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MULTIDIMENSIONAL ANALYSIS OF THE SEA ECONOMY: A CASE STUDY FOR THE MADEIRA ISLAND, PORTUGAL

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Abstract

Since the inception of the concept of the Blue Economy, numerous studies have made efforts to identify the contributions of the sea to national economies. This has required the use of disaggregated data, which is not always available for regions. In this context, the National Institute of Statistics (INE) has identified activities directly or indirectly related to the Blue Economy on the mainland and islands of Portugal. More specifically, in the Autonomous Region of Madeira (ARM), it is believed that the sea contributed €922 million of the regional output of 2017. Using the linkages provided by the Input-Output Matrix (IOM), we could make three significant contributions to this analysis. Firstly, a partial hypothetical extraction is a formal approach that accurately identifies the indirect effects of the marine sector on the entire Portuguese supply chain. Secondly, we can simultaneously impose restrictions on the demand side. This is relevant since most marine activities are labor-intensive and thus affect the payment structure. Finally, we can delve deeper into measuring the impact of Madeira's maritime economy on employment level and its composition, and regional CO_2 emissions. Our findings reveal that the marine sector contributes €2.049 billion (28%) to Madeira's economy and €2.451 billion (0.70%) to Portugal's gross output. Without the sea on the ARM, national employment levels for women, young people, and the immigrants would decline by 0.83%, 0.7% and 0.53%, respectively.

Keywords: Blue economy, Portuguese islands, Economic impacts.

JEL: Q56, R11, R15.

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1. Introduction

The measurement of the contribution of natural resources to any economy is crucial for acknowledging their importance and ensuring their correct preservation. In this context, the concept of Blue Economy was created to define sectors and cross-sectoral activities related to oceans, seas, and coastal areas (Ecorys, 2012). Viewed as a sector, the sea was responsible directly for 4.5 million jobs and €176 billion for the European economy in 2018 (European Commission, 2021).

Given that the concept of Blue Economy involves sectors such as tourism, fishing, aquaculture, maritime transport, biotechnology, and energy, their environmental and socioeconomic importance becomes evident. In the context of climate changes, concerns about indicators related to sustainable development and addressing inequalities among minority groups highlight research opportunities in the marine sector. This emphasizes the relevance of studying the theme to help policymakers plan strategically for coastal regions.

The maritime economy has been extensively studied to assess its significance in national economies. In this regard, Ram, Ramrattan, and Frederick (2019) developed a Sea Satellite Account for Jamaica, focusing on fishing industries, coastal tourism, and maritime transport. They estimate that the marine sector contributes 6.9% of added value, highlighting its role in local development. In the Spanish part of the Atlantic Arc, Fernández Macho et al. (2015) estimate that the contribution of the sea is 0.67% of Spain's gross output, representing 1.1% of employment. Other studies also quantify the marine sector as representing 1% of the Irish economy (Morrisey et al., 2011), 4% for the Chinese (Zhao et al., 2014), 1,5% for the American (Kildow et al., 2014), 2,6% for the Brazilian (Carvalho and Moraes, 2021) and 3,9% for the Portuguese (Statistics Portugal, 2020). Despite their contributions, these studies do not explore the value chain perspective of the blue economy, including the estimation of regional and sectoral indirect effects. This approach is only addressed in the work of Haddad and Araújo (2024), where they estimate that Brazil's maritime economy contributes 6.39% to GDP, with 3.48% indirectly and 2.91% directly linked to ocean-related activities.

The development of Sea Satellite Accounts within countries' Systems of National Accounts (SNA) statistics (Ram, Ramrattan, and Frederick, 2019; Statistics Portugal, 2020; Nicolls et al., 2020) is a significant step in harmonizing accounting principles. This, in turn, establishes comparability across countries and enhances the accuracy in blue economy statistics (Haddad and Araújo, 2024). Nevertheless, the concept of the blue economy is not unique; its measurement can vary depending on the definition employed, which is criticized by Graziano et al. (2022). Their research indicates that it can range from $9 to $71 billion annually in Michigan in 2018, depending on the measurement concept used. For Scotland, the product varies from £3 to £24 billion, revealing an even greater difference. According to the authors, the greatest divergence between definitions concerns the inclusion of activities related to the exploration of natural resources from the sea.

In the case of a small island economy, the relevance of the maritime sector is even greater due to geographic isolation, reduced territorial extension and limited diversification possibilities (Vrontisi et al., 2022). Specifically, the Autonomous Region of Madeira (ARM), is highly dependent on the sea for tourism, transportation, and fishing activities. The dimension of the blue economy for ARM was estimated by the National Institute of Statistics (INE) through the Sea Satellite Account (SSA); however, it is convenient to also evaluate the direct and indirect effects through its linkages in the Portuguese supply chain.

Our primary goal is to estimate the size of the blue economy in ARM by combining the methodologies used in Haddad and Inácio (2024) with that of the SSA to integrate the marine sector in the Input-Output Matrix (IOM). Additionally, this study aims to define the systemic effects of ARM's blue sector for Portugal by adopting a hypothetical partial extraction approach. This enables us to measure the importance of Madeira's maritime economy value chain both regionally and across sectors, in terms of added value, employment in level and composition, as well as CO_2 emissions.

This paper not only contributes to the literature by providing a measurement of the systemic effects, but also discusses the multidimensional importance of the sea across the sectors and regions of a small island, and how it integrates into the national system. In the economic aspect, we measure the impact of the blue sector in terms of value added. In the social dimension, we account for the effect in terms of employment by gender, age group, and nationality. Finally, in the environmental aspect, we explore how the blue economy can either increase or decrease CO_2 emissions relative to the value added in each region.

By examining the systemic effects from various perspectives, policymakers can understand the complexity and the relevance of the issue, which can assist them in making decisions about the theme.

Through this process it can be observed that the blue economy from the Autonomous Region of Madeira accounts directly and indirectly 1.37 billion of euros in terms of added value, corresponding to 0.81% of the Portuguese gross output. The maritime economy of Madeira is still responsible for 42,569 jobs and the emission of 297.9 tons of CO_2, representing 0.89% and 0.60% of Portugal as a whole, respectively.

This paper begins with a concise overview of the Autonomous Region of Madeira, focusing on its historical development and demographic characteristics. Following this, the methodology and data are structured around the general framework, our definition of blue economy, hypothetical extraction approach, and specific database details. Subsequently, the result section is segmented into direct and systemic contributions, which discuss the economic, social, and environmental impacts of Madeira's Blue Economy. Finally, the conclusion provides concluding remarks based on the principal findings.

2. Study Site: Madeira Island, Portugal

The Autonomous Region of Madeira (ARM) is an archipelago in the Atlantic Ocean and one of the nine regions of Portugal, according to the new NUTS II division proposed in 2024. It is the most populated overseas Portuguese territory, with 250,744 inhabitants, in 2021, spread across eleven municipalities. The archipelago includes the Savage, Desertas, Madeira, and Porto Santo islands, though only the latter two host cities. The regional capital, Funchal, located on Madeira Island, lies almost 1,000 kilometers from Lisbon.

From a historical perspective, the islands were occupied by Portuguese citizens in 1419 during expeditions to the African Coast. Since then, Madeira Island has served as a regular port for ships, with its habitants engaging in fishing, and the cultivation of vineyards and sugar cane. However, sugar production declined in the sixteenth century due to the competition with Brazil and Açores, leaving wine as the primary economic activity. Along with the progressive settlement, the region gained recognition in Europe as a renowned destination for the treatment of pulmonary diseases, such as tuberculosis, due to its warm, moist climate. This notoriety increases the number of visitors and physicians, thereby developing tourism. Following significant infrastructure investments, the first airport in ARM was inaugurated in 1960. The regional economy experienced growth during the Revolution of 1974 and Portugal's entry into the European Union (EU) in 1986. The early 1990's crisis and the financial crisis of 2008 posed challenges, leading to a decline in the resident population.

Currently, the region faces an aging and declining population. From 2011 to 2021, the number of residents decreased by 6.4%, while the population over 65 years increased from 14.9% to 20%. In terms of the economy, the wine industry remains significant, but the services sector (public administration, retail and wholesale trade) has expanded its share in output and employment. Tourism, or accommodation and food services, is the most prominent sector in the economic structure, with the second-highest growth rate.

3. Methodological Approach

3.1. General Framework

This paper is based on the interindustry and interregional input-output model, where a single matrix can identify trades between sectors within each region, as well as final demand sales. The interindustry sales from industry i in region r, represented on the row, to industry j in region s, represented on the column, is denoted by z_{ij}^{rs}. Similarly, we can identify the payments in imports, indirect taxes, labor and other payments made by the industry j in region s as m_j^s, t_j^s, l_j^s, and n_j^s, respectively. The final demand components, namely, household and non-profit organizations consumption, investment and government purchases, and exports are also divided by region and displayed on the last columns. Consequently, the final demand components in region s for products from sector i, located in region r, are represented by $f_{ic}^{rs}, f_{ic_n}^{rs}, f_{ii}^{rs}, f_{ig}^{rs}$, and f_{ie}^{rs}.

When summing the values in rows, that is, adding the interindustry sales with final demand purchases, we have the total output of sector i in region r, described as x_i^r. This is known as the production approach. Conversely, summing the columns is the expenditure approach and also achieve x_i^r. Therefore, the IOM is intrinsically connected to the country' System of National Accounts statistics. To align the IOM with the SSA, we need to correlate sectors with activities, as Satellite Accounts use more disaggregated data. Each sector i is associated with an exclusive set of K_i activities identified by the 5-digit Economic Activity Code (EAC). If we define x_k^r as the total output of activity k in region r, then the equivalent for sector i in region r is given by:

$$x_i^r = \sum_{k=1}^{K_i} x_k^r \quad (1)$$

3.2 Defining the Blue Economy

In order to assess the linkage effects of the blue economy on ARM, we first need to explicitly identify it inside the input-output model. This is the fundamental issue to be addressed since there is no standard definition of what constitutes a national marine sector (Morrissey, et al, 2011; Graziano et al., 2022, Katila et a., 2019) and often there is a lack of comparable and replicable data (Morrissey, et al, 2011). The efforts made by INE on the SSA have already provided a definition of the marine economy as "the conjunct of activities that happen in the sea and others that, not happening there, depend on it, including natural sources and non-tradable services provided by marine ecosystems" (Statistics Portugal, Methodological Report, p.8, 2022).

Notice that, following this broad definition, activities can be distinguished into three groups. First, the ones that are allocated on the sea and create value directly through it, such as marine fishing and coastal tourism. Second, the activities that provide services for the first group, and those include fish processing, port activities, and hotels. Finally, the third is those activities connected to the value chains created by marine activities, such as fish trade and cultural activities. As one of our objectives is to follow the SSA methodology, we adopt the same definition of blue economy, but we exclude the third group. This decision is based on the lack of data to estimate the coefficient that reflects the extent to which these activities utilize the marine value chain and because the third group does not provide goods for the marine sector. This inter-sectorial connection is better identified through hypothetical extraction, a technique described in section 3.3. A limit of our approach is that we are not able to identify those connections between activities of group three with the others if they are in the same sector.

To isolate the marine sector of ARM in the IOM we deploy a bottom-up approach. Firstly, we identify how much the activity k in region r depends and/or contributes to the

Madeira's blue economy, defining this as θ_k^r, where it belongs to the interval $[0,1]$. We assume that activities taking place outside Madeira's region do not contribute to its marine sector, then $\theta_k^r = 0, \forall(k,r)|_{r\neq 07}$. Following the definition given before, if activity k of the Region of Madeira belongs to the first group, it takes place in the sea. Consequently, it is entirely part of the marine sector and $\theta_k^r = 1$. If activity k is in the second group we must evaluate θ_k^r based on other relevant information. Then, the total output of this activity that is depended on Madeira's blue economy is $\breve{x}_k^r = \theta_k^r x_k^r$. In order to do the same for sector i we take advantage of equation (1), writing:

$$\breve{x}_i^r = \sum_{k=1}^{K_j} \theta_k^r x_k^r \quad (2)$$

Finally, the marine sector of Madeira in the IOM is given by the share of the blue economy in each sector in each region, and for a specific pair (i,r) we have:

$$BLUEM_i^r = \frac{\breve{x}_i^r}{x_i^r} \quad (3)$$

3.3 Hypothetical Extraction

In this interindustry and intersectoral input-output model, the output of the economy is given by:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \quad (4)$$

Where x is the column vector of gross output, containing the list of x_i^r for all J sectors in R regions, $\mathbf{I}$ is an $(RJ \times RJ)$ identity matrix, $\mathbf{A}$ is the matrix of technical coefficients, where each component (a_{ij}^{rs}) is the ratio between z_{ij}^{rs} and x_i^r, and $\mathbf{f}$ is the column vector with the sum of final demand components. In this system, the matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is known as Leontief inverse matrix, and its elements (b_{ij}^{rs}) represents output in sector i from region r directly and indirectly required to satisfy one unit of final demand in industry j in region s. Identifying those both effects through linkages is an advantage of this model (Miller and Lahr, 2001).

In order to evaluate the socioeconomic and environmental impacts that the access to sea in Madeira's region provides to all the country, we could impose restrictions on both **A** and **f**, and get a new vector of outputs ($\bar{\mathbf{x}}$).This approach is referred to in the literature as hypothetical extraction. Originally, this method was conceived by Paelinck et al. (1965) and extended to a regional approach by Miller (1966; 1969). The basic logic is to quantify how much the output of an economy would decrease ($\Delta\mathbf{x}$) if a sector or region were to be removed. However, notice that, in our study case, the sector we have identified is not a cohesive one, since it does not have its own final demands and interindustry flows, but rather, these are diffused into other sectors. To address this issue, adopt a variant of the extraction approach. Instead of hypothetically extracting an entire sector in a specific region, we partially extract all sectors, according to their relation to Madeira's blue economy.

The first part is to define $J \times R$ supply-side factors, which describe the share of output in each sector and region that is not directly related to Madeira's marine sector. As an example, for the pair (i, r) we have $F_i^r = 1 - \frac{\breve{x}_i^r}{x_i^r}$ or simply $F_i^r = 1 - BLUEM_i^r$. Once these factors are computed we may reduce the interindustrial flows. The restricted flow will be designated by $\overline{z_{ij}^{rs}}$,and the extent of reduction depends on which is more affected: the sector who is selling or the one who is buying. In practical terms, this means taking:

$$\overline{z_{ij}^{rs}} = \begin{cases} F_i^r z_{ij}^{rs}, \text{if } F_i^r < F_j^s \\ F_j^s z_{ij}^{rs}, \text{if } F_i^r > F_j^s \end{cases}$$

In order to impose constraints on the demand side, we must construct one factor for each demand user. Beginning with household and non-profit organizations consumption, we first identify earnings of workers. If we define n_k^r as the total earning of labor in activity k in region r, then using the same θ_k^r defined earlier, we can write the earnings of this activity related to the Madeira's marine sector as $\breve{n}_k^r = \theta_k^r n_k^r$. Thus, the factor for consumption is given by

$$F_c = 1 - \frac{\sum_{r=1}^{R} \sum_{j=1}^{J} \sum_{k=1}^{K_j} \breve{n}_k^r}{\sum_{r=1}^{R} \sum_{j=1}^{J} \sum_{k=1}^{K_j} n_k^r}$$

We can consider that $F_c = F_{c_n}$, as both depend on income-related changes. We obtain F_i and F_g in a similar manner. For the first, we replace the total labor earning with corporation investments, and for the last, we use net indirect taxes and production taxes on corporations. Finally, since the exterior demand is assumed to be fully exogenous, we settle $F_e = 1$.

Once again, we must identify which plays the major restriction in the trade: the sector offering or the final user who is buying:

$$\overline{f_{iu}^{rs}} = \begin{cases} F_i^r f_{uj}^{rs}, \text{if } F_i^r < F_u \\ F_u f_{uj}^{rs}, \text{if } F_i^r > F_u \end{cases} \forall f_{uj}^{rs}, i = 1, \dots, J, u = c, c_n, i, g, e \text{ and } r, s = 1, \dots, R$$

Similarly to what we have done with z_{ij}^{rs} and f_{uj}^{rs} we can use $\overline{z_{ij}^{rs}}$ and $\overline{f_{iu}^{rs}}$ to construct the restricted matrixes $\bar{\mathrm{A}}$ and $\bar{f}$. While the first of those indicates the intersectoral trade flows with supply restrictions, the second is the correspondingly final-demand matrix with the sea-related restrictions we have imposed. Using both matrices, the final output of the Portuguese economy under supply and demand restrictions is

$$\bar{\mathbf{x}} = (\mathbf{I} - \bar{\mathbf{A}})^{-1}\bar{\mathbf{f}} \quad (5)$$

Consequently, the impact on total output in each region and sector is equal to restricted output minus the output of the complete system:

$$\Delta\mathbf{x} = \bar{\mathbf{x}} - \mathbf{x} \quad (6)$$

This represents the direct and indirect effects that the access to the sea in Madeira's Islands provides in the Portuguese production. However, this approach is not limited to economic variables. We can also exploit CO_2 emissions by regions and sectors and social indicators such as employment by sex, age and nationality. The first step is to divide each value that those variables assume per sector and region, divided by the respective sectoral-regional output. This ratio will be main diagonal of the diagonal matrix $\widehat{\boldsymbol{V}}$. Taking $\boldsymbol{i}'$ as the $(RJ \times 1)$ unit vector, the matrix product $\boldsymbol{i}'\Delta\mathbf{x}\widehat{\boldsymbol{V}}$ gives us the changes in the desired variables.

3.4 Database

This paper employs the interregional input-output matrix for the seven regions of Portugal and their 65 sectors in the year of 2017, obtained by the method of Interregional Input-Output Adjustment System (IIOS), based on Haddad et al. (2016). All these values are in millions of euros. The matrix also includes CO_2 emissions, labor payments and employment by sectors and regions. The proportion of employment by sex and age group comes from the Employment Inquiry database, while the nationality comes from the Personnel Table micro-data for employees.

We assume that the total output of activities (x_k^r) are proportional to retail sails, which we get from the Integrated Business Accounts System (SCIE) micro-data. The earnings by labor, corporation investments, net indirect taxes, and taxes on corporations also come from SCIE. The exception is national defense and other public services, where we use the Statistical Yearbook of National Defense and National Accounts, respectively.

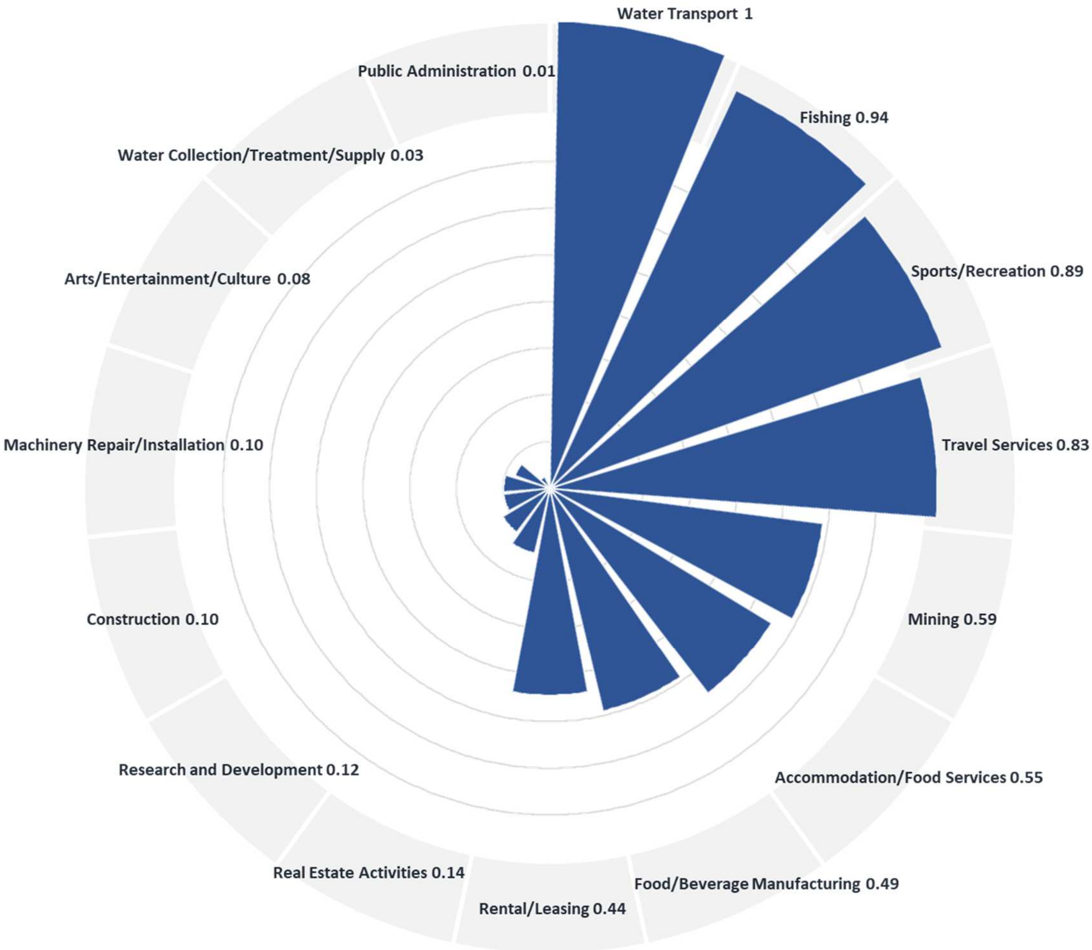
The ratio θ_k^r is provided by the SSA for the activities related to accommodation, catering and travel agencies. For other activities, the ratios were constructed based on secondary databases such as PORDATA, the Portuguese Housing Stock and the Construction and Housing Statistics.

4. Results and discussion

4.1 Direct Contribution

The blue economy is critically important for islands as many activities rely heavily on marine resources, with some being entirely dependent on access to the sea. Considering the sectors within the ARM, we quantify this dependence on marine resources through $BLUEM_i^r, r = 07, \forall i = 1, \dots, J$, which values are depicted in Figure 1. As expected, the sectors where the sea serves almost as an input such as Water Transport, Fishing, and those associated with tourism exhibit the highest dependency ratios. Several other sectors including Mining, Food Manufacturing and Real Estate are also significantly interconnected with Madeira's marine sector.

Figure 1 - Share of the Blue Economy in Gross Output, by Sector

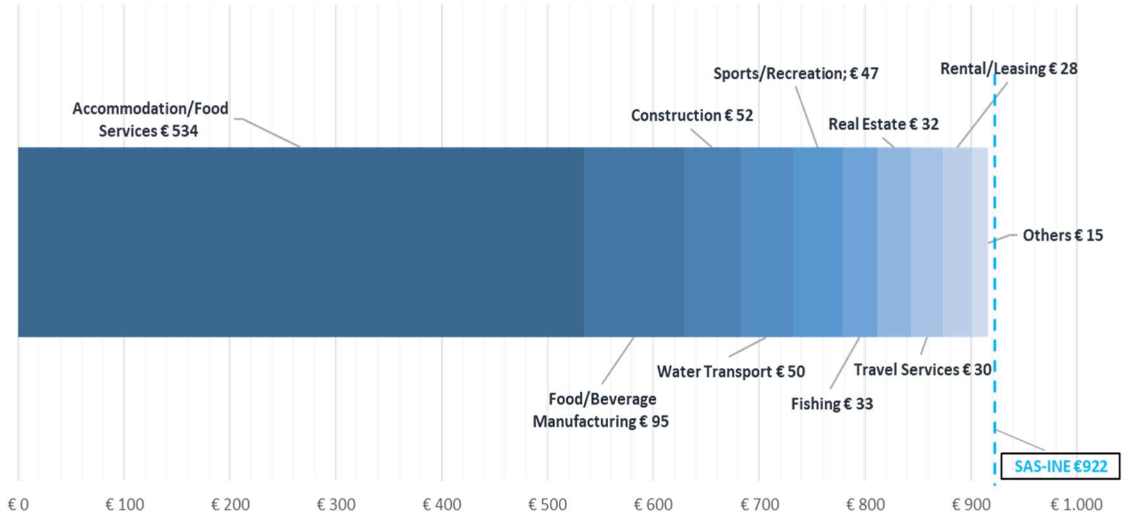


Source: Elaborated by the authors.

Based on these estimates, in 2017, the Madeira's Marine Sector directly generated €916.8 million in gross output, accounting 0.54% of the Portuguese total output. In terms of added value, it corresponds to €491.6 million, representing 1.15% of Portugal's total added value. It was also responsible for 0.30% of the national workforce and 0.19% of Portugal's CO_2 emissions.

It is important to note that this effect is restricted to the region in question and, reflecting the unique characteristics of the Madeira and its relationship with the sea. In the region of Madeira itself, the blue economy corresponds to 13.19% of total gross output, 11.75% of added value, 11.63% of employment and 11.26% of CO_2 emission. Figure 2 illustrates that the blue economy is most relevant to sectors related to tourism, such as Accommodation/Food Services, but it is also important to sectors related to fishing and fish processing.

Figure 2 - ARM's Blue Economy Gross Output (mi) in 2017 by Sector



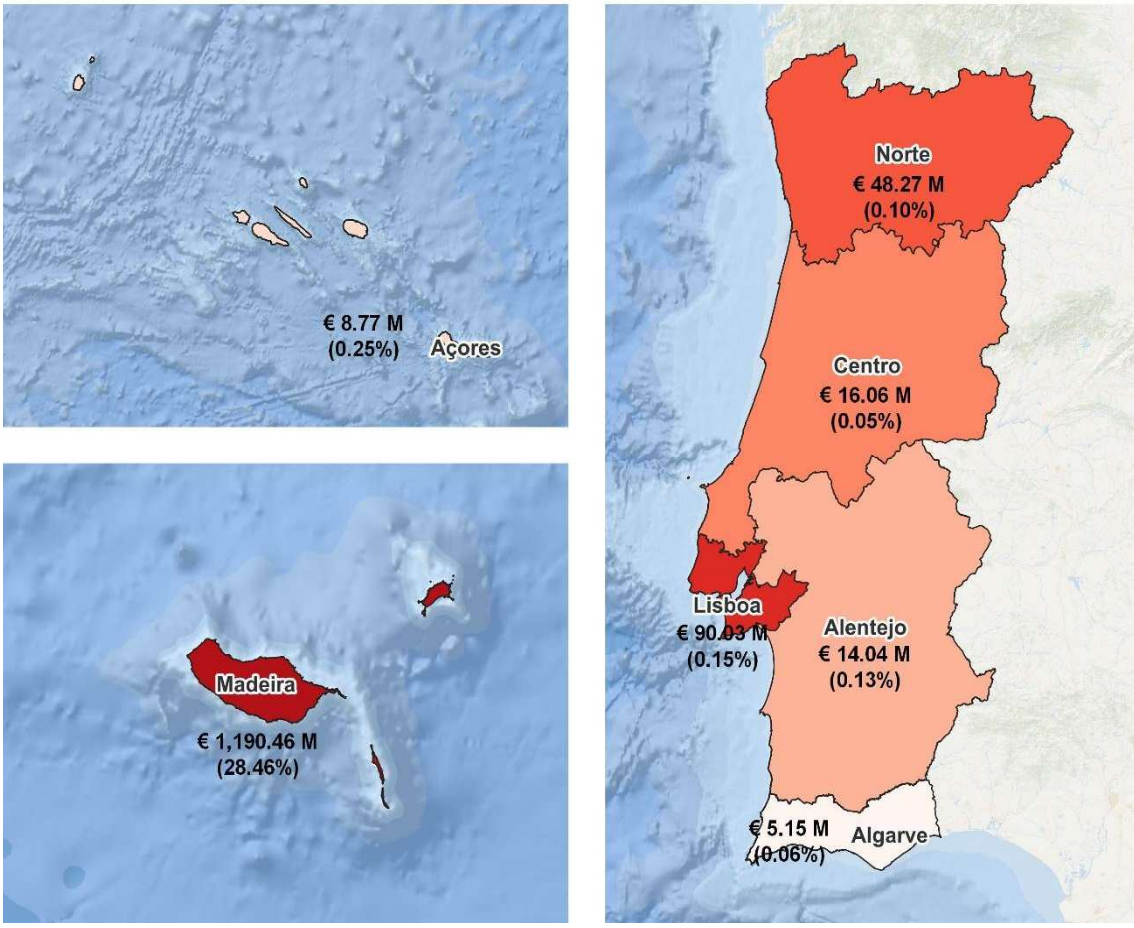
Source: Elaborated by the authors.

Notably, the SSA reports €922.4 million as the portion of Madeira's share of maritime activities. The close alignment of our estimate with the SSA figure, derived from similar microdata methodology, enhances the robustness of our results.

4.2 Systemic Contribution

The application of the input-output analysis enables us to capture the indirect effects of Madeira's blue economy on the national system. While the direct effect accounts for 0.54% of the GDP, the overall impact is estimated at €2.45 billion, representing 0.70% of the country's total output. This difference equates to a multiplier of 2.67, indicating that each euro invested in the marine sector in ARM generates €2.67 across the entire economic system. Conversely, the hypothetical extraction method suggests that, without access to the sea, the industries in ARM and other regions would lose both production and demand contributions from Madeira's blue sector. The final demands for all regions would also decrease as the region loses labor income, taxes and investments. Consequently, the negative effect of this restriction would extend to other regions. Madeira's GDP loss would be followed by decreases in Açores (0.25%), Lisboa (0.15%), Alentejo (0.13%), Norte (0.10%), Algarve (0.06%), and Centro (0.05%).

Figure 3 – GDP from the Madeira's Blue Economy by Region (NUTS II, 2013)



Source: Elaborated by the authors.

From a geographical perspective, the regions of the Açores and Madeira are small markets, distant from the mainland, and heavily dependent on the ocean. When considering economic activities, the Algarve is also similar to both as its gross output is significantly dependent on Accommodation/Food services (13%) and Fishing (13%). None of the three regions concentrates the national production of a specific sector. However, the systematic impact on the Açores is the highest after Madeira itself. Of the €8.77 million in added value that the ARM's marine sector produced, 27% came from Education, 20% from Crop/Animal production and 10% from Residential/Social care. In contrast, Algarve experiences the second smallest regional percentage importance of the Madeira's sea, which comes mostly from Education (21%) and Health services (13%).

The northern regions, being the farthest from the islands, are less dependent in terms of percentage added value. However, this might be mainly due to their different industrial structures. The Norte is, historically, the most industrialized region of the country, especially Porto and the nearby cities. The region concentrates 86% of the gross output in textile industry and 51% of plastics. The manufacturing industry is relatively independent of Madeira's blue economy. From the €48.27 million in added value related to ARMs blue economy, Education represents 15% and Food products manufacturing 9%. Similarly, the Centro concentrates the sectors of non-metallic minerals, paper and electrical equipment, but Madeira's marine added value is predominantly generated by Education (23%) and Health services (13%).

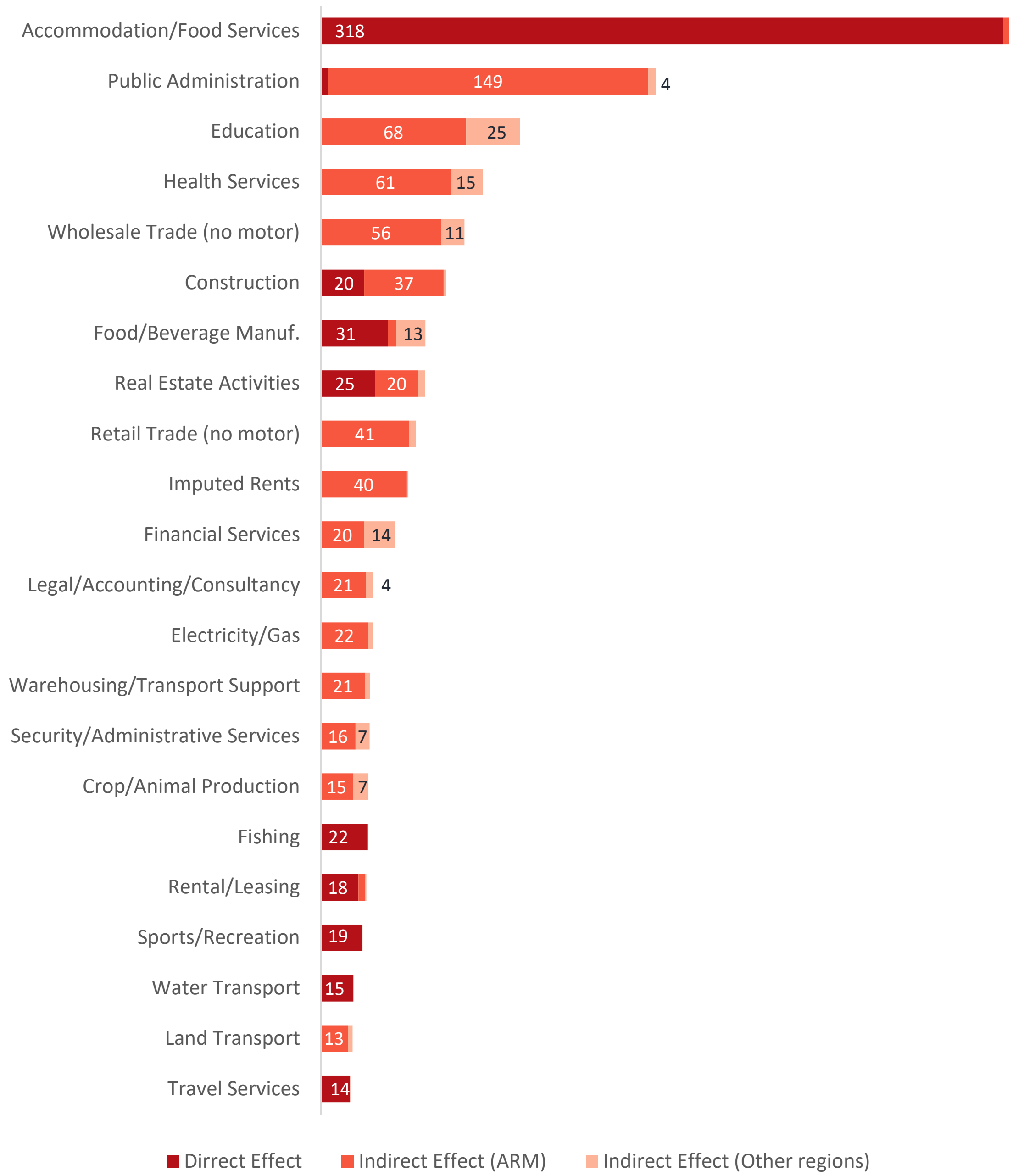
In the south, the region of Alentejo is notable for concentrating 50% of the country's Mining, and 45% of its Petroleum products manufactures. It seems that the Madeira's blue economy takes a part in Alentejo's petroleum chain, as 7% of marine's added value comes from the Petroleum products manuf. sector. The food chain also received a share in blue added value, with 18% in Crop/Animal production and 11% in Food/Beverage manufacturing. Finally, the Metropolitan region of Lisboa, as the largest urban area, concentrates the country's cultural and media activities, like Printing (48%), and Film/TV production (90%). It also concentrates Pharmaceutical manuf. (59%), Air Transport (90%) and Financial services (66%). Therefore, the ARM's marine sector is responsible for €48.27 million in the regional added value, principally from Financial services (12%), Education (10%), Food/Beverage manuf. (8%) and Health services (8%).

All these results help to elucidate how the marine sector is interconnected with others. For example, Education and Health services were common drives of losses across all six regions. This occurs because Education is the second largest expenditure of Madeira's government outside the region (2.5% of total spending), and Health services is the fourth (0.54%). Similarly, Education is the ninth largest expenditure of Madeira's households outside the region (0.5%), and Health services is the fourth (0.9%). Consequently, a significant portion of the income and public spending generated by the sea in Madeira is directed towards Education and Health services in other regions, implying the second and third largest indirect effect, respectively.

As illustrated in figure 4, the Public administration sector has the highest indirect effect at €152.99 million. However, only €3.56 million of this comes from other regions, suggesting that the sea is much more important for the public services in the islands than the direct effect indicates. This is because many intermediate consumptions of the Public administration in ARM come from sectors within the blue economy, such as Construction

(6.8%), Accommodations (5.6%) and Water Transport (5.3%). Therefore, the blue economy continuously demands the public sector.

Figure 4 – Direct and Indirect Effects on Added Value of the Blue Economy in ARM by sector



Source: Elaborated by the authors.

Beyond Public administration, Education, and Health services, examining the overall final demand destinations reveals that the largest expenditures outside the region are for Food/Beverage manuf. (2.4%), Residential/Social Care (0.9%), Financial services

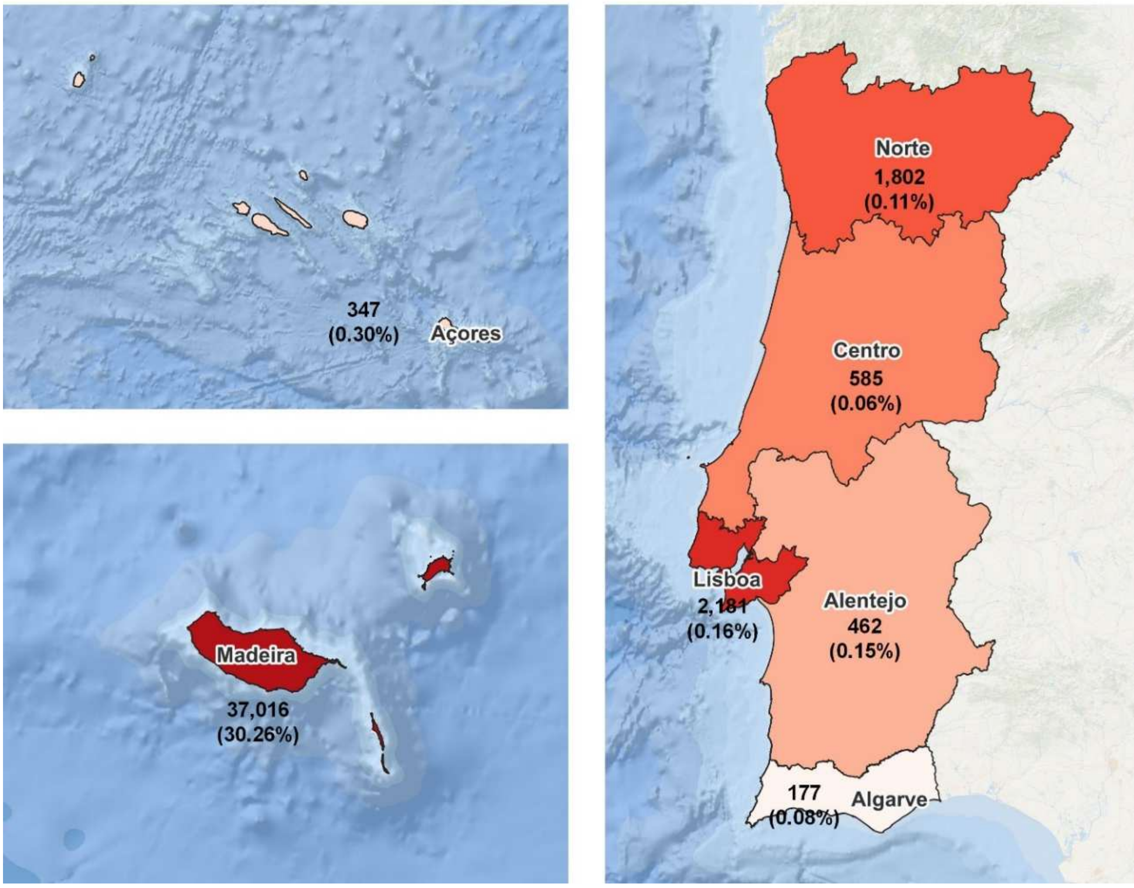
(0.8%), and Petroleum products manuf. (0.7%). This explains why some of these activities, despite having minimal direct effects, can exhibit noticeable indirect effects.

4.2.2 Social Effects

It is crucial to differentiate between social and economic impacts when analyzing the blue economy. For instance, employment generation does not directly equate to economic output, as labor intensity varies across sectors. Certain industries, like Crop/Animal production in the ARM, require significantly more labor. Specifically, this sector employs 319 workers to produce €1 million in added value attributable to Madeira's blue economy. In contrast, the Chemical manufacturing sector necessitates only 15 workers to produce the same added value. Therefore, it is feasible to enhance the blue GDP through investments without proportionately increasing employment.

A comparative analysis of Figures 3 and 5 reveals that regional employment is more dependent on the maritime sector than GDP. In ARM, for example, the maritime sector contributes 30.3% of regional employment, while its GDP contribution stands at 28.5%.

Figure 5 – Employments from the Madeira's Blue Economy by Region (NUTS II, 2013)

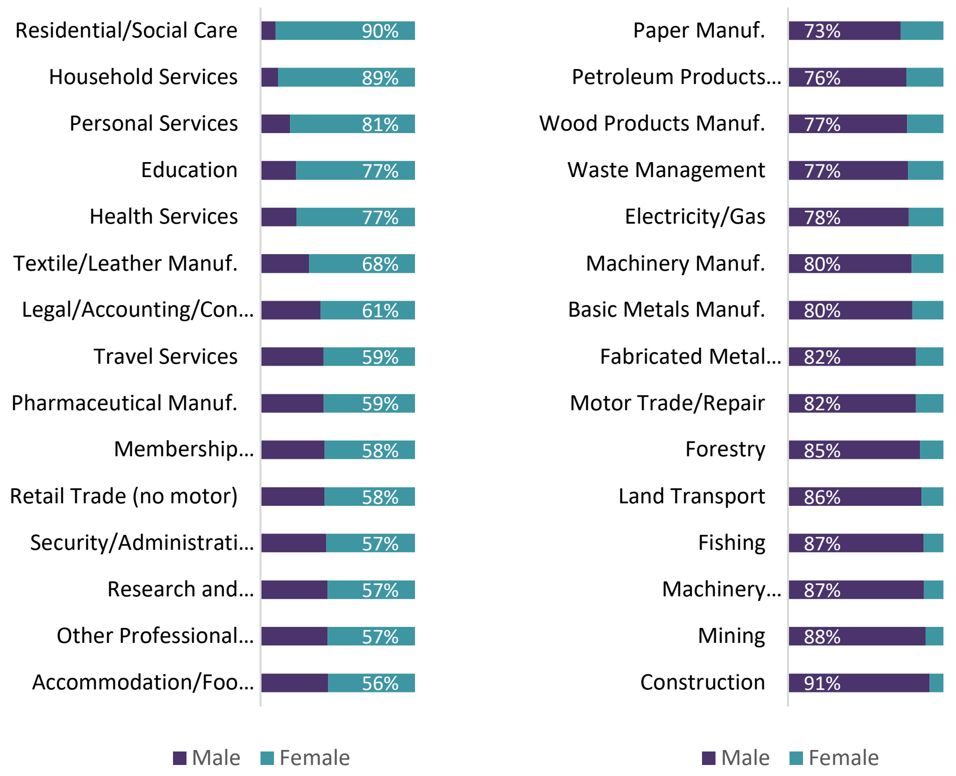


Source: Elaborated by the authors.

The overall economic system indicates that Madeira's blue economy directly and indirectly supports 42,569 jobs, with 37.016 situated in ARM. Beyond the level, the social dimension also includes employment composition. Job creation often affects minority groups adversely, potentially diminishing their independence and opportunities.

An examination of gender composition reveals significant disparities. The two sectors with the highest employment in ARM's blue economy, Water Transport (8.9%) and Fishing (7.1%), employ less than 30% and 13% female workers, respectively. Among the top twenty sectors related to ARM's blue economy, only six have a workforce comprising at least 50% women. This gender inequality stems from sector-specific biases. As illustrated in Figure 6, sectors with high female employment are typically social care services, whereas manufacturing sectors predominantly employ men, often exceeding 73% male representation. Consequently, the ARM's blue economy accounts for 0.95% of male employment and 0.83% of female.

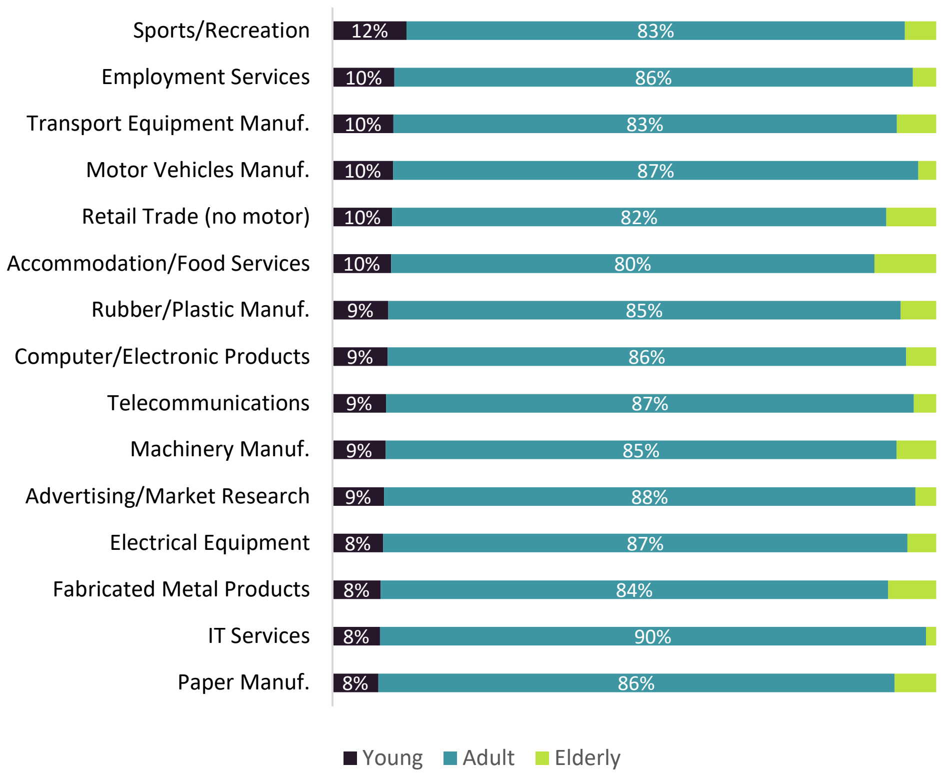
Figure 6 – Gender participation in Blue Economy employment



Source: Elaborated by the authors.

Analyzing the age composition within ARM's blue economy reveals further insights. Of the ten sectors with the highest employment associated with the marine sector, six have over 10% of their workforce aged 60 and above, whereas only two have nearly 10% of workers aged between 15 and 24. Overall, only six of the 65 sectors report that almost 10% of the blue workforce is young individuals, as displayed in figure 7. These are target sectors for policies aimed at boosting youth employment and enhancing the marine sector's value chain.

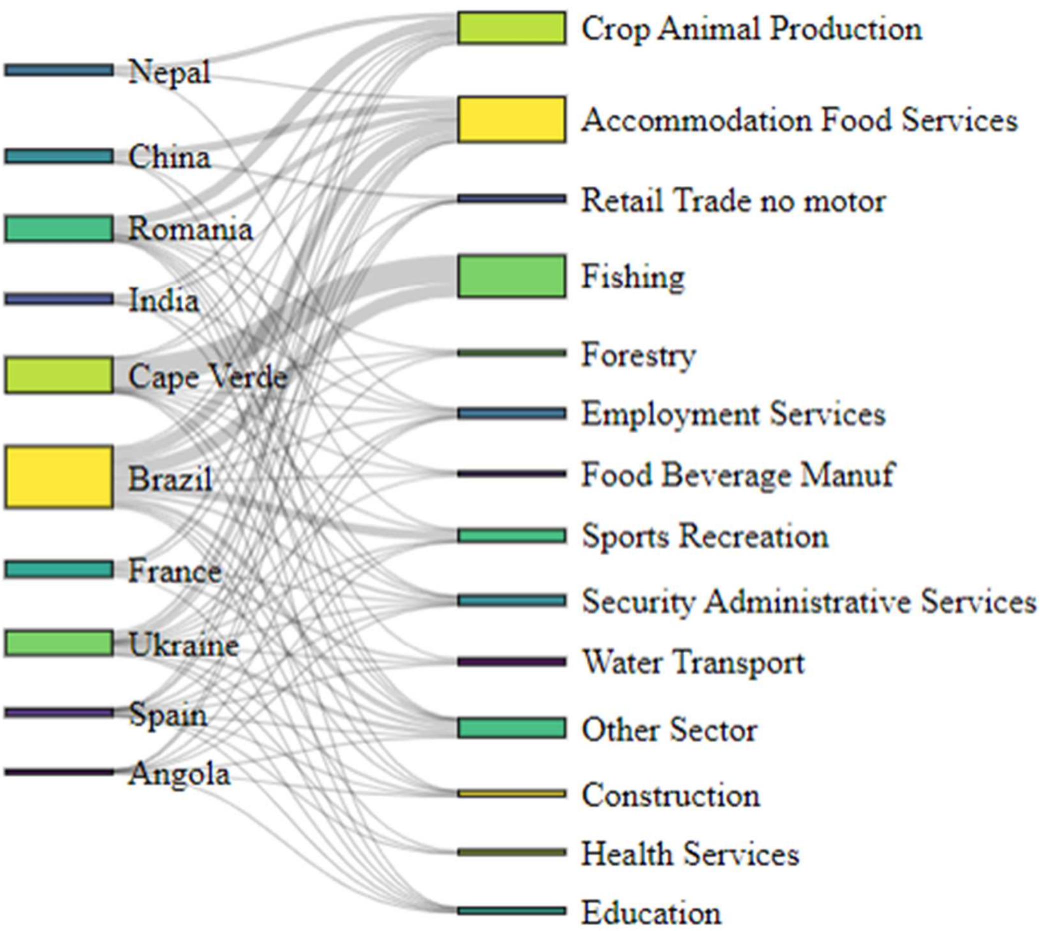
Figure 7 – Employment Generated by the Blue Economy - Age group



Source: Elaborated by the authors.

To examine the nationality of the workforce, we use data that is restricted to jobs reported by business, which means it excludes Public Administration, Imputed rents, and Household services. Based on this data, the ARM's blue economy is responsible for 37,883 jobs, with 36,719 occupied by Portuguese nationals. The Portuguese jobs are primarily concentrated in Accommodation/Food services (23%), Crop/Animal production (15%), Education (8%) and Fishing (5%). Immigrants constitute 6% of reported labor force, but when considering the labor force generated by ARM's blue economy, they represent only 3%. This indicates that the marine sector requires less immigrant labor than the overall economy. However, there is considerable heterogeneity when we consider the country of origin, as depicted in Figure 8. It has been observed that immigrants originating from Lusophone countries constitute a notably significant in terms of employment numbers. While some nationalities are diversely distributed among different sectors, the Brazilians and Cape Verdeans predominantly compose the non-Portuguese workforce in the Fishing sector.

Figure 8 – Employment Generated by the Blue Economy – Destination of Immigrant Labor.



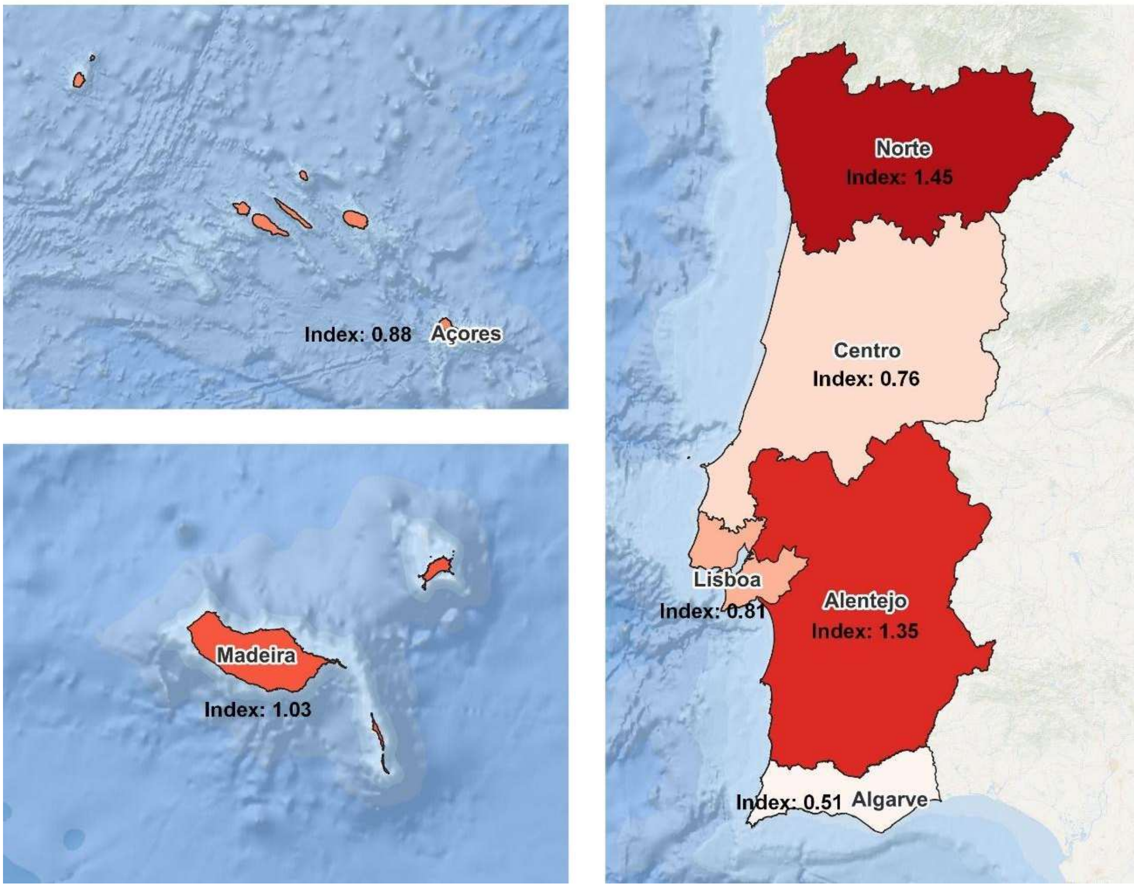
Source: Elaborated by the authors.

4.2.3 Environmental Effects

The environmental systemic effect of Madeira's blue economy can be evaluated using a carbon dioxide emission intensity index, which quantifies the concentration of CO_2 emission within a specific sector or region relative to the generation of added value. Madeira's blue economy is not carbon-intensive, as each 1% increase in added value corresponds to 0.74% more emissions, direct and indirect across the entire country.

In terms of regional impacts, it is observed that a 1.03% increase in emissions is required to achieve a 1% increase in added value within Madeira's own region, as we can see in Figure 9. The index is highest in the Norte region (1.45). From a final demand perspective, this is because 1% of household consumption in Madeira is allocated to the Food/Beverages manuf. sector in Norte, and 0.5% is to the Textile/Leather manuf., both of which exceed the regional median CO_2 per added value ratio (0.04). In contrast, Algarve region has the lowest index (0.51), as Madeira citizens spent their incomes in the region primarily on Accommodation (0.05%), Imputed rents (0.05%), and Health services (0.04%), all of which fall below the regional median ratio of emissions (0.04).

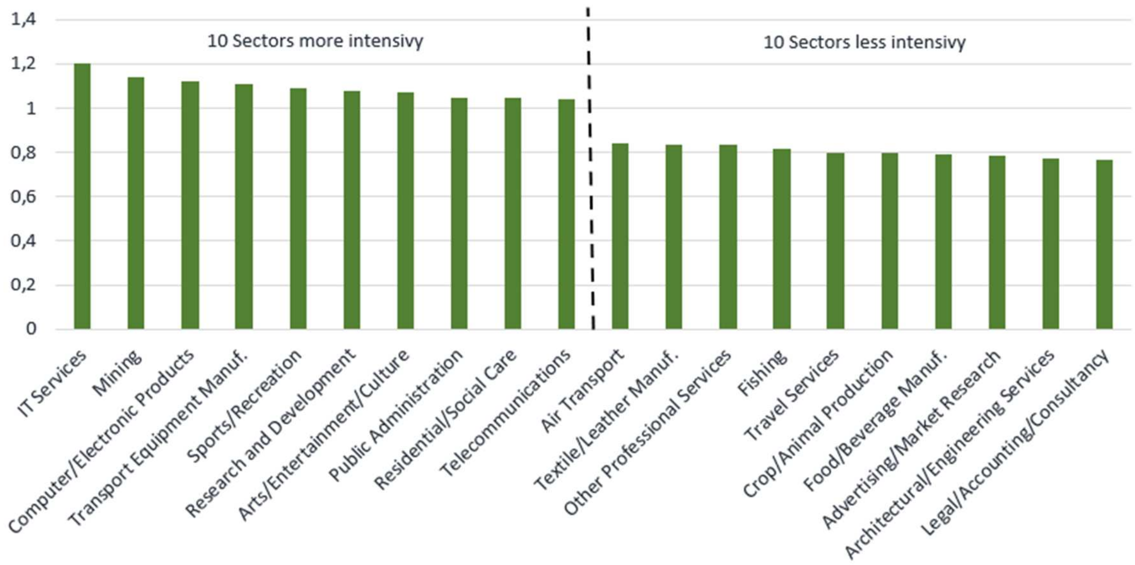
Figure 9 - CO_2 emission intensity index by region for Madeira's blue economy.



Source: Elaborated by the authors.

The emission intensity index also can be examined across sectors, as observed in Figure 6. Initially, it may appear counterintuitive that sectors like IT Services and Research and Development are among those with higher intensity. However, the index reveals that despite their relatively low CO_2 emissions, a substantial portion emanates from Madeira's blue economy, while a smaller fraction of added value originates from the Madeira's Sea. It is worth highlighting those sectors such as Fishing, and Travel Services are among the least intensive. Their interpretation is more straightforward and demonstrates the capacity of Madeira's blue economy to contribute to sustainable development.

Figure 10 – CO_2 emission intensity index by sector for Madeira's blue economy



Source: Elaborated by the authors.

6. Final Remarks

In 2015, the UN established to conserve and sustainably use the ocean, seas and marine resources for sustainable development as one of the Sustainable Development Goals for the 2030 Agenda, aiming to promote sustainable development. Within this context, the blue economy is recognized as a critical concept for understanding the economic, social, and environmental importance of the sea for the country and specially for island economies. Consequently, accurate measurement of the blue economy is essential for implementing informed, effective, and accountable policies (Head, 2016).

The European Union (EU) has prioritized the development of Maritime Spatial Planning (MSP), understanding the relevance of accurate measurement of the marine sector by member states. Consequently, a significant body of literature and several national statistical agencies have engaged in this task. A notable example is the creation of the Portuguese Satellite Account for the Sea (Statistics Portugal, 2020). However, the measurement of marine-related activities alone is not totally sufficient for evaluating the significance of the blue economy. Understanding the sector's interconnection with other industries and its contribution to final demand is essential for accurately assessing the full extent of value chain generation within the Portuguese economy.

This study progress by quantifying the significance of the blue economy within the Autonomous Region of Madeira (ARM), aiming to capture both its direct and systemic effects on the national economy through the analysis of accessible microdata. Adopting a bottom-up approach, the study seeks to operationalize these insights and develop methods for integrating blue growth into strategic planning (Katila, 2019). Our article further advances by delivering a multidimensional analysis of the impacts of the blue economy, highlighting the nuances and specificities of its socio-environmental effects across various sectors and sectors. Consequently, it provides valuable insights for policymakers by delineating strategies for leveraging the blue economy to foster sustainable development and address social inequalities.

Declaration of Competing Interest

The authors report there are no competing interests to declare.

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