Blue Economy as a Policy-Driven Innovation System: Research Funding and the Direction of Ocean-Related Innovation

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Abstract. The "Blue Economy" has been identified as a driver of European growth, through the development of new competences and activities that enable a sustainable exploitation of ocean resources. This paper conducted an assessment of the directions followed by the research and innovation activities performed by Portuguese organisations in the fields encompassed by the "Blue Economy", at the light of national and EU strategies. The paper draws on an analysis of the projects developed by Portuguese actors in the context of European framework programmes to investigate: the areas that are being privileged and the role and positioning of different types of actors in the developments taking place. The results point to the emergence of new activities such as marine biotechnology and marine renewable industries, as well as the development of innovations in established industries exploiting marine living resources (fisheries and aquaculture). They likewise reveal that the research and technological activities towards the revitalisation of other established sea-related industries is still very limited. The results also highlight the prominent position of research organisations in both new and established areas. But they equally uncover the relevant position occupied by new technology intensive firms, particularly in areas that require the development of more application oriented methods, products, services, where they are often involved in tripartite relationships, intermediating between research and industrial application. Finally the results suggest that the international cooperation favoured by these projects permit to open-up the national system, contributing to broaden the organisations' knowledge bases and to extend their international networks.

Keywords: Blue economy · Innovation system · Research and innovation · New technology intensive firms · Sustainability · Portugal

1 Introduction

The "Blue Economy" was identified at EU level as a driver of European growth, through the development of new competences and activities that "harness the untapped potential

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of Europe's oceans, seas and coasts for jobs and growth" while simultaneously striving to use the sea sustainably and "respect potential environmental concerns given the fragile nature of the marine environment" [10]. Strategies and policies were defined, to achieve these goals. Research and innovation, aiming at the revitalisation of established sectors and the development of emerging industries as well as at a better understanding of the marine environment and the requirements for its preservation were regarded as key elements in these strategies [10, 11].

EU level initiatives, namely the Integrated Maritime Policy for the European Union [11] and the Communication on Blue Growth [10], were translated into policy instruments. This is the case of funding instruments in the scope of the Framework Programmes, which shaped the R&D and innovation activities of a broad variety of actors that engaged in sea-related activities. The EU strategies and policies were also highly influential in policy formulation at the level of member-states. This was the case of Portugal that launched, in 2012, a revised National Ocean Strategy and Action Plan, whose model of development and areas of intervention were strongly influenced by the European framework.

The objective of the paper is to understand the influence of the EU and national strategies in the activities of the actors involved in the Blue Economy innovation system in Portugal. Therefore, the paper conducts an analysis of the directions followed by Portuguese organisations in the research and technology development activities conducted in the areas encompassed by the "Blue Economy", in order to understand:

a) which areas appear to be privileged, and the relative importance of new areas versus established ones;
b) the role and position of different types of actors in the developments taking place in the Blue Economy innovation system, namely the extent of firm involvement; and the role played by new technology intensive companies in developing new technologies and products and/or in linking between research and industrial activity.

The paper is structured as follows. Section 2 presents the concepts of Blue Economy and Blue Growth, identifies the strategies and policies that have been followed by the EU in the area and discusses how these initiatives can be understood in the context of the creation of a Blue Economy innovation system. Section 3 presents the development of the Blue Economy in Portugal, focusing on the public policies and strategies. Section 4 discusses the role that the several actors and their interaction can have in the building of the Blue Economy innovation system. The methodology used in the empirical analysis is presented in Sect. 5, while the results are presented in Sect. 6. Section 7 draws the main conclusion of the analysis.

2 The Blue Economy – A Policy-Driven Innovation System

The ocean provides a wide set of valuable natural resources, both renewable and non-renewable, which are used by several economic sectors [8, 25]. Over the last decades, the importance of these resources and the number and the activity of the sectors using them have increased [41]. At the same time, the sustainable use of ocean resources and

the ecosystems integrity – namely environmental concerns with climate change and the overexploitation of natural resources [15] - are increasingly at the center of the strategies of both private and public actors involved in ocean-related activities [40].

In this context a new concept has emerged and gained momentum – the Blue Economy. Although it is not possible to find a consensual definition for this concept in the literature [43], there is agreement on the fact that it tries to address the economic activities related with a twofold perspective: the socio-economic development and expansion of sectors, and the achievement of the integrity and sustainability of ocean ecosystems [28, 43].

It is possible to identify several economic sectors involved in the Blue Economy. Although the sectoral classification varies by country and region [30, 35], the sectors involved in the Blue Economy usually have at least one of the following characteristics: are physically located in the ocean, use an ocean resource as an input in their production process, or are directly outputting goods or services to the ocean [30].

Along the concept of Blue Economy we can find the concept of "Blue Growth" that remits to strategies and public policies to promote the sustainable expansion of ocean-related economic activities in the marine and coastal environment [10] and their transformation through the development of new technologies and 'eco-innovation' [12, 13, 17].

This is the case of the European Union (EU), where, in 2007, a Communication from the European Commission (EC) recommended an Integrated Maritime Policy, setting the scene for the emergence and the sustainable development of marine-related activities [11]. This document addressed the conditions for the development of economic activities related to the sea – both established sectors and emerging industries – as well as the capacity to counteract the negative impacts of increased marine based activity on the quality of the marine environment, marine safety security and also the effects of climate change in oceans and coastal regions. This strategy would be anchored in excellence in marine research, technology and innovation.

Following this document, in 2012 the EC published a Communication on Blue Growth, defining a set of opportunities for marine and maritime sustainable growth, with a view to "place the blue economy firmly on the agenda of Member States, regions, enterprise and civil society" [10]. The document identifies the current key value-chains and activities and a set of new activities/sectors where targeted action could drive sustainable growth (e.g. blue energy and blue biotechnology), and proposes a number of initiatives to achieve this goal. Later, in 2014, it was complemented, by another Communication on Innovation in the Blue Economy that reinforced the role of research and innovation in the development of the blue economy while ensuring the protection of the marine environment and proposed additional actions to address the gaps in existing policies [12, 13].

The impact of these strategies and policies has been followed up by the Directorate-General for Maritime Affairs and Fisheries, which publishes an annual Blue Economy Report [14]. These documents contributed to establish a working definition of Blue Economy and its composition, which has been updated over time. According to the 2019 report the "EU's Blue Economy encompasses all sectoral and cross-sectoral economic activities related to the oceans, seas and coasts, including those in the EU's outermost

regions and landlocked countries. This includes the closest direct and indirect support activities necessary for the sustainable functioning and development of these economic sectors within the single market. It comprises emerging sectors and economic value based on natural capital and non-market goods and services" [14].

Therefore, according to the EU perspective, the Blue Economy includes:

- Established traditional sectors, namely: Maritime transport; Coastal tourism; Marine living resources, extraction and commercialisation (fisheries, aquaculture; processing and distribution); Marine extraction of minerals, oil and gas; Ports, warehousing and water projects; Shipbuilding and repair.
- Emerging and innovative industries, namely: Blue energy (offshore wind energy; ocean energy); Blue bio economy; Marine minerals; Desalination; Maritime defence.
- Natural capital and ecosystem services.

The initiatives at EU level were reflected upon the design of the Framework Programme for Research and Innovation that was launched in 2014: the Horizon 2020. So it is to be expected that the areas of intervention defined as strategic received greater attention in the funding programmes, shaping the R&D activities of the actors' active in this domain and therefore contributing for the emergence of a new innovation system.

The innovation system literature considers that the construction of a new innovation system is a complex and gradual process along which the main components of the system – actors, networks and institutions – co-evolve [16]. This process involves a number of key functions [29], which include development of formal knowledge, direction of search, entrepreneurial experimentation, resource mobilization, materialization, market formation, legitimation, development of positive externalities.

In this approach innovation is conceptualized as a collaborative and distributed process, requiring the interaction between different actors, including firms and other organisations, such as universities and research centers, government agencies and industry associations, among others [16]. The institutional context where innovation unfolds is also central in the analysis, and includes the role of public policies in the field of innovation, particularly for the reorientation of innovation systems towards grand challenges, such as sustainability [6].

Innovation policies increasingly follow a system-centred approach [32], stimulating interaction between actors, interactive learning and cross-fertilisation. This entails collaboration processes between firms and other actors (e.g. research organisations), but also between firms with different characteristics and from different sectors [5, 18, 31].

3 Blue Economy in Portugal

Portugal is a maritime country with a large Atlantic continental coast that together with the two Archipelagos (Azores and Madeira) represent an exclusive economic zone with 1,72 million square kilometres. The country has historically engaged on sea-related activities. However, until recently some of the established marine sectors were struggling to adapt to structural changes and increased international competition; and the country was still underperforming in the emerging areas. Moreover, while there were some

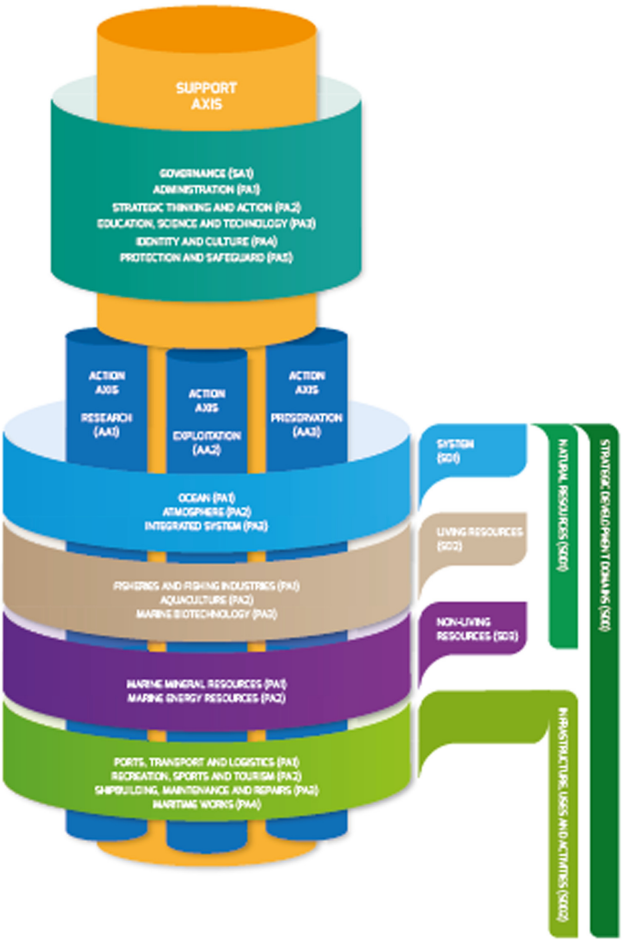

Fig. 1. Blue Economy strategic domains in Portugal [9]

organisations conducting marine research, the knowledge about marine ecosystems was regarded as insufficient to fully explore the sea resources and to address the environmental challenges that are increasingly central.

The Blue Economy EU strategies and policies had a strong impact upon the formulation of the Portuguese National Ocean Strategy 2013–2020. The political and financial relevance attributed to this area by the UE was regarded as an opportunity to formulate a strategy that enabled the country to recover the "national maritime identity" and regain a position in this area. This recovery translates into an increased contribution of maritime sectors to the domestic product, the strengthening of the scientific and technological capacity, and the stimulus to the development of new areas of action [38].

The strategy was operationalised by the Mar-Portugal Action Plan, which is organised along three Strategic Development Domains (SD), each including several Programme

Table 1. Blue Economy priority areas in European and Portuguese strategic documents

PLAN MAR PORTUGAL (DGPM, 2015)	BLUE ECONOMY REPORT (EU, 2019)	Type
SD1 – Governance		
Strategic thinking and action		
Education (ocean literacy)		N
Identity and culture		N
Protection & safeguard	Maritime Defence	N
SD2 – System		
Ocean	Natural capital and ecosystem services	NC
Atmosphere	Natural capital and ecosystem services	NC
Integrated system	Natural capital and ecosystem services	NC
SD3 - Natural resources: living resources		
Fisheries and fishing industries	Marine living resources - Fisheries	E
Aquaculture	Marine living resources - Aquaculture	E
Marine Biotechnology	Blue Bio economy	N
SD4 - Natural resources: non-living resources		
Marine mineral resources	Marine minerals & extraction of mineral, oil and gas	N&E
Marine energy	Blue energy	N
SD5 - Infrastructure, uses and activities		
Ports, transport & logistics	Ports, warehousing & maritime transport	E
Recreation, sports and tourism	Coastal tourism	E
Shipbuilding	Shipbuilding & repair	E
Maritime works	(Ports, … and) water projects	E

Source: Authors' own elaboration
Legend: E-established sectors; N – new industries; NC – new areas/natural capital

Areas (PA) (Fig. 1). It covers the main fields that compose the EU "Blue Economy" definition, with some adaptations to the country specificities. The programmes can include actions along one or more Axis: Research, Exploitation, and Preservation. The Plan also includes a Support Axis that includes several Programme Areas concerned with "Governance". Besides covering administrative issues and strategic issues, the Governance domain is also concerned with cultural issues, such as national identity and education, as well as with security.

Table 1 presents the main Programme Areas from Mar-Portugal Action Plan and relates them with the areas defined as strategic in EU Blue Economy policy documents. As becomes evident, there is strong overlap between them, even if there are some differences in thematic aggregation and sectoral organisation, reflecting the country specialisation.

Similarly to the European strategy, the Portuguese Strategy and the related Action Plan give a central role to research and innovation in the fulfilment of the goals established. The production of new scientific knowledge and the development of new technologies, products and services were seen as central to stimulate the creation of new industrial activities, to revitalise established industries and to tackle the environmental problems associated with increased human activity in the ocean environment. One of the goals of the Action Plan was to increase the participation of firms in these activities in order to strengthen the industrial structure around the "Blue Economy". This included the involvement of existing firms and the creation of new ones exploiting emerging technologies.

The Strategy and Plan have guided the sea-related activities conducted in Portugal. Following a period of some economic difficulties experienced by the country due to the financial crisis, it was revitalised and re-adjusted in 2015 [9]. Thus, the directions it establishes, namely in terms of areas of intervention to be privileged, are equally likely to have influenced the investment decisions of the Portuguese actors.

4 Actors and Networks in the Blue Economy Innovation System

As already pointed out the industrial activities encompassed by the Blue Economy include both established and new fields. Established sectors are mostly mature industries, while new technological advances often originate from outside the industry. Thus they may be related to activities conducted by research organisations or by new technology intensive firms (NTIFs), sometimes in partnerships with the potential users.

As already mentioned, the development of new activities and technologies has a central role in the industrial renewal of the Blue Economy and in promoting its sustainability. For this, research organisations and NTIFs tend to be key players. Research organisations are vital by performing their role as knowledge creators in the innovation system. NTIFs are young independent firms involved in the development and exploitation of new technological knowledge [19]. They can be particularly important in the Blue Economy since they often play a relevant part in the transformation of research results steaming from the academia in technologies, products and services, which are indispensable for the country to fully benefit from the R&D efforts. In fact, NTIFs often occupy an intermediate position between academic research and the market [4, 22] and create value in innovation systems, as agents of knowledge acquisition, transformation and diffusion [26, 36, 44].

Accordingly, research organisations and NTIFs are likely to be particularly active in the development of the new innovation system. Therefore, investigating the activity of these organisations, their relative positioning as well as their relationships – both between them and with existing companies from established sectors – are important to understand the dynamics of technological development in the field.

Relationships between these actors deserve a detailed analysis. Partnerships, namely collaborative R&D projects, have become a privileged instrument of firms in the development of new technologies. Through them, organisations share the risk and huge investments associated to the R&D process [24]. These collaborations are of utmost importance to small firms, which are unable to have in-house the various resources necessary for

their activities. This is particularly the case of NTIFs, to whom competitiveness largely depends on the ability to quickly develop and renew the knowledge base, in order to generate a steady stream of innovations. Since knowledge is often complex and distributed, they need to rely extensively on relationships with other organisations [23, 33, 34]. But large and established firms are also intensively engaged in networking through collaborative R&D projects, in a world of increased specialization and distributed knowledge [3, 42]. Also, universities and research laboratories are very active in cooperating in R&D projects, not only with other academic partners, but also increasingly with the industry [37].

The objective of this paper is to conduct a first assessment of the directions followed by the research and technology development activities conducted by Portuguese organisations in the areas encompassed by the "Blue Economy", in order to understand:

a) which areas appear to have been privileged and thus are likely to be developing faster; and namely the relative importance of new areas vs. advances targeting established ones;
b) the role and position of different types of actors in the research activities conducted, namely to what extent they involve firms; and also, the role played by NTIFs in developing new technologies and products and/or in linking between research and industrial activity.

For this purpose, the paper analyses the research and technological development (RTD) activities conducted by Portuguese organisations in the context of European funded projects. The RTD Framework Programmes (FPs), launched in the early 1980s, are a major EU policy instrument, due to the vast budgets allocated to them. Collaborative research is highly supported by these multi-annual Programmes [1], stimulating research institutions, government agencies and industrial partners to cooperate in R&D projects and generating knowledge that spans across national borders. They are seen as pivotal for transforming nation-based research networks into formal collaboration arrangements between organisations at European level [27]. In the several FPs, collaborative research projects in both basic and applied research have been organized under broad thematic areas, such as Energy, ICT, Health, covering a wide range of the EU priorities [1].

While EU projects only correspond to a subset of the RTD activities potentially being conducted by Portuguese organisations, it can be argued that European programmes have nevertheless been a very important source of research funding. This was particularly so during part of the period under analysis, as the country was still in the aftermath of a financial crisis that hit Portugal strongly; and only recently there were conditions to increase national funding for RTD activities.

Thus, it can be assumed that the projects funded by European programmes offer a good overview of the areas where the most innovative Portuguese organisations decided to develop RTD activities. Thus they provide evidence of the areas being privileged, among the ones defined as priority by the public policy and enable us to start uncovering the influence of these policies in the research directions followed.

European projects, which in most programmes require multinational teams[1], also provide some information on the areas in which Portuguese organisations search for international partners or attempt to integrate international networks, and on the structure of these relationships thus offering some indications towards the transnational processes at work in the field.

5 Methodology

The paper focuses on the RTD activities conducted by Portuguese organisations in the context of projects funded under the most recent European Framework Programme for Research and Innovation: the Horizon 2020, active between 2014 and 2020. The Horizon 2020 operationalised some of Blue Growth strategic goals, particularly (but not exclusively) in the context of one of its Societal Challenges programmes - Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy [13].

The research is based on all the projects with Portuguese participation funded since the beginning of the Programme (2014) until the end of 2018. In order to identify these projects a search was conducted in the database provided by the Community Research and Development Information Service (CORDIS) [https://cordis.europa.eu/projects/en] using a series of keywords related with the ocean and with sea-related activities and industrial sectors.

The projects obtained through this search were individually analysed in order to confirm whether they were effectively related to the Blue Economy themes and those unrelated were removed. As a result of this process we were left with 136 projects. For the projects selected we resorted again to the CORDIS database in order to collect information on the projects (Start date, End date, Overall budget, EU contribution, Objective, Coordinator and Participants) and on the participants (Type of organisation; Country; EU funding received).

Using the categories defined in the Portuguese Strategy and Action-Plan (Strategic Development Domains and Programme Areas presented in the first column of Table 1), the projects were subsequently classified according to the main area of activity.

The Portuguese organisations participating in these projects were also object of an additional treatment. NTIFs were singled out and distinguished from the remaining companies, since we intended to understand their role in the construction of a Blue Economy in Portugal.

To depict the system of relations emanating from the projects, a Social Network Analysis was performed. Collaborative projects constitute two-mode networks that link organisations to an event - the project. From these we extracted one-mode networks, considering inter-organisational networks, where a tie joins two organisations that collaborate in the same project. Symmetric adjacency matrices were built, valued by the number of common projects. Network diagrams were built using the NetDraw software.

[1] It should nevertheless be noticed that in Horizon 2020 some Programmes do not require those international partnerships and namely, that some are directed to individual firms (e.g. SME instrument) or researchers (ERC Grants). Thus, not all the projects analysed were composed of (international) teams.

6 Results

6.1 The Role and Position of Actors

The 136 projects with Portuguese participation that were identified as developing RTD activities related with the Blue Economy include both projects whose focus is exclusively in ocean related activities (78%) and a smaller number of projects whose activities have a broader scope and ocean is only one of the target areas (22%). A total of 33 projects were coordinated by Portuguese organisations. The network that reflects the system of collaborations emanating from these projects is depicted in Fig. 2.

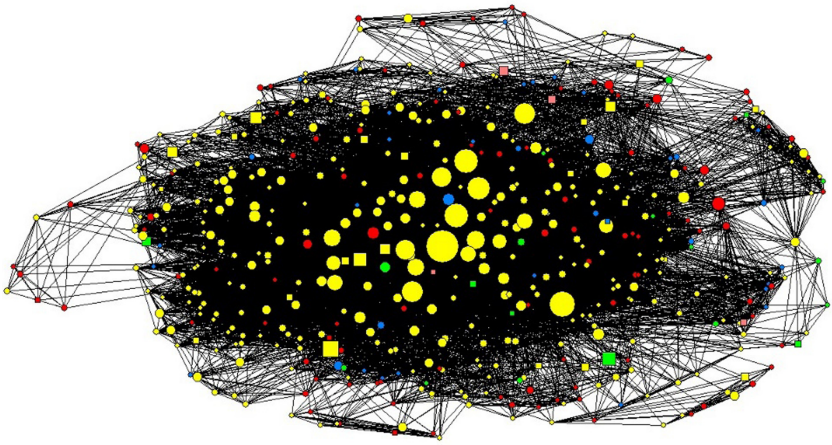

Fig. 2. Inter-organisational network considering all projects. Legend: Squares – Portuguese organisations; Circles – Foreign organisations; Red – Firms; Light Red – NTIFs; Yellow – Research Organisations; Blue – Public Organisations; Green – Other Organisations. The size of the node is proportional to the EU funding received by the organisation. (Color figure online)

These projects involve a total of 2279 participations from different types of organisations (Fig. 3), of which 226 are from Portuguese ones. Over half of the 226 Portuguese participations are from research organisations (ROs) and about 1/3 are from firms, the majority from NTIFs (Fig. 4). However, several organisations are involved in more than one project, which means that the number of organisations is lower than the number of participations in European projects. Considering the type of the 94 Portuguese organisations integrating the project teams, and classifying them by type, (Fig. 4), it is visible that the number of research organisations is similar to the number of firms and that, among the latter, NTIFs prevail over the other firms.

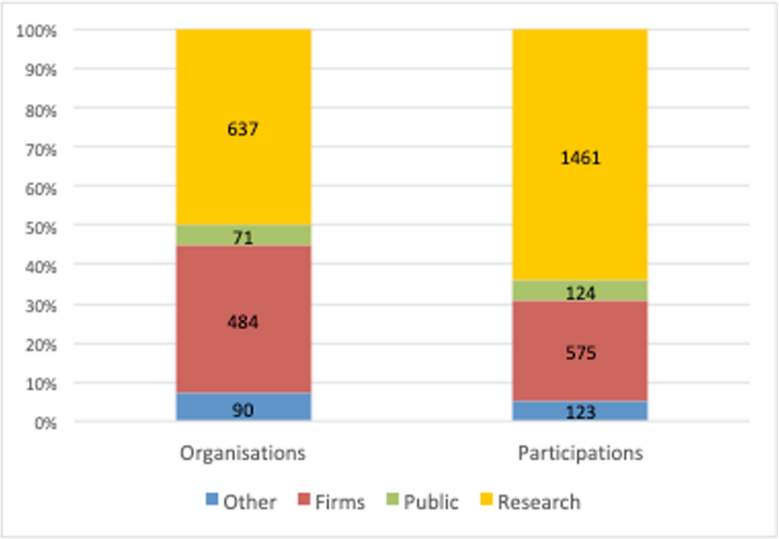

Fig. 3. Organisations and their participation in all projects. Source: Authors' own calculations.

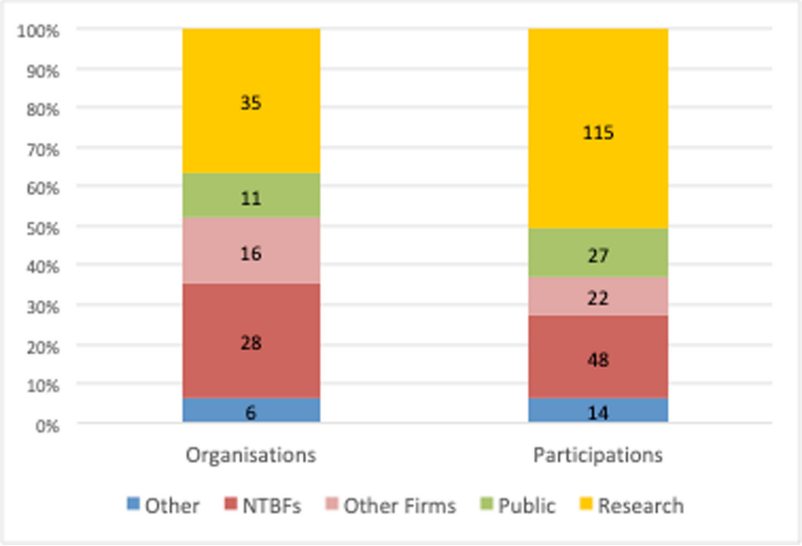

Fig. 4. Portuguese organisations and their participation in all projects. Source: Authors' own calculations.

The remaining participations are from public organisations (e.g. government departments or public agencies), corresponding to about 12% and from other types of organisations (e.g. associations and foundations), with a much lower weight (Figs. 3 and 4). Interestingly the relative weight of firm participations is higher than their expression in term of participant organisation.

The projects involve a total investment of 853 Million €, to which the EU contributed with almost 679 Million € (79,6%). The Portuguese organisations received a contribution from the EU of more than 73 Million €, which was distributed by type of organisation as shown in Table 2. Once again research organisations emerge as a central player.

Table 2. EU contribution to Portuguese participants by type of organization

Partner type	EU funding (€)	Percentage
Research organisations	6 710 568.80	51.4%
Firms – NTIF	20 904 288.90	9.2%
Firms – other	37 608 058.05	28.6%
Public organisations	7 004 129.32	9.6%
Others	947 662.50	1.3%
Total	73 174 707.57	100.0%

Source: Own calculations.

We have analysed the composition of project teams, in terms of Portuguese organisations. More than a half of the projects do not involve any Portuguese firm (Table 3). Considering those that do (Table 4), we found that mixed teams involving research organisations and firms are the most frequent. These mixed teams sometimes also encompass public or other organisations. Teams composed exclusively of research organisations or exclusively of firms are also present but are less frequent. Research organisations also sometimes partner with public or other organisations. Table 3 also shows the composition of teams where NTIFs are present: they are more frequently engaged with ROs and less frequently with other types of organisations. In some of these teams NTIFs are effectively part of tripartite relationships that include also other firms, namely firms from established sectors, to whom they are likely to act as knowledge intermediaries [7]. They are also engaged in individual projects, in the context of the SME instrument programme. It is also relevant to point out that, the 28 new technology intensive firms involved in these projects not only corresponded to 21.2% of the total of Portuguese project partners (68.5% of the firm partners) and to 29.8% of the individual organisations, but also coordinated 16 projects – corresponding to 48% of the Portuguese coordinators. This suggests that these firms effectively played an important role in the Blue Economy RTD activities being developed by Portuguese organisations in the context of EU projects.

Table 3. Project teams – involvement of Portuguese firms

Project team	Total projects	Percentage
Includes PT firms	57	41.9%
No PT firms	79	58.1%
Total	136	41.9%

Source: Authors' own calculations.

Table 4. Composition of Portuguese teams

Team	Total Number of projects	Including NTIFs Number of projects
RO only	16	
Firm only	13	13
R0 + Firm	41	13
RO + Public	07	
RO + Firm + Public	07	02
RO + Firm + Other	29	09
RO + Public + Other	05	
RO + Firm + Public + Other	18	04
Total	136	41

Source: Authors' own calculations.

It should nevertheless be noticed that the large majority of projects were composed of multinational teams, creating the conditions for international research cooperation. Only 20 projects involved exclusively Portuguese participants, in general one individual organisation, either a firm (13) or a research organisations (7). The international character of these collaborations is evident from the analysis of Fig. 5 that shows that Germany, Spain, France, the United Kingdom and Italy have an important participation in these projects. The centrality of foreign actors is also evident from the analysis of Fig. 1. Moreover, if we consider the top 10 organisation in terms of funding and participation in project (Tables 5 and 6) we see that the rankings are dominated by foreign organisations, which mostly are ROs.

While this may point to a lower relevance of Portuguese organisations in some of these projects and areas, it can also be regarded as an indicator of the efforts being conducted by several organisations to be part of the central RTD networks at work in some fields of the Blue Economy and to engage in the most advanced research being conducted in them at European level. The fact that 33 Portuguese organisations were coordinators of projects indicates that a few organisations have already gained enough competence and visibility to lead research in some of these areas.

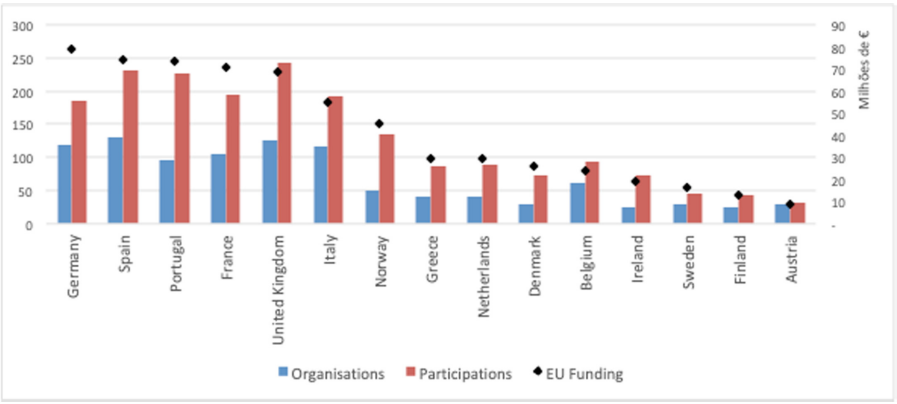

Fig. 5. Organisations, participations and funding by country – top 15 countries. Source: Authors' own calculations.

Table 5. Top 10 organisations in terms of funding

Organisation	Country	Type	Funding (€)
SENVION GMBH	Germany	Firm	12 236 926,11
INSTITUT FRANCAIS DE RECHERCHE POUR L'EXPLOITATION DE LA MER	France	Research	11 487 018,93
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	France	Research	10 967 341,39
EDP RENOVAVEIS SA	Spain	Research	9 829 783,38
HELLENIC CENTRE FOR MARINE RESEARCH	Greece	Research	8 857 187,54
CONSIGLIO NAZIONALE DELLE RICERCHE	Italy	Research	8 209 487,40
DANMARKS TEKNISKE UNIVERSITET	Denmark	Research	7 941 488,86
UNITED KINGDOM RESEARCH AND INNOVATION	UK	Research	7 591 401,25
AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	Spain	Research	6 734 511,72
FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V	Germany	Research	6 610 803,75

Source: Authors' own calculations.

6.2 The Identification of Priority Areas

In order to understand the decisions of Portuguese organisations concerning the conduction of activities in the areas defined as priority in the Blue Economy strategies, we have

Table 6. Top 10 organisations in terms project participations

Organisation	Country	Type	Projects
INSTITUT FRANCAIS DE RECHERCHE POUR L'EXPLOITATION DE LA MER	France	Research	23
HELLENIC CENTRE FOR MARINE RESEARCH	Greece	Research	23
CONSIGLIO NAZIONALE DELLE RICERCHE	Italy	Research	21
AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	Spain	Research	21
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	France	Research	20
DANMARKS TEKNISKE UNIVERSITET	Denmark	Research	20
NATURAL ENVIRONMENT RESEARCH COUNCIL	UK	Research	16
UNITED KINGDOM RESEARCH AND INNOVATION	UK	Research	15
UNIVERSITETET I BERGEN	Norway	Research	15
MARINE INSTITUTE	Ireland	Research	13

Source: Authors' own calculations.

classified the projects according to the areas defined in the Portuguese strategy (presented in Table 1) and analysed each group in terms of number of projects, investment (project budget and EU contribution) (Table 7) and composition of the teams involved in the projects (Table 8). Network diagrams are also presented to support the analysis.

The analysis shows differences in what concerns the relative importance of the priority areas, as well as the position of different types of Portuguese organisations in them.

The System domain (SD2) is the most important in terms of investment and is also in the top in terms of number of projects, fact that is clearly visible in the size of the network (Fig. 6). In this domain the projects are mostly concerned with the ocean ecosystem and its interactions with other systems, focusing both on production of new knowledge about the marine environment, and on research on modes of monitoring, risk assessment and conservation. Therefore in this domain research is more focused on the sustainable oceans management than on the use of ocean resources. Considering the Portuguese actors, this domain is clearly dominated by research organisations, being the one with the largest share of teams not involving at least one firm (Table 7). This is also the domain with the highest share of projects involving tripartite teams (Research – Industry – Public /Other organisations), probably due to the fact that is dealing with the system. Some Portuguese firms – mostly NTIFs - appear in joint teams, as shown in the network diagram (Fig. 6) in activities concerned with monitoring services, namely firms active in the areas of instrumentation or marine robotics. Several foreign universities play a central role in this network.

Table 7. Relative weight of Blue Economy priority areas in EU projects with Portuguese participation

	Budget (%)	Funding (%)	No. projects (%)
SD 1 – Governance	12.3	10.8	15.4
Strategic thinking and action	4.7	3.2	5.1
Education (ocean literacy)	0.9	1.1	2.2
Identity and culture	0.9	1.1	2.9
Protection and safeguard	5.8	5.4	5.1
SD 2 – System	30.1	36.9	28.7
Ocean	13.8	17.0	15.4
Atmosphere	5.8	7.2	3.7
Integrated system	10.5	12.7	9.6
SD 3 – Natural resources: living resources	25.9	28.1	31.6
Fisheries and fishing industries	3.9	4.6	4.4
Aquaculture	6.3	7.5	7.4
Aquaculture and fisheries	1.5	1.7	1.5
Marine biotechnology	14.3	14.3	18.4
SD 4 – Natural resources: non-living resources	20.0	18.2	16.2
Marine mineral resources	0.2	0.3	0.7
Marine energy resources	19.7	17.9	15.4
SD 5 – Infrastructure, uses and activities	11.8	6.0	8.1
Ports, transport and logistics	7.7	2.6	2.2
Recreation, sports and tourism	0.0	0.0	0.0
Shipbuilding, maintenance and repairs	0.7	0.9	0.7
Maritime works	0.0	0.0	0.0
Several activities and marine energy	3.4	2.5	5.1
Total	100.0	100.0	100

Source: Authors' own calculations.

Research concerned with the exploitation of natural resources is also well positioned in terms of investment and number of projects (Table 6). The domain of Living Resources is the one that has the highest number of projects and is second in terms of investment. In this domain we find projects targeting both established and new activities. Projects targeting established activities – namely fisheries and aquaculture – have a lower weight than the ones targeting new activities – namely marine biotechnology. In fact, marine biotechnology appears as the most important programme area in terms of projects and the second in terms of investment. This may be explained by the large volume of investment made by the country in biotechnology in the last decades [2, 20]. Portuguese firms are present in several projects, as depicted in the network diagram (Fig. 7), often partnering with research organisations, but there is still a substantial number of projects, both in the new and in the established areas that only have Portuguese research organisations (Table 7). NTIFs are particularly important in marine biotechnology, where they seem to perform a bridging role among teams/projects. These firms also have some weight in aquaculture that is a still relatively new field in Portugal. A small group of Portuguese

Table 8. Composition of the project teams by Domain – percentage of the projects

Composition of the team	Governance (n = 18)	Living resources (n = 42)	Non-living resources (n = 22)	System level (n = 43)	Infrastructure, uses and activities (n = 11)	Total (n = 136)
Only ROs	22.2	16.7	4.5	4.7	18.2	11.8
Only Firms	0.0	14.3	13.6	2.3	27.3	9.6
ROs + Firms	11.1	23.8	50.0	37.2	18.2	30.1
ROs + Public/Other	22.3	4.8	9.0	9.3	0.0	8.8
ROs + Firms + Public/Other	44.4	40.4	22.7	46.5	36.4	39.7
Total	100	100	100	100	100	100

Source: Authors' own calculations.

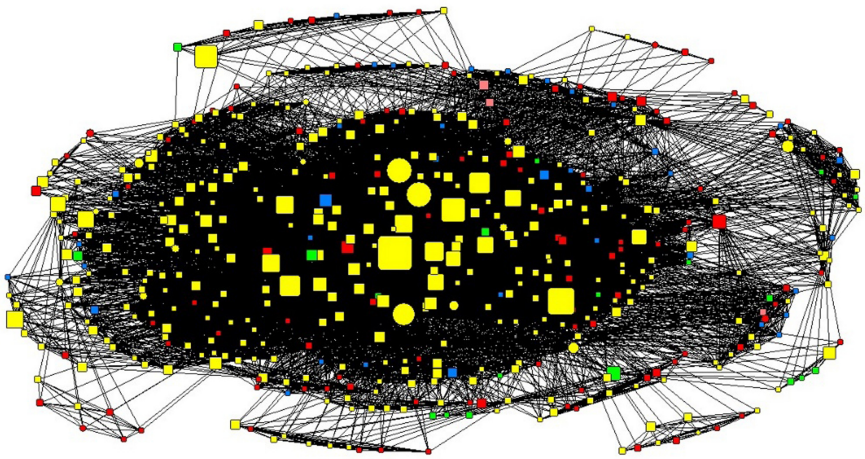

Fig. 6. Inter-organisational network – Projects in the System domain. Legend: Squares – Portuguese organisations; Circles – Foreign organisations; Red – Firms; Light Red – NTIFs; Yellow – Research Organisations; Blue – Public Organisations; Green – Other Organisations. The size of the node is proportional to the EU funding received by the organisation. (Color figure online)

established firms from the user sectors also participate in some teams. Foreign firms are particularly important in the established areas.

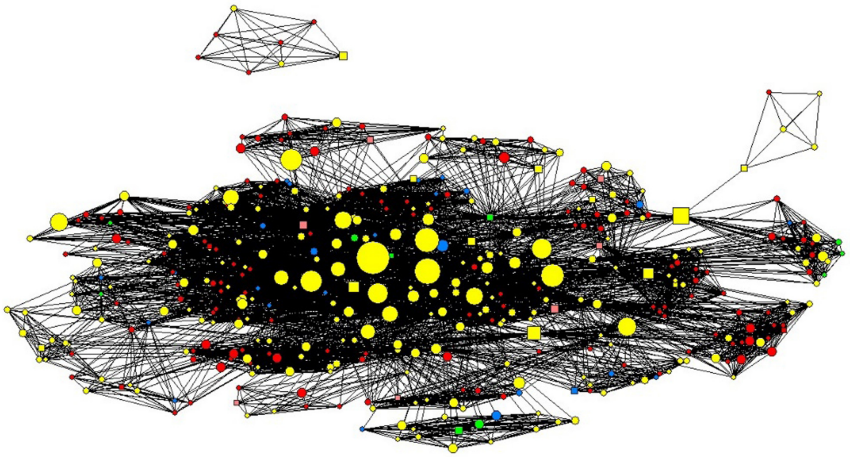

Fig. 7. Inter-organisational network - Projects in the Living Resources domain. Legend: Squares – Portuguese organisations; Circles – Foreign organisations; Red – Firms; Light Red – NTIFs; Yellow – Research Organisations; Blue – Public Organisations; Green – Other Organisations. The size of the node is proportional to the EU funding received by the organisation. (Color figure online)

The domain of Non-living Resources is almost exclusively composed of projects in marine energy, since the exploitation of mineral resources is a still underdeveloped area in Portugal. The focus is clearly on renewable energies, with oil and gas having a negligible position. This programme area is the one with the highest level of investment and the second in number of projects. This reflects the important activity that has been conducted by Portuguese organisations in marine renewables (wave and offshore wind energies) for several decades [21, 39]. This area combines projects that aim at the test of energy production prototypes, where firms appear alone or in partnership with research organisations; and projects that are concerned with the structuring of the field that tend to involve only research organisations. In the first case, partnerships can combine new technology intensive companies with large energy firms (both Portuguese and foreign as shown in Fig. 8). The network is clearly less populated than the ones of System and Living Resources domains shown above.

The Infrastructure, Uses and Activities domain is concerned with research targeting the other sea-related industries and has attracted the lowest number of projects and investment. Despite its potentially more application-oriented nature, there is still a few projects where the only Portuguese participants are research organisations (in some cases performing the role of bridges between teams/projects, as shown in Fig. 9). The exception are a set of projects with a broad scope whose results are relevant to any industrial activities located at sea and thus can be pertinent to the activities in this domain and to those in the area of marine energies. In this sub-set new technology intensive firms, namely firms active in new materials, have an important position. It is also worth noticing the absence of projects in the areas of Recreation, sports and tourism and of Marine Works.

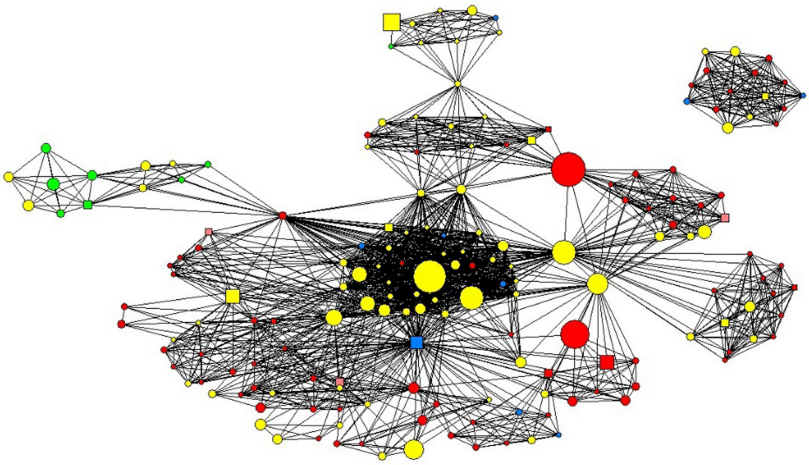

Fig. 8. Inter-organisational network - Projects in the Non-Living Resources domain. Legend: Squares – Portuguese organisations; Circles – Foreign organisations; Red – Firms; Light Red – NTIFs; Yellow – Research Organisations; Blue – Public Organisations; Green – Other Organisations. The size of the node is proportional to the EU funding received by the organisation. (Color figure online)

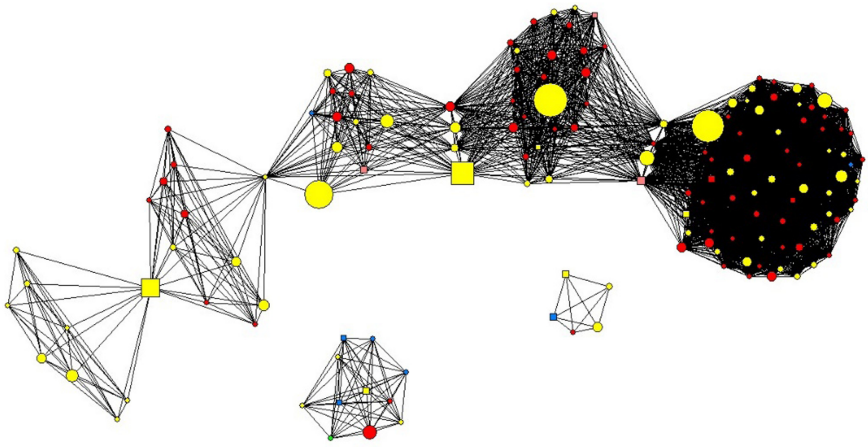

Fig. 9. Inter-organisational network - Projects in the Infrastructure, Uses and Activities domain. Legend: Squares – Portuguese organisations; Circles – Foreign organisations; Red – Firms; Light Red – NTIFs; Yellow – Research Organisations; Blue – Public Organisations; Green – Other Organisations. The size of the node is proportional to the EU funding received by the organisation. (Color figure online)

Finally, in the Governance domain (Fig. 10), it is possible to distinguish two main types of activities. One is concerned with cultural issues - the role played by the ocean in the national identity and the promotion of ocean literacy, which were important elements

in the national strategy - where we find exclusively research organisations and also some public organisations, when it comes to Portuguese organisations. The other is concerned with ocean security, where we find a majority of mixed teams (research/firm and often also public organisations). In this area projects tend to involve development of instruments for monitoring and surveillance, developed by new technology intensive companies, which in some cases perform a bridging role in the network. It is also noticeable the presence of many public organisations and other type of organisations.

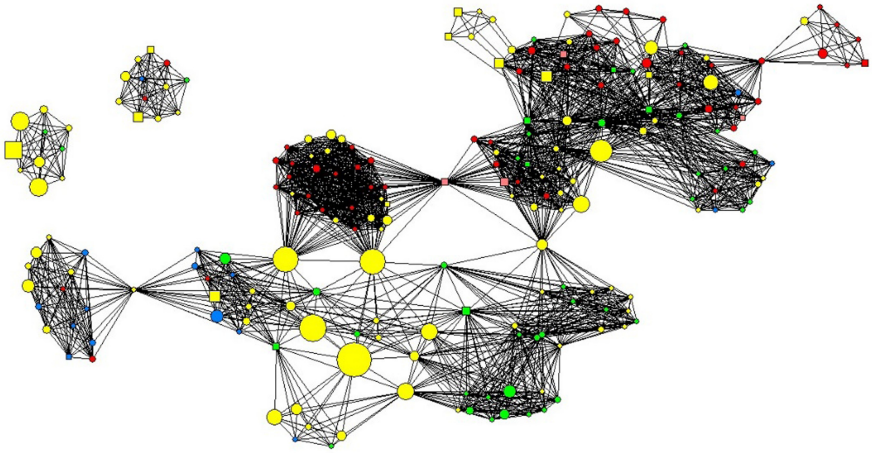

Fig. 10. Inter-organisational network - Projects in the Governance domain. Legend: Squares – Portuguese organisations; Circles – Foreign organisations; Red – Firms; Light Red – NTIFs; Yellow – Research Organisations; Blue – Public Organisations; Green – Other Organisations. The size of the node is proportional to the EU funding received by the organisation (Color figure online)

7 Conclusion

This paper conducted an assessment of the directions followed by the research and technology development activities conducted by Portuguese organisations in the areas encompassed by the "Blue Economy" – an emergent innovation system that is being policy-driven, both at European and national levels. More specifically the paper addressed the areas that are being privileged and the position of different types of actors in the developments taking place. For this purpose, the paper analysed the research and technological development (RTD) activities conducted by Portuguese organisations in in the context of projects funded by the most recent European Framework Programme, the Horizon 2020, between 2014 and 2018.

The results indicate an important investment, in particular by research organisations, towards the increase of the sustainability of ocean-related activities, in what can be described as system structuring activities. This encompasses the development of knowledge about the marine resources and marine environment, as well as on the impacts of

human activity and ways to reduce or remediate them. This area has been identified as a gap in the national strategy and is a critical step in the sustainable exploitation of the ocean.

The results also indicate that, so far, activities targeting industrial activity are mostly concentrated in the exploitation of living resources and in marine energies. In the first case, by attempting to revitalise established industries – fish capture and transformation – that have a long tradition in the country, namely through research investment in aquaculture. But also by investing strongly in a new area – marine biotechnology – whose activities target a variety of potential application sectors (e.g. fisheries, agrofood, health, cosmetics, environment), with a important component of activities whose goal is to upgrade established industries or increase their sustainability. In the second case, by strengthening the investment made in marine renewable energies by the country, in the last decades. The results also suggest that some areas are still attracting less attention: the principal gaps appear to be the limited activities targeting other sea-related industries, such as shipbuilding or ports and marine transportation that also have an important weight in the country economy, and the absence of activity in the area of marine mineral resources.

Concerning the role and positioning of the several types of organisations, the results show the central role of research organisations that not only dominate in more structural activities but are often part of mixed teams in more application-oriented projects. They also point to an important role of new technology intensive companies, active in areas with a higher technological intensity (such as biotechnology, instrumentation, underwater robotics and materials) and in areas that require development of more application oriented methods, products, services. These companies often perform the role of intermediaries between research organisations and other firms. A similar role is played in some areas by a few other technology-oriented companies, either large firms or firms belonging to large groups, as is the case of the marine energy area (non-living resources). These two types of firms are often part of mixed teams with research organisations and, in a few cases, also with established companies from user sectors. But there is a very limited participation of this latter group in the projects related to their area of activity.

The analysis was mostly focused on Portuguese organisations. However, the majority of the projects also involve organisations from other countries. In fact, the main actors in these projects, both in terms of received funding and in terms of participation in projects, are foreign organisations. In this broader context, where mixed teams – involving firms and research organisations – were frequent, Portuguese organisations could also profit from the interaction with reputed foreign partners, namely in areas where new competence was being acquired. Thus, the areas targeted by these projects were also the areas where the development of country capabilities in the Blue Economy fields could reap the benefits from international research cooperation, which potentially contributed to broadening knowledge bases and extending international networks.

These results can be relevant for policy makers, providing some indications on the relative success of the strategies and policy instruments devised to develop a Blue Economy in Portugal and signalling the areas that may still require greater attention.

This research can be expanded in three different ways. Firstly, it is possible to extend the analysis to the projects funded at national level, which may provide additional insights

into the activities of organisations that may not have the capacity to successfully apply to European projects (which have very high requirements), but can also play a role in the development of the Blue Economy in Portugal. Secondly, it is possible to perform a more detailed analysis of the contents and outcomes of the projects funded, in order to gain a deeper understanding of the areas being targeted and the advances achieved. Finally, it is possible to do a more detailed analysis of the interactions between different areas, as well as the potential sectoral interactions and cross-fertilization the projects may enable. In particular, this would allow to understand the part played by the new areas in the development of established industries, which is one important objective of the Blue Growth strategy.

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