

Creating a Blue Economy: Research and innovation partnerships to accelerate the development of ocean-related industries

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ABSTRACT

The Blue Economy can be a driver of European growth, through the development of new competences and activities that enable a sustainable exploitation of ocean resources. This paper assesses 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. It analyses the projects developed by Portuguese actors in the context of European framework programmes to uncover: the areas privileged - namely the relative importance of emerging areas vs. new advances targeting established ones - and the relative position of different types of organisations in the developments taking place.

The results point to stronger efforts in system domains related to marine resources and the marine environment and in some industry oriented domains. Among the latter, emerge new industries such as marine biotechnology and marine renewable energies and established industries exploiting marine living resources (fisheries, aquaculture). The results highlight the prominent position of research organisations in both new and established areas, as well as the relevant position of new technology intensive firms, in areas that require the development of application-oriented activities, where they often intermediate between research and industry. The results suggest that the international cooperation favoured by these projects permitted to open-up the national system, contributing to broaden the organisations’ knowledge bases and to extend their international networks.

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CCS CONCEPTS

• Applied computing → Law, social and behavioral sciences → Economics • Social and professional topics → Economic impact

KEYWORDS

Blue economy; Innovation System; New Technology Intensive Firms; Portugal.

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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 of Europe’s oceans, seas and coasts for jobs and growth” while simultaneously striving to use the sea sustainably (EC, 2012). Strategies and policies were defined to achieve these goals, targeting the broad variety of actors engaged in sea-related activities. Key elements in these strategies were research and innovation, aiming at the revitalisation of established sectors and the development of emerging ones; as well as at a better understanding of the marine environment and the requirements for its preservation.

EU level initiatives such as the definition of an Integrated Maritime Policy for the European Union (EC, 2007) and the Communication on Blue Growth (EC, 2012), which were subsequently translated with policy instruments, had an important impact upon the R&D and innovation activities of public and private actors that engaged in sea-related activities, and influenced policy formulation at country level. This was the case of Portugal that launched, in 2012, a National Ocean Strategy and Action Plan (RCM, 2014), whose model of

development and areas of intervention were inspired by the European framework.

The paper addresses the research, and technology development activities conducted by Portuguese organisations in the context European funded projects, to understand the directions followed by the research and innovation in the Blue Economy at the light of the guidelines set by EU and national strategies. For this, it investigates which areas appear to be receiving greater attention - namely the relative importance of emerging areas vs. advances targeting established ones - as well as the position of different types of organisations in the developments taking place.

2. THE BLUE ECONOMY – A POLICY DRIVEN INNOVATION SYSTEM

In 2007 a Communication from the European Commission proposed an Integrated Maritime Policy (EC, 2007) that set the ground for the sustainable development of marine-related activities in the European Union. As a follow-up, in 2012, a Communication from the European Commission on Blue Growth (EC, 2012) defined the opportunities for marine and maritime sustainable growth. It presented a balance of the current activities and key value chains, identified new areas where targeted action could drive sustainable growth (blue energy, aquaculture, maritime tourism, marine mineral resources, blue biotechnology), and proposed initiatives to achieve this goal.

EU documents provided a working definition of Blue Economy and its composition (EC, 2019). 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 includes:

- Established sectors: Maritime transport; Coastal tourism; Marine living resources, (fisheries, aquaculture; processing and distribution); Marine extraction of minerals, oil and gas; Ports, warehousing and water projects; Shipbuilding and repair.
- Emerging and innovative industries: 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 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.

3. BLUE ECONOMY IN PORTUGAL

The Blue Economy development structure established by EU strategies and policies had a strong impact upon the formulation of the Portuguese National Ocean Strategy 2013-2020 (RCM, 2014). Portugal is a maritime country with a large Atlantic coast and historically engaged on sea-related activities. However, some of the established marine sectors experience difficulties in adapting to structural changes or withstanding international competition, and the country still has a limited activity in the

emerging areas. On the other hand, while there are organisations conducting marine research, the knowledge about marine ecosystems was regarded as insufficient to explore the sea resources and to address the environmental challenges.

Therefore, the political and financial relevance attributed to this area in European policies was regarded as an opportunity to formulate a strategy that enabled the country to recover the “national maritime identity” and to regain a position in this area, by increasing the contribution of maritime sectors to the domestic product, strengthening the scientific capacity, and stimulating new areas of action (RCM, 2014).

The Mar-Portugal Action Plan was the instrument to operationalise the strategy. It is organised along 3 Strategic Development Domains (SD), each including several Programme Areas (PA), encompassing the main fields that compose the “Blue Economy” definition, with some adjustments to the country conditions (DGPM, 2015).

Table 1 presents the main Programme Areas and relates them with the areas defined as strategic in EU Blue Economy policy documents, showing the strong overlap between them, despite some country-specific differences in thematic aggregation and sectoral organisation.

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

PLAN MAR PORTUGAL (DGPV, 2015)	BLUE ECONOMY REPORT (EU, 2019)	Type
SD - Governance Strategic Thinking and Action Education Identity and Culture Protection and Safeguard	Maritime Defence	N
SD - System Ocean Atmosphere Integrated System	Natural Capital and Ecosystem Services Natural Capital and Ecosystem Services Natural Capital and Ecosystem Services	
SD - Natural Resources - Living Resources Fisheries and Fishing Industries Aquaculture Marine Biotechnology	Marine Living Resources - Fisheries Marine Living Resources - Aquaculture Blue Bio Economy	E E N
SD - Natural Resources - Non-Living Resources Marine Mineral Resources Marine Energy Resources	Marine Minerals & Extraction of Minerals Blue Energy & Extraction of (Minerals) Oil and Gas	N&E N&E
SD - Infrastructure, Uses and Activities Ports, Transport and Logistics Recreation, Sports and Tourism Shipbuilding, Maintenance & Repairs Maritime Works	Ports, Warehousing & Maritime Transport Coastal Tourism Shipbuilding, Maintenance & Repairs (Ports, Warehousing and) Water Projects	E E E E

E-established sectors; N - new industries

The Portuguese Strategy and Action Plan equally put great emphasis on the role played by research and innovation in the fulfilment of the goals established. One of the goals of the Plan was to increase the participation of companies in these activities in order to strengthen the industrial structure around the “Sea Economy”. This included the involvement of existing companies and the creation of new ones exploiting emerging technologies.

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, where new technological advances often originate outside the industry. Thus, they may result from activities conducted by research

organisations or by new technology intensive firms (NTIF), sometimes in partnerships with potential users. But the development of new areas has a central role in the renewal of the Blue Economy. At this level, research organisations and NTIF are equally relevant players.

NTIF are young independent firms involved in the development and exploitation of new technological knowledge (Fontes & Coombs, 2001). They often occupy an intermediate position between academic research and the market, as agents of knowledge acquisition, transformation and diffusion in knowledge networks (Walter et al, 2006; Harrison & Leitch, 2010). Thus, they can play a part in the translation of research results into products and services (Autio, 1997; Fontes, 2005), which is indispensable for the country to benefit from the R&D efforts.

It is therefore important to investigate the activities of these two types of organisations, their relative positioning as well as their relationships – between them and with companies from established sectors – in order to understand the dynamics of technological development in the field.

Collaborative relationships, namely joint R&D projects, are a privileged instrument used by firms for the development of new technologies, enabling them to share R&D risk and huge investments (Hagedoorn, 2002). They are particularly important for new firms in knowledge-intensive sectors, where competitiveness depends on the ability to quickly renew the knowledge base in order to generate a steady stream of innovations, and where knowledge is often complex and distributed (Ozman, 2009). But large firms are also intensively engaged in collaborative R&D (Veugelers & Cassiman, 2005). Research organisations equally engage in joint R&D projects, not only with academic partners, but also increasingly with the industry (Perkmann & Walsh, 2007).

The objective of this paper is to conduct a first assessment of the directions followed by the research and technology development activities of Portuguese organisations in the areas encompassed by the “Blue Economy”, in order to understand: (i) which areas appear to be privileged and thus are likely to be developing faster; namely the relative importance of new areas vs. advances targeting established ones; (ii) the position of different types of actors in the developments taking place in the field; and namely the role played by new technology intensive companies in developing new technologies/products or 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 EU funded projects. RTD Framework Programmes (FPs) are a major EU policy instrument, stimulating research organisations, government agencies and industrial partners to cooperate in R&D projects and generating knowledge that spans across national borders (Amoroso, et al, 2018). They are pivotal for transforming informal nation-based research networks into formal collaboration arrangements at European level (Heller-Schuh et al, 2011).

While EU projects only correspond to a subset of the RTD activities being conducted by Portuguese organisations,

European programmes have nevertheless become a very important source of research funding. Thus, it can be assumed that the projects submitted to these programmes offer an overview of the areas where the most innovative Portuguese organisations decided to develop RTD activities, providing some indications of the type of areas privileged by them, among those defined as priority. Since there is a close correspondence between the priority areas defined at EU level for the Blue Economy and those defined by the national strategy, this data enables us to start uncovering the influence of these policies in the research directions followed.

EU projects, which in most programmes require multinational teams, also provide 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. METHODS

The paper focuses on the research and technology development 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.

The research is based on all the projects with Portuguese participation funded since the beginning of the Programme (2014) until the end of 2018. The projects were identified in the database provided by the Community Research and Development Information Service (CORDIS), using a series of key words related with the ocean, sea-related activities and industrial sectors.

For the 136 projects selected, we also used the CORDIS database to collect additional information on: Start and End date, Budget, EU contribution, Objective, Coordinator, Participants. Data was equally collected on each Participant: Type of organization (Research Organisation, Firm, Public Organisation, Other), Country.

The projects were subsequently classified according to their main area of activity, using the categories defined in the Portuguese Strategy and Action-Plan: Strategic Development Domains and Programme Areas (Table 1).

The Portuguese Participants were also object of an additional treatment. NTBFs were singled out and distinguished from the remaining companies. The objective was to explore the potential role played by these organisations in the construction of a Blue Economy in Portugal.

To assess relationships we used the methods of social network analysis. Collaborative projects constitute two-mode networks that link organisations to an event - the project. From these we extract a one-mode network, 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.

6. RESULTS

6.1 The position of different actors

The 136 projects with Portuguese participation that were identified as involving 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 the ocean is only one of the target areas (22%). 33 projects were coordinated by Portuguese organisations.

These projects involve 2279 participations from different types of organisations, of which 226 are Portuguese. Over half of the Portuguese participations are from research organisations and about 1/3 are from firms, the majority from new technology intensive firms (Table 2). However, considering the individual organisations involved, it can be concluded that the number of research organisations equals the number of firms and that, among the latter, NTIFs prevail (Table 3). Other participations are from public organisations (e.g. government departments or public agencies), corresponding to about 12%, and from other types of organisations, with a much lower weight. Nevertheless, more than a half of the projects do not involve any Portuguese firm (Table 4).

Table 2. Portuguese participations by type of organisation

Type organisation	Number participations	Percentage
Research organisations	124	54.9%
Firms	70	31.0%
of which NTIF	48	21.2%
Public organisations	27	11.9%
Others	5	2.2%
Total	226	100.0%

Table 3. Individual organisations by type

Type organisation	Number organisations	Percentage
Research organisations	34	36.2%
Firms - NTIF	28	29.8%
Firms - Other	16	17.0%
Public organisations	11	11.7%
Others	5	5.3%
Total	94	36.2%

Table 4. Project composition – involvement of Portuguese firms

Project composition	Total projects	Percentage
Include PT Firms	57	41.9%
No PT Firms	79	58.1%
Total	136	41.9%

Table 5 shows the composition of teams in terms of Portuguese organisations. Mixed teams involving research organisations and firms are the most frequent. These teams sometimes also encompass public or other organisations. Teams composed exclusively of research organisations are also present but less frequent, the same being the case for teams exclusively composed of firms. Research organisations sometimes partner with public or other organisations. The table also shows the types of partnerships where NTIF are present: they are more frequently engaged with research organisations and less frequently with other types of organisations. But in some of these teams, they are part of tripartite relationships that include

also other firms, namely from established sectors, to whom they are likely to act as knowledge intermediaries (Conceição et al, 2017). They are also engaged in individual projects, in the context of the SME instrument programme.

Table 5. Composition of Portuguese teams

Team	Total Number of projects	Including NTIFs Number of projects
RO only	16	
Firm only	13	13
RO + 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

It should nevertheless be noticed that the large majority of projects are composed of multi-national teams, creating conditions for international research cooperation. Only 20 projects involved only Portuguese participants, in general one individual organisation, either a firm (13) or a research organisation (7).

Finally, it is relevant to point out that, the 28 NTIF involved in these projects represented 21.2% of the total of Portuguese project partners (68.5% of the firm partners) and 29.8% of individual organisations. They 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 developed by Portuguese organisations in the context of EU projects.

6.2 The 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 classified the projects according to the areas defined in the Portuguese strategy. Then we analysed each group in terms of number of projects, investment (project budget and EU contribution) (Table 6) and composition of the teams involved in the projects (Table 7). Network diagrams support the analysis.

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

Table 6. Relative weight of Blue Economy priority areas in EU projects

	Budget (%)	Funding (%)	No projects (%)
SD - Governance	12.3	10.8	15.4
Strategic Thinking and Action	4.7	3.2	5.1
Education	0.8	1.1	2.3
Identity and Culture	0.8	1.1	2.9
Protection and Safeguard	5.8	5.4	5.1
SD - 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 - 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 & Fisheries	1.5	1.7	1.5
Marine Biotechnology	14.3	14.3	16.4
SD - Natural Resources - Non-Living Resources	16.0	18.2	16.2
Marine Mineral Resources	0.2	0.3	0.7
Marine Energy Resources	15.7	17.9	15.4
SD - Infrastructure, Uses and Activities	11.8	8.0	8.1
Ports, Transport and Logistics	7.7	2.8	2.2
Recreation, Sports and Tourism	0.0	0.0	0.0
Shipbuilding, Maintenance & Repairs	0.7	0.9	0.7
Maritime Works	0.0	0.0	0.0
Various Activities and Marine Energy	3.4	2.5	5.1
Total	100.0	100.0	100

Table 7. 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=18)	Infrastructure, Uses & Activities (n=21)	Total (n=124)
Only Non	22.2	14.7	4.5	4.7	18.2	11.9
Only Firms	0.0	14.3	13.6	2.3	27.3	6.4
ROS + Firms	11.1	23.8	50.0	37.2	19.2	30.1
ROS + Public /Other	22.2	4.3	6.0	0.3	0.0	9.8
ROS + Firms + Public /Other	44.4	40.4	22.7	46.5	36.4	39.7
Total	100	100	100	100	100	124

The System domain is the most important in terms of investment and is also in the top in number of projects. Activities in this domain are mostly concerned with knowledge development on the ocean ecosystem and its interactions with other systems, focusing on production of new knowledge about the marine environment, and on research about modes of monitoring, risk assessment and conservation. It is dominated by research organisations, being the one with the highest share of teams without firms (Table 7). This is also the domain with the highest share of projects involving tripartite teams (Research - Industry - Public / Other organisations). Some Portuguese firms, mostly NTIF, active in the areas like instrumentation or marine robotics, appear in joint teams engaged in activities concerned with monitoring services, as shown in the network diagram (Figure 2).

Figure 2. Inter-organisational network – Projects in the System domain (Legend: Squares – Portuguese organisations; Circles – Foreign organisations; Red – Firms; Blue – NTIFs; Yellow – Research Organisations; Green – Public Organisations; Pink – Other Organisations. The size of the node is proportional to EU funding received by the organization)

Research concerned with the exploitation of natural resources is also well positioned (Table 6). The domain of Living Resources has the highest number of projects and is second in terms of investment. It includes activities targeting established and new activities. However, projects targeting the former - fisheries and aquaculture - have a lower weight than those in marine biotechnology, which emerges as the most important programme area in terms of projects and the second in investment. This may be explained by the strong investment made by the country in biotechnology in the last decades (Arantes-Oliveira, 2007; Fontes & Sousa, 2016). Portuguese firms are present in several projects (Figure 4) often partnering with research organisations. But there is still a substantial number of projects, in new and in established areas, that only have Portuguese research organisations. NTIF are particularly important in marine biotechnology, where they seem to perform a bridging role across teams/projects (Figure 4). These firms also have some weight in aquaculture, a still relatively new field in Portugal. A small group of Portuguese established firms from user sectors also participate in some teams. Foreign firms are particularly important in established areas (Figure 3).

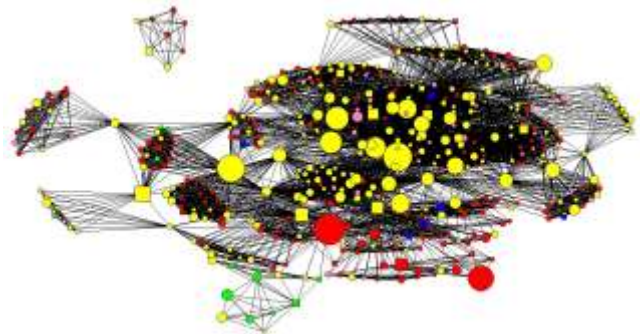


Figure 3. Inter-organisational network - Living Resources domain: Fisheries and Aquaculture areas (Legend: see Figure 2)

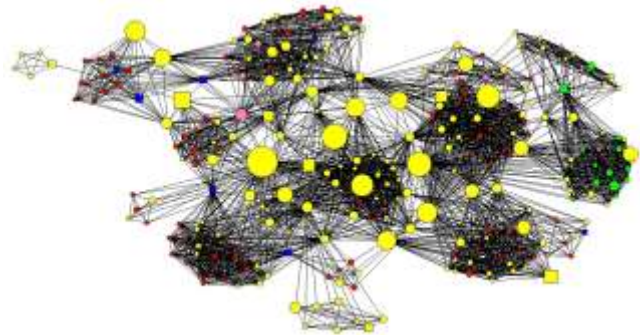
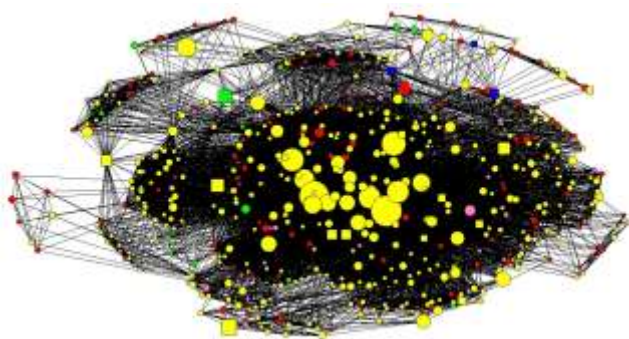


Figure 4. Inter-organisational network - Living Resources domain: Marine Biotechnology area (Legend: see Figure 2)

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, 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 conducted by Portuguese organisations in marine renewables (wave and offshore wind energies) for several decades (Sarmento et al, 2014; Fontes et al, 2016). This area combines projects testing prototypes, where firms appear alone or in partnership with research organisations; and projects concerned with the structuring of the field that tend to involve only research organisations. In the former, partnerships can join NTIF and large energy firms (both Portuguese and foreign), as shown in Figure 5).

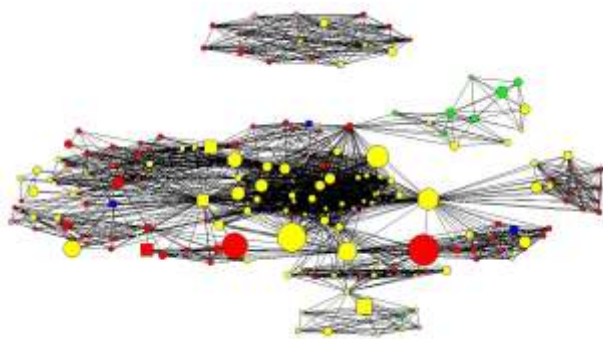


Figure 5. Inter-organisational network - Non-Living Resources domain (Legend: see Figure 2)

The Infrastructure, Uses and Activities domain, which is concerned with research targeting the other sea-related industries, is the one attracting the lowest number of projects and investment. Despite its more application-oriented nature, there is still a number of projects where the only Portuguese participants are research organisations (in some cases performing the role of bridges between teams/projects, as shown in Figure 6). 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. NTIF, namely firms active in new materials, have an important position in this sub-set. It is worth noticing the absence of projects in the areas of Recreation, sports and tourism and Marine Works.

Finally, in the Governance domain, 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. Here we find almost exclusively research organisations, and some public organisations (Figure 7). The other is concerned with ocean security, where we find a majority of mixed teams (research/ firm and often also public organisations). Projects in this area tend to involve development of instruments for monitoring and surveillance, developed by

NTIF, which in some cases perform a bridging role in the network (Figure 8).

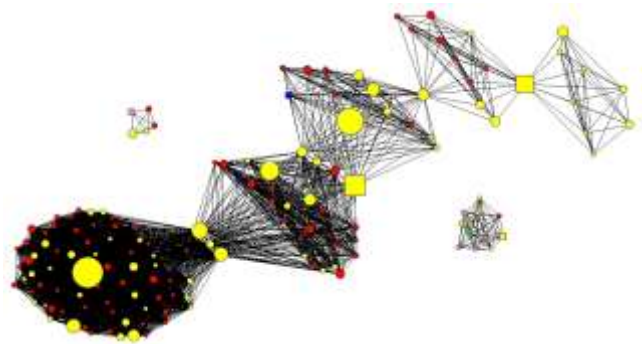


Figure 6. Inter-organisational network - Infrastructure, Uses and Activities domain (Legend: see Figure 2)

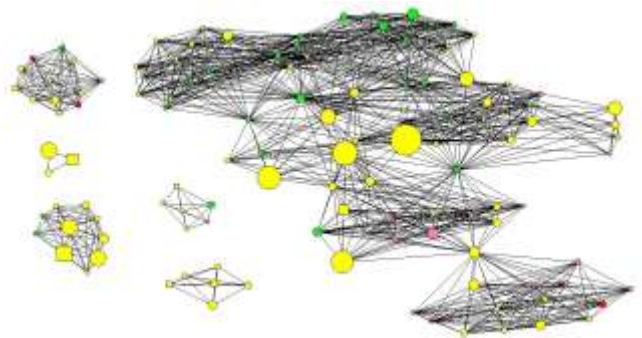


Figure 7. Inter-organisational network - Governance domain: Cultural areas (Legend: see Figure 2)

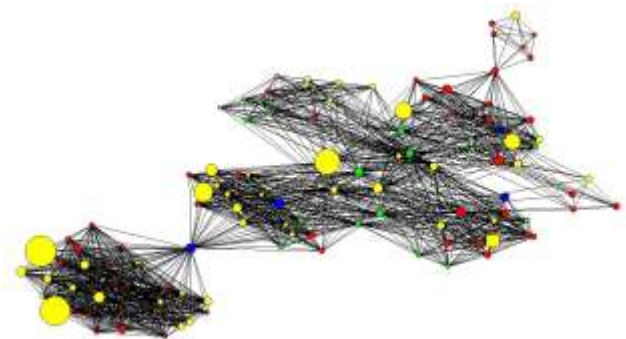


Figure 8. Inter-organisational network - Governance domain: Protection and Safeguard area (Legend: see Figure 2)

7. CONCLUSION

This paper assessed 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, at both European and national levels. More specifically, the paper examined the research and technological development activities conducted by Portuguese organisations in the context European

funded projects, to uncover the areas that are being privileged and the position of different types of actors in the developments taking place.

The results indicate an important investment, in particular by research organisations, in what can be described as system structuring activities, i.e. the development of knowledge about the marine resources and marine environment, as well as on the impacts of human activity, and ways to reduced or remediate them. This area was identified as underdeveloped by the national strategy, being a critical step in the sustainable exploitation of the ocean. The results also show that activities targeting industrial activity are concentrated in the exploitation of living resources and in marine energies. In the first case, by revitalising established industries with a long tradition in the country - fish capture and transformation - namely through research in aquaculture. But also by investing strongly in a new area - marine biotechnology - whose activities target a variety of application sectors (e.g. fisheries, health, cosmetics, environment). In the second case, by strengthening the investment made in marine renewable energies in the last decades. The principal gaps appear to be the limited activities targeting other sea-related industries, and the absence of activity in the area of marine mineral resources.

Concerning organisations positioning, the results show the central role of research organisations that not only dominate in more structural activities, but also 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 biotechnology, instrumentation, underwater robotics and materials - particularly in areas that require development of application oriented methods, products, services. A similar role is played in some areas by a few other technology-oriented companies, either large firms or firms belonging to large groups. These two types of firms are often part of mixed teams with research organisations that, in a few cases, also include established companies from user sectors. However, there is a limited participation of the latter group in the projects related to their area of activity.

The analysis was mostly focused on Portuguese organisations. However, the majority of projects also involve organisations from other countries. In fact, the main actors in most projects, in terms of funding and participation, are foreign organisations. In this broader context, where mixed teams involving firms and research organisations were frequent, Portuguese organisations could 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 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.

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