Blue Decarbonisation: Quantifying Emissions from Brazil's Ocean Economy

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Abstract: Oceans are seen as a new economic frontier. Economic activities related to the ocean have grown considerably in recent years. However, concern has also grown about the health of the oceans and their ecosystems, which are seen as key to fighting climate change. However, the Ocean Economy is poorly analysed as an important driver of the green transition. A development strategy needs to be drawn up to ensure a productive, fair and sustainable ocean. The aim of this study is to quantify the generation of CO2 produced by economic sectors linked to the ocean in Brazil, as well as the capacity of these sectors to generate pollution indirectly, considering the sectors they stimulate through their demand for inputs or services. Using data on sectoral CO2 emissions, we created a pollution vector to use in the input-output matrix. The findings indicate that as well as polluting little (both in relation to the total economy and per unit of output), the ocean-related sectors also have a low capacity to multiply pollution in the economy when stimulated. We conclude the paper with suggestions for drafting a Maritime Productive Policy for Brazil.

INTRODUCTION

The oceans cover more than 70 per cent of the planet's surface and are important sources of resources, food and minerals, as well as being ecologically important for maintaining life on Earth. When people think about the study of the seas and oceans, the idea is usually associated with the environmental aspect, ecosystems and marine life, but in recent years several countries have begun to think about their economic aspect, creating the idea of an economy of the sea.

The word ‘idea’ in the previous paragraph was deliberately used instead of ‘concept’ so that we can present the economy of the sea as something broad and diverse, which varies between countries, but which does not yet have a universal definition. There is no consensus defining it, but various countries have created their own definitions, which can consider only activities located at sea (directly related) or include activities developed on land that produce for the sea or process its inputs (indirectly related).

According to the European Union (2021), ocean economy can be defined as the sum of economic activities (commercial industrial, scientific and technological research, governmental, among others) that have the aquatic environment as their base or interest, with the economic assets, goods and services belonging to the respective ecosystems. The blue economy would then encompass all sectoral and intersectoral economic activities based on or related to the oceans, seas and coasts.

The OECD considers the blue economy to be all activities linked to water, the sea and the ocean, ranging from the more traditional, such as fishing and aquaculture, but also combining a range of activities linked to the economic and sustainable development of coastal economies. The sectors are divided into established (the most traditional) and emerging.

The established sectors, according to the most recent OECD (2021), are divided into seven categories: living resources, non-living resources, offshore wind energy, ports, shipbuilding, maritime transport and coastal tourism. Emerging sectors include renewable ocean energy and blue biotechnology with a focus on algae production.

Despite using the OECD classification as a basis, it is important to point out that it is impossible to reproduce some categories in a similar way, either because they do not exist in Brazil, as is the case with emerging sectors, or because of limitations in the National Classification of Economic Activities (CNAE) and the System of National Accounts (SCN) in relation to the breakdown of some activities.

This article sets out to discuss industrial policy as a way of promoting structural change in sectors linked to the ocean economy, which would act as a vector for economic development. The ocean economy accounted for around 4.61% of the Brazilian economy in 2018 (Marques, 2022). Although this is not a significant figure (even if it is similar to

that observed in other countries), of the 67 activities considered in the estimate and which would make up the Brazilian economy as a whole, 16 are related to the sea. This is a niche in the economy which, although small in terms of its share of GDP, accounts for 23 per cent of economic activities, many of which are linked to industry.

For this work, the OECD definition will be used, which characterises the economy of the sea as the sum of economic activities (commercial industrial, scientific and technological research, governmental, among others) that have the aquatic environment as their base or interest, with the economic assets, goods and services belonging to the respective ecosystems. The blue economy, then, encompasses all sectoral and intersectoral economic activities based on or related to the oceans, seas and coasts.

The aim of this paper is to discuss industrial policies aimed at the economy of the sea that take into account the need to develop national industry allied to sustainable development. The 16 activities of the Brazilian economy linked to the sea will be grouped into five sectors according to the OECD classification:

living resources, non-living resources, maritime transport and ports, shipbuilding and tourism.

The first session will focus on defining these five sectors, the second session will review the literature on industrial policy, green development and synergistic and antagonistic relationships between the maritime sectors, the third session will present the methodology and the fourth the results.

SECTORS OF THE OCEAN ECONOMY

Living resources

The European Union (2021) defines the living resources sector as covering the harvesting of renewable resources (primary sector), their conversion into food, feed, bio-based products and bioenergy (processing) and their distribution along the supply chain. The living resources sector can be divided into three sections, the first being the primary sector, made up of fish catching (whether low-scale and coastal, large-scale or industrial) and aquaculture. Then there is the fish processing and preservation sector, which covers the preparation of meals, the manufacture of oils and fats and other food products. Finally,

there is the fish distribution sector, which covers the retail sale of fish, crustaceans and molluscs in specialised shops and wholesale trade. In the Brazilian economy, this sector corresponds to the activities of Forestry, fishing and aquaculture (0280), Slaughtering and meat products, including dairy and fishery products (1091) and Other food products (1093).

Although the basic activities of the non-living resources sector are centred on extractive activities, it is strongly related to high-tech sectors such as shipbuilding. In addition, aquaculture is an important source of technological innovation, since it requires scientific research related to the reproduction and improvement of species. Although the focus of industrial policy is on industry sectors, it is important to analyse the economy (and therefore the economy of the sea) as sectors that are related and interlinked. It is therefore necessary to look at the living resources sector for its ability to stimulate the shipbuilding industry, indirectly, and also the importance of investing in and developing scientific research related to aquaculture, which would increase the sector's productivity and the country's competitiveness in world supply.

Non-living resources

The non-living resources sector involves the production, extraction and processing of non-living resources from the ocean. The European Union (2021) includes oil and gas exploration and mineral extraction in this sector. In Brazil specifically, mineral extraction refers to the extraction of stone, sand and clay and the extraction and refining of sea salt and rock salt. Oil and natural gas extraction are also counted in this sector for international comparison purposes. For the purposes of aggregation, we are talking about the sectors Extraction of coal and non-metallic minerals (0580) and Extraction of oil and gas, including support activities (0680).

Manufacturing and shipbuilding

Present in almost all activities linked to the ocean economy, the marine equipment manufacturing sector is very broad. Focussed on the production of machinery and equipment, it is the most capital-intensive sector and therefore one of those that generates the most added value. Its products range from electronic devices for navigation to the manufacture of machinery for ice factories, equipment and parts for ships, instruments

for oil exploration, artefacts for fishing and sport, etc. The shipbuilding sector includes economic activities carried out in shipyards that provide construction, repair and maintenance services for vessels of various sizes. In addition to services on platforms and other floating structures. It also includes ship dismantling activities.

For aggregation purposes, this sector includes the activities of Manufacture of metal products, except machinery and equipment (2500), Manufacture of computer, electronic and optical products (2600), Manufacture of electrical machinery and equipment (2700), Manufacture of mechanical machinery and equipment (2800), Manufacture of other transport equipment, except motor vehicles (3000), Manufacture of furniture and miscellaneous industrial products (3180) and Maintenance, repair and installation of machinery and equipment (3300).

Maritime transport and ports

According to data from the OECD (2021), maritime transport plays an important environmental role, as it is the most carbon-efficient means of transport, responsible for only 3% of the world's carbon dioxide emissions, as well as producing fewer exhaust gases, such as nitrogen oxide, hydrocarbons, carbon monoxide and sulphur dioxide, compared to air and road transport. In addition to the environmental issue, maritime transport is of great economic and strategic importance in world trade, accounting for an estimated 80 per cent of the world's goods transport. In this work, the sector includes the activities of Water Transport (5000) and Construction (4180).

Tourism

Brazil is a continental country which, according to the IBGE (2019), has more than seven thousand kilometres of coastline and diverse ecosystems, as well as being recognised worldwide for its natural beauty, which attracts tourists and drives the economy. In this work, it includes the activities of Accommodation (5500) and Food (5600).

The methodology section presents a list of the sectors mentioned and also a description of why they were chosen, since in some cases the name of the activity doesn't

lead us to immediately relate it to the sea, making it necessary to use the services, industry and construction surveys for greater detail.

INDUSTRIAL POLICY AND GREEN DEVELOPMENT

The maritime economy is not a separate block of the national economy, it is present in various economic activities and has links with all sectors of the economy, so it is interesting to think about an industrial policy aimed at the ocean and the impact it would have on the economy as a whole. Allied to the need to resume the development of national industry, it is necessary to think about the impact that these policies have on the environment and which sectors should be stimulated in order to generate growth with a low environmental impact.

According to Morceiro (2019), in order to better understand the role played by each sector of activity, the OECD has revised and updated its classification of technological intensity to include service and non-manufacturing sectors, since they have gained participation in the creation of technologies, especially information technology. This classification would create a hierarchy between productive sectors to classify them into groups of technological intensity, which would be based on the ratio between investments in research and development and GDP at basic prices.

The author emphasises that the OECD classification captures the technological intensity of the group of countries operating on the technological frontier, which will not be the same for individual countries and especially for developing countries. Brazil would be far from the OECD's technological intensity in research and development in most sectors of the economy (both among the very research-intensive and the low-intensive), but there would be exceptions such as the cleaning, cosmetics/perfumery and personal hygiene sector, the electricity, gas, water, sewage and urban cleaning sector, the extractive industry, agriculture and metallurgy. The author also points out that although the structure of the Brazilian economy is different from the main developed economies, the sectors with the highest R&D intensity in Brazil are practically the same as in the OECD, but in smaller proportions.

Table 1: Technological intensity (R&D / GDP) of the productive sectors in Brazil and the OECD

	Brazil (A)	OCDE (B)	A/B
Other transport equipment	10,74	20,44	0,53
Computer equipment: electronic and optical	9,97	24,05	0,41
Chemicals	8,13	6,52	1,25
Motor vehicles and auto parts	5,99	15,36	0,39
Pharmaceuticals and pharmaceutics	5,13	27,98	0,18
Architecture, engineering, technical analyses and R&D	4,40	11,80	0,37
Electrical machinery and equipment	3,08	6,22	0,50
Mechanical machinery and equipment	2,55	7,89	0,32
Metallurgy	2,47	2,07	1,19
Agriculture	1,51	0,27	5,59
Systems development, other information services	1,47	8,56	0,17
Rubber and plastics	1,44	3,58	0,40
Pulp, paper and paper products	1,22	1,58	0,77
Mining and quarrying	1,11	0,80	1,39
Telecommunications	1,05	1,45	0,72
Electricity, gas, water, sewage and urban cleaning	1,02	0,35	2,91
Footwear and leather goods	0,95	1,65	0,58
Food, beverages and tobacco	0,79	1,44	0,55
Non-metallic minerals	0,50	2,24	0,22
Clothing and accessories	0,41	1,40	0,29
Metal products, except M&Es	0,39	1,68	0,23
Furniture and miscellaneous industrial products	0,36	2,43	0,15
Textiles	0,36	1,73	0,21
Publishing and publishing integrated with printing	0,29	0,57	0,51
Wood products	0,22	0,70	0,31
Commerce	0,10	0,28	0,36

According to UNCTAD (2016), during the process of economic growth, the economies that are now considered advanced were all able to diversify their production, moving away from agriculture, the extraction of natural resources and the production of traditional manufactured goods such as food, beverages and textiles. In contrast, the countries that are today considered less advanced are those that would not have been able to engage in a similar process of transformation of their productive structures and would remain stuck at low and medium levels of income.

Industrial policy should aim to change the productive structure towards a process of industrialisation, which brings benefits such as increased productivity and productive

diversification. Tregenna and Andreoni (2020) point out that the effectiveness of industrial policy in effectiveness of industrial policy in low- and middle-income countries depends on the specific characteristics of their industrial system, the sectoral composition, the structural trajectory, as well as the changing nature of premature deindustrialisation and the global distribution of industrial production.

The authors point out that middle-income countries are highly heterogeneous in terms of their sectoral composition and their experiences of deindustrialisation. In addition, fewer than twenty countries currently control almost 90 per cent of the value added in manufacturing. In addition to the fact that many low- and middle-income countries are not included in this group of industrialised nations, many of those that have achieved middle-income status would show signs of premature deindustrialisation.

For Evenett et al (2023), a fundamental challenge of the industrial policy approach is the lack of systematic, quality information on what governments around the world are implementing, because industrial policy is different from monetary and fiscal policies, which have publicly available targeting measures. The authors consider industrial policy to be any targeted government intervention aimed at developing or supporting specific national companies, industries or economic activities to achieve economic or non-economic objectives (e.g. security, social or environmental).

For Juhász et al (2023), industrial policy can be defined as policies that explicitly aim to transform the structure of economic activity in pursuit of a specific objective, which can be the stimulation of innovation, productivity and economic growth, but also climate transition, the creation of good jobs, the development of backward regions or export and import substitution. The authors point out that industrial policy has traditionally focused on promoting manufacturing industries such as steel, automobiles, shipbuilding, aeronautics or semiconductors, but they open up the definition to include services and research.

As well as developing a policy that allows industry to resume its growth, environmental demands must be considered. It is common for industry to be associated with high emissions of pollutants, but we need to demystify this idea. When we analyse Brazilian emissions for 2019 in the data provided by Alvarenga Junior et al (2020), we see that in the Brazilian emissions matrix, the biggest polluters are the sectors linked to

agriculture. Of the 67 sectors of the Brazilian economy, the three linked to agriculture account for 70% of national CO2 emissions. The industrial sectors, in general, are less polluting in terms of emissions (the two that stand out are linked to mining and iron production, with around 2 per cent of national emissions each). The agricultural and livestock sectors, as well as standing out in terms of total emissions, also stand out in terms of emissions per unit of product.

Avenyo and Tregenna (2022) point out that while higher percentages of production in low-tech industries would be associated with higher emissions (at increasing rates), higher percentages in the production of medium and high-tech industries would be associated with lower emissions, suggesting that an orientation towards the production of more sophisticated and technologically intensive goods would be associated with lower levels of emissions. A shift towards production processes linked to technology-intensive manufacturing could therefore be a sustainable industrialisation path for developing countries.

According to Gramkow (2019), sustainability was definitively incorporated into ECLAC's thinking through the view that sustainable economic development depends on a healthy environment and an egalitarian society. Sustainability would become part of the core of ECLAC's proposal for changing development styles, which argues that Latin American and Caribbean countries should build a path of progressive structural change, characterised by productive specialisation in knowledge- and learning-intensive processes that are capable of radiating technological change and innovation throughout the economy, operating in rapidly expanding domestic and international markets to achieve gains in scale and scope, and decoupling economic growth from greenhouse gas emissions.

In order to think about an industrial policy aimed at the ocean, it is necessary to consider the interactions that exist between the sectors of the blue economy. The word interaction is extremely important in defining these relationships, because it shows that activities do not exist in isolation from each other, but interact and generate positive or negative externalities. These externalities can extend to other activities as well as to the environment. In this context, the concepts of synergy and antagonism between activities are created, which respectively define activities that benefit others (or whose benefit is

reciprocal) and activities that harm others, or whose harmful interaction is reciprocal. Maritime policy must specificities, taking advantage of synergies and minimising, where possible, antagonistic impacts.

Crona (2021) divides interactions, both synergistic and antagonistic, into four types: space, natural capital, tourism value and operations. In space interactions, activities share the same physical environment and can result in synergy or antagonism. An example of synergistic activities are platforms that combine activities such as aquaculture and wind energy production, and antagonism is the drilling sector, which generates increased competition for ocean space. Interaction also has this dual influence on natural capital. Drilling platforms can act as artificial reefs, benefiting fish populations and generating profits for the fishing industry, but they can also cause environmental damage such as oil spills and contamination by drilling muds.

Synergistic interactions related to tourism value would result in value improvements in the tourism sector while antagonistic ones would result in losses. A wind farm, for example, could generate interest in tourism focused on renewable energy, while a location with many aquaculture farms could become less desirable for tourism. Finally, operational relationships can occur in such a way that the interaction between sectors generates benefits or losses for one or both. The provision of electricity, for example, can be done at renewable energy stations (synergistic relationship), while fishing nets can damage the power cables of wind farms (antagonistic relationship).

Industrial policy must act by articulating the sectors and their respective synergistic and antagonistic relationships. Based on pre-defined objectives, which should involve the development of medium and high-tech industries, the reduction of pollutant emissions and the generation of more qualified jobs, the policy should consider which activities are the most advantageous to stimulate and find ways to minimise their possible negative externalities.

METHODOLOGY

This article will use data from the 2019 input-output matrix (Alves-Passoni; Freitas, 2023) and data on CO2 emissions from economic activities (Alvarenga et al, 2023).

Firstly, it is necessary to identify the sectors linked to the sea in the Brazilian economy, using the CNAE 2.0 classification. It is important to note that there is a disaggregation limitation in the matrices provided and the activities considered will be treated as 'linked to the sea' because they contain elements that do not belong to the economy of the sea.

As there is not yet a satellite account for the sea that allows a detailed breakdown of what really belongs to the ocean in each activity and in order to compare with the emissions data provided by Alvarenga Júnior et al (2023), we will use the product of the activities. The concept of the economy of the sea used is that of the OECD, which works with the degree of maturity of markets and defines the economy of the sea as the sum of economic activities (commercial industrial, scientific and technological research, governmental, among others) that have the aquatic environment as their base or interest, with the economic assets, goods and services belonging to the respective ecosystems (EUROPEAN UNION, 2021).

Table 2: Activities linked to the ocean economy

Activity Code (CNAE 2.0)	Activity
0280	Forestry production; fishing and aquaculture
0580	Extraction of mineral coal and non-metallic minerals
0680	Oil and gas extraction, including support activities
1091	Slaughter and meat products, including dairy and fishery products
1093	Other food products
2500	Manufacture of metal products, except machinery and equipment
2600	Manufacture of computer, electronic and optical equipment
2700	Manufacture of electrical machinery and equipment
2800	Manufacture of machinery and mechanical equipment
3000	Manufacture of other transport equipment, except motor vehicles
3180	Manufacture of furniture and miscellaneous industrial products
3300	Maintenance, repair and installation of machinery and equipment
4180	Construction
5000	Water transport
5500	Accommodation
5600	Catering

The activities in table 2 will be aggregated into five groups based on the OECD definitions: Living resources (0280 + 1091 + 1093), Non-living resources (0580 + 0680), Manufacturing and shipbuilding (2500 + 2600 + 2700 +2800 + 3000 + 3180 + 3380), Tourism (5500 + 5600) and Maritime transport and ports (5000 + 4180).

The sectors related to the maritime economy were chosen on the basis of the CNAE 2.0 categories, the Annual Industrial Survey (PIA), the Annual Survey of the Services Sector (PAS) and the Annual Survey of the Construction Sector (PAIC). Despite the impossibility of a quantitative breakdown of the maritime sectors, the surveys are useful because they detail what is produced in each activity. This selection is explained in more detail in Table 3.

Table 3: Breakdown of the content of each activity linked to the ocean

Activity Code (CNAE 2.0)	What the Activity covers
0280	Fishing and aquaculture
0580	Stone, sand and clay extraction
	Extraction and refining of sea salt and rock salt
0680	Oil and natural gas extraction and support activities
1091	Industrialised fish
1093	Frozen ready meals based on fish, crustaceans and molluscs
2500	Lighthouse structures, masts and hatches
	Heavy boiler works (dykes, jetties and breakwaters)
	Manufacture of anchors and propellers for ships.
2600	Radiodetection and radiosounding apparatus, radionavigation apparatus and radio navigation apparatus
	Compasses and other instruments and apparatus for navigation
	Parts and pieces of radiodetection, radiosounding (radar) and radionavigation apparatus
2700	Electrical signalling, safety and traffic control equipment for inland waterways
2800	Manufacture of machinery and equipment for oil exploration and extraction
	Oil extraction machines; fish gutting machines
3000	Construction of boats and floating structures
	Construction of boats for sport and leisure
3180	Manufacture of fishing and sports artefacts
3300	Boat maintenance and repair
4180	Harbour, sea and river works
5000	Water transport
5500	Coastal tourism
5600	Coastal catering establishments

Indicators

Considering the output of each of the activities, which will be aggregated into the five defined sectors, it is possible to compare the production of each sector with its CO2 emissions. More important than the emission of the activities themselves is the emission per unit of product. Considering that most of the Brazilian economy's CO2 emissions are related to the agricultural sector, a comparison will be made of the sectors linked to the economy of the sea with and without the activity 'Slaughter and meat products, including dairy and fishery products (1091)', because as the emissions of this activity are high (both among the sectors of the sea and in the Brazilian economy) and are mostly related to livestock, there will be a distortion of the results.

In order to come up with an industrial and environmental policy for the sea, in addition to considering qualitative aspects intrinsic to the sectors, such as synergies and antagonisms, it is necessary to map out the production structure. This will be done using simple multipliers for production, added value and pollution, obtained through input-output analysis.

The basic input-output equation is given by:

$$\boldsymbol{B = (I - A)^{-1}}$$

Where $(I - A)^{-1}$ is the Leontief inverse matrix, with I as an identity matrix and A as the matrix of technical coefficients. Initially, a square matrix containing 67 productive activities is used. The aggregation of the marine sectors into the five previously described sectors reduces this matrix to 56 activity sectors, with the aggregates being referred to as "RV," "RNV," "MAN," "TUR," and "TRANS."

Simple Multipliers

Multipliers represent the total production variation (both direct and indirect) of the economy due to an exogenous variation of one monetary unit in final demand for a particular sector. In other words, it is the total monetary value of production from all

sectors of the economy necessary to satisfy a variation of R$1.00 in final demand for the product of sector j (Perobelli et al., 2015).

$$\mathbf{Oj} = \sum_{i=1}^{n} \mathbf{bij}$$

The production multiplier of each sector is given by the sum of its column in the Leontief inverse matrix. Where j is a specific sector of the economy and b_{ij} are the elements of the Leontief inverse matrix.

The simple added value multiplier measures the effects of a one-unit change in final demand on the added value generated by activity sectors. To calculate the multiplier, it is first necessary to estimate its added value generation coefficient:

$$\frac{\boldsymbol{vj} = \mathbf{vaj}}{\mathbf{Xj}}$$

Where vaj is the added value generated in sector j and Xj is its gross production value.

After calculating the added value coefficients, a matrix V (nxn) is created where the diagonal values correspond to the added value coefficients and the other values are equal to zero. Multiplying matrix V by the Leontief inverse matrix (B) yields matrix MV:

$$\boldsymbol{MV = VB}$$

Each element of matrix MV represents the amount of added value generated in sector i to meet a variation of R$1.00 in final demand for sector j. The added value multiplier of each sector is given by the sum of their respective columns from matrix MV:

$$\mathbf{MVj} = \sum_{i=l}^{n} \mathbf{mvij}$$

The production multiplier of each sector is given by the sum of its column in the Leontief inverse matrix, where j represents a specific sector of the economy and b_{ij} are the elements of the Leontief inverse matrix. The pollution multiplier measures the effects of a one-unit change in final demand on pollution generated by activity sectors. To calculate the multiplier, it is first necessary to estimate a pollution vector for the sectors. This work uses the vector developed by Alvarenga Junior et al. (2023), but with the aggregation of the 16 activities related to the sea.

$$\boldsymbol{vj} = \frac{\mathbf{emj}}{\mathbf{Xj}}$$

Where emj is the value of emissions generated in sector j and Xj is its gross production value.

After calculating the pollution coefficients, a matrix E (nxn) is created where the diagonal values correspond to the pollution vector, and the other values are equal to zero. Multiplying matrix V by the Leontief inverse matrix (B) yields matrix ME:

$$\boldsymbol{ME = VB}$$

Each element of matrix ME represents the amount of CO2 emissions generated in sector i to meet a variation of R$1.00 in final demand for sector j. The emission multiplier for each sector is given by the sum of their respective columns from matrix ME:

$$\mathbf{MEj} = \sum_{\boldsymbol{i=l}}^{\boldsymbol{n}} \mathbf{meij}$$

For impact analysis, we create an impact vector that is multiplied by the Leontief inverse matrix to simulate how variations in final demand from specific sectors affect the rest of the economy. Direct impacts are given by the product of the technical coefficient matrix with the created impact vector.

RESULTS ANALYSIS

From the emissions data provided by Alvarenga Júnior et al (2023), it can be seen that CO2 emissions from the Brazilian economy are mostly concentrated in sectors linked

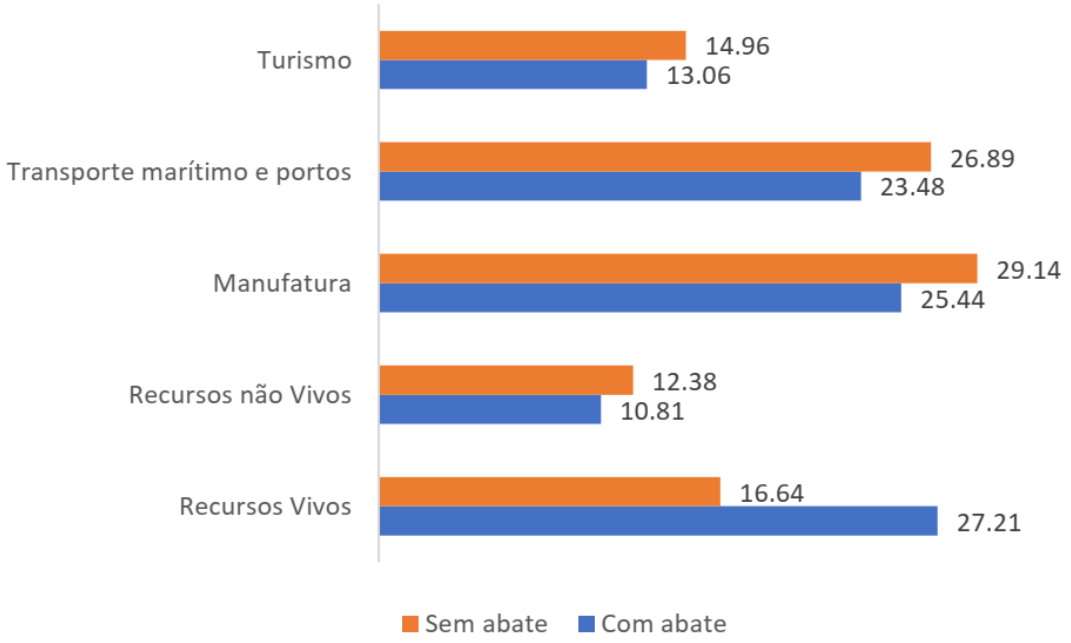
to agriculture. The ‘Agriculture, including support for agriculture and post-harvest (0191)’ sector was the leader in CO2 emissions in 2019, responsible for 38 per cent in the period, followed by ‘Livestock, including support for livestock (0192)’, responsible for 18 per cent of emissions and ‘Slaughtering and meat products, including dairy and fishery products (1091)’, with 13 per cent of national emissions.

The pollution generated by the national industry is small when compared to the agricultural and livestock sectors, the most relevant sectors within it in terms of CO2 emissions are ‘Manufacture of non-metallic mineral products (2300)’ and ‘Production of pig iron/iron alloys, iron and steel. iron/alloys, steelmaking and seamless steel tubes (2491)’, which account for only 2.1% and 2.5% of national emissions respectively.

Having divided the activities linked to the sea into the categories defined by the OECD, it is possible to analyse the participation of each sector (living resources, non-living resources, manufacturing and shipbuilding, maritime transport and ports and tourism) in the composition of CO2 emissions and the gross value of production of the economy of the sea. It is important to remember, however, that the activities used were not disaggregated due to methodological limitations. As the living resources sector contains an activity that adds slaughtering of cattle and pigs to the list of activities, it is important to remember that the activities used were not disaggregated due to methodological limitations. For this reason, we will analyse the maritime economy with and without this sector.

Figure 4 shows the participation of maritime sectors in the composition of gross production value (GPV) with and without cattle slaughter. In the scenario that includes slaughter, Living Resources, Transport and Manufacturing account for around ¼ of the seafood economy each, with shares of 27.21%, 23.48% and 25.44% respectively. The remainder is divided between Tourism (13.06%) and Non-Living Resources (10.81%).

Figure 1: Participation of activities linked to the ocean in the gross value of production



When we analyse the formation of the VBP disregarding slaughter, the living resources sector loses 10% of its share in production, becoming 16.64% of the sea's economy in 2019. Manufacturing would stand out as the largest sector, with 29.14%, followed by Transport (26.89%), Tourism (14.96%) and Non-living resources (12.38%).

Analysing the CO2 emissions of activities linked to the sea (figure 5), it can be seen that the Living Resources sector leads the emissions in a scenario that considers slaughter (84.51%). When slaughter is removed, the sector's emissions fall to 34 per cent, while the non-living resources sector increases from 10.89 per cent to 46.4 per cent, making it the largest emitter in the maritime economy.

Figure 5: Share of Ocean-Related Activities in CO2 Emissions

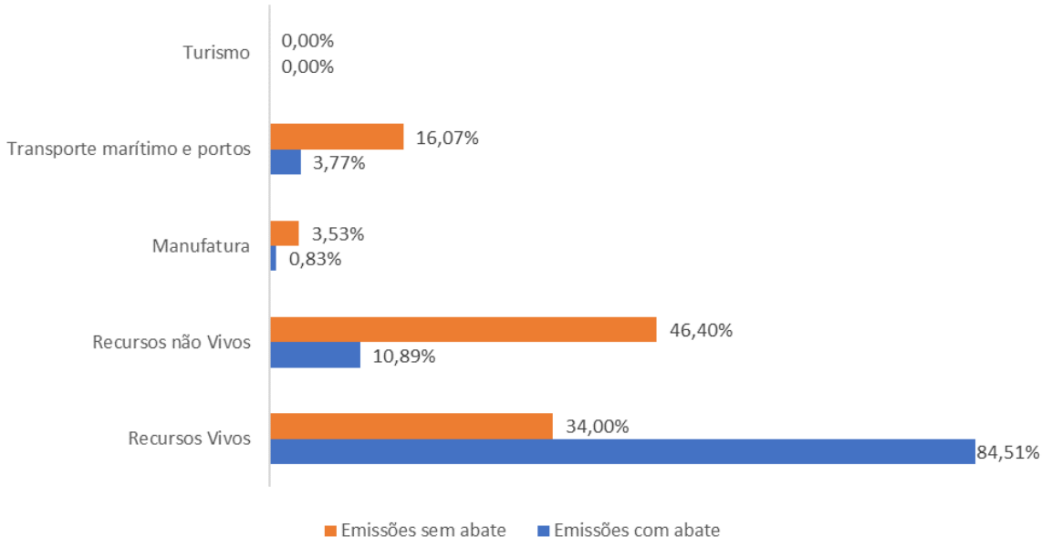
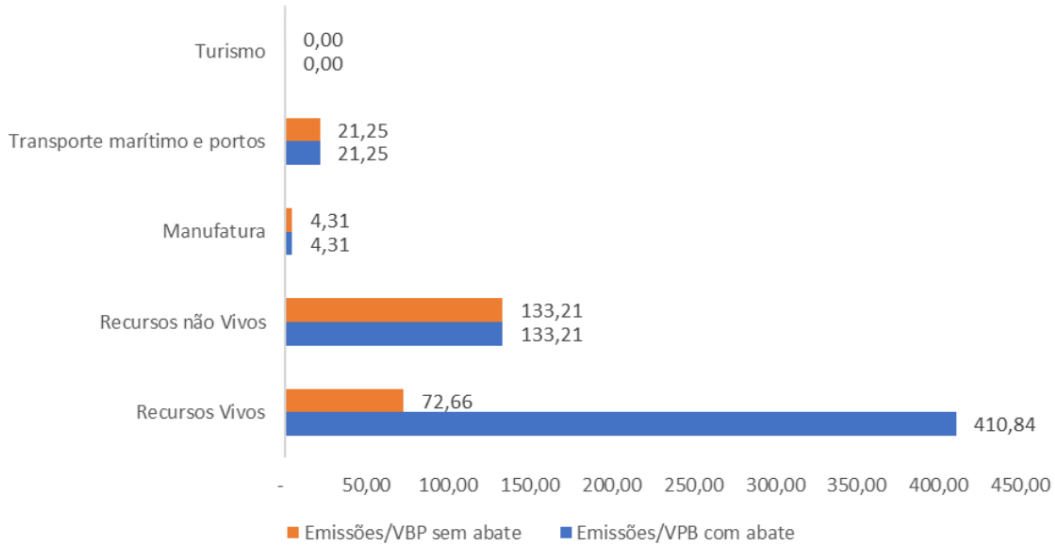


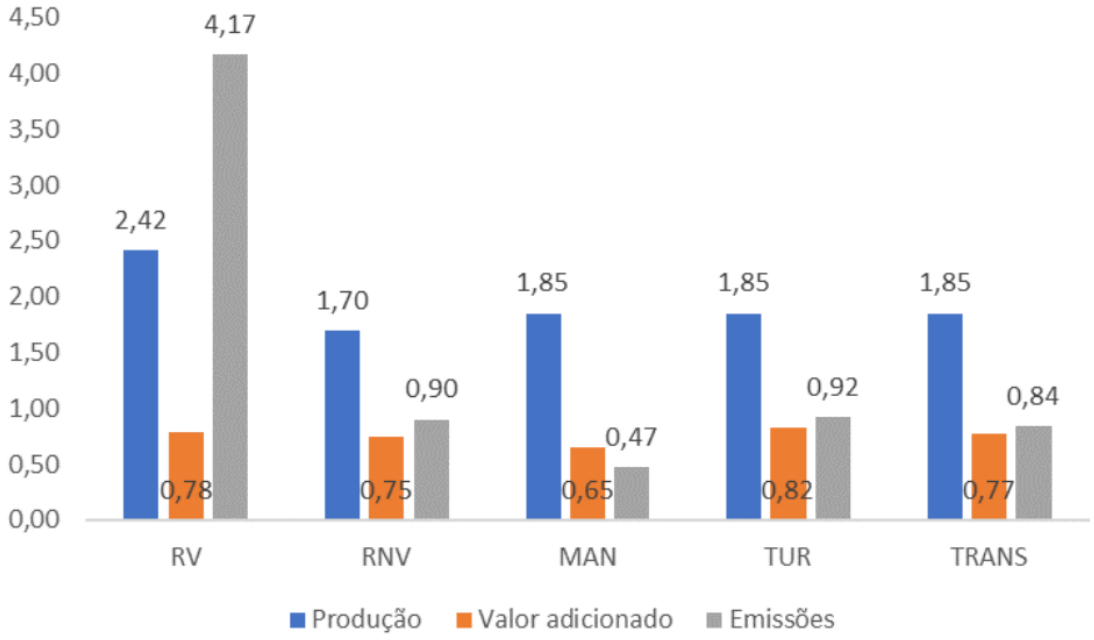
Figure 6 shows the emissions of sectors linked to the sea per unit of GRV produced. The unit used in this paper for GVP is millions, so we are analysing tonnes of C02 emitted per million products. This is one of the most important indicators because it allows us to analyse the real capacity to pollute. Before bovine slaughtering was phased out, the Live Resources sector led the way in terms of emissions per unit of product, with 410.84 tonnes of CO2 per million products (almost three times more polluting than the Non-Live Resources sector). After slaughter, this figure drops to 72.66 tonnes. Without slaughter, the Non-Living Resources sector leads the way in terms of pollution per unit of product, while manufacturing not only has a low share of total emissions, but also pollutes little per unit (4.31 tonnes of CO2 per million GVA). The non-living resources sector pollutes 30 times more per unit of product than manufacturing, while living resources without slaughter pollute 16 times more.

Figure 6: Emissions/GDP ratio of sectors linked to the Ocean Economy



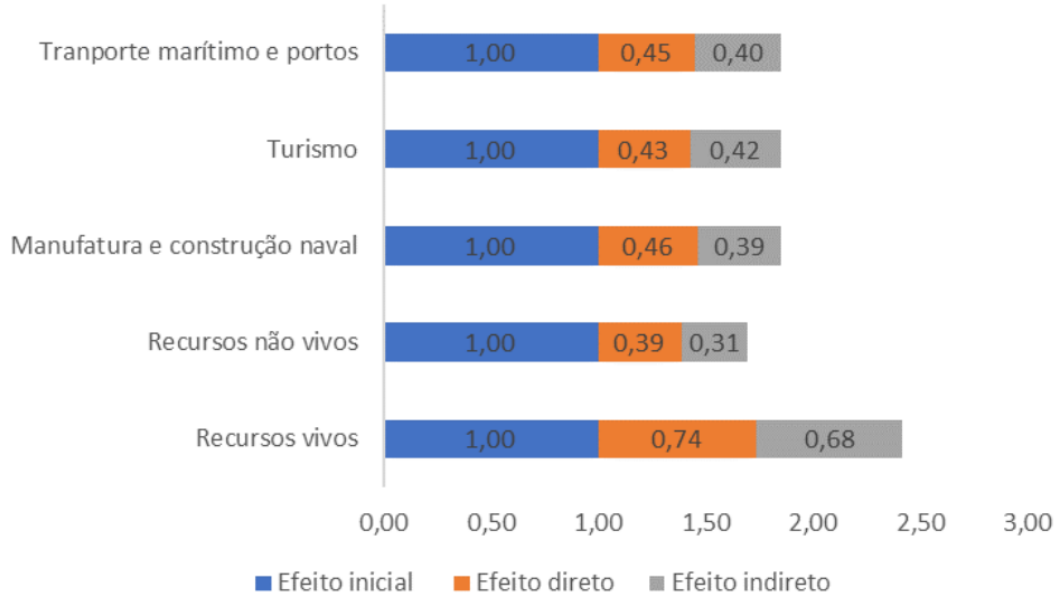
When we analyse the sea economy's multipliers (production, added value and emissions), we can see that the Living Resources sector has the highest production and emissions multipliers (2.42 and 4.17 respectively). The presence of cattle slaughtering may explain these values being higher than the average for the other sectors of the maritime economy. In terms of production, Manufacturing, Tourism and Transport have the same multiplier value (1.85), while Tourism leads the way in generating added value (0.82). In terms of C02 emissions, industry is the sector with the lowest pollution multiplier (0.47), a considerable difference compared to the other sectors: Non-Living Resources (0.90), Tourism (0.92) and Transport (0.84). Figure 7 shows the multipliers for the maritime economy; the indicators for the rest of the economy can be found in the annexes. It is important to emphasise that the production and value added multipliers consider a unit variation in final demand, while the pollution multiplier considers a variation of R$1000.00.

Figure 7: Simple production multipliers of the ocean economy



The production multiplier gives us the total effect on the economy of a unit change in final demand. This indicator can be broken down into direct and indirect effects on the economy. Figure 8 shows how these effects are presented in sectors linked to the sea. Of the R$2.42 total effect generated by the Living Resources sector, R$0.74 is a direct effect and R$0.68 is an indirect effect. Manufacturing is the second maritime sector with the greatest direct effect on the economy (0.46) and the second smallest sector in terms of indirect impact (0.39). Although Transport, Manufacturing and Tourism are equal in value of the production multiplier (all three with 1.85), Manufacturing affects the economy more directly than the other two sectors, while Tourism generates greater indirect impacts. The full table is available in the annexes section.

Figure 8: Direct and indirect effects of unit variations in final demand



Using the technical coefficients and inverse Leontief matrices, it is possible to analyse the impact of variations in the final demand of sectors. The total impact on production, represented by the production multiplier, can be broken down into a direct effect (through the technical coefficients matrix) and an indirect effect. It is also possible to calculate which other sectors are being most impacted by this variation in demand.

An increase of R$100.00 in the final demand of the Living Resources sector, for example, generates R$241.88 in the economy, taking into account the direct and indirect impacts. This amount is divided between the sectors of the economy, the most impacted of which is naturally the Living Resources sector itself, which contributes R$118.96. The second sector most impacted by this increase in demand is ‘Livestock, including support for livestock’, with an impact of R$17.76, followed by ‘Wholesale and retail trade’ (R$16.57) and ‘Agriculture, including support for agriculture and post-harvest’ (R$15.90). It is interesting to note that two sectors linked to agriculture were heavily impacted, demonstrating the existence of a strong link with Living Resources, which is explained by the presence of the slaughter sector.

When the same shock of R$100.00 is applied to Manufacturing and shipbuilding, the final impact on the economy is less when compared to living resources, generating R$184.90. The sectors most impacted are Manufacturing and shipbuilding itself

(R$115.51), followed by ‘Wholesale and retail trade’ (R$14.02), ‘Production of pig iron/iron alloys, steel and seamless steel tubes’ (R$6.76) and ‘Land transport’ (R$5.15).

We noted earlier that the Manufacturing, Tourism and Transport sectors have the same impact on the economy after a variation in their final demands (the three sectors have a production multiplier of 1.85), but they affect the other sectors in the economy differently. Tourism, in addition to the impact on itself (R$100.29), affects the Living Resources sector to a greater extent (R$13.61), Wholesale and Retail Trade (R$11.34) and Beverage Manufacturing (R$9.83). The Maritime transport and ports sector affects itself (R$111.04), Wholesale and retail trade (R$10.15), Manufacturing of non-metallic mineral products (R$9.25) and Manufacturing and shipbuilding (R$9.05).

FINAL REMARKS

This paper set out to discuss the sectors linked to the economy of the sea as vectors of economic and environmental development. We have worked with some limitations, such as the lack of a satellite account for the ocean, which prevents more precise estimates of both the product and the environmental vector. The initial work of identifying sectors linked to the sea and defining what the economy of the sea in Brazil would be, however, is essential if we are to move forward with the discussion

Considering the importance of industrial policy as a way of restarting the country's economic development, generating technology and more qualified jobs, combined with current environmental demands, it is necessary to discuss the role of industry in sustainable development, overcoming the idea of industry as a major polluter. As you can see, the biggest emitters of CO2 in Brazil are sectors linked to agriculture. Economic development combined with environmental development should not be thought of in spite of industry, but in conjunction with it.

As sectors linked to the sea cut across various segments of the national economy, it is interesting to think of the ocean as a possible vector for industrial and environmental development. Sectors such as shipbuilding and parts manufacturing are highly technology-intensive and have the potential to spill over into the rest of the economy.

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ANNEXES

Multipliers of production, added value and emissions

Code	Sectors	Production Multiplier	Added Value Multiplier	Emissions Multiplier
		R$ 1,00 Variation on the Final Demand	R$ 1,00 Variation on the Final Demand	R$ 1000,00 Variation on the Final Demand
LR	Living Resources	2,42	0,78	4,17
NLR	Non Living Resources	1,70	0,75	0,90
MAN	Manufacture and Shippbuilding	1,85	0,65	0,47
TUR	Tourism	1,85	0,82	0,92
TRANS	Maritime Transport and Ports	1,85	0,77	0,84
0191	Agriculture, including agricultural and post-harvest support harvest	1,76	0,76	4,83
0192	Livestock farming, including support for livestock farming	1,88	0,81	15,10
0791	Iron ore extraction, including beneficiation and agglomeration	1,77	0,80	0,58
0792	Extraction of non-ferrous metallic minerals, including processing	1,88	0,74	2,34
1092	Manufacture and refining of sugar	2,48	0,76	4,10
1100	Manufacture of beverages	2,30	0,78	0,96
1200	Manufacture of tobacco products	2,29	0,81	2,62
1300	Manufacture of textile products	2,03	0,71	1,10
1400	Manufacture of clothing and accessories	1,88	0,76	0,50
1500	Manufacture of footwear and leather goods	2,01	0,77	0,67
1600	Manufacture of wood products	2,07	0,78	0,86
1700	Manufacture of pulp, paper and paper products	2,13	0,73	1,14

1800	Printing and reproduction of recordings	1,84	0,78	0,52
1991	Oil refining and coking	2,39	0,58	0,87
1992	Manufacture of biofuels	2,34	0,80	3,04
2091	Manufacture of organic and inorganic chemicals, resins and elastomers	1,99	0,51	0,79
2092	Manufacture of pesticides, disinfectants, paints and chemicals	1,98	0,56	0,94
2093	Manufacture of cleaning products, cosmetics/perfumery and personal hygiene products	2,13	0,67	1,61
2100	Manufacture of pharmochemical and pharmaceutical products	1,68	0,78	0,34
2200	Manufacture of rubber and plastic products products	2,04	0,62	0,48
2300	Manufacture of non-metallic mineral products	2,14	0,75	6,21
2491	Production of pig iron/iron alloys, steel and seamless steel tubes	2,25	0,68	3,33
2492	Nonferrous metallurgy and metal casting metal casting	2,14	0,65	2,80
2991	Manufacture of cars, lorries and buses, except parts	2,27	0,61	0,57
2992	Manufacture of parts and accessories for motor vehicles vehicles	2,05	0,69	0,69
3500	Electricity, natural gas and other utilities	1,96	0,80	0,69
3680	Water, sewage and waste management	1,55	0,86	10,34
4580	Wholesale and retail trade	1,57	0,88	0,29
4900	Land transport	2,03	0,78	1,42
5100	Air transport	1,85	0,60	7,57

Effects: Initial, Direct, Indirect and Total

Code	Sector	Initial Effect	Direct Effect	Indirect Effect	Total Effect
LR	Living Resources	1,00	0,74	0,68	2,42
RNV	Non Living resources	1,00	0,39	0,31	1,70
MAN	Nanufacture and Shippbuilding	1,00	0,46	0,39	1,85
TUR	Tourism	1,00	0,43	0,42	1,85
TRANS	Maritime Transport and Ports	1,00	0,45	0,40	1,85
0191	Agriculture, including agricultural and post-harvest support harvest	1,00	0,40	0,37	1,76
0192	Livestock farming, including support for livestock farming	1,00	0,44	0,44	1,88
0791	Iron ore extraction, including beneficiation and agglomeration	1,00	0,43	0,35	1,77

0792	Extraction of non-ferrous metallic minerals, including processing	1,00	0,48	0,41	1,88
1092	Manufacture and refining of sugar	1,00	0,83	0,65	2,48
1100	Manufacture of beverages	1,00	0,67	0,63	2,30
1200	Manufacture of tobacco products	1,00	0,73	0,56	2,29
1300	Manufacture of textile products	1,00	0,55	0,47	2,03
1400	Manufacture of clothing and accessories	1,00	0,48	0,41	1,88
1500	Manufacture of footwear and leather goods	1,00	0,53	0,48	2,01
1600	Manufacture of wood products	1,00	0,55	0,52	2,07
1700	Manufacture of pulp, paper and paper products	1,00	0,59	0,54	2,13
1800	Printing and reproduction of recordings	1,00	0,45	0,38	1,84
1991	Oil refining and coking	1,00	0,67	0,71	2,39
1992	Manufacture of biofuels	1,00	0,72	0,62	2,34
2091	Manufacture of organic and inorganic chemicals, resins and elastomers	1,00	0,52	0,47	1,99
2092	Manufacture of pesticides, disinfectants, paints and chemicals	1,00	0,54	0,45	1,98
2093	Manufacture of cleaning products, cosmetics/perfumery and personal hygiene products	1,00	0,58	0,54	2,13
2100	Manufacture of pharmochemical and pharmaceutical products	1,00	0,40	0,29	1,68
2200	Manufacture of rubber and plastic products products	1,00	0,55	0,49	2,04
2300	Manufacture of non-metallic mineral products	1,00	0,61	0,53	2,14
2491	Production of pig iron/iron alloys, steel and seamless steel tubes and seamless steel tubes	1,00	0,67	0,57	2,25
2492	Nonferrous metallurgy and metal casting metal casting	1,00	0,60	0,53	2,14
2991	Manufacture of cars, lorries and buses, except parts	1,00	0,67	0,60	2,27
2992	Manufacture of parts and accessories for vehicles	1,00	0,55	0,50	2,05
3500	Electricity, natural gas and other utilities	1,00	0,51	0,45	1,96
3680	Water, sewage and waste management	1,00	0,31	0,24	1,55
4580	Wholesale and retail trade	1,00	0,34	0,23	1,57
4900	Land transport	1,00	0,51	0,52	2,03
5100	Air transport	1,00	0,46	0,39	1,85

Code	Sector	Initial effect	Direct effect	Indirect effect	Total effect
5280	Storage, activities auxiliary to transport and mail	1	0,352611	0,228595	1,581206
5800	Publishing and editing integrated with printing	1	0,402619	0,288708	1,691327
5980	Television, radio, cinema and recording/editing activities recording/editing activities	1	0,509031	0,343363	1,852394
6100	Telecommunications	1	0,499772	0,31342	1,813192
6280	Systems development and other information services	1	0,268061	0,147897	1,415958
6480	Financial intermediation, insurance and pension funds insurance	1	0,294181	0,150872	1,445052
6800	Real estate activities	1	0,066455	0,038474	1,104928

6980	Legal, accounting, consultancy and corporate headquarters activities head offices	1	0,257818	0,144512	1,402329
7180	Architectural, engineering, technical testing/analysis testing/analyses and R&D	1	0,296275	0,181008	1,477283
7380	Other professional, scientific and technical activities	1	0,562707	0,409957	1,972664
7700	Non-real estate rentals and management of intellectual property assets	1	0,287268	0,197719	1,484987
7880	Other administrative activities and activities	1	0,263485	0,174378	1,437864
8000	Surveillance, security and investigation activities	1	0,154838	0,094755	1,249593
8400	Public administration, defence and social security	1	0,242935	0,148401	1,391337
8591	Public education	1	0,136908	0,092788	1,229696
8592	Private education	1	0,24047	0,146215	1,386685
8691	Public health	1	0,294935	0,209123	1,504058
8692	Private health	1	0,355873	0,226759	1,582631
9080	Artistic, creative and entertainment activities	1	0,373625	0,215834	1,589459
9480	Membership organisations and other personal services	1	0,379667	0,269113	1,64878
9700	Domestic services	1	0	0	1

The production multiplier provides the overall effect on the economy from a unit variation in final demand. This indicator can be further broken down into direct and indirect effects on the economy.

From R$2.42 generated by total effect from the Living Resources sector, R$0.74 are direct effect and R$0.68 are indirect effect. Manufacturing emerges as the second sector with the highest direct economic impact (0.46) and is the second lowest in terms of indirect impact (0.39). Although Transport, Manufacturing, and Tourism have equal production multiplier values (all three being 1.85), Manufacturing directly affects the economy more intensely than the other two sectors, while Tourism generates larger indirect impacts.

From the technical coefficients and inverse Leontief matrices, it is possible to conduct further impact analyses based on variations in final demand for the sectors. The total impact on production, represented by the production multiplier, can be decomposed into direct (via the technical coefficient matrix) and indirect effects. It is also feasible to calculate which other sectors are most impacted by variations in demand.

An increase of R$100.00 in final demand for the Living Resources sector, for example, generates R$241.88 in the economy, factoring in both direct and indirect impacts. This amount gets distributed among the sectors of the economy; the most impacted sector, naturally, is the Living Resources sector itself, contributing R$118.96. The second most impacted is "Livestock, including support for livestock," with an impact of R$17.76, followed by "Wholesale and retail trade" (R$16.57) and "Agriculture, including support for agriculture and post-harvest" (R$15.90).

When the same R$100.00 shock applies to Manufacturing and Shipbuilding, the final economic impact is lower compared to that of Living Resources, generating R$184.90. The sectors most impacted are Manufacturing and Shipbuilding itself (R$115.51), followed by "Wholesale and retail trade" (R$14.02), "Production of pig

iron/alloys, steelmaking, and seamless steel pipes" (R$6.76), and "Land transport" (R$5.15).

As previously noted, the Manufacturing, Tourism, and Transport sectors each have the same economic impact following variations in their final demands (all three with production multipliers of 1.85), but they affect other sectors in the economy differently. Tourism has the most significant impact on itself (R$100.29) and a notable impact on the Living Resources sector (R$13.61), "Wholesale and retail trade" (R$11.34), and "Beverage manufacturing" (R$9.83). Meanwhile, the Maritime Transport and Ports sector most intensely affects itself (R$111.04), "Wholesale and retail trade" (R$10.15), "Manufacturing non-metallic mineral products" (R$9.25), and "Manufacturing and Shipbuilding" (R$9.05).

FINAL CONSIDERATIONS

This work aimed to explore the sectors linked to the marine economy as vectors of economic and environmental development. We faced several limitations, including the absence of a satellite account for the ocean, which hinders more precise estimations of both product and environmental indicators. Initial efforts to identify the sectors related to the sea and define what the marine economy comprises in Brazil are essential for advancing this discussion.

Considering the critical role of industrial policy in resuming the nation's economic development, fostering technology, and creating more qualified jobs in line with contemporary environmental demands, it is imperative to discuss the significance of the industry in sustainable development, transcending the notion that industry is a major source of pollution. As evidenced, in Brazil, the largest CO2 emitters are linked to agricultural sectors. Economic development coupled with environmental development must be conceptualized not in terms of industry as an adversary but in the context of its partnership with it.

Given that the sectors linked to the marine economy traverse various segments of the national economy, it is interesting to consider the ocean as a potential vector for industrial and environmental development. Sectors such as shipbuilding and parts

manufacturing are heavily technology-intensive and possess potential spillover effects for the rest of the economy.