

Public Funding, Collaboration and Intellectual Assets in a Moderate Innovator: Evidence From Portugal

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Abstract: Innovation is a central driver of economic competitiveness, which grants science, technology and innovation policies a prominent role. In this respect, Portugal is a paradigmatic case: across successive editions of the European Innovation Scoreboard, it has remained a moderate innovator, below the European Union average, despite sustained public investment, with persistent weaknesses in intellectual assets and in the commercial translation of innovation. Although the literature widely discusses the relationship between public policy and innovation ecosystems at the macro level, firm-level evidence on the mechanisms linking public funding and collaboration to the creation of intellectual assets remains scarce, particularly in peripheral economies dominated by small and medium-sized enterprises. This study addresses that gap by analysing how public funding, collaboration and export orientation relate to the patenting activity of Portuguese firms. An explanatory sequential mixed-methods design is adopted. In the quantitative phase, hypotheses on the association between patent applications and factors of public funding, collaboration and internationalisation are tested using chi-square and t-tests on data from the Community Innovation Survey (CIS 2022), covering 13,802 national firms. In the qualitative phase, two interviews with national experts, analysed through content analysis, interpret and contextualise the observed patterns. The results show that public funding is significantly associated with patenting, but with small effect sizes, whereas collaboration, particularly with universities, displays the strongest association, exceeding inter-firm cooperation; patenting, in turn, is associated with greater export orientation. An asymmetric articulation of the innovation system's helices emerges: a robust academic sphere and a structurally fragile business sphere that does not generate enough demand to convert funding and knowledge into intellectual assets. Reading these results through the triple helix model suggests that, in a moderate innovator, strengthening the articulation between academia and the business fabric is a precondition for the transition towards more complex and sustainable innovation ecosystems. The study contributes to the innovation management literature with firm-level empirical evidence from an under-explored peripheral context, and offers practical implications for innovation policy, underlining that public effort is more effective when directed at science-industry articulation rather than at direct funding alone. It also warns of the limits of indicators such as the European Innovation Scoreboard in assessing economies with Portugal's profile.

Keywords: Innovation Policy, Intellectual Assets, Triple Helix, University-Industry Collaboration, Moderate Innovator, Portugal

1. Introduction

Innovation is today one of the main drivers of economic competitiveness, which is why science, technology and innovation (STI) policies hold a prominent place on the political agenda (Freeman 1987; Edler and Fagerberg 2017). The literature stresses that a country's innovative performance does not stem from the isolated action of firms, but from the interactions among the institutions that make up its National Innovation System (Nelson 1993). Within this framework, the articulation between university, industry and government, formalised in the triple helix (Etzkowitz and Leydesdorff 1998), has been extended to the quadruple and quintuple versions, which incorporate civil society and the natural environment (Carayannis et al. 2012; Cai 2022). The present study situates itself within this line of thought but concentrates its empirical analysis on the three original helices, state, academia and industry, as these are the spheres whose interaction the available data allow to be tested directly.

Despite the consensus on the importance of public policy, the question remains of how public investment translates into innovation outcomes, particularly in peripheral economies dominated by small and medium-sized enterprises. Portugal is a paradigmatic case: across successive editions of the European Innovation Scoreboard (EIS), it has remained a moderate innovator, below the European Union average, even after sustained public investment in STI. Its weaknesses are persistently concentrated in intellectual assets and in the commercial translation of innovation, precisely the dimensions that reflect the capacity to derive economic value from knowledge.

Although the literature discusses the macro-level relationship between public policy and innovation ecosystems, firm-level evidence on the mechanisms linking public funding and collaboration to the generation of intellectual assets in moderate-innovator contexts remains scarce (Zheng and Cai 2022). This is the gap the study seeks to address, drawing on data from Portuguese firms to examine how public funding and collaboration relate to

patenting and export orientation. The article draws on a master's dissertation of broader scope, from which the subset of variables concerning patent-applicant firms is extracted.

The study is guided by two questions: in which of the EIS indicators should Portugal improve its performance, and which firm-level relationships between patenting and the factors of funding, collaboration and internationalisation offer clues for that improvement. The analysis is anchored in the triple helix and in the national innovation systems approach, and employs an explanatory sequential mixed-methods design. Following this introduction, Section 2 presents the theoretical background, Section 3 the methodology, Section 4 the results, Section 5 the discussion and Section 6 the conclusions.

2. Theoretical Background

A country's innovative performance is now understood less as the sum of the isolated efforts of its firms and more as the product of the interactions among a set of public and private institutions, the National Innovation System (NIS). Nelson (1993) defines it as the set of institutions whose interactions determine the innovative performance of national firms, stressing that what distinguishes each country is its institutional arrangements: intellectual property rights, university-industry relations and the role of small firms. Freeman (1987) assigns public policies supporting science, technology and innovation a central role in building national innovative capacity. This perspective is particularly relevant for peripheral economies, where institutional weaknesses constrain the translation of knowledge into economic outcomes (Albuquerque 2007). The Portuguese case illustrates this: a fabric of small and medium-sized enterprises, an intellectual property valuation system poorly suited to the national reality, and an incipient articulation between science and industry constitute the main constraints on national performance (Godinho 2016).

The formalisation of the interaction among actors finds its reference framework in the triple helix model. Etzkowitz and Leydesdorff (1998) describe innovation as an endogenous phenomenon, sustained by the trilateral articulation among university, industry and government. The model has been successively extended: the quadruple helix incorporates civil society and the quintuple adds the natural environment, linking innovation to sustainability (Carayannis et al 2012). Cai (2022) synthesises these variants in the neo-triple helix model, distinguishing a genetic level, corresponding to the university-industry-government relations that generate innovative dynamics, from a systemic level, in which those dynamics interact with social structures and the environment. It is this core, the three original helices, that the present study mobilises, as these are the spheres whose interactions the data allow to be observed; the dimensions of civil society and the environment are taken up in the discussion as research frontiers.

At the level of mechanisms, the literature highlights three pathways. First, public policies structure enduring institutional capacities beyond political cycles (Edler and Fagerberg 2017), although research on their translation into outcomes remains scarce (Zheng and Cai 2022); at firm level, public funding reinforces innovative performance, especially when combined with external knowledge flows (Costa and Moreira 2022). Second, collaboration is an essential channel for knowledge transfer: university-industry cooperation stimulates technological innovation (Perkmann et al 2021) and inter-firm cooperation also contributes, albeit with a smaller effect (Radicic et al 2020). Third, the valuation of knowledge takes the form of formal protection through patents, long associated with export performance and international competitiveness (Fagerberg 1988; Dosi et al 1990) and, in recent firm-level evidence, with the commercial success of innovation (Lambrecht et al 2026). The empirical design in the following section rests on these three mechanisms.

3. Methodology

3.1 Research Design

The research adopts a mixed-methods approach with an explanatory sequential design (Creswell and Plano Clark 2017), justified by the complementarity of the two logics: quantitative methods offer strong external validity and qualitative methods strong internal validity, their combination ensuring a reasonable degree of validity in both (Serapioni 2000). A first phase tests hypotheses on the association between firms' patenting and a set of factors; a second phase deepens the identified patterns with national experts, in order to interpret them.

3.2 Hypotheses

Anchoring the analysis in the triple helix (Etzkowitz and Leydesdorff 1998), the hypotheses are organised into three blocks reflecting a pathway of creation and valuation of intellectual assets, and are framed in terms of association, not causation. Block A, public funding: H1, association between patents and local or regional public funding; H2, between patents and central public funding. Block B, collaboration: H3, between patents and cooperation with universities; H4, between patents and cooperation with other firms. Block C, internationalisation: H5, between patents and export orientation. Hypotheses H3 and H4 are tested separately for national and European Union partners.

3.3 Data and Analysis

The data come from the Community Innovation Survey (CIS 2022, reference period 2020-2022), released as open data by the DGEEC/INE/FCT partnership. The sample comprises 13,802 national firms with ten or more employees, mostly small: 64.6% employ between ten and 49 workers and 82.2% have been active for nine years or more.

The dependent variable records whether the firm applied for a patent during the period. The independent variables correspond to the factors in each hypothesis: in Block A, two dichotomous items on the receipt of local/regional and central public funding; in Block B, the type of cooperation partner, disaggregated by geographic location; in Block C, the percentage of turnover derived from EU/EFTA and non-EU markets. The funding and cooperation items refer to the 2020-2022 period and the export item to 2022.

The analysis was conducted in IBM SPSS Statistics. Given the dichotomous nature of the variables in Blocks A and B, the association was tested using Pearson's chi-square test of independence; in Block C, since export orientation is continuous, an independent-samples t-test was used, which justifies presenting the results in two tables. A significance level of 0.05 was adopted, and effect sizes are reported: Phi and Cramér's V in the association tests and Cohen's d in the t-test, following the conventional benchmarks whereby, for one degree of freedom, V values close to 0.10 denote small effects and 0.30 moderate ones (Cohen 1988). The observational and cross-sectional nature of the data does not allow causal inferences.

3.4 Qualitative Phase

The qualitative phase draws on two structured interviews with national experts experienced in the field of R&D and innovation investment. The interview guide, built from the quantitative results, covered the institutional reorganisation of the system, the diagnosis of national performance and the policy pathways; in line with the study's scope, the analysis privileges the dimensions linked to patenting. The responses were subjected to content analysis (Bardin 2016), with aggregated and anonymised treatment under informed consent.

4. Results

4.1 Quantitative Results

The association tests between patenting and the factors of public funding and collaboration are shown in Table 1 (N = 13,802; one degree of freedom throughout). In Block A, both types of funding show a significant association: the proportion of applicants is higher among firms with local/regional funding (4.4% versus 2.0%) and central funding (4.5% versus 1.8%). However, the effect sizes are very small (Cramér's V = 0.041 and 0.062), indicating limited practical relevance despite statistical significance.

Block B reveals a different pattern. The associations with university cooperation are significant and of greater magnitude (V = 0.194 for national universities and 0.180 for EU ones), representing small to moderate effects. Inter-firm cooperation is also significant, but weaker (V = 0.158 national and 0.151 EU). Two regularities stand out: cooperation with universities is more strongly associated with patenting than inter-firm cooperation, and, in both, national partners slightly exceed European ones, which may reflect institutional proximity.

Table 1: Association tests (chi-square) between patent applications and the factors of public funding and collaboration

Hypothesis	Factor	$\chi^2(1)$	p	Cramér's V	Magnitude
H1	Local/regional public funding	22.934	< 0.001	0.041	Very small
H2	Central public funding	52.585	< 0.001	0.062	Very small
H3a	University cooperation (PT)	519.846	< 0.001	0.194	Small to moderate
H3b	University cooperation (EU)	449.431	< 0.001	0.180	Small to moderate
H4a	Firm cooperation (PT)	342.607	< 0.001	0.158	Small to moderate
H4b	Firm cooperation (EU)	313.741	< 0.001	0.151	Small to moderate

Note: N = 13,802. Source: own elaboration based on CIS 2022.

In Block C, the relationship between patenting and export orientation was examined using the t-test (Table 2). Applicant firms show a greater propensity to export: on average 4% of turnover in EU/EFTA exports versus 1% for non-applicants, and 5% versus 1% in non-EU markets. Both differences are significant, with small but consistent effect sizes (Cohen's d = 0.15).

Table 2: T-tests between patent applications and export orientation

Hypothesis	Market	Mean Turnover (With Patent)	Mean Turnover (Without Patent)	t	p	Cohen's d
H5a	EU/EFTA	4%	1%	9.04	< 0.001	0.15
H5b	Non-EU	5%	1%	10.29	< 0.001	0.15

Note: Source: own elaboration based on CIS 2022.

In sum, public funding is associated with patenting in a significant but tenuous way; collaboration, particularly with universities, shows the strongest association; and patenting is associated, downstream, with greater export orientation.

4.2 Qualitative Results

The two interviews, analysed through content analysis, help interpret these patterns through five themes.

4.2.1 Structural Constraints

The experts attribute the moderate-innovator position to persistent structural problems, linked to a fabric dominated by micro-enterprises with no innovation strategies and oriented towards the domestic market. This frames the very small effects in Block A: funding meets a base with little propensity to convert it into intellectual assets.

4.2.2 Asymmetry of the Helices

An uneven development is emphasised: universities and research centres have attained international excellence, while few firms are competitive and exposed to the pressure that stimulates innovation. This reading interprets the central finding of Block B, the stronger association with university cooperation than with inter-firm cooperation.

4.2.3 *Misalignment of the Patent System*

The adequacy of the patent as an indicator is questioned: much process innovation is not patentable, the fragmented model penalises SMEs, part of multinationals' R&D is registered in their home countries, and software is protected under US law. This calls for caution in reading patents as an absolute measure.

4.2.4 *Public Funding as a Conditioned Lever*

Funding is acknowledged to play a decisive role, though dependent on the capacity to stimulate private investment, historically scarce and risk-averse, with a strong association between the withdrawal of funding and the contraction of business effort during the troika and pandemic periods.

4.2.5 *Focus on Strategic Technologies*

The experts recommend concentrating effort on a limited number of differentiating domains, replacing the logic of sectors with that of technologies, with emphasis on biotechnology, energy, digital technologies, and security and defence.

5. Discussion

The results allow the mechanisms linking public funding, collaboration and the valuation of intellectual assets to the performance of Portuguese firms to be interpreted through the triple helix, following the order of the three blocks.

5.1 Public Funding: Significant but Insufficient

Block A confirms that public funding, local/regional and central, is significantly associated with patenting (H1, H2), but with very small effect sizes. This combination, robust significance and limited practical relevance, is the most informative finding: funding matters, but is not, on its own, a strong determinant of the creation of intellectual assets. The experts' interpretation provides the key: in a fabric dominated by micro-enterprises with no innovation strategies and oriented towards the domestic market, funding meets a business base with little propensity to convert it into patents. The result dialogues with Costa and Moreira (2022), who find a robust effect of funding especially when combined with external knowledge flows, suggesting that it is not funding itself that generates assets, but its articulation with collaboration. The experts further note a strong association between the withdrawal of funding and the contraction of business effort during the troika and pandemic periods, pointing to an asymmetric relationship: if the marginal effect of more funding is contained, its removal produces disproportionate negative effects. Given the cumulative nature of innovation capabilities (Nelson 1993), the stability and predictability of instruments become as relevant as their amount.

5.2 Collaboration and the Asymmetry of the Helices

Block B constitutes the core of the contribution. The associations of patenting with university cooperation (H3) are clearly higher than those with public funding and with inter-firm cooperation (H4), an ordering consistent with Perkmann et al (2021) and Radicic et al (2020). The experts give it systemic meaning: the asymmetry reflects an uneven development of the helices, with an academic sphere that has attained international excellence and a business sphere in which few firms are competitive. Read through the triple helix (Etzkowitz and Leydesdorff 1998), the Portuguese situation constitutes a trilateral articulation operating at half capacity. It is here that the multi-helix evolution acquires meaning: the extension to civil society (quadruple) and the environment (quintuple), proposed by Carayannis et al (2012) and Cai (2022), does not replace the underlying work but presupposes it. In a moderate innovator, the path towards more complex ecosystems runs first through strengthening the business helix and its link to academia.

5.3 Patenting, Internationalisation and the Limits of the Indicator

Block C confirms that patenting is associated, downstream, with greater export orientation (H5), with small but consistent effects, closing the input-asset-outcome pathway. This reading nonetheless requires the caution the experts recommend: the misalignment of the patent system, the non-patentability of much process innovation, the registration by multinationals in their home countries and the penalisation of SMEs by the fragmented model, suggests that the patent underestimates real innovative effort. The observed effects thus probably represent a lower bound of the true relationship. This underestimation reaches the very construction of indicators such as

the European Innovation Scoreboard, which, by anchoring themselves in metrics oriented towards technologically advanced production structures, tend to penalise economies with the Portuguese profile. Acknowledging this does not invalidate the diagnosis, the weaknesses in intellectual assets are real, but it calls for caution in the literal reading of the scores. Taken together, the three blocks converge: Portugal's performance does not stem from the absence of public funding, but from the structural fragility of business demand and its insufficient link to a robust scientific capacity.

6. Conclusions

The study sought to identify the dimensions in which Portugal, as a moderate innovator, shows the greatest weaknesses in the European Innovation Scoreboard, and to examine, at firm level, the relationships that offer clues for overcoming them. The evidence points to intellectual assets and the commercial translation of innovation as the most critical sub-areas. Focusing the analysis on patenting, the results outline a coherent pathway: public funding is associated with the creation of assets in a significant but tenuous way; collaboration, particularly with universities, is the strongest associated factor; and patenting is accompanied, downstream, by greater export orientation. The experts' interpretation situates this picture within a fabric of small and medium-sized enterprises, with structurally weak business demand for innovation that is insufficiently linked to a robust scientific capacity.

Three contributions follow. Theoretically, the study offers firm-level empirical evidence on the operationalisation of triple helix interactions in a moderate innovator, revealing an academic helix that fulfils its role and a business helix that does not generate enough demand to draw out its full potential. In practical terms, public effort will be more effective if directed at science-industry articulation rather than at direct funding alone, requiring stable instruments and a focus on strategic technological domains. Methodologically, the triangulation of large-scale data with expert interpretation strengthens the validity of the inferences.

The study has limitations that open avenues for future research. The data are observational and cross-sectional, precluding causal inferences; the qualitative validation rested on a small number of experts, with an interpretive function; and the unavailability of regionalised CIS data prevented the testing of territorial hypotheses. Extending the framework to the quadruple and quintuple layers of the helix model, incorporating civil society and the environment, would make it possible to examine the extent to which the consolidation of the underlying interactions opens space for more complex and sustainable innovation ecosystems.

Data Availability Statement

The data can be made available by the paper's authors upon request.

Ethics Declaration

This study did not require ethical clearance, as it ensured the anonymity of all participants and obtained their informed consent prior to conducting the interviews.

AI Declaration

In this article, the authors utilised an AI tool to assist with language refinement and grammar checks. The authors reviewed and verified all AI-generated content to ensure its accuracy and integrity and take full responsibility for the final manuscript.

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