,534,471.00	24,702,232.00	25,148,019.00	168,421,371.00
SI	3400,584.00	3444,026.00	3475,509.00	3531,839.00	3614,022.00	3638,734.00	3704,400.00	24,809,114.00
SK	2163,649.00	2191,290.00	2211,321.00	2247,162.00	2299,451.00	2315,174.00	2356,953.00	15,785,000.00
FI	10,197,069.00	10,327,335.00	10,421,739.00	10,590,653.00	10,837,087.00	10,911,188.00	11,108,097.00	74,393,168.00
SE	16,469,779.00	16,680,178.00	16,832,654.00	17,105,477.00	17,503,503.00	17,623,188.00	17,941,225.00	120,156,004.00
UK	33,327,114.00	33,752,863.00	34,061,403.00	34,613,468.00	35,418,887.00	35,661,073.00	36,304,629.00	243,139,437.00
EU27 (*)	788,060,689.00	798,128,031.00	805,423,852.00	818,478,098.00	837,523,233.00	843,250,018.00	858,467,679.00	5,749,331,600.00

Source: EC (2016) [9]. Units: € million

6.2. Backward and forward multipliers

Table 7 shows the productive sectors with highest multipliers. The multipliers for the backward linkages are shown in the left column, while the multipliers for the forward linkages are indicated in the right column. With the backward multipliers calculated through expression (3), we can identify which sectors are essential buyers of other sectors. The sectors that present the highest multipliers of this type are considered “driving” sectors of the economy; that is, they require the production of other sectors to be able to carry out theirs. They are the construction sector (2.30); transportation and storage (2.16); manufacture of pharmaceutical, medicinal chemical and botanical products (2.09).

Using expression (4) we can extract the forward linkage multipliers, as shown in the right column (Table 7). The first positions are occupied by the electricity, gas, steam and air conditioning supply (2.64); manufacture of food products, beverages and tobacco (2.41); and manufacture of basic metals and fabricated metal products, except machinery and equipment (2.29). The outputs of these three industries are

Table A.2

Rest of EMFF funds.

	EU	National Contribution	TOTAL
Favour the application of the CFP	79,041,351 € 67,174,603 € 9738,751 €	19,760,338 € 7463,845 € 4173,751 €	98,801,689 € 74,638,448 € 13,912,502 €
Increase employment and territorial cohesion	107,673,734 €	19,001,248 €	126,674,982 €
Favour the development and execution of the Integrated Maritime Policy	5334,672 €	17,605,526 €	22,940,198 €
Technical assistance	59,850,976 € 328,814,087 €	19,950,326 € 87,955,034 €	79,801,302 € 416,769,121 €

Source: EC (2018) [10]

Table A.3

Amount of funds allocated to the different categories of subsidies.

Country	Beneficial	Harmful	Ambiguous	Total
China	434	5.886	941	7.261
UE	1523	2036	244	3803
USA	2187	1136	106	3429
Rep. Korea	1635	1,5	50	3185
Japan	534	2111	215	2,86
Russian Federation	295	1162	54	1512
Thailand	74	1069	6	1149
Canada	388	194	271	853
Norway	278	527	41	846
Spain	150	683	11	844
Taiwan	69	708	10	787

Source: Sumaila et al., [41]. Units: Millions of \$

Table A.4

Total estimate of subsidies granted in Spain by category, 2013–2019.

Category	Type	Constant 2018 USD
Beneficial	Fisheries management	25,413,428.31
Beneficial	Fishery R&D	36,118,031.01
Beneficial	MPAs	88,665,450.12
Capacity-enhancing	Boat construction & renovation	4823,053.74
Capacity-enhancing	Fisheries dev, projects	16,033,494.34
Capacity-enhancing	Fishing port development	7675,249.92
Capacity-enhancing	Market, & storage infrastructure,	16,243,693.93
Capacity-enhancing	Tax exemption	461,545,847.80
Capacity-enhancing	Fishing access	90,588,507.18
Capacity-enhancing	Fuel subsidies	85,922,565.74
Ambiguous	Fisher assistance	3622,852.51
Ambiguous	Vessel buyback	7000,077.80
Ambiguous	Rural fisher communities	0.00

Source: estimates by the authors of this study based on data from Sumaila et al. [41]. Units: millions of \$ (constant 2018 \$).

in high demand by other industries for their production processes. As seen in both classifications, none of the three marine resource sectors analysed is among the top ten positions (Table 7), which indicates that they do not stand out as suppliers or buyers within the Spanish economy.

Expression (3) allows us to analyse the multipliers of the three sectors considered in their input producers. We see that the fishing sector is the one that generates the most significant impact among its suppliers. Thus, for every euro produced, a total economic impact of € 1.406 is generated in the economy, followed by the aquaculture sector with € 1.131 (Annex 1, Table A.6). Analysed individually (Table 8), the sector that receives the greatest indirect impacts from the fishing and aquaculture sectors is the sector wholesale and retail trade, repair of motor vehicles and motorcycles; € 0.053 and € 0.016, respectively. The impacts on the sector transport and storage sector are also important, € 0.049 and € 0.015, respectively. They also make significant use of supplies from the electricity, gas, steam and air conditioning supply sector, generating significant indirect impacts (€ 0.023 from the fishing sector and € 0.007 from the aquaculture sector). Although it stands out that the aquaculture sector has the fishing sector among one of its principal suppliers, generating € 0.008 indirectly.

As regards the seafood processing sector, it has its highest indirect multipliers over its suppliers in the sector of food products, beverages and tobacco products (€ 0.013); agricultural and forestry (€ 0.008); and, thirdly, the fishing sector (€ 0.003). As can be seen, the fishing sector appears as one of the main sectors for aquaculture and seafood processing, where more significant indirect economic impacts are generated (Table 8).

With expression (4) we calculate the total individual impacts that the supplier industries produce on the buyer industries. Doing the analysis individually, shown in Table A.7 (Annex 1), we highlight that the fishing sector shows the most significant impact on the Spanish economy, despite all three sectors presenting similar impacts. Every euro invested

in this sector generates € 1.476 in the economy, followed by the aquaculture sector (€ 1.144). Table 9 shows the highest impacts that the sectors analysed have on their 'client' industries for each monetary unit of production. In this case, every euro produced in the fishing sector indirectly generates € 0.073 in the sector of transportation and storage; € 0.051 in wholesale and retail trade, repair of motor vehicles and motorcycles; and € 0.038 in the production of food products, beverages and tobacco products. As regards the aquaculture sector, every euro indirectly produces € 0.022 in the transport and storage sector; € 0.015 in wholesale and retail trade, repair of motor vehicles and motorcycles; and € 0.011 in the production of food products, beverages and tobacco. Finally, every euro in the seafood processing industry indirectly produces € 0.014 in the sector manufacture of food products, beverages and tobacco products; and € 0.008 in the agricultural sector. Of the top 10 industries with the highest multiplier suppliers to customers, five belong to the services sector, three to the industrial sector and two to the primary sector. It indicates the remarkable dependence they have on the tertiary sector.

6.3. Variations in final demand

In this section, we present the variations in final demand due to the elimination of subsidies. The values presented in Tables 10 and 11 were calculated with expression (7). It can be observed that the greatest reductions in demand occur in the sectors for which subsidies are eliminated, except for Scenario 2, where the accommodation and food services sector is the most affected.

Due to the withdrawal of subsidies, the industries analysed will also experience a reduction in the demand for their products. It can be observed in Table 11 that Scenario 5 involves a reduction in final demand of all sectors as a whole of € 28.72 million. This scenario would cause a € 19.73 million loss in demand from sectors related to fishing activity and a significant decrease in the seafood processing sector (€ 13.91 million). This fall is 0.62% greater than this sector in Scenario 4. Likewise, in Scenario 5, the decrease in demand in the rest of the productive sectors reaches € 8.99 million.

It should be noted that, after Scenario 5, it is in Scenario 2 where there is the most significant reduction in demand from the rest of the sectors (€ 7.38 million). Actually, this is the sector where the largest amount of subsidies is subtracted (€ 59.73 million). Finally, Scenario 4 presents the most significant impacts compared to scenarios 2 and 3 (€ 14.26 million), being the most significant reductions in the sector where subsidies are removed, the seafood processing sector (€ 13.83 million).

6.4. Discussion of the results

The economic activity of the marine resource sectors can be affected by shocks of different kinds. They can occur due to natural causes (weather events), new regulations (reductions in TACs), as well as shocks in demand for their products [42]. In our case, it is interesting to see that the impacts of the regulation of subsidies occur in the sectors analysed and extend to other sectors.

As shown in Table 12, as Scenario 5 is the aggregation of scenarios 2, 3 and 4, it has, as expected, the most significant implications in terms of the total reduction in GVA in the three marine resource sectors (€ 127.11 million). This is less than the total amount added by all the subsidies subtracted in the three sectors (€ 129.94 million). It indicates that eliminating the subsidies considered in the three sectors would release a bulk of public resources higher than the impact caused in the GVA of the three marine resource sectors, approximately € 2.82 million (though it will also have some negative impacts on the GVA of the rest of sectors of the economy that should be considered). This situation would also occur in the other scenarios, although these net differences are lower than those mentioned before. For example, in Scenario 2, the reduction in the total GVA of the three marine resource sectors (€ 58.75 million) is less than the total sum of the subsidies removed in the fishing sector (€ 59.73

Table A.5

GVA reductions by sector and by scenario with respect to the initial scenario.

	SC1GVA	SC2GVA	SC3GVA	SC4GVA	SC5GVA
Agriculture and forestry	48131.8158	48131.4347	48131.7550	48131.7327	48131.2909
Fishing	16097.9870	16039.8948	16097.8897	16097.9844	16039.7949
Aquaculture	4958.4048	4957.9463	4928.0688	4958.4040	4927.6095
Mining and quarrying	21586.6134	21586.5906	21586.6098	21586.6113	21586.5848
Manufacture of food products, beverages and tobacco products	69098.7434	69092.1828	69097.6972	69098.2310	69090.6243
Seafood processing	2098.2304	2098.0283	2098.1982	2060.3367	2060.1023
Manufacture of textiles, apparel, leather and related products	28738.5116	28738.4051	28738.4946	28738.4906	28738.3672
Manufacture of wood and paper products, and printing	31733.7274	31733.6331	31733.7124	31733.7093	31733.6000
Manufacture of coke, and refined petroleum products	17221.3493	17221.3132	17221.3436	17221.3433	17221.3014
Manufacture of chemicals and chemical products	41301.1664	41301.0582	41301.1492	41301.1507	41301.0252
Manufacture of pharmaceuticals, medicinal chemical and botanical products	23300.1756	23300.1354	23300.1692	23300.1718	23300.1252
Manufacture of rubber and plastics products, and other non-metallic mineral products	39402.1896	39402.1260	39402.1795	39402.1825	39402.1088
Manufacture of basic metals and fabricated metal products, except machinery and equipment	29056.4296	29056.4050	29056.4256	29056.4268	29056.3983
Manufacture of computer, electronic and optical products	31587.0408	31586.9967	31587.0337	31587.0362	31586.9851
Manufacture of electrical equipment	31442.8829	31442.8492	31442.8776	31442.8798	31442.8407
Manufacture of machinery and equipment n.e.c.	15677.6927	15677.6818	15677.6909	15677.6917	15677.6791
Manufacture of transport equipment	34191.9560	34191.9318	34191.9521	34191.9536	34191.9257
Other manufacturing, and repair and installation of machinery and equipment	34567.5862	34567.5599	34567.5820	34567.5842	34567.5537
Electricity, gas, steam and air-conditioning supply	49526.2428	49526.2082	49526.2373	49526.2389	49526.1988
Water supply, sewerage, waste management and remediation	33530.3459	33530.3170	33530.3413	33530.3432	33530.3097
Construction	93343.2925	93343.2400	93343.2841	93343.2869	93343.2261
Wholesale and retail trade, repair of motor vehicles and motorcycles	141505.2101	141505.0605	141505.1862	141505.1949	141505.0215
Transportation and storage	97150.2042	97150.1091	97150.1891	97150.1977	97150.0874
Accommodation and food service activities	116894.3073	116889.8707	116893.5999	116894.1116	116888.9676
Publishing, audiovisual and broadcasting activities	50549.5583	50549.5107	50549.5507	50549.5548	50549.4997
Telecommunications	40277.4337	40277.3970	40277.4278	40277.4308	40277.3883
IT and other information services	61835.3814	61835.3183	61835.3714	61835.3765	61835.3033
Financial and insurance activities	71360.2133	71360.1820	71360.2083	71360.2110	71360.1747
Real estate activities	238516.1561	238516.0763	238516.1434	238516.1515	238516.0590
Legal, accounting, management, architecture, engineering, technical testing and analysis activities	63329.9331	63329.8814	63329.9248	63329.9303	63329.8704
Scientific research and development	23672.4939	23672.4686	23672.4899	23672.4921	23672.4627
Other professional, scientific and technical activities	45051.5901	45051.5100	45051.5773	45051.5855	45051.4927
Administrative and support service activities	60384.0797	60384.0257	60384.0711	60384.0764	60384.0138
Public administration and defence, compulsory social security	82636.8202	82636.6996	82636.8010	82636.8139	82636.6740
Education	81849.8847	81849.4032	81849.8079	81849.8668	81849.3085
Human health services	65863.9307	65863.8196	65863.9130	65863.9235	65863.7946
Residential care and social work activities	22550.8740	22550.6904	22550.8447	22550.8695	22550.6566
Arts, entertainment and recreation	38340.0055	38339.8897	38339.9871	38339.9975	38339.8632
Other services	37778.7677	37778.6620	37778.7508	37778.7621	37778.6396
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	37900.1154	37900.0539	37900.1056	37900.1116	37900.0402
Activities of extra-territorial organisations and bodies	0.0000	0.0000	0.0000	0.0000	0.0000

Source: estimates of the authors of this study based on INE data (2020) [25]. Units: millions of € Note: Scenario 1 includes the initial values of the GVA before eliminating the subsidies. The rest of the scenarios (2, 3, 4 and 5) represent the variations that occur after subtracting subsidies.

million). Likewise, Scenario 3 presents a net difference of € 0.78 million, while Scenario 4 would entail positive net impacts of € 1.05 million. However, if we only compare the individual impacts on the GVA of each specific sector where the subsidies are removed with the total amount of subsidies extracted, these net differences are obviously greater (Table 12), particularly in Scenario 2 (where it is a 67% higher, reaching € 1.64 million).

However, when considering the impacts of a withdrawal of subsidies, policy makers must consider the impact of this withdrawal on all the sectors of the economy, not just the three marine resource sectors. If we compare total economic impacts with the amount of subsidies removed, we observe that scenarios 2 and 5 present similar net impacts, € – 13.04 and € – 14.43 million, respectively. It is crucial to remember that, despite both net differences being quite similar, the former amount is given only in one sector (fishing). This result indicates the need for designing concrete plans to mitigate the impacts of removing the subsidies of the fishing sector, without neglecting the impacts on the rest of sectors. Contrary to the rest of the scenarios, Scenario 4 is the only one where the amount of subsidies subtracted is greater than the total sum of impacts on the economy, € 0.05 million. It happens because the impacts on the entire economy (€ – 38.89 million) are mainly concentrated in the seafood processing sector (€ – 37.89 million). That is, contrary to Scenario 2, a vast part of impacts is concentrated in just one sector. It should

also be noted that the impacts on final demand in Scenario 4, as it happens in each scenario, are mainly given in the sector where subsidies are eliminated. However, the effects on the seafood processing sector demand are substantially higher than in the fishing and aquaculture sectors. In any case, the total impact in any analysed scenario will also depend on the use of the public resources released, which is beyond the scope of this paper.

The three sectors analysed allocate most of their production to final consumers, or it is exported. However, one of the leading sectors demanding its production is the transport and storage sector; and the production of food products, beverages and tobacco products. This fact shows that reducing the supply of inputs to these industries could impact other sectors that depend on them. It is also interesting to note that the multipliers that the extractive fishing sector has as a supplier of inputs to other industries are much higher (five times greater) than the aquaculture sector and almost seven than the seafood processing sector. It points out its importance in the supply chain and potential consequences on the production of their "client" companies.

We can do a similar reading when any of the three sectors analysed is in the role of the 'client' of other sectors. In this case, by reducing its input demands, mainly from the transportation and storage; wholesale and retail trade; repair of motor vehicles and motorcycles; and supply of electricity, gas, steam and air conditioning sectors, these will also see

Table A.6
Backward multipliers.

#		Fishing		Aquaculture		Seafood processing
1	Fishing	1.0106	Aquaculture	1.0024	Seafood processing	1.0004
2	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0525	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0162	Manufacture of food products, beverages and tobacco products	0.0135
3	Transport and storage	0.0491	Transport and storage	0.0151	Agriculture and forestry	0.0081
4	Electricity, gas, steam and air-conditioning supply	0.0235	Fishing	0.0080	Fishing	0.0035
5	Other manufacturing, and repair and installation of machinery and equipment	0.0209	Electricity, gas, steam and air-conditioning supply	0.0072	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0032
6	Administrative and support service activities	0.0203	Other manufacturing, and repair and installation of machinery and equipment	0.0064	Transport and storage	0.0019
7	Manufacture of coke, and refined petroleum products	0.0200	Administrative and support service activities	0.0062	Administrative and support service activities	0.0015
8	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0192	Manufacture of coke, and refined petroleum products	0.0061	Manufacture of wood and paper products, and printing	0.0013
9	Manufacture of transport equipment	0.0186	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0059	Electricity, gas, steam and air-conditioning supply	0.0012
10	Financial and insurance activities	0.0167	Manufacture of transport equipment	0.0057	Manufacture of chemicals and chemical products	0.0012
11	Water supply, sewerage, waste management and remediation activities	0.0143	Financial and insurance activities	0.0051	Aquaculture	0.0011
12	Construction	0.0143	Water supply, sewerage, waste management and remediation activities	0.0044	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0010
13	Manufacture of chemicals and chemical products	0.0142	Construction	0.0044	Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0009
14	Manufacture of textiles, wearing apparel, leather and related products	0.0128	Manufacture of chemicals and chemical products	0.0044	Financial and insurance activities	0.0008
15	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0114	Manufacture of textiles, wearing apparel, leather and related products	0.0039	Water supply, sewerage, waste management and remediation activities	0.0008
16	Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0110	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0035	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0008
17	Telecommunications	0.0099	Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0034	Construction	0.0007
18	Manufacture of wood and paper products, and printing	0.0092	Telecommunications	0.0030	Other professional, scientific and technical activities	0.0005
19	Agriculture and forestry	0.0062	Manufacture of wood and paper products, and printing	0.0028	Other manufacturing, and repair and installation of machinery and equipment	0.0005
20	Other professional, scientific and technical activities	0.0056	Agriculture and forestry	0.0019	Telecommunications	0.0004
21	Manufacture of electrical equipment	0.0051	Other professional, scientific and technical activities	0.0017	Manufacture of transport equipment	0.0004
22	Real estate activities	0.0050	Manufacture of electrical equipment	0.0016	Manufacture of machinery and equipment n.e.c.	0.0003
23	Other services	0.0047	Real estate activities	0.0015	Real estate activities	0.0003
24	Mining and quarrying	0.0041	Other services	0.0014	Manufacture of electrical equipment	0.0002
25	Manufacture of machinery and equipment n.e.c.	0.0036	Mining and quarrying	0.0013	Manufacture of coke, and refined petroleum products	0.0002
26	Education	0.0033	Manufacture of machinery and equipment n.e.c.	0.0011	IT and other information services	0.0002
27	Aquaculture	0.0032	Education	0.0010	Education	0.0002
28	IT and other information services	0.0028	IT and other information services	0.0009	Mining and quarrying	0.0002
29	Manufacture of computer, electronic and optical products	0.0024	Manufacture of computer, electronic and optical products	0.0007	Manufacture of textiles, wearing apparel, leather and related products	0.0002
30	Human health services	0.0023	Human health services	0.0007	Manufacture of computer, electronic and optical products	0.0001
31	Manufacture of food products, beverages and tobacco products	0.0022	Manufacture of food products, beverages and tobacco products	0.0007	Human health services	0.0001
32	Accommodation and food service activities	0.0015	Accommodation and food service activities	0.0005	Other services	0.0001
33	Publishing, audiovisual and broadcasting activities	0.0012	Publishing, audiovisual and broadcasting activities	0.0004	Accommodation and food service activities	0.0001
34	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0011	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0003	Arts, entertainment and recreation	0.0001
35	Arts, entertainment and recreation	0.0009	Arts, entertainment and recreation	0.0003	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0001

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Table A.6 (continued)

#		Fishing		Aquaculture		Seafood processing
36	Public administration and defence, compulsory social security	0.0005	Public administration and defence, compulsory social security	0.0002	Publishing, audiovisual and broadcasting activities	0.0001
37	Scientific research and development	0.0004	Scientific research and development	0.0001	Public administration and defence, compulsory social security	0.0000
38	Residential care and social work activities	0.0001	Residential care and social work activities	0.0000	Scientific research and development	0.0000
39	Seafood processing	0.0001	Seafood processing	0.0000	Residential care and social work activities	0.0000
40	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0000	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0000	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0000
41	Activities of extra-territorial organisations and bodies	0.0000	Activities of extra-territorial organisations and bodies	0.0000	Activities of extra-territorial organisations and bodies	0.0000
	TOTAL	1.4046		1.1307		1.0464

Source: estimates of the authors of this study based on INE data (2020) [25]. Units: euros

their demand reduced. As we have seen, some of its main suppliers are among the Spanish economy's ten most relevant strategic sectors. Therefore, reducing demand for these key sectors may drag down other sectors, spreading the impacts through the Spanish productive sectors. It can be seen, for example, when we analyse the percentage represented by the inputs demanded by the fishing and aquaculture sectors from these sectors. In the case of the fishing sector, in 2015, the intermediate inputs demanded by these three sectors represented 21.34% of their cost structure. In aquaculture, expenses represented 26.91% of intermediate consumption expenses [29]. In contrast, the seafood processing sector acquired inputs from the agricultural and forestry sector; wholesale and retail trade in the repair of motor vehicles and motorcycles; and transportation and storage, the amount of which represented 31% of its intermediate consumption [16].

Regarding the reductions that demand would experience, it is necessary to highlight the repercussion that the three analysed sectors have with a common sector: accommodation and food service activities. The connection with this sector can be seen in the four scenarios analysed. In particular, the demand in this sector is very elastic and sensitive to price increases. This buying behaviour may be conditioned mainly by the wide range of restaurants and accommodations since Spain is one country that attracts the most tourists in the world.⁵ In addition, an essential attraction that this sector has is, among others, the gastronomic offer. It can include various seafood and fish dishes (including those sourced from fish farms). Therefore, variations in the prices of fish products (fresh or processed) can, in turn, condition the consumer's choice of accommodation or restaurant. In the case of the seafood processing sector, the significant reduction that would occur is justified because the demand for this type of product in the Spanish market is relatively elastic, unlike what occurs in most European countries [19].

When interpreting the results, some limitations of the methodology and the data used should be pointed out. Regarding the data, only part of the subsidies included in the EMFF is considered. In addition, the reliability of the work will depend on how close to reality the assumption made about the national allocation of funds to the different sectors, as well as the estimates (following [41]) of the distribution of total funds between types of subsidies. In some cases, we also find minor differences in the information collected to carry out the disaggregation of the sectors analysed (for example, the value of intermediate consumption or the final value of production). They may be due to the differences in the data collection and analysis methodology used by the different sources consulted [22]. In any case, these differences were minimal, so they cannot

significantly influence the results.

Regarding the methodology, the input–output models imply a series of assumptions. First, they assume constant returns to scale (the inputs purchased are proportional to the output obtained); there is no possibility of substituting some inputs for others (there are fixed technology coefficients); and the supply of inputs is unlimited (this implies that the necessary amounts of employment, raw materials and natural resources are available to cover the demand of the industrial sectors) [34]. Furthermore, our methodology analyses the impact on the economy of the elimination of subsidies in the sectors studied but does not consider the impact that the alternative use of these public resources may have. Finally, another limitation of the study is due to the inherent static feature of the input–output model and our assumptions of complete removal in each scenario, as subsidies will likely be removed gradually and not entirely in one year.

7. Conclusions and policy recommendations

The protection of marine resources is a priority issue for the EU. One way to help them is by eliminating "harmful" fishing subsidies, included as a priority objective of Horizon Europe (2021–2027). By applying an input–output model, this study simulates the potential economic impacts of removing these subsidies in Spain, in the context of the EMFF from 2013 to 2020. It should be noted that both addressing this problem in the Spanish case, and doing it through the methodology applied in this study, represent novel contributions to the literature. The application of the input–output analysis has empirically shown us the magnitude of the negative shock that the elimination of harmful subsidies for the different sectors of the Spanish economy will entail. The breakdown of the input–output table has provided a more detailed exploratory analysis of the impacts in the three sectors analysed and how other productive sectors connected to them are affected.

We have shown to what extent the elimination of harmful fishing subsidies will affect the GVA of the industries related to marine resources. This analysis gives us a first picture of which sectors will be most affected. Likewise, we have estimated the shocks that could occur in the supply chain from producing industries to client industries and vice versa due to the withdrawal of these subsidies. The results show us to what extent the impacts can be expanded throughout the Spanish productive sectors. Finally, the incidence of the political reform of subsidies in the last link of the supply chain (final household demand) is also shown. These three analyses' perspectives allow us to offer estimates that give policymakers a broad view to evaluate the most convenient alternatives to smooth the impacts of the complete withdrawal of "harmful" subsidies.

Scenario 5, which shows the whole elimination of harmful subsidies is, obviously, the one with presents higher impacts. Moreover, while the

⁵ It was the second most visited country in the world in 2018. Source: UN World Tourism Organization (UNWTO) (report published in November 2019 on data from 2018.)

Table A.7
Forward multipliers.

#	Fishing	Multiplier	Aquaculture	Multiplier	Seafood processing	Multiplier
1	Fishing	1.0081	Aquaculture	1.0007	Seafood processing	1.0004
2	Transportation and storage	0.0738	Transportation and storage	0.0224	Manufacture of food products, beverages and tobacco products	0.0145
3	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0513	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0155	Agriculture and forestry	0.0082
4	Manufacture of food products, beverages and tobacco products	0.0382	Manufacture of food products, beverages and tobacco products	0.0116	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0031
5	Electricity, gas, steam and air-conditioning supply	0.0319	Electricity, gas, steam and air-conditioning supply	0.0097	Transportation and storage	0.0028
6	Administrative and support service activities	0.0267	Administrative and support service activities	0.0081	Administrative and support service activities	0.0018
7	Manufacture of coke, and refined petroleum products	0.0248	Manufacture of coke, and refined petroleum products	0.0075	Electricity, gas, steam and air-conditioning supply	0.0017
8	Other manufacturing, and repair and installation of machinery and equipment	0.0223	Other manufacturing, and repair and installation of machinery and equipment	0.0068	Manufacture of wood and paper products, and printing	0.0012
9	Financial and insurance activities	0.0205	Financial and insurance activities	0.0062	Manufacture of chemicals and chemical products	0.0011
10	Mining and quarrying	0.0188	Mining and quarrying	0.0057	Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0010
11	Manufacture of transport equipment	0.0180	Manufacture of transport equipment	0.0054	Financial and insurance activities	0.0009
12	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0121	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0037	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0009
13	Manufacture of chemicals and chemical products	0.0116	Manufacture of chemicals and chemical products	0.0035	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0007
14	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0111	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0034	Other professional, scientific and technical activities	0.0006
15	Manufacture of textiles, apparel, leather and related products	0.0108	Manufacture of textiles, apparel, leather and related products	0.0033	Real estate activities	0.0005
16	Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0101	Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0030	Construction	0.0004
17	Telecommunications	0.0092	Telecommunications	0.0028	Mining and quarrying	0.0004
18	Real estate activities	0.0087	Real estate activities	0.0026	Other manufacturing, and repair and installation of machinery and equipment	0.0004
19	Agriculture and forestry	0.0084	Agriculture and forestry	0.0025	Telecommunications	0.0003
20	Construction	0.0082	Construction	0.0025	Water supply, sewerage, waste management and remediation	0.0003
21	Other professional, scientific and technical activities	0.0076	Fishing	0.0025	Manufacture of coke, and refined petroleum products	0.0003
22	Manufacture of wood and paper products, and printing	0.0068	Other professional, scientific and technical activities	0.0023	Manufacture of machinery and equipment n.e.c.	0.0003
23	Water supply, sewerage, waste management and remediation	0.0064	Manufacture of wood and paper products, and printing	0.0021	Accommodation and food service activities	0.0002
24	Other services	0.0052	Water supply, sewerage, waste management and remediation	0.0019	Education	0.0002
25	Education	0.0035	Other services	0.0016	IT and other information services	0.0002
26	IT and other information services	0.0031	Education	0.0011	Arts, entertainment and recreation	0.0001
27	Accommodation and food service activities	0.0029	IT and other information services	0.0009	Human health services	0.0001
28	Human health services	0.0027	Accommodation and food service activities	0.0009	Manufacture of electrical equipment	0.0001
29	Aquaculture	0.0025	Human health services	0.0008	Manufacture of textiles, apparel, leather and related products	0.0001
30	Manufacture of machinery and equipment n.e.c.	0.0019	Manufacture of machinery and equipment n.e.c.	0.0006	Other services	0.0001
31	Manufacture of electrical equipment	0.0019	Manufacture of electrical equipment	0.0006	Manufacture of computer, electronic and optical products	0.0001
32	Manufacture of computer, electronic and optical products	0.0017	Manufacture of computer, electronic and optical products	0.0005	Manufacture of transport equipment	0.0001
33	Arts, entertainment and recreation	0.0016	Arts, entertainment and recreation	0.0005	Fishing	0.0001
34	Publishing, audiovisual and broadcasting activities	0.0013	Publishing, audiovisual and broadcasting activities	0.0004	Publishing, audiovisual and broadcasting activities	0.0001
35	Seafood processing	0.0012	Seafood processing	0.0004	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0000
36	Public administration and defence, compulsory social security	0.0006	Public administration and defence, compulsory social security	0.0002	Public administration and defence, compulsory social security	0.0000
37	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0005	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0001	Aquaculture	0.0000

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Table A.7 (continued)

#	Fishing	Multiplier	Aquaculture	Multiplier	Seafood processing	Multiplier
38	Residential care and social work activities	0.0000	Residential care and social work activities	0.0000	Residential care and social work activities	0.0000
39	Scientific research and development	0.0000	Scientific research and development	0.0000	Scientific research and development	0.0000
40	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0000	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0000	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0000
41	Activities of extra-territorial organisations and bodies	0.0000	Activities of extra-territorial organisations and bodies	0.0000	Activities of extra-territorial organisations and bodies	0.0000
	TOTAL	1.4759		1.1441		1.0435

Source: estimates of the authors of this study based on INE data (2020)[25]. Units: euros

Table A.8

Impacts on demand.

Sectors	Impact	Sectors	Impact
Scenarios 2 and 3			
	SC2		SC3
Accommodation and food service activities	4.4690	Aquaculture	2.5100
Fishing	3.2588	Accommodation and food service activities	0.7126
Education	0.0777	Education	0.0124
Seafood processing	0.0738	Seafood processing	0.0118
Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0669	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0107
Residential care and social work activities	0.0564	Residential care and social work activities	0.0090
Real estate activities	0.0486	Real estate activities	0.0077
Arts, entertainment and recreation	0.0472	Arts, entertainment and recreation	0.0075
Other services	0.0453	Other services	0.0072
Manufacture of textiles, wearing apparel, leather and related products	0.0399	Manufacture of textiles, wearing apparel, leather and related products	0.0064
Aquaculture	0.0379	Fishing	0.0055
Agriculture and forestry	0.0339	Agriculture and forestry	0.0054
Human health services	0.0253	Human health services	0.0040
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0188	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0030
Administrative and support service activities	0.0096	Administrative and support service activities	0.0015
Telecommunications	0.0079	Telecommunications	0.0013
Manufacture of chemicals and chemical products	0.0075	Manufacture of chemicals and chemical products	0.0012
Transport and storage	0.0075	Transport and storage	0.0012
Financial and insurance activities	0.0074	Financial and insurance activities	0.0012
Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0072	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0011
Manufacture of coke, and refined petroleum products	0.0061	Manufacture of coke, and refined petroleum products	0.0010
Electricity, gas, steam and air-conditioning supply	0.0057	Electricity, gas, steam and air-conditioning supply	0.0009
Manufacture of transport equipment	0.0057	Manufacture of transport equipment	0.0009
Manufacture of food products, beverages and tobacco products	0.0039	Manufacture of food products, beverages and tobacco products	0.0006
Manufacture of wood and paper products, and printing	0.0038	Manufacture of wood and paper products, and printing	0.0006
Manufacture of computer, electronic and optical products	0.0031	Manufacture of computer, electronic and optical products	0.0005
Other manufacturing, and repair and installation of machinery and equipment	0.0029	Other manufacturing, and repair and installation of machinery and equipment	0.0005
Water supply, sewerage, waste management and remediation activities	0.0027	Water supply, sewerage, waste management and remediation activities	0.0004
Publishing, audiovisual and broadcasting activities	0.0026	Publishing, audiovisual and broadcasting activities	0.0004
Construction	0.0023	Construction	0.0004
Manufacture of electrical equipment	0.0020	Manufacture of electrical equipment	0.0003
Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0016	Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0003
Public administration and defence, compulsory social security	0.0011	Public administration and defence, compulsory social security	0.0002
Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0008	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0001
Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0007	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0001
Other professional, scientific and technical activities	0.0005	Other professional, scientific and technical activities	0.0001
Manufacture of machinery and equipment n.e.c.	0.0002	Manufacture of machinery and equipment n.e.c.	0.0000
Mining and quarrying	0.0000	Mining and quarrying	0.0000
IT and other information services	0.0000	IT and other information services	0.0000
Scientific research and development	0.0000	Scientific research and development	0.0000
Activities of extra-territorial organisations and bodies	0.0000	Activities of extra-territorial organisations and bodies	0.0000
TOTAL	8.3922		3.3280
Scenarios 4 and 5			
	SC4		SC5
Seafood processing	13.8333	Seafood processing	13.9189
Accommodation and food service activities	0.1971	Accommodation and food service activities	5.3787
Manufacture of textiles, wearing apparel, leather and related products	0.0078	Fishing	3.2644
Agriculture and forestry	0.0074	Aquaculture	2.5480
Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0068	Education	0.0930
Arts, entertainment and recreation	0.0033	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0844

(continued on next page)

Table A.8 (continued)

Sectors	Impact	Sectors	Impact
Education	0.0029	Residential care and social work activities	0.0667
Real estate activities	0.0028	Real estate activities	0.0591
Other services	0.0024	Arts, entertainment and recreation	0.0580
Human health services	0.0016	Other services	0.0549
Residential care and social work activities	0.0014	Manufacture of textiles, wearing apparel, leather and related products	0.0541
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0012	Agriculture and forestry	0.0467
Manufacture of chemicals and chemical products	0.0011	Human health services	0.0309
Manufacture of coke, and refined petroleum products	0.0010	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0.0230
Manufacture of wood and paper products, and printing	0.0007	Administrative and support service activities	0.0117
Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0007	Manufacture of chemicals and chemical products	0.0098
Electricity, gas, steam and air-conditioning supply	0.0007	Telecommunications	0.0098
Telecommunications	0.0006	Transport and storage	0.0092
Administrative and support service activities	0.0006	Financial and insurance activities	0.0091
Manufacture of transport equipment	0.0005	Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.0090
Financial and insurance activities	0.0005	Manufacture of coke, and refined petroleum products	0.0081
Transport and storage	0.0005	Electricity, gas, steam and air-conditioning supply	0.0073
Manufacture of computer, electronic and optical products	0.0003	Manufacture of transport equipment	0.0072
Manufacture of food products, beverages and tobacco products	0.0003	Manufacture of wood and paper products, and printing	0.0051
Water supply, sewerage, waste management and remediation activities	0.0002	Manufacture of food products, beverages and tobacco products	0.0049
Construction	0.0002	Manufacture of computer, electronic and optical products	0.0039
Other manufacturing, and repair and installation of machinery and equipment	0.0002	Other manufacturing, and repair and installation of machinery and equipment	0.0035
Publishing, audiovisual and broadcasting activities	0.0002	Water supply, sewerage, waste management and remediation activities	0.0033
Manufacture of electrical equipment	0.0002	Publishing, audiovisual and broadcasting activities	0.0032
Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0002	Construction	0.0029
Fishing	0.0001	Manufacture of electrical equipment	0.0025
Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0001	Manufacture of rubber and plastics products, and other non-metallic mineral products	0.0021
Aquaculture	0.0001	Public administration and defence, compulsory social security	0.0013
Public administration and defence, compulsory social security	0.0001	Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0010
Legal, accounting, management, architecture, engineering, technical testing and analysis activities	0.0000	Manufacture of basic metals and fabricated metal products, except machinery and equipment	0.0008
Other professional, scientific and technical activities	0.0000	Other professional, scientific and technical activities	0.0006
Manufacture of machinery and equipment n.e.c.	0.0000	Manufacture of machinery and equipment n.e.c.	0.0002
Mining and quarrying	0.0000	Mining and quarrying	0.0000
IT and other information services	0.0000	IT and other information services	0.0000
Scientific research and development	0.0000	Scientific research and development	0.0000
Activities of extra-territorial organisations and bodies	0.0000	Activities of extra-territorial organisations and bodies	0.0000
TOTAL	14.0773		25.7975

Source: estimates of the authors of this study based on data from INE [25]. Units: millions of €

impact on the GVA of the three marine resource sectors is € 2.82 million below the subsidies subtracted, the impacts on the whole economy are € 14.43 million above the amount of subsidies removed (Table 12). Nevertheless, looking at each scenario when subsidies are eliminated individually, Scenario 4 is the only one that produces positive net differences between the subsidies subtracted and the impact on the three marine resource sectors (€ 1.05 million) and on the whole economy (€ 0.05 million). Moreover, all economic losses are concentrated in the seafood processing sector (€ 37.89 million), with hardly any impacts on the rest sectors (around € 1 million). Therefore, in this case policy efforts could just be focused on mitigating impacts on the processing sector by using part of the released funds, and the rest of funds could be allocated to address the economic difficulties of the industries that were also affected. Therefore, while the impacts of the subtraction of subsidies in the processing sector seem more manageable with an appropriate use of the released subsidies, the authorities should be more careful with the design of the subtraction of subsidies in the other sectors.

Regarding indirect impacts on other sectors' GVA, in particular, the manufacture of food products and accommodation service sectors are the most affected by removing subsidies in Scenario 4, € 6.56 million and € 4.43 million (Table 6). Total combined losses in those sectors are almost five times greater than those given in Scenario 2 and 3 jointly (€ 2.46 million). This offers valuable information to policymakers. Moreover, the extractive fishing sector has the most substantial indirect

impacts, which indicates that it is the marine 'key' sector for other industries.

Interrupting the supply chain in any direction, either from the marine industries' client side or the seller side, has consequences not only among the involved industries but also for the rest of the Spanish industries. This knock-on effect will be more significant when the sector is more strategically linked to economic development. Even though the processing sector presents the highest dependency on these key sectors, the fishing sector, with less dependency on them, presents the highest backward and forward multipliers. Therefore, both arguments should be clear to policymakers and put them together when designing the subsidies removal policy.

Policy makers should also focus on the impact of the removal of subsidies in the demand of the different sectors. Our results highlight the important impact of the subtraction of subsidies on the demand of the seafood processing sector, while the subtraction of fishing sector subsidies would have the greatest impacts on the demand of the rest of sectors of the economy.

Finally, although it goes beyond the scope of this study, it should also be investigated the possible impact of the use of public resources released by eliminating subsidies. These resource allocations could be directed to other, more beneficial uses for the marine industry [38]. This recycling of resources could help offset the possible social impacts of the withdrawal of subsidies and the economic impacts we have analysed.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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Annex 1

See Tables A.1–A.8.

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