Policy Paper

Qualitative Evaluation of Innovation Ecosystems: Example Portugal

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Qualitative Evaluation of Innovation Ecosystems: Example Portugal

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Abstract[1]

The design of efficient and effective innovation ecosystems is crucial to every society, particularly for addressing structural change through innovation. We developed a methodology to map the established research and innovation landscape based on responses to a qualitative questionnaire and interviews. The dimensions for assessing entities that undertake knowledge creation and technology transfer are Scientific Merit, Economic and Social Impact, and Compliance. This approach complements the conventional methodology, based on quantitative key performance indicators, also used (Wehrspohn et al, 2025). We successfully tested our methodology in the Portuguese Research & Development (R&D) system.

JEL Codes: O32; O38.

Keywords: Science & Technology Policy; Technological System; Innovation Policy; Technological Centres; Technological System Evaluation

1. Introduction

The innovation ecosystem is complex (Nelson, 1993), including entities dedicated to different aims, namely: education and training institutions, research and technology organizations, testing laboratories, public agencies, globally operating companies, and small and medium size enterprises, funding entities, education and training entities, and interface institutions. All these actors have distinct objectives, different skills, purposes, motivations, incentives, and temporal agendas. At the starting end of the spectrum is basic science, whose outcomes are expected mainly in the long term, with results often emerging after decades of sustained effort. At the other end, companies aim to achieve results from their investment in the short- to medium-term. They are open to converting scientific results into economic value through innovative products with potential demand. Many companies conduct process and product development and, in some leading-edge high-tech sectors, research as well.

Publicly funded research organizations are crucial for developing innovation ecosystems within a country. Interface institutions, mostly research and technology organizations (RTOs) and testing

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labs (TLabs), develop and transfer technology, bridging academia and industry for economic benefit. They are both creators and disseminators of knowledge to the economy and society.

2. Methodology - Indicators to assess interface institutions

The qualitative methodology presented in this paper is based on information collected through detailed questionnaire sent to entities, which they filled in and returned. The purpose of the questionnaires is to obtain information on three main dimensions: Merit; Impact; and Compliance with the domestic and European agendas, the guidelines of the funding program and the contracted objectives.

We propose the following indicators for Scientific Merit, Impact, and Compliance.

Merit

Is the interface institution creating scientific and technological knowledge and / or providing high-quality, relevant technical and technological support to companies and other entities in the economic sector or region?

Economic and Social Impact

What specific economic and social impacts have resulted from its technical support and technological knowledge dissemination efforts?

Compliance

Is it complying with the contracted objectives?

- Alignment with national and EU agendas and Sustainable Development Goals (SDGs) - Is the interface institution aligned with the objectives of national and EU agendas for strategic autonomy (defense, energy, electronics, AI, pharma, etc.), sustainable transition, and digital transformation? (EC, 2025)

- Compliance with contracted objectives - Is the interface institution complying with the contracted objectives? Will it be able to continue its strategy after the Recovery and Resilience Plan funding is completed?

Each dimension is addressed by several questions in the questionnaire.

In each item, the performance of the interface institution has been graded using the scale:

3 – corresponds to Excellent or Very Good

2 – corresponds to Good or Fair

1 - corresponds to Poor.

After the assessment of each entity, overall recommendations were formulated, considering some fundamental issues:

- Does the specific CTI (or CoLAB) have enough merit and impact to deserve future public funding?
- In case it deserves it, does it really need public base funding to pursue and deploy its activity? Or, on the contrary, can it do without public base funding?
- Instead of base funding, would it not be more appropriate, in some cases, to provide one-off funding, such as funding for equipment, excluding funding for running costs?

In addition to the qualitative approach presented in this paper, our analysis also included a quantitative section – based on a set of Key Performance Indicators, evaluating Excellence in Science and Excellence in Technology Transfer of the interface institutions (Wehrspohn et al, 2025).

3. Example: Centros de Tecnologia e Inovação (Technology and Innovation Centers) and Collaborative Laboratories in Portugal

Portugal has a broad research infrastructure comprising about one hundred Higher Education institutions, about three hundred funded Research Units (UIDs), 40 associate laboratories, some state laboratories, 31 Centros de Tecnologia e Inovação (CTIs), 35 funded Collaborative Laboratories (CoLABs) and some other entities. UIDs are fundamental research centers within universities or polytechnic institutes. Internationally accepted criteria for scientific excellence are used to evaluate them. The primary mission of the so-called interface institutions, i.e., mostly CTIs and CoLABs, is innovation and technology transfer to industry. Economic impact is of utmost importance. Specifically, the additional support provided by the Interface Program is expected to help the CoLABs and the CTIs improve and expand their support to industries in realizing the green and digital transitions and enhancing their competitiveness. The Portuguese Interface Program is funded by the National Recovery and Resilience Plan, within the framework of the EU's NextGenerationEU fund, and contracted with each entity's objectives and goals, with multiannual public base funding.

CTIs are a group of independent research institutes with the legal form of a public association of public interest (PAPI) and a focus on applied research and technology transfer. There are two main groups of CTIs: the 'old' technological centers created in the 1980s and recognized as CTIs, and the recent CTIs built on pre-existing R&D organizations that chose to adopt this new format to extend their technological transfer activities. As to the first group, comprising fewer than 10

entities, they are focused on specific mature industrial sectors (footwear; textile and clothing; leather industries; cork; ceramic and glass; molds and plastics; and metalworking).

CoLABs were legally created by a Portuguese Ministry of Science initiative launched in late 2016, with most established between 2018 and 2022. They are more complex entities, characterized by multifaceted and much broader missions than CTIs. Beyond generating scientific and technological knowledge and facilitating technology transfer and product innovation, they are committed to fostering academia-industry collaboration, creating scientific and highly qualified employment, revitalizing the country's interior regions (a regional dimension), and increasing internationalization. Finally, they support the regional technological development and the spread of scientific and technological competencies and resources across the country.

The assessment has been based on information collected through detailed questionnaires sent to the interface entities. The primary purpose of the questionnaires is to obtain systematic information to answer questions regarding: the quality of technological development and technology transfer; the impact on the region and the country as a whole; and compliance with the Program's guidelines and the objectives set in the applications submitted and approved. Regarding compliance, the questionnaires also elicit explicit alignment with the main domestic and European agendas, mostly related to the dual transition: digitalization and environmental sustainability. Finally, it was intended to help decision-makers determine whether the entities are worth the funding obtained from this Program and whether it is crucial to continue providing this kind of support.

General recommendations that can be drawn regarding the assessed interface institutions are that particular attention should be paid to strategic technological fields in the EU and Portugal, namely those related to green transition, digitalization, strategic autonomy, and defense (EC, 2025; Draghi et al, 2024).

3.1 Analysis of CTIs

29 CTIs were evaluated based on the responses to the qualitative questionnaires. These interface institutions are located on the central and northern coastal strip. Elder CTIs were founded decades ago as technological centers closely linked to specific industries to provide technical assistance and transfer technology. In several cases, they created branches in locations other than the leading site.

The data analysis provides the following information (Table 1):

- 13 CTIs are graded as excellent or very good in the 3 dimensions, Merit, Impact, and Compliance: 4 in Advanced Manufacturing; 4 in ICT & Digitalization; 2 in Bioeconomy, including Agrifood, 2 in Materials & Circularity; and 1 in Health.

- 6 CTIs are in a mixed group: they are graded as Excellent in "Merit", but they perform less well regarding the other dimensions, and 10 belong to a low-performance group.

- The majority of the CTIs are considered excellent or very good regarding "Merit": 19 out of 29, with 8 considered good or fair, and only 2 considered poor.

- The dimension "Impact" rates almost as well: 18 out of 29 are considered excellent or very good in terms of impact, 8 are good or fair, and 3 are poor.

- In terms of compliance with the contracted objectives, the picture is different. Only 15 received the top grade, 7 the intermediate grade, and 7 the poor grade. This highlights the need for closer monitoring and targeted support to improve adherence to contractual commitments.

- Almost all technological fields have excellent or very good entities in Merit: Advanced Manufacturing (5); Bioeconomy (2); Energy (1); ICT & Digitalization (4); Health (2); and Materials and Circularity (5). Only Blue Economy still does not have a top CTI. This is very positive, as it indicates that technological capabilities are present across nearly all areas.

- Top entities originated either from the academy or from industry initiatives. However, the latter represent a minority (7 out of 19). It seems clear that Higher Education Institutions (HEIs) are contributing in a very relevant way to technological innovation and economic upgrading, far more than simply providing highly qualified human resources.

Table 1 – CTIs Merit and Impact – a performance assessment (qualitative questionnaire) (Total = 29)

Number	Merit	Impact	Compliance	Technological Field
# 13	3	3	3	Advanced Manufacturing
# 4	3	3	3	Advanced Manufacturing
# 1	3	3	3	Advanced Manufacturing
# 5	3	3	3	Advanced Manufacturing
# 2	3	3	3	Bioeconomy
# 21	3	3	3	Bioeconomy
# 18	3	3	3	Health
# 9	3	3	3	ICT
# 12	3	3	3	ICT
# 17	3	3	3	ICT
# 19	3	3	3	ICT
# 25	3	3	3	Materials
# 6	3	3	3	Materials
# 24	3	3	2	Materials
# 10	3	3	2	Materials
# 16	3	3	2	Energy
# 22	3	3	1	Health
# 20	3	2	3	Materials
# 14	3	2	3	Advanced Manufacturing
# 27	2	3	1	Bioeconomy
# 23	2	2	2	Materials
# 8	2	2	2	Materials
# 11	2	2	1	Advanced Manufacturing
# 15	2	2	1	Advanced Manufacturing
# 29	2	2	1	Materials
# 28	2	2	1	Materials
# 7	2	1	2	Advanced Manufacturing
# 26	1	1	2	Blue Economy
# 3	1	1	1	Advanced Manufacturing

Note – Assessment used the following scale: 3 (Excellent or Very Good); 2 (Good or Fair); 1 (Poor). Colors are green for 3; yellow for 2; orange for 1.

Discussion

Table 1 shows that there is room for improvement across all dimensions and signals a few problematic cases in merit and impact. The many examples of unsatisfactory performance in achieving the contracted objectives require serious consideration.

Figures 1 and 2 reveal a strong cluster of top CTIs and an apparent correlation between merit and impact. This suggests that quality may be associated with impact and possibly is a precondition

of the latter. On the other hand, Figures 2 and 3 show much greater dispersion in compliance and a likely lack of correlation with the other two dimensions.

In summary, CTIs evolve into two types of entities: RTOs (Research Transfer Organizations), which perform well in both scientific production and technology transfer; and Testing Labs, which perform well in technology transfer but have modest scientific performance. The former group typically originated in academia, while the latter was generally an industry initiative. Both types play an essential role in the innovation system (Nelson, 1993).

Regarding CTIs, our analysis confirmed the existence of two groups: high-quality RTOs, on the one hand, and high-performance Testing Labs, on the other. It also revealed the presence of some "problematic entities" that fail to meet expectations across all dimensions. These entities should be further analyzed in an individual entity-specific evaluation process.

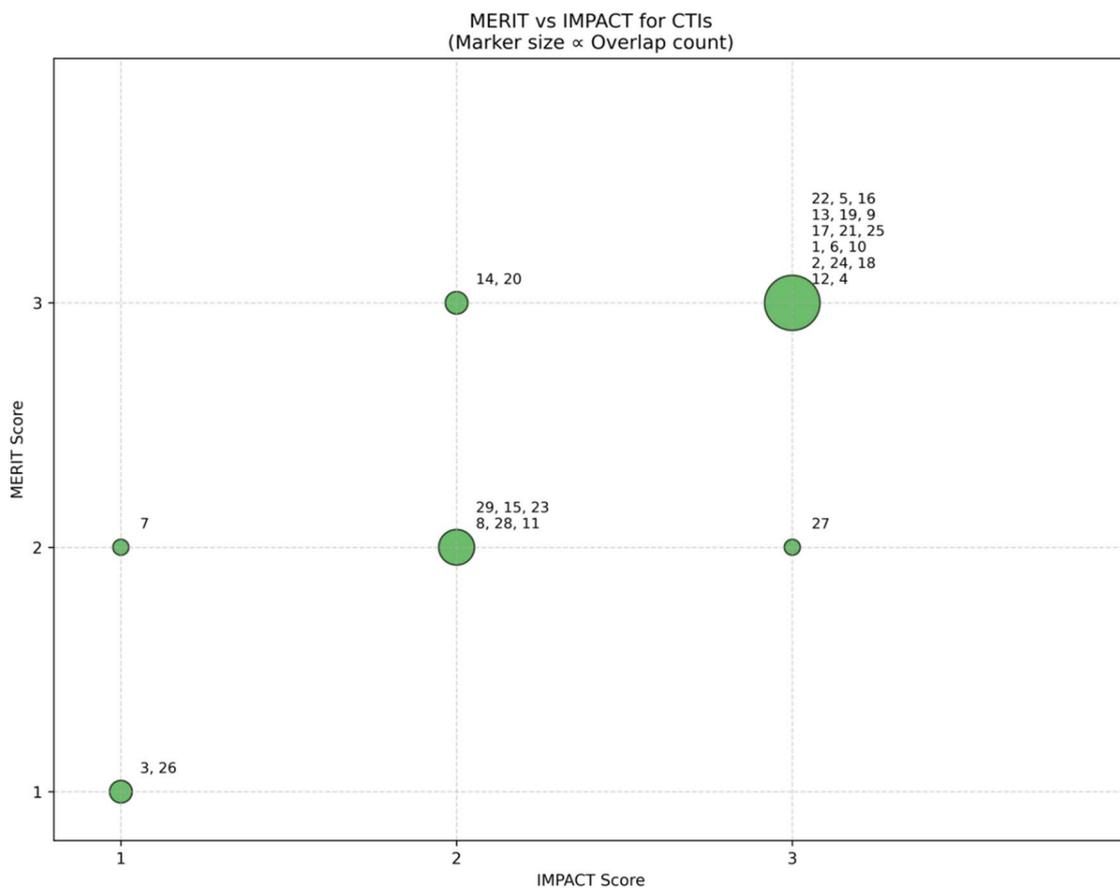**Figure 1 - Merit versus Impact for the 29 CTIs (left), using a 1–3 scoring scale**
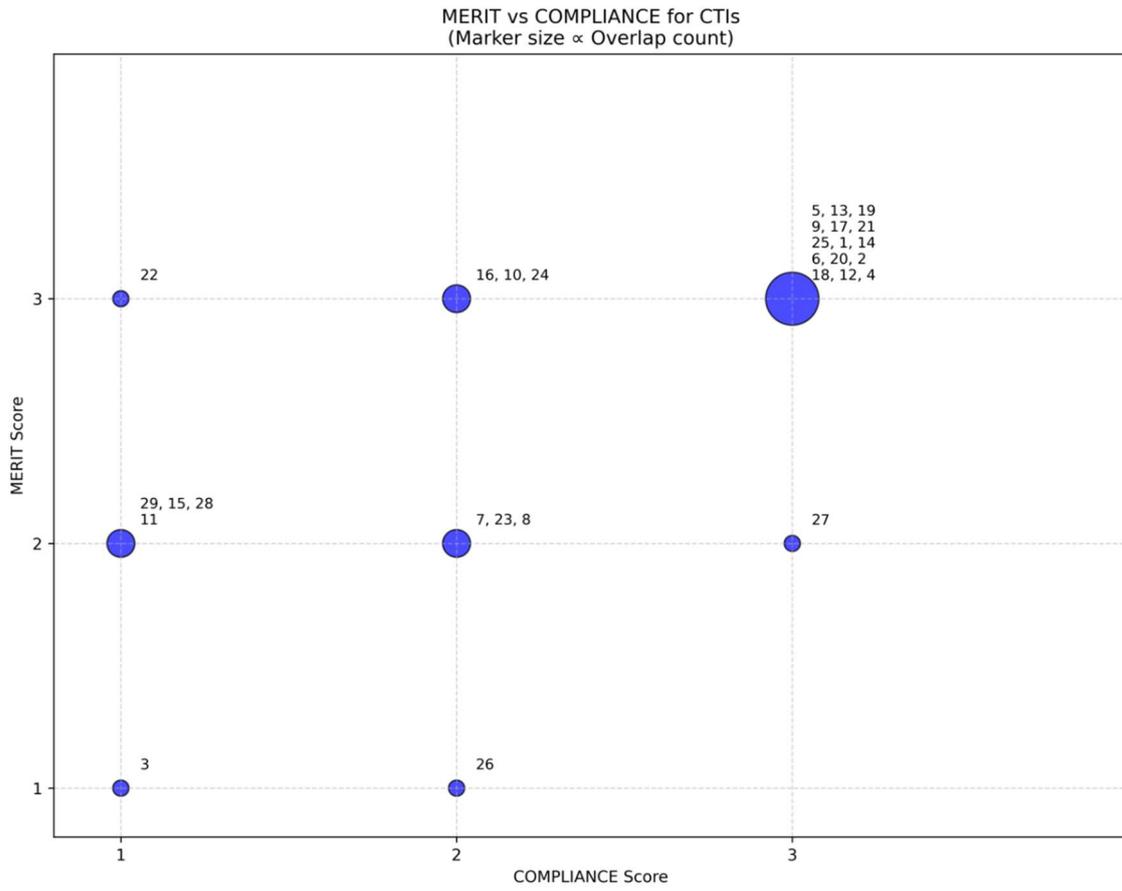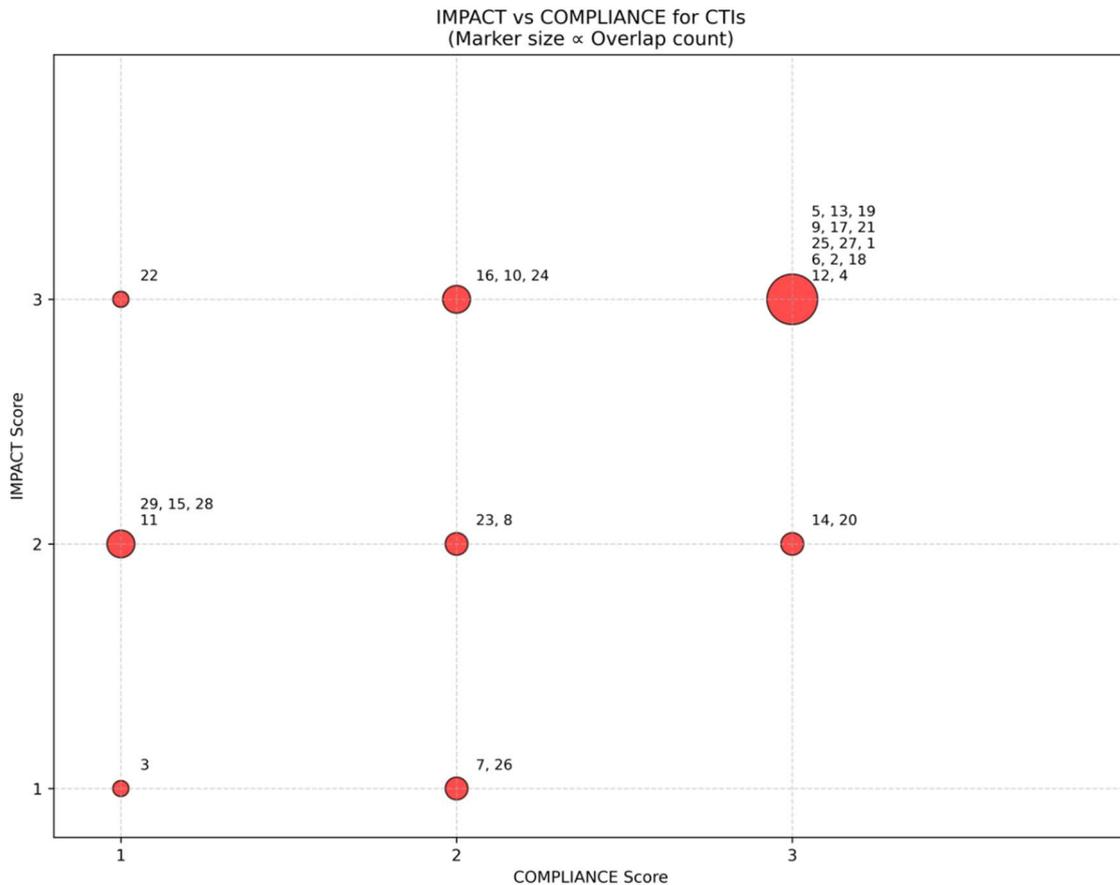
Figure 2 - Merit vs. Compliance for the 29 CTIs (left), using a 1–3 scoring scale

MERIT vs COMPLIANCE for CTIs
(Marker size ∝ Overlap count)

Figure 3 - Impact vs. Compliance for the 29 CTIs (left), using a 1–3 scoring scale

IMPACT vs COMPLIANCE for CTIs
(Marker size ∝ Overlap count)

3.2 Analysis of CoLABs

32 CoLABs were evaluated based on the responses to the qualitative questionnaires. CoLABs are located across the country, more widespread than CTIs. They were created more recently, and one of their missions is to reinforce technological capabilities at regional level.

The data analysis provides the following information (Table 2):

- 14 CoLABs may be considered as Excellent or Very Good, due to the grades obtained in most subdimensions, particularly Scientific Merit (15) and Research Agenda (18); four show a mixed performance; and 14 appear with an overall poor performance.

- As to impact, in the subdimension Innovation and potential innovation, only nine out of 32 CoLABs display excellent or very good performance, against 17 in the creation of scientific or highly skilled employment. This means that while economic impact is (still) modest, CoLABs' performance is much better in employment creation.

- In terms of compliance with the contracted objectives, the picture is gloomy. Only 6 out of 32 received the top grade, 18 the intermediate grade, and 8 were assigned the poor

grade. Though CoLABs are generally very young, since they were formed after 2018, this raises the issue of unrealistic contracted commitments or inability to meet them, or both. In either case, close monitoring is needed.

- All technological fields have at least one excellent or very good entity in Scientific Merit: Bioeconomy (1); Blue Economy (1); Energy & Sustainability (4); Health (2); ICT & Digitalization (2); Materials and Circularity (4); Social & Tourism (1). The picture is better if we consider their Research Agenda. This is positive, as it indicates that technological capabilities are present across all areas. But, of course, some fields stand out.

Table 2 – CoLABs Merit, Impact, and Compliance – a performance assessment (qualitative questionnaire) (Total = 32)

	Merit		Impact		Compliance		
	Scientific Merit	Research Agenda	Innovation	Employment	Alignment	Compliance with objectives	Fields
# 29	3	3	3	3	3	3	Materials
# 20	3	3	3	3	3	3	Blue Economy
# 23	3	3	3	3	3	3	Energy
# 1	3	3	3	3	3	2	Energy
# 5	3	3	3	3	3	2	Energy
# 3	3	3	3	3	3	2	Health
# 4	3	3	3	3	3	2	Materials
# 6	3	3	3	2	3	2	Materials
# 10	3	3	2	3	3	2	Energy
# 27	3	3	2	3	3	2	Bioeconomy
# 7	3	3	2	3	3	2	ICT
# 21	3	3	2	3	3	1	ICT
# 8	3	3	2	3	2	3	Social
# 24	2	3	3	3	3	1	Bioeconomy

Table 2 – CoLABs Merit, Impacts and Compliance – a performance assessment (qualitative questionnaire) (Total = 32) (continued)

	Merit		Impact		Compliance		
	Scientific Merit	Research Agenda	Innovation	Employment	Alignment	Compliance with objectives	Fields
# 2	3	3	2	2	2	1	Health
# 9	3	3	1	3	3	1	Materials
# 11	2	3	2	3	3	2	ICT
# 18	1	3	2	1	3	2	Blue Economy
# 17	2	2	1	3	2	2	Bioeconomy
# 22	2	2	1	2	2	2	Bioeconomy
# 19	2	1	1	2	2	2	Bioeconomy
# 25	2	1	1	2	2	2	Blue Economy
# 16	2	1	1	3	1	3	Health
# 28	2	1	1	1	1	2	Health
# 12	2	1	2	1	1	2	Social
# 13	1	1	2	2	1	3	Blue Economy
# 31	1	2	1	1	3	1	Energy
# 15	1	1	1	1	2	2	Health
# 26	1	1	2	1	2	1	Health
# 14	1	2	1	1	2	1	Health
# 30	1	1	1	2	2	2	Materials
# 32	1	1	1	2	1	1	Social

Note 1 – Assessment used the following scale: 3 (Excellent or Very Good); 2 (Good or Fair); 1 (Poor). Colors are green for 3; yellow for 2; orange for 1.

Note 2 – Extreme-right column - Light Green Group = High Merit; Light Yellow Group = Mixed Merit; Red Group = Poor Merit.

Discussion

From Table 2, we can infer a significant correlation between "Merit" and "Impact", suggesting that high-level innovative activity requires a top-level research agenda. The consistency and quality of the initial research agenda seem to be the best predictors of the later-revealed innovation capacity.

We can also stress the relevance of the assessment criteria of "Scientific Merit" and "Research Agenda", due to the CoLABs' short life and its consequences on the achievement of innovative outcomes. Likewise, compliance seems also less important as an assessment criterion. A high correlation between Scientific Merit and global quality has appeared. The former seems to be a 1st-order criterion for evaluating overall quality.

Figure 4 and Table 2 show the existence of three clusters:

- a top-level cluster (in green) made primarily of entities from Energy & Sustainability, ICT & Digital, Bioeconomy, Materials & Circularity, but also including Health, and Social & Tourism

- an intermediate-level cluster (in yellow), made of entities from Blue Economy, Materials & Circularity, ICT & Digitalization, and Health

- and a low-level cluster (in red) made mostly of entities from Bioeconomy and Health, but also comprising Blue Economy, Energy & Sustainability, Materials & Circularity, and Social & Tourism.

We also conclude the existence of a strong correlation between "Merit" and "Impact", and some correlation between "Compliance" and any of the other two dimensions. Therefore, the global performance metric enables the identification of three distinct clusters, characterized by well-defined thresholds and associated with clear technological fields.

In summary, we identified a group of high-potential CoLABs and a group of "problematic entities" that neither exhibit Excellence in Science nor Excellence in Technology Transfer, nor create qualified employment. Our suggestion is for further entity-specific analysis and monitoring, especially of those in emergent strategic areas (such as the blue economy).

Figure 4 – Graphical analysis of CoLABs performance

3D Visualization: MERIT, IMPACT, COMPLIANCE vs Overall Result
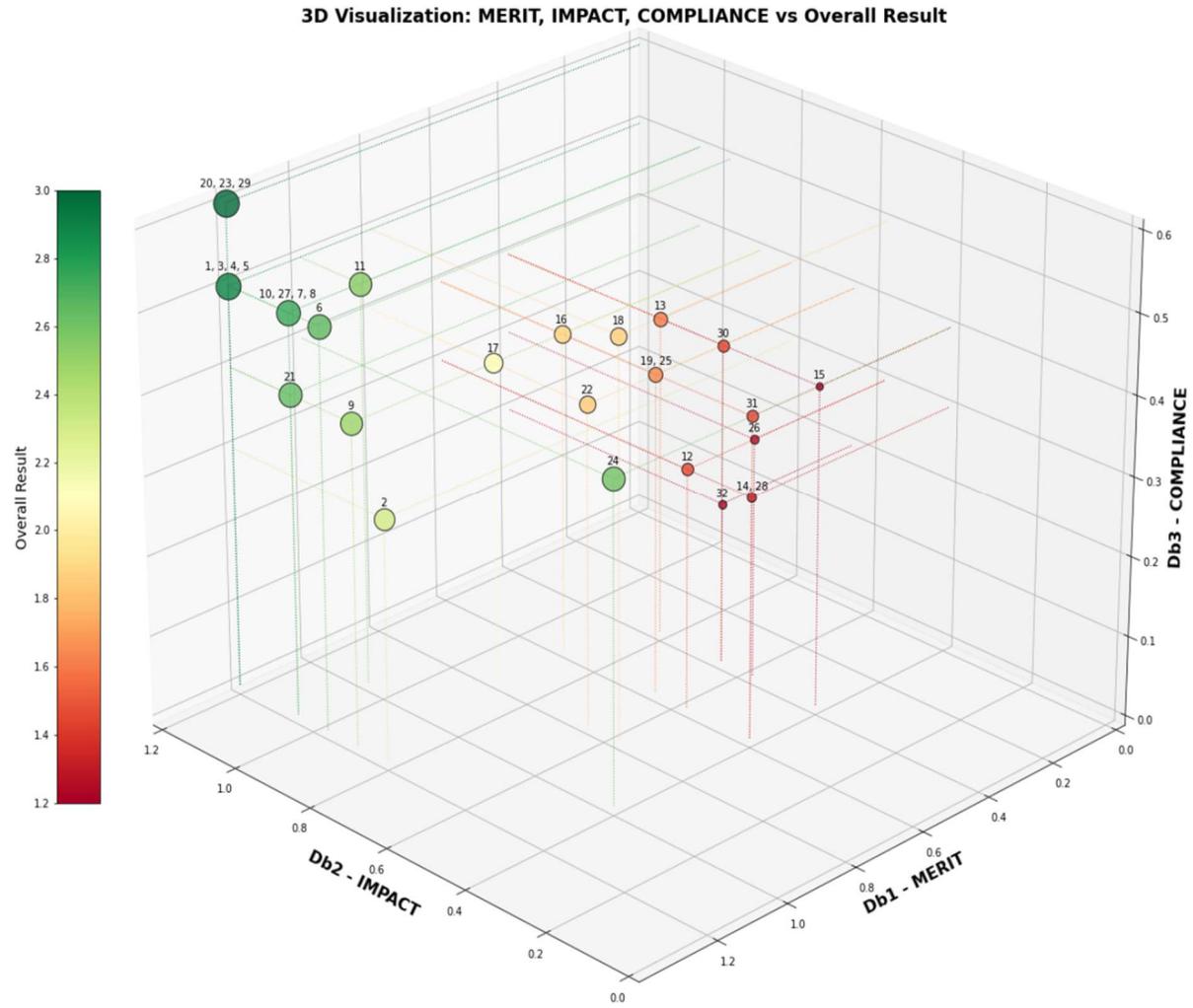
4. Conclusion

We developed a methodology for evaluating the technological system, with a particular focus on interface institutions in Portugal. We tested the methodology for interface entities, CTIs and CoLABs, in Portugal, which represent a substantial part of the Portuguese technological system. The methodology delivers good to very good quality information on the assessed entities.

Our methodology may help research organizations in their strategy planning, as well as funding agencies, in allocating conditionally mission-specific base funding. Furthermore, the model can also help to design funding programs to support mergers of research units, foster collaboration between new and established organizations, and guide policies to strengthen innovation ecosystems.

Regarding the evaluation qualitative methodology we created, three general conclusions can be drawn:

- First, the theoretically grounded methodology for collecting and analyzing qualitative data is effective and yields valuable insights into the Portuguese technological system.

- Second, the results are rich, consistent, relevant, and insightful, revealing unexpected aspects, problems, and outcomes.

- Third, the findings can inform general recommendations regarding the Portuguese technological system, particularly concerning the relevance, effectiveness, structure, and future of public funding.

The proposed qualitative framework provides a replicable approach for assessing technology transfer performance in other national contexts, complementing traditional KPI-based methodologies.

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