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Blazing the trail: Describing and assessing a new policy instrument whereby indirect tax incentives fuel collaborative innovation

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ABSTRACT

Governments incentivize positive externalities from R&D activities via direct (i.e., capital grants) and indirect (i.e., tax incentives for proceeds from operations) subsidies. In this regard, direct subsidies are often presumed to be more explicitly geared toward encouraging collaborative innovation through the formation of consortia. However, the potential of indirect subsidies in this domain remains underexplored in extant studies. Moreover, these mechanisms rely on an unstated assumption: the entities receiving support are the best placed for its use. This article relaxes these assumptions by assessing a unique R&D tax break initiative, called the 64Bis, introduced by the provincial council of Biscay in the Basque Country, Spain. The 64Bis initiative enables an enterprise (Developer) to allocate the proceeds from this mechanism to an external organization (Financier). In exchange, the Financier sponsors the publicly backed R&D project. This article not only describes this policy instrument for the first time but also exploits the quasi-natural experiment conditions to examine between- and within-group heterogeneities. The between-group heterogeneities were analyzed using accounting data and one-to-one propensity score matching in order to construct a synthetic control group. Developers benefiting from this initiative between 2017 and 2021 were found to have acquired more knowledge than comparable enterprises during the same period. The within-group heterogeneities were examined using survey data and fuzzy-set Qualitative Comparative Analysis (fsQCA) to identify optimal configurational pathways that enhance knowledge acquisition via this policy instrument. Altogether, the findings suggest that implementing R&D tax incentives can encourage the formation of collaborative innovation systems, and have significant implications for both academic research and policy development.

1. Introduction

Ken Arrow, economist and Nobel laureate, famously observed that since the private returns from R&D investment were lower than the societal returns from R&D, enterprises spent less on R&D than was societally optimal. He thus presented the first economic rationale for the public subsidy of R&D activity (Arrow, 1972). Today it is widely acknowledged that the majority of developed countries are those which most invest in R&D, with a significant share of investment coming from the private sector (Hall and Van Reenen, 2000; Özçelik and Taymaz, 2008). This outcome suggests that enterprises investing in R&D generate positive externalities for society, stimulating growth and well-being (Akcigit and Kerr, 2018) - a conclusion Arrow would have strongly supported.

On the basis of the above considerations, the following question arises: how can governments incentivize enterprises to invest more heavily in R&D? This has traditionally been achieved by a combination of policies, encompassing 'soft' or locally-oriented policies such as industrial cluster policies (Becattini, 2002; Nishimura and Okamuro, 2011) and more ambitious and costly policies, commonly referred to as 'hard' policies, where enterprises receive direct subsidies (e.g., R&D grants) and/or indirect subsidies (R&D tax incentives) in response to

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increased R&D investment (Busom et al., 2014). However, while direct subsidies are the most common incentives, enterprises are known to use the financial resources these bring to fund projects that would have been financed regardless of the incentives provided, or to replace originally planned R&D investment (Boeing, 2016). Governments are therefore keen to promote tax incentives as they do not require an initial outlay for R&D investment because tax credits are awarded only after the investment has been made. Tax incentives also do not require governments to determine ex ante where R&D subsidies would best be spent. This, in turn, implies that the associated monitoring costs of tax breaks are substantially lower as they follow a market-conforming, rights-based approach, and therefore result in minimal government involvement (Dimos et al., 2022). This is a view supported by previous evidence indicating that tax credits deliver a higher payoff in terms of innovative outcomes when compared with direct subsidies (Møen, 2007).

However, innovation processes have evolved since Arrow's time. Today, the challenge lies in the increasingly collaborative nature of innovation, which, at present, comprehensively relies on a diverse knowledge base (Pintar and Scherngell, 2022), complementary capabilities (Stuart, 2000), open innovation (Chesbrough, 2003) and risk-sharing (Rothaermel and Boeker, 2008). Furthermore, it is widely acknowledged that collaborative innovation models benefit from geographic proximity (Chesbrough and Bogers, 2014; Radziwon and Bogers, 2019). Moreover, multi-collaboration models, where public and private enterprises collaborate to develop an ecosystem based on collaborative relationships, have also been studied extensively (Chesbrough et al., 2018; De Noni et al., 2018).

While collaborative innovation has been incentivized by direct subsidies for consortia rather than individual enterprises (Broekel, 2015), there is scant evidence to date suggesting that collaborative innovation can be incentivized by tax incentives. And there remains the distinct possibility that the entity that is best able to supply an innovation may not be the entity able to directly receive the incentive. What if a mechanism could be constructed to enable an organization eligible to receive an incentive to direct that incentive to another organization instead? This study aims to bridge this gap, where a new initiative, the 64Bis, promoted in the province of Biscay, Basque Country, has been introduced: an innovative fiscal policy enabling enterprises to obtain funding for R&D or technology innovation projects in the form of tax deductions. A quantitative study, adopting a quasi-natural experiment design (Chiappini et al., 2022) with an exploratory-descriptive scope, has been undertaken to provide evidence that collaborative innovation can be fostered by tax incentives. The empirical design combines propensity score matching to account for 'between-' group comparisons, and fuzzy-set Qualitative Comparative Analysis (fsQCA) to account for 'within' group heterogeneities. The analysis presents novel evidence of enterprises benefiting from this innovative fiscal initiative.

Thanks to institutional sponsorship by the provincial council of Biscay, a unique dataset of 44 enterprises benefiting from the 64Bis initiative from 2017 to 2021 was accessed. 40 of these enterprises were approached by means of a specifically designed online survey (self-administered questionnaire). The SABI (Iberian Balance Sheet Analysis System) database, a service provided by Bureau Van Dijk (BVD), was also used to access accounting and financial data from the enterprises, which was then compared with similar enterprises in other regions and/or recipients of direct subsidies. This approach enabled policy additionality to be accounted for in relation to the increase in intangible assets such as patents, licenses and/or industrial designs.

Three significant results emerged from this study. First, it confirms that collaborative innovation can be encouraged by a fiscal tool such as the 64Bis tax incentive; an innovative industrial policy initiative that has not thus far been reported in the literature. The introduction of this initiative opens a whole new avenue of possibilities oriented toward the proper allocation and optimization of fiscal resources in order to maximize the positive externalities generated by inter-enterprise innovation collaboration (Chesbrough, 2003; Roper et al., 2013). Second, the study proves that enterprises benefiting from the 64Bis tax incentive increase their relative levels of intangible assets, thereby enhancing their potential for future innovation. This favorable result is of great importance as it confirms the positive impact of such a fiscal policy and validates its efficacy at improving the collaborative innovation outcomes of enterprises. Third, it documents the existence of configurational arrangements to improve knowledge acquisition in enterprises collaborating in the 64Bis initiative. The results imply the existence of optimal pathways for collaboration strategies, in terms of institution type (public/private), recurrence and business network associations, so as to increase knowledge in cooperative innovation projects (Wan et al., 2022).

This study makes several contributions to the literature. First, by introducing and analyzing a novel tax break initiative, it illustrates the importance of indirect tax incentives in fostering collaborative innovation and stimulating knowledge acquisition. In this vein, it is argued here that the 64Bis initiative can serve as a benchmark mechanism for designing other fiscal policies seeking to allocate public R&D funds more efficiently, while offering an alternative to traditional direct subsidies (Crespi et al., 2016). Second, to our knowledge, this is the first paper that assesses the effect of the 64Bis initiative and its impact on critical aspects relating to sustainable collaborative business innovation, such as intangible capital and knowledge acquisition. Third, a broad analysis is presented that disentangles the configurational arrangements required to optimize and favor knowledge acquisition in collaborative innovation endeavors favored by the 64Bis initiative. However, above all, the results obtained give clues to a tax instrument that is capable not only of fostering and incentivizing collaboration between innovation-oriented enterprises, but also of feasibly signaling the emergence of a breeding ground or primordial soup wherein a collaborative innovation ecosystem (Aversa et al., 2022) can evolve.

The section below provides the background literature. It focuses on what is known in terms of fiscal policy as an incentive for R&D investment, and on the increasing relevance of collaborative innovation systems. Section 3 introduces the quasi-natural experiment represented by the 64Bis initiative, and Section 4 makes use of this context to put forward a series of hypotheses and research questions. Sections 5 and 6 outline the methodology and present the results. The conclusions, along with several policy recommendations, draw the study to a close.

2. Background literature

2.1. Direct and indirect R&D subsidies

Research on supply-side innovation policy has evolved over time in order to tackle the predominant challenges faced by innovation policy at various junctures. While significant strides have been made in conceptualizing models and strategies to promote innovation, recent years have seen a dramatic shift in the innovation policy landscape. The changes observed reflect the increasing demand for collaborative innovation,[1] and call for a more complex set of public incentives to be introduced for enterprises (Schot and Steinmueller, 2018).

One significant category of supply-side policy deployed to encourage innovation is fiscal policy (i.e., government spending and taxation). These policies are termed "hard" owing to their substantial reliance on public resources. The seminal work by David et al. (2000) provides a valuable conceptual framework for analyzing the microeconomic

[1] This surge in interest arises due to several factors. By including the growing specialization of scientific knowledge and integration of diverse knowledge bases, such as robotics incorporating biotechnology (Pintar and Scherngell, 2022), the complexity of innovation makes it impossible for enterprises to internalize all the required capabilities (Stuart, 2000). Also, alliances mitigate the risks associated with radical technologies, and offer a flexible and cost-effective response to escalating R&D expenses (Rothaermel and Boeker, 2008).

ramifications of R&D fiscal policies, and their impact on the macroeconomic behavior of enterprises in relation to R&D investment. In a simplified microeconomic model that treats R&D investment akin to asset acquisition decisions, it becomes apparent that fiscal incentives mitigate the marginal costs associated with R&D projects, thus incentivizing enterprises to broaden their R&D investments. Nonetheless, the macroeconomic consequences of such policies are likely to be influenced by market imperfections and externalities that mold the behavior of enterprises with regard to R&D investment (Montmartin and Herrera, 2015).

Whilst fiscal incentives aimed at promoting R&D activities can yield advantageous outcomes for enterprises such as enhanced learning and skills development, which bolster their efficiency at executing R&D initiatives, the potential drawbacks warrant consideration. Such drawbacks include the provision of financial support for R&D projects that would have been undertaken regardless, or fail to contribute to a genuine increase in R&D expenditure, can present challenges (Boeing, 2016). This underscores the possibility of policy instruments which serve as partial substitutes for private R&D funding (Sterlacchini and Venturini, 2019). Moreover, such measures may engender distortions between subsidized and unsubsidized enterprises and industries, which could influence the macroeconomic implications of such policies (Montmartin and Massard, 2015). A third concern relates to the impact of support on R&D input prices, particularly those characterized by low short and medium-term elasticity. It is anticipated that substantial R&D policies may prompt an upsurge in demand for R&D inputs, notably labor, which would lead to higher R&D costs and lower profitability from R&D investments (Arqué-Castells and Mohnen, 2015).

In addition to considering potential positive and negative externalities, fiscal policy aimed at innovation encompasses two main approaches (Song and Wen, 2023). First, there is direct subsidy policy, which involves financial assistance directly provided by the government to specific businesses or entities engaged in R&D activities. These subsidies are typically allocated to back specific projects or initiatives aimed at fostering innovation and technological advancement in the economy. Note, though, that the government must know ex ante which businesses to support. Second, there is indirect tax incentive policy for enterprises investing in R&D. This involves government measures aimed at encouraging businesses to invest in R&D activities by awarding tax benefits or credits. Such incentives usually lessen the tax burden on enterprises engaged in R&D, either in the form of tax deductions on R&D expenses or by awarding tax credits that directly reduce the amount of tax due. These incentives also demand much less knowledge ex ante from the government on which businesses to fund. In this way, the 64bis mechanism has similarities to an innovation voucher (Kleine et al., 2022).

Besides individual externalities, understanding the potential interplay between direct and indirect subsidies is pivotal in order to comprehend the macroeconomic ramifications of innovation policies. Disparities in design and timing between these forms of support can engender complementarity effects because they target different enterprises or projects via differing incentive mechanisms. Complementarity is substantiated by Busom et al. (2014), who argue that specific business characteristics dictate preferences for each instrument. While the notion of complementarity holds merit, the prospect of substitutability also warrants consideration. Administrative overheads and grant allocation bias toward top R&D performers may result in larger enterprises primarily benefiting from both forms of support. Lokshin and Mohnen (2013) argue that tax credits prove more effective at stimulating R&D investment in Small and Medium Enterprises (SMEs) compared with larger corporations. This brings about the possibility that R&D policies could act as substitutes, and thus increase crowding out effects. Even where different enterprises take advantage of these forms of support, an increase in indirect support could supplant incentives to seek public capital grants, which may potentially undermine the policy's quality and efficacy.

From the perspective of public agencies, indirect subsidies in the form of tax incentives have a significant advantage in that there is no need to advance the investment cost; the enterprises make the investments to undertake the projects, who only reap the benefits, when they have managed to make taxable proceeds (Becker, 2015; Crespi et al., 2016). Hence, enterprises failing to generate profitability cannot claim tax credits. Moreover, tax refunds enable corporate evolution to be better assessed by public agencies because tax credits are required. However, direct subsidies gain a significant advantage over indirect subsidies as they enable the formation of consortia, which encourages the construction and development of R&D partnerships (Busom and Fernández-Ribas, 2008) and broader collaborative innovation systems (see Broekel, 2015 or Szücs, 2018). Indirect incentives fail to provide the above due to their inherent nature; that is, all enterprises generate different profit levels, and there can also be significant disparities in tax regimes (e.g., different tax rates in different countries or regions; or according to company size). This study aims at proposing a solution that enables indirect subsidies—specifically tax incentives—to expedite the formation of consortia and, consequently, collaborative innovation systems.

2.2. *Collaborative innovation systems*

In the R&D context, enterprises clearly cannot rely solely on in-house endeavors for several reasons (Alexy et al., 2013). Not all basic innovation projects lead to practical commercial applications, which highlights the inherent risk in exclusively pursuing in-house R&D initiatives (Schuhmacher et al., 2018). Moreover, technologies often transcend industrial boundaries, meaning that innovations developed for one sector may be found to have unexpected uses in others, a concept known as 'cross-fertilized innovations' (Björkdahl, 2009; Malerba, 2002). Furthermore, given the intense competition in the global market, it is crucial for enterprises to acknowledge that other private entities worldwide also invest in R&D, and may potentially introduce disruptive technologies that could reshape entire industries (Malerba and Orsenigo, 1997). Enterprises must therefore actively monitor and adapt to emerging technology trends. Finally, a distinction exists between different research orientations (Tijssen, 2018). Publicly funded research conducted by universities or public research-oriented organizations is not always directly translatable into commercial products (Rasmussen, 2008). In contrast, private and/or hybrid (industry-public entities) engagements focus on commercial viability, so they can leverage this exploratory research in the form of licensing agreements should the technology prove to be commercially viable (Plantec et al., 2023; Vanino et al., 2019).

In response to the recognition that valuable ideas and resources extend beyond the confines of individual organizations, the open innovation paradigm emerged. Coined by Chesbrough (2003), this concept challenges the traditional, closed innovation model, which is predominantly reliant on internal research and development. Instead, open innovation advocates collaboration with external partners such as customers, suppliers and even competitors, so as to tap into a broader pool of ideas and expertise (Nambisan et al., 2019). This paradigm not only emphasizes the importance of leveraging external knowledge (outside-in innovation) but also highlights the need for enterprises to share their knowledge with external actors (inside-out innovation), thereby extending the enterprise's boundaries to foster mutual learning and cocreation (Enkel et al., 2009).

Collaborative innovation systems thus refer to interconnected networks of enterprises that collaborate in open innovation so as to drive innovation forward (Adner, 2017; Jacobides et al., 2018). These systems facilitate the pooling of resources and expertise from different-sized enterprises, enabling them to collectively develop solutions that meet customer needs (Chesbrough et al., 2014). Scholars have studied these systems extensively, and highlight the critical role of trust, cooperation and commitment among participant enterprises, as well as the positive outcomes arising from collaboration (Fasnacht, 2018; Williamson and De Meyer, 2012). By sharing resources and knowledge, enterprises in these systems enhance their capacity to innovate, and are more willing to take on ambitious projects as the risks can be shared by the different stakeholders (Villena et al., 2019; Zhong et al., 2017). Hence, transparency in these collaborative innovation systems is essential in order to maintain trust, and promote ongoing collaboration (Chesbrough et al., 2018). In a culture of openness and mutual support, enterprises in collaborative innovation systems are able to achieve sustainable competitive advantages, and drive continuous innovation in their respective industries (Adner and Kapoor, 2010; Alam et al., 2022).

2.3. Are indirect tax incentives and collaborative innovation systems compatible?

From the analysis conducted in the above sections, three pivotal insights emerge. First, it is increasingly apparent that the landscape of innovation endeavors rarely sees the involvement of one single entity; rather, such ventures call for a multi-stakeholder approach that draws on diverse inputs and expertise (Alexy et al., 2013). Cultivating collaborative innovation should not therefore merely be seen as advantageous, but rather as imperative for enterprises striving to maintain their competitive edge in an ever-evolving marketplace (Adner, 2017; Chesbrough et al., 2014; Jacobides et al., 2015).

Second, existing illustrative examples of how innovation systems, such as R&D consortia involving multiple partners, can be publicly supported consistently emphasize the use of direct subsidies (Broekel, 2015; Szücs, 2018). The transformative impact of public R&D programs on business cooperation strategies, as noted by Busom and Fernández-Ribas (2008), facilitates collaboration and mitigates barriers to information exchange and learning.

Third, as noted above, direct subsidies often result in funding for large organizations, putting SMEs at a disadvantage when accessing such support. Yet, in many countries, SMEs employ the majority of the workforce, so their ability to secure innovation funding is essential for the overall health of the economy (Blanes and Busom, 2004; Broekel and Boschma, 2012; Chiappini et al., 2022). This highlights the potential importance of indirect mechanisms to address this imbalance.

These insights highlight a potential tension: while collaboration is increasingly essential for innovation, the policy tools most effective at encouraging it (i.e., direct subsidies) are not always accessible or equitable, especially for SMEs. In contrast, more scalable tools like tax incentives may not be well suited to fostering collaborative systems. The case discussed in the following section aims to bridge this gap by means of a pioneering industrial policy initiative, offering a unique opportunity to explore these dynamics within a quasi-natural experiment framework.

3. Study context: the 64Bis case in Biscay

Fiscal policy in the autonomous community of the Basque Country operates at provincial level as it is dependent on individual provinces (Magro and Wilson, 2013).[2] In this community, the province of Biscay has implemented a unique mechanism, known as the 64Bis,[3] which facilitates the transfer of tax incentives associated with R&D activities from enterprises engaged in such activities to those providing financial support. This innovative approach has established a secondary market for tax credits related to innovation, and has effectively channeled private resources toward funding R&D endeavors. Although this initiative was conceptualized and approved in 2013, its implementation commenced in 2017. Biscay thus serves as a useful context to examine how indirect tax incentives can bolster collaborative innovation and, as such, warrants consideration as a quasi-natural experiment.

The abovementioned provincial policy aims to address a crucial challenge associated with tax credits. Traditional tax credit schemes assume that enterprises make profits and pay taxes. However, this assumption fails to accommodate situations where enterprises seeking to invest in R&D may not make substantial proceeds, or may even operate at a loss, for a certain period of time. In order to tackle this initial problem, the 64Bis initiative provides a practical solution by enabling the transfer of tax credits to other eligible enterprises in the province. Essentially, enterprises that make substantial profits may qualify for tax credits (Financier) originating from enterprises that invest in R&D but lack the financial capacity to make significant taxable profits (Developer). This mechanism ensures greater tax credit utilization in the province, fostering local collaborative innovation networks. Notably, it enables Developers to retain intellectual property rights over the advancements achieved.

A remarkable feature of this measure is that it is not merely conceived as a means of injecting liquidity into innovative enterprises to offset indirect tax incentives for R&D investment. This measure also includes elements that encourage closer relationships between enterprises investing in R&D and receiving fiscal support (Developer) and sponsoring enterprises to whom the tax credits are transferred (Financier). The presence of this secondary market for innovation tax credits allows organizations with innovative ideas to pursue them, even where the required financial resources are lacking for their development without fiscal support. This policy also enables organizations with resources to deploy these in innovation outside the organization, as well as supporting their own internal innovation activities. This aspect is significant because it seeks to promote collaborative innovation activities.

To fully understand this rationale, the implementation of this provincial law needs to be explained in greater detail. The implementation of fiscal laws governing R&D and technology innovation involves the assessment of qualification reports by BEAZ, a public agency for the provincial council of Biscay[4] BEAZ assesses the reports to determine the amount eligible for tax credits. By way of example, if an enterprise invests 100,000 euros in R&D, only the portion directly linked to innovation, for instance 50,000 euros, qualifies for tax credit.

To ensure that the process goes smoothly, enterprises must submit the '*Qualification Report*' application before the project starts or within the first three months of execution. This gives BEAZ sufficient time to assess the project qualification status comprehensively. Interestingly, rather than separate reports for each tax return, a single overall report covers the entire project duration, streamlining the report process and enhancing efficiency. Once issued, the report includes the project qualification status and approved budgeted amount allocated to R&D and technology innovation activities. This information is vital for enterprises in order to plan and allocate resources appropriately. It is essential for enterprises to understand the assessment process conducted by BEAZ, and how the eligible tax credit amount is determined, in order to navigate the qualification process effectively and maximize the benefits offered by the tax incentives.

The application must detail the aforementioned information in order to transfer the tax credit to another enterprise. It must include one or more sponsoring enterprises -Financier(s)- who are to cover part or all of the project costs. It must also clarify whether the relationship with the

[2] The province of Biscay has its own tax legislation and tax authority, with two main caveats: overall tax proceeds from the economy should be equivalent to that from the rest of Spain; and a fixed rate must be contributed to Spanish budgetary expenses in a number of non-devolved powers. Biscay is the largest province in the autonomous community of the Basque Country, both in population and GDP.

[3] Further information regarding the provincial policy on tax incentives for enterprises (64Bis) available at https://www.investinbiscay.com/en/bizkaia-tax-breaks.

[4] Additional information can be found at the following website: https://een.ec.europa.eu/local-contact-points/es/beaz-sau.

sponsoring enterprise is a one-off arrangement, which may not be favorable in terms of the project's eligibility for tax credits, or whether it will lead to future collaborations. It is worth mentioning that these collaborations can be collaborative innovation developments or license agreements, or through other types of business-to-business relationships such as commercial agreements. Finally, it is important to note that the sponsoring enterprise is incentivized as 120 % of the approved tax credit in R&D expenditure can be deducted.

Table 1 provides an overview of the various agents involved, their respective roles, and the direct and desired outcomes associated with their participation in this tax incentive program. Furthermore, it is worth highlighting that the 64Bis initiative exhibits certain heterogeneities depending on the applications received. For instance, some Developers approach BEAZ directly alongside their Financiers, while others identify Financiers via consultants or through BEAZ itself (which provides access to a vast business network). Another heterogeneity lies in the number of Financiers involved, with some applications featuring a single Financier and others multiple Financiers. Finally, although there are no restrictions on benefiting from the initiative over consecutive years, many enterprises only benefit intermittently. Such heterogeneities merit a comprehensive analysis of the nuances associated with the initiative's functioning.

Table 1
Agents involved in the tax credit secondary market and their expected outcomes.

	Developer	Financier	Provincial government
Background/ role	The enterprise has an innovation project and seeks tax incentives. May not make proceeds, so cannot directly benefit from tax incentives.	A large corporation with headquarters in the province, and strong financial position, normally sponsors innovation through a third-party enterprise in order to obtain tax benefits.	The provincial council of Biscay assesses applications for tax credits via the entrepreneurship and innovation agency BEAZ. Projects must include details on how the Developer and Financier will interact throughout the course of the project. If the project assessment by BEAZ is positive, applications are subject to final approval by the tax authority.
Direct outcome	The Developer can undertake the R&D project or test a technology innovation without the need to raise financial backing. If the project is approved, the Financier incurs the costs. The Developer keeps the intellectual property rights.	If the project is approved, the Financier makes the investment and is awarded a tax credit equivalent to 120 % of the investment. This creates a guaranteed surplus.	Ensures that the incentives are appropriate and fair. All enterprises seeking to invest in innovation can benefit from tax credits, regardless of their financial position or profit levels.
Desired indirect outcome	By collaborating with the Financier, the enterprise may be able to broaden its knowledge base.	By collaborating with a number of Developers, the enterprise may be able to establish and facilitate a local collaborative innovation system. Also offers the opportunity to scan innovative projects in strategic industries throughout the province.	This policy may attract enterprises from elsewhere to set up in Biscay, which could lead to the formation of start-up clusters and innovative enterprises in the region.

4. Development of testable hypotheses and research questions

Having established the theoretical framework, and specified the unique context of analysis, a number of testable relationships can be developed. To this end, the target variable is the capacity of Developers to gain in know-how, that is, knowledge acquisition. The focus is on four main areas, namely: (i) Policy additionality, referring to the initiative's capability to enable beneficiaries to enhance their knowledge acquisition capacity compared with non-beneficiaries; (ii) Existing network, assessing the value of having prior relationships with Financiers; (iii) Project scope, examining the extent to which enterprises benefit from having multiple Financiers or from applying for this initiative multiple times; and (iv) Strategies for building collaborative systems, exploring the configurational approaches that lead to greater knowledge acquisition. While the first area requires comparison between 64Bis and non-64Bis enterprises, the remaining areas explore the heterogeneities found in 64Bis beneficiaries.

4.1. Policy additionality

Developers should be prepared to experience enhanced knowledge acquisition in the years following their engagement with the 64Bis policy initiative. The scheme is expected to stimulate knowledge generation by enabling firms to undertake R&D projects that might not have materialized without public support (Arqué-Castells and Mohnen, 2015; Boeing, 2016; Howell, 2017). Participation in the policy typically coincides with the launch of new R&D investments, which are likely to increase the value of internally developed patents and industrial designs. These investments not only foster essential internal knowledge creation but also allow firms to evaluate the potential applications of that knowledge (Rosenberg, 1990). Furthermore, internal R&D capabilities enhance a firm's ability to absorb and apply external knowledge, supporting its integration into organizational processes (Artz et al., 2010).

64Bis enterprises can also leverage a newly-established formal network, and so benefit from licenses obtained by some of their partners, such as Financiers (Markman et al., 2008). Furthermore, recognition by the provincial government grants 64Bis enterprises access to public institutions, and serves as a form of signal or certification (Chiappini et al., 2022; Howell, 2017). Such recognition may ease access to fundamental knowledge developed by universities (Lam, 2007), or to international knowledge due to increased participation in industrial conferences (Maskell et al., 2006).

These factors collectively suggest that 64Bis enterprises may have greater capacity to increase their intangible assets in the years immediately following their participation in the initiative, which therefore supports the hypothesis put forward.

Hypothesis 1. 64Bis Developers experience greater knowledge acquisition in the years following their involvement in the policy initiative compared with their non-participant counterparts.

4.2. Existing network

The discussion surrounding 64Bis enterprises reveals two distinct pathways for engaging with Financiers: via their existing network, which may include clients, suppliers, competitors, associations or personal links; or via external contacts, which may include external consultants and the governing body itself (i.e., BEAZ). Each approach is now examined to find the most effective in fostering knowledge generation and acquisition.

Engaging in knowledge-sharing activities such as co-innovation, mentoring or establishing collaborative R&D/commercial collaborations requires a high degree of trust (Chen et al., 2014; Renzl, 2008). Partnering with existing network contacts, where trust, mutual recognition and a psychological contract have been nurtured over time, therefore differs significantly from embarking on a project with Financiers sourced by third parties (Parkhe, 1993; Pisano, 1990). In the first scenario, partnering with existing network contacts improves the cooperative environment and information flow, enhancing long-term, collaborative innovation relationship payoffs (Brockman et al., 2018). This results in an increase in knowledge-sharing among the collaborating enterprises and decrease in the risk involved in the innovation process (Xie et al., 2023), building trust in the existing network over repeated iterations (Wan et al., 2022). Moreover, partnering with existing network contacts reduces, if not eradicates, search costs as it attracts the most suitable partners and mitigates opportunistic behaviors caused by unsuitable partner selection—thus promoting collaborative innovation performance (Bierly and Gallagher, 2007).

In innovation-focused knowledge networks, the choice of partners suggests the possible existence of the proximity paradox, which posits that while enterprises may benefit more from expanding their networks, they often gravitate toward acquainted partners due to ease of connection and tie stability (Broekel and Boschma, 2012; Soda et al., 2021). In the context of the 64Bis initiative, this paradox takes on unique dimensions. The dual role of the Financier as a knowledge-sharing partner and economic sponsor skews the incentives. For external partners, the financial incentive is dominant due to the policy's substantial guaranteed returns (e.g., 20 % annual return via a 120 % tax deduction), which potentially undermines their focus on the policy's knowledge-sharing objectives (Henkel, 2006; Ritala et al., 2015). In contrast, pre-existing partners are more likely to align equally with both the financial and knowledge-sharing policy goals.

Taken together, these insights suggest that existing network ties are more conducive to realizing the knowledge acquisition aims of the 64Bis policy. This leads to the following research question:

> Research Question 1. Is having at least one 64Bis Financier within the Developer's pre-existing network a sufficient condition for knowledge acquisition?

4.3. Project scope

Aligning the demand for and supply of financial resources for projects is both costly and time consuming. Developers and Financiers alike invest significant resources in identifying suitable partners. This raises the question of whether involving multiple Financiers (Cipollone and Giordani, 2019) or exploiting recurring applications with the same Financier (Blanes and Busom, 2004) is necessary for effective project development. More specifically, to what extent is the initiative's efficacy contingent on its scope? There are differing arguments about whether, in the specific context of the 64Bis initiative, project scope should lead to higher levels of knowledge acquisition.

In relation to recurring applications, Developers experienced in applying for R&D financial support are predisposed to sustaining their engagement in these activities because previous involvement enhances their capability to diversify their R&D project portfolio, and reduces substantial initial costs (Blanes and Busom, 2004). In this regard, Feldman et al. (2022) examined the role of enterprises that repeatedly received government R&D awards (referred to as “mills”), challenging the perception that they fail to advance innovation and, instead, highlights their contributions to the broader innovation system through patenting, market product introduction, spinoffs and government procurement. Hence, the following research question is posed:

> Research Question 2a. Is the submission of multiple applications a sufficient condition for firm-level knowledge acquisition?

Regarding the involvement of multiple Financiers in an application, it can be argued that, in general, an enterprise stands to benefit from engaging more partners as it increases opportunities for knowledge exchange (Cipollone and Giordani, 2019). Empirical evidence supports this perspective, particularly when the number of partners remains within reasonable limits (Hottenrott and Lopes-Bento, 2016). For instance, Mishra et al. (2015) identify an inverse U-shaped relationship between the number of partners and the success of technological alliances. This finding aligns with the typical structure of the 64Bis program, where the number of Financiers rarely exceeds five. Building on this rationale, the following research question is put forward:

> Research Question 2b. Does the presence of multiple financiers serve as a sufficient condition for firm-level knowledge acquisition?

The answer to these research questions is not straightforward, and alternative explanations may exist (Crespi et al., 2016). Single applications may be sufficient to achieve the 64Bis collaborative aims by providing the “spark” needed for knowledge transfer between Financier and Developer (Aversa et al., 2022). Similarly, partnerships with a single Financier could minimize coordination costs, yielding comparable benefits (Vivona et al., 2023; Wu et al., 2024). These perspectives highlight the need for a nuanced assessment of the varying configurations.

4.4. Accommodating collaborative systems for heterogeneous projects

The 64Bis initiative is designed to provide the flexibility needed to support a diverse range of innovation projects, encompassing various stages and orientations. On the basis of Stokes' (2011) framework, which categorizes research according to its quest for fundamental understanding and practical application, three distinct configurational approaches emerge in this policy. We adopt a flexible interpretation of this framework, recognizing that in firm-led R&D contexts, research orientation often falls along a continuum and is best understood in relative terms.[5]

The first configuration is Publicly-Driven Basic Research, which aligns with pure basic research. Projects in this category focus on advancing fundamental understanding with no immediate practical application (Pavitt, 1991). In the 64Bis framework, publicly-driven basic research provides enterprises with credibility by means of public support, which serves as a quality signal that grants access to the broader public innovation system, including universities, research centers and non-research institutions (Heinze and Kuhlmann, 2008).

The second configuration is Privately-Driven Applied Research, which emphasizes practical applications with direct market relevance. Enterprises pursuing this pathway leverage broad private networks, including Financiers, to orchestrate collaborative endeavors aimed at achieving applicable outcomes (Ritala et al., 2023). This approach is inherently market-driven and focuses on innovation commercialization, reflecting a strong alignment with industry needs (Vanino et al., 2019).

Finally, the third configuration is Use-Inspired Basic Research, which combines fundamental understanding with practical application.

[5] While the Stokes framework was originally developed in relation to public research and academic science, we adopt a loose interpretation that fits our empirical setting, which consists of R&D projects led by private firms. Rather than aiming for strict categorical distinctions, we use the model to highlight relative differences in project orientation—some initiatives in our sample are more exploratory and knowledge-driven, while others are clearly market-led. This continuum-based view allows us to distinguish among configurations without assuming a rigid separation between basic and applied research. Moreover, unlike innovation typologies such as STI/DUI, which are designed for broader innovation modes, the Stokes framework focuses specifically on the nature of R&D activities, making it more appropriate for our analysis.

Projects in this domain are characterized by iterative experimentation and testing, often requiring multiple applications and partnerships with non-research-focused entities in order to perform market testing (Anckaert et al., 2020). The 64Bis initiative supports these endeavors by fostering collaboration that unites basic and applied research, enabling both knowledge expansion and practical utility.

The 64Bis initiative's flexibility allows enterprises to align their collaborative systems with their specific innovation needs, and to select a configurational approach that best matches their strategic priorities. Publicly-driven basic research emphasizes fundamental knowledge creation and credibility, privately-driven applied research targets market-driven solutions, and use-inspired basic research seeks to balance theoretical advancement with practical application.

These configurations are not mutually exclusive. Rather, they represent complementary orientations within a broader collaborative system. For example, publicly-driven basic research prioritizes fundamental knowledge creation and public-good outcomes; privately-driven applied research focuses on immediate commercial benefits; and use-inspired basic research operates at the intersection, addressing societal challenges whilst retaining application-driven goals.

By accommodating this diversity of research configurations, the 64Bis initiative fosters a balanced innovation ecosystem where enterprises can pursue projects tailored to their objectives, regardless of their market proximity, or reliance on fundamental versus applied knowledge. This policy design reduces trade-offs, creates a supportive framework for heterogeneous innovation types, and enhances knowledge acquisition across various contexts. Based on the above, the following hypothesis is proposed.

Hypothesis 2. Knowledge acquisition is achieved through specific causal configurations composed of (a) Publicly-Driven Basic Research, (b) Privately-Driven Applied Research, and (c) Use-Inspired Basic Research approaches to collaborative innovation.

5. Empirical strategies

5.1. Accessing exclusive information on benefiting enterprises

Thanks to an official collaboration agreement between BEAZ and the university employing two of this paper's authors, exclusive access was gained to a list of 44 enterprises (representing the total population of enterprises) that have benefited from the 64Bis initiative as Developers between 2017 and 2021. Financial and accounting information was retrieved, using the abovementioned list, from the SABI financial database; a BVD service for Spanish enterprises. Primary information was also gathered by means of a questionnaire completed by 40 of the above enterprises.[6] A high response rate was obtained due to institutional support from the provincial council of Biscay, which provided support by securing the participation of the enterprises. Table 2 provides an overview showing the characteristics of benefiting Developer enterprises.

The first two sections in Table 2 show considerable heterogeneity among Developers in terms of industry and size. Enterprises are classified into ten different NAICS codes, however, for the sake of simplicity, can be divided into three groups: Manufacturing (NAICS 31, 32, 33), accounting for 41 % of the total; Retail Trade and Wholesale Trade (NAICS 42, 44), representing 4.5 %; and Professional and Technical Services (NAICS 51, 53, 54, 56, 62), comprising 54.5 %. Moreover, there is significant representation of micro-enterprises[7] (approximately 23 % of enterprises have fewer than 10 employees) and large/very large enterprises (approximately 13 % of enterprises have >250 employees). However, overall, most of the enterprises can be considered SMEs, with approximately 64 % employing between 10 and 249 workers. Another interesting factor regarding heterogeneity is market scope. While 27.5 % do not operate outside the Spanish market, 42.5 % operate outside the European Union.

Other aspects requiring attention include the timing and motivations behind applications submitted by enterprises for this tax incentive. The

Table 2
Descriptive information on Developers.

Industry - NAICS[a]	# observations	%	# employees[a]	# observations	%
31	1	2.27 %	1–9	10	22.72 %
32	2	4.55 %	10–19	5	11.36 %
33	15	34.09 %	20–29	2	4.55 %
42	1	2.27 %	30–49	2	4.55 %
44	1	2.27 %	50–99	4	9.09 %
51	2	4.55 %	100–149	2	4.55 %
53	2	4.55 %	150–199	12	27.27 %
54	18	40.91 %	200–249	1	2.27 %
56	1	2.27 %	250–999	4	9.09 %
62	1	2.27 %	+1000	2	4.55 %

Fiscal incentive[c]	# observations	%	Collaborative innovation[c]	# observations	%
Strongly disagree	1	2.50 %	Strongly disagree	10	25.00 %
Disagree	2	5.00 %	Disagree	7	17.50 %
Neutral	4	10.00 %	Neutral	6	15.00 %
Agree	4	10.00 %	Agree	9	22.50 %
Strongly agree	29	72.50 %	Strongly agree	8	20.00 %

Financier knowledge[c]	# observations	%	Year of application[b]	# observations	%
Strongly disagree	13	32.50 %	2017	3	4.69 %
Disagree	2	5.00 %	2018	7	10.93 %
Neutral	3	7.50 %	2019	9	14.06 %
Agree	12	30.00 %	2020	18	28.12 %
Strongly agree	10	25.00 %	2021	27	42.19 %

Know-how	# observations	%	Market scope	# observations	%
Decreased	2	5.00 %	National	11	27.50 %
Unchanged	17	42.50 %	European Union	12	30.00 %
Increased	21	52.50 %	Global	17	42.50 %

[a] SABI database. Other variables were obtained from the survey.
[b] The unit of analysis for this variable is application; not enterprise.
[c] Likert scales. Refer to each reason's importance for involvement in the 64Bis project.

[6] Further details on the acquisition of this data, including how and when it was obtained, will be provided at a later date.

[7] The OECD business size classification, determined by number of employees, was used to classify enterprises. Further information available at https://data.oecd.org/entrepreneur/enterprises-by-business-size.htm.

initiative's popularity is clearly on the rise, with only 3 applications approved in 2017, increasing to 7 in 2018, 9 in 2019, 18 in 2020 and 27 in 2021. Furthermore, the primary motivation for most enterprises applying for this initiative is the tax reduction (82.5 % strongly agree or agree with this statement), while other considerations such as participation in a collaborative innovation system (42.5 % strongly agree or agree) and accessing knowledge/expertise from the Financier (55 % strongly agree or agree) are also significant.

Drawing on this information, a quasi-natural experiment was constructed. Despite the initiative's novelty and ability to construct counterfactuals, the need remained for an artificially generated control group, making a natural experiment impracticable (Meyer, 1995). Two separate strategies were considered. First, a counterfactual analysis enabling assessment of what would have happened in other regions in Spain had the same initiative been implemented, which then allows a comparison to be made of knowledge acquisition capacity between 64Bis enterprises and comparable enterprises in other regions. Second, the aim of grasping an understanding of in-group heterogeneities; that is, by analyzing optimal configurations, the characteristics of enterprises reaping the most benefit from the initiative in terms of knowledge acquisition were examined. Both empirical strategies are described below, the first addresses Hypothesis 1 and the second, the remaining research questions (1, 2a and 2b) and Hypothesis 2.

5.2. Does 64Bis lead to an increase in knowledge acquisition across the enterprise?

A counterfactual analysis was conducted to assess whether 64Bis leads to an increase in knowledge acquisition across the enterprise. In other words, the hypothetical scenario was explored in terms of what would have happened to enterprises in other provinces, benefiting from other public initiatives, had they been awarded the 64Bis.

As described earlier, the SABI database provides information on industries in which treated enterprises operate using NAICS codes, and on their size distribution. Based on this preliminary stratification, enterprises can be identified in other regions of Spain that share similar characteristics in terms of industry and size. Different regions have been included, which also entail different nuances. In particular, the identification of statistically comparable enterprises operating in three different provinces was carried out: Madrid (selected as the Capital province), Barcelona (as the Leading province) and Seville (as the Lagging province), using 1:1 propensity score matching.

The same method used by Quintana-García and Benavides-Velasco (2005), and Ortín-Ángel and Vendrell-Herrero (2014) was employed to construct a comparison group of enterprises that have benefited from R&D subsidies. To do so, a sample of enterprises listed in the Industrial Technology Development Center (CDTI) 2017 catalog was used, an agency belonging to the Spanish Ministry of Industry, Tourism and Commerce which promotes innovation and technology development in Spanish enterprises. These enterprises have undertaken R&D projects that are partly or fully subsidized by the CDTI and are primarily selected on the basis of their business viability. Adding these firms to our comparison group is essential because CDTI support is not intended for collaborative innovation. Therefore, if a difference is observed between the CDTI and 64Bis groups, it will likely be attributed to the collaborative innovation aspect, rather than the core R&D subsidy effect shared by both initiatives. One-to-one (1:1) matching is a method used in observational studies to create synthetic comparison groups by pairing each participant in the treatment group with a similar participant in the control group according to key characteristics. This ensures that the groups are balanced in terms of potential confounders, making the treatment effect estimation more reliable. This pairing creates a counterfactual scenario for each untreated participant whose outcome is compared with what would have happened, had they received the treatment. Essentially, the treated participant serves as a counterfactual for the untreated matched participant, and provides insight into what would have happened, had the treatment been made available to the untreated participant. Another design advantage is that the treated participants can be compared with a wider control sample that includes all the untreated matched enterprises from the three comparison groups, which can effectively be defined as a 4:1 matching -see Vendrell-Herrero et al. (2022) for a similar strategy. The results obtained are presented starting with the sample with the most expected differences in knowledge accumulation, and continuing to the sample with the least expected. The results are therefore presented in the following order: Lagging province (Seville), Leading province (Barcelona), Capital province (Madrid) and subsidized enterprises (CDTI). Given that each group contains different nuances, the result obtained by aggregating all the control group enterprises (4:1) was expected to be the most reliable in order to understand the policy's capacity for additionality. Particular attention was therefore paid to this specification.

In terms of timing, both the matching and independent variable should be measured at the beginning of the period (2017), while the dependent variable should be a change occurring throughout the period analyzed (2017–2021).[8] The dependent variable is the increase in knowledge acquisition. Knowledge acquisition is thus measured by calculating the percentage of intangible assets over total assets; *the intangible ratio*. This measurement has been used in previous studies as a proxy for knowledge acquisition (e.g., Arrighetti et al., 2014). It specifically assesses the relative significance of intangible assets such as patents, trademarks, licenses and other valuable knowledge in relation to an enterprise's total assets.[9]

5.3. What factors contribute to increased knowledge acquisition in 64Bis enterprises?

The second set of arguments aims to reveal the configurations underlying knowledge acquisition in the group of benefiting enterprises. To do so, a questionnaire was developed containing pertinent information on the heterogeneities in the application processes, which is crucial for testing research questions 1, 2a and 2b and Hypothesis 2. The questionnaire also captured data on changes in knowledge acquisition in terms of patents, licenses and/or industrial designs before and after benefiting from the initiative. The objective variable, representing this change, can take three values: −1 if the enterprise transitioned from knowledge capture to non-capture after receiving the tax incentive; 1 if movement was positive; and 0 if no change occurred. This variable should aim to measure the same as the change in intangibles, but via primary data. The variable's distribution is reported in Table 2.

Enterprises were contacted using the web-based survey tool Qualtrics, employing procedures supported by the existing literature (Bäker and Goodall, 2020). A self-administered questionnaire was used for data collection, given its cost-effectiveness and ability to capture relevant behavior (Sauermann and Roach, 2013). Prior to questionnaire distribution, a pilot test of the survey was conducted by an expert panel of two academics, two innovation and technology managers, and a policymaker in order to ensure its validity, reliability and ease of understanding (Holtom et al., 2022). The results obtained were used to make

[8] While some enterprises in the control sample received a subsidy in 2017 (CDTI), other enterprises in the treatment sample received the tax incentive later. This bias made it more likely that no significant effect would be found since the CDTI enterprises received prior assistance, and had more time to change the objective variable. It is therefore understood that if all the enterprises had had the same amount of time to achieve intangible growth, the result would be even stronger, and not the opposite.

[9] Note that this variable relates to Tobin's Q, a widely accepted outcome variable. The main difference lies in the numerator. In Tobin's Q, the numerator represents an enterprise's market value, which is only applicable to listed enterprises. For unlisted enterprises, such as those in the sample, the value of intangible assets can serve as a proxy for the enterprise's growth potential, which provides crucial information to estimate the enterprise's market value.

modifications to the questionnaire in order to obtain the final survey instrument. The questionnaire, written in Spanish, underwent a dual translation process to ensure consistency with the original version. In all cases, a professional translation service was used. Email was used to distribute the questionnaire, with periodic reminders sent over a 12-week data collection period from October 2023 to January 2024. Throughout the course of this period, a 91 % response rate was achieved (40 full responses), facilitated, as stated above, by institutional support for this study. The questionnaire was answered by the Chief Executive Officer (CEO), Chief Innovation Officer (CINO), Chief Technology Officer (CTO), Chief Operations Officer (COO) or founders/owners in senior managerial positions.

Research Questions 1, 2a and 2b and Hypothesis 2, fuzzy-set Qualitative Comparative Analysis (fsQCA) was used. This technique works particularly well with small samples and is efficient at identifying optimal configurations as it accommodates complex causal relationships, enabling simultaneous analysis of multiple conditions. Furthermore, it can reveal combinations of conditions that lead to a desired outcome, offering insights into the most effective configurations. Hence, a non-parametric methodological approach, fsQCA, was used to assess optimal configurations.

This technique employs Boolean algebra to apply comparison principles by examining configurations of conditions linked to an outcome (Rihoux and Ragin, 2008). This methodology was chosen because the net effect - parametric effect – was not under analysis, but rather the collective impact of a set of conditions leading to knowledge acquisition. Furthermore, this approach helps to understand equifinality, where different combinations of variables yield the same outcome (Vendrell-Herrero et al., 2021). It also facilitates the study of interactions, and mitigates cases of over-determination between highly correlated variables (Pappas and Woodside, 2021). Moreover, the fsQCA technique incorporates counterfactuals that essentially provide three solutions: a) intermediate, where counterfactuals are justified by researchers - the recommended approach (Ragin, 2009); b) parsimonious, where counterfactuals are processed by software, such as Ragin's fs/QCA software, as in this case; and c) complex solutions where counterfactuals are not considered. Thus, counterfactual analysis assesses the hypothetical outcome of a substantively relevant combination of causal conditions that do not exist empirically (Ragin, 2009). Indicators for assessing configurations include consistency, which measures agreement in outcome display between cases with the same conditions, and coverage, which assesses the extent to which a causal combination explains instances of an outcome, indicating empirical relevance (Xie and Wang, 2020). Finally, fsQCA is highly recommended for testing configurations where theoretical explanatory variables are presented together (in this case, collaborative innovation knowledge sources) at specific levels in both conditions and outcomes (presence/absence). Overall, this technique offers a holistic approach that analyzes configurations in terms of their complexity and uniqueness by considering the conditions that must be present as necessary, and those that independently produce an outcome as sufficient (Rihoux and Ragin, 2008).

6. Results

6.1. Study 1: intangible assets grow more in 64Bis enterprises than in non-64Bis enterprises

As outlined in the methodology section, this analysis began by constructing a synthetic comparison sample from other regions and CDTI-subsidized enterprises in order to establish a counterfactual. 8057; 37,632; 42,321 and 1254 untreated enterprises were potentially available for matching in the Lagging, Leading and Capital provinces, and subsidized enterprises, respectively.[10] In total, financial and accounting information was obtained on all 89,264 enterprises.[11]

Propensity scores were estimated by logistic regression, with membership of the treated group (64Bis) as the dependent variable. Independent variables included industry dummies and lagged values for enterprise age, labor productivity, intangible ratio and number of employees. Graphic comparison of the density plots for the propensity scores for treated and untreated enterprises is shown at the top of Fig. 1. This analysis reveals considerable differences, which are statistically significant according to the Kolmogorov-Smirnov (KS) test prior to matching.

Subsequently, 1:1 matching without replacement was conducted using a 0.01 caliper. This analysis produced positive outcomes, with matches found for nearly all treated enterprises. Specifically, 42 treated enterprises were matched from Madrid and Barcelona, along with 40 from Seville and 23 from subsidized enterprises. This results in the 4:1 analysis being performed on 42 treated versus 147 untreated enterprises. The density plot for the matched enterprises at the bottom of Fig. 1 shows practically negligible differences, with the KS test indicating that post-matching distributions are not statistically significant.

A reduction bias analysis is provided in Table 3 for greater transparency, where the differences between treated and untreated enterprises before and after matching are given for the variables used in matching. The results reveal a 72 % average reduction bias and, significantly, there is a decrease in bias for all variables. Taken together, the reduced reduction bias and equal density distributions of propensity scores made us confident that the synthetic control group was suitable for a counterfactual analysis.

Following the creation of matched samples, a series of linear regressions was performed with the change in *intangible assets* as the dependent variable, and participation in the 64Bis initiative as the key independent variable. Control variables were incorporated. Total assets and age were not lagged, given that this analysis refers to 2021. Meanwhile, intangible assets were lagged to account for their individual growth effect, i.e., establishing their initial state value against future growth. The results detailed in Table 4 reveal that comparable enterprises in Lagging, Leading and Capital provinces would have respectively increased their intangible assets by 0.179 ($p < 0.05$), 0.170 ($p < 0.05$) and 0.143 ($p < 0.1$) percentage points, had they participated in the policy. While the effect for subsidized enterprises (CDTI) is not statistically significant, the estimated parameter remains comparable at 0.154. The lower increase in intangible assets observed in other subsidized enterprises further supports our argument that knowledge transfer in collaborative innovation is the primary factor driving 64Bis firms to accumulate more intangible assets than their counterparts. Notably, when all control enterprises are included (4:1 ratio), the parameter is both significant and robust, with an estimated effect of 0.154 ($p < 0.01$).

Furthermore, for additional robustness, the average treatment effect (ATE) was also estimated, with the results showing qualitative consistency with the linear regression results (see bottom of Table 4). Use of counterfactual logic for the all the sample enterprises in the control group would have increased their relative value of intangible assets by 12.2 percentage points per year, had they benefited from the 64Bis initiative.

ATE analysis is also interesting from a descriptive perspective. The parameter baseline gives the average of the dependent variable for the

[10] So as to avoid redundant cases, CDTI-subsidized enterprises were excluded from the provincial data, where applicable.

[11] The sample size was substantial, and as is common with secondary data, a small proportion of missing values was present—<5 % in our case. To address this, we followed the recommendations of Ma et al. (2023). Assuming that the missing data were missing completely at random (MCAR), we applied a machine learning-based K-nearest neighbours (KNN) imputation method to estimate the missing values.

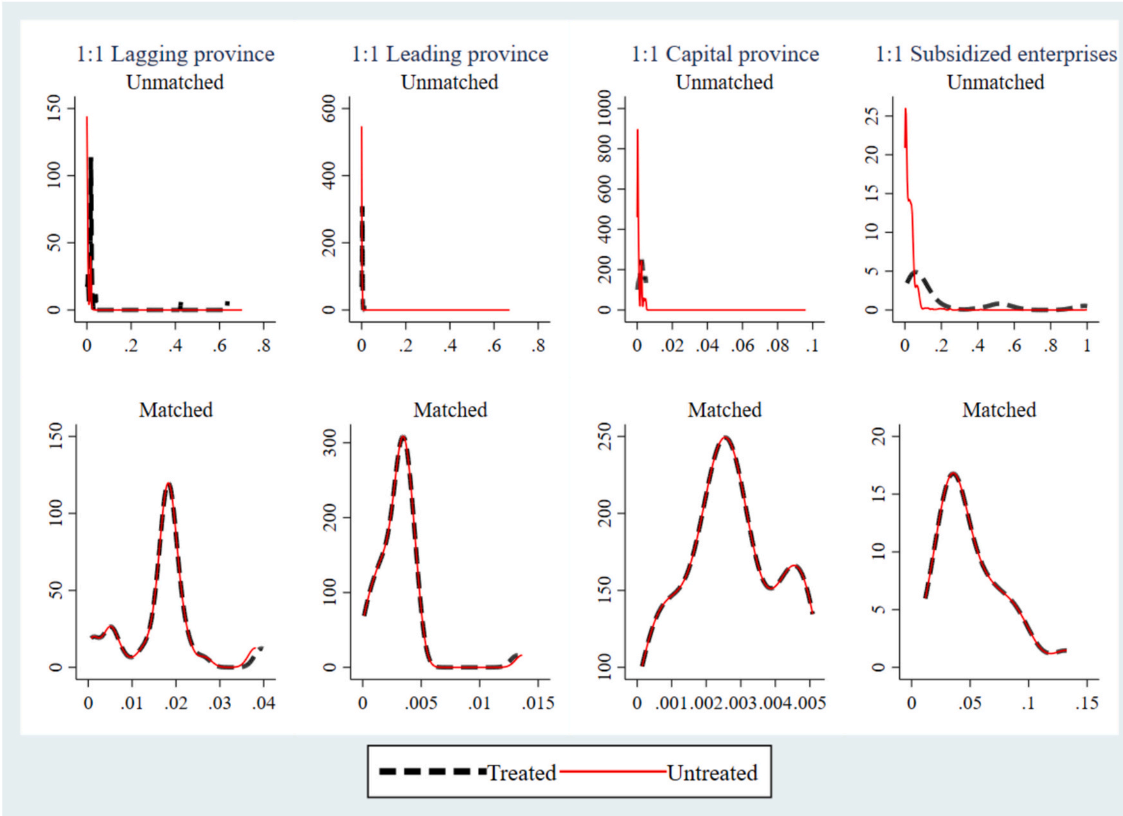

Fig. 1. Propensity score: matched vs unmatched sample.
Notes: In the study, Seville represents the Lagging province, Barcelona the Leading province and Madrid the Capital province. Subsidized enterprises were awarded R&D subsidies by the CDTI in 2017. The dataset includes 42,321 untreated enterprises from the Capital province, 35,632 from the Leading province, 8057 from the Lagging province, and 1252 untreated subsidized enterprises. Nearest neighbor 1:1 matching without replacement, using industry dummies, enterprise age (t-1), labor productivity (t-1), intangible ratio (t-1) and number of employees (t-1), results in 42 untreated enterprises from the Capital province, 40 from the Lagging province and 23 subsidized enterprises under analysis.
The Kolmogorov-Smirnov (KS) test results before and after matching are summarized as follows: 64Bis vs. the Lagging province: Before matching, the combined KS was 0.574 ($p < 0.01$), decreasing to 0.050 ($p > 0.1$) after matching. 64Bis vs. the Leading province: Before matching, the combined KS was 0.508 ($p < 0.01$), increasing slightly to 0.024 ($p > 0.1$) after matching. 64Bis vs. the Capital province: Before matching, the combined KS was 0.507 ($p < 0.01$), decreasing to 0.023 ($p > 0.1$) after matching. 64Bis vs. Subsidized enterprises: Before matching, the combined KS was 0.586 ($p < 0.01$), decreasing to 0.043 ($p > 0.1$) after matching.

Table 3
Reduction bias analysis.

	All enterprises			Matched enterprises			Reduction bias
	Treated	Untreated	Diff.	Treated	Untreated	Diff.	%
Observations	44	89,262	–	42	147	–	–
Intangible capital (t − 1)	0.230	0.320	0.090	0.240	0.250	0.010	89 %
Labor productivity (t − 1)	60.900	48.400	12.5	61.200	62.300	1.100	91 %
Employees (t − 1)	122.400	78.300	44.1	119.27	108.78	10.49	76 %
Age (t − 1)	16.886	19.279	2.393	17.452	18.245	0.793	67 %
NAICS-31	0.022	0.070	0.048	0.024	0.020	0.004	92 %
NAICS-32	0.045	0.084	0.039	0.048	0.020	0.028	28 %
NAICS-33	0.341	0.128	0.213	0.357	0.313	0.044	79 %
NAICS-42	0.022	0.155	0.133	0.024	0.034	0.010	92 %
NAICS-44	0.022	0.086	0.064	0.024	0.020	0.004	94 %
NAICS-51	0.045	0.075	0.03	0.048	0.068	0.02	33 %
NAICS-53	0.045	0.039	0.006	0.048	0.054	0.006	0 %
NAICS-54	0.409	0.153	0.256	0.405	0.456	0.051	80 %
NAICS-56	0.022	0.104	0.082	0.024	0.014	0.01	88 %
NAICS-62	0.022	0.106	0.084	0.000	0.000	0.000	100 %
Average bias							**72 %**

Notes: (t − 1) refers to data measured in 2017.

Table 4
Regression and treatment effects on matched samples.

	Lagging province	Leading province	Capital province	Subsidized enterprises	Main analysis
	1:1	1:1	1:1	1:1	4:1
Treatment group (64Bis)	0.1789**	0.1699**	0.1428*	0.1542	0.1544***
	(0.0794)	(0.0780)	(0.0833)	(0.1109)	(0.0508)
	0.0275	*0.0329*	*0.0908*	*0.1734*	*0.0027*
Total assets	−14.7623***	−11.2962	−80.6018**	−86.2275	−14.6562**
	(4.2444)	(12.2350)	(37.2121)	(51.9299)	(7.0634)
	0.0009	*0.3590*	*0.0337*	*0.1058*	*0.0394*
Age	0.0145***	0.0106***	0.0095***	0.0094	0.0078***
	(0.0053)	(0.0038)	(0.0033)	(0.0059)	(0.0018)
	0.0086	*0.0066*	*0.0050*	*0.1200*	*0.0000*
Intangible ratio (t − 1)	−0.0016***	−0.0013***	−0.0013***	−0.0101*	−0.0017***
	(0.0003)	(0.0003)	(0.0003)	(0.0053)	(0.0002)
	0.0000	*0.0000*	*0.0000*	*0.0630*	*0.0000*
Constant	−1.1577***	−0.5405***	−0.4660***	−0.1044	−0.5380***
	(0.3907)	(0.1848)	(0.1711)	(0.1044)	(0.1695)
	0.0042	*0.0046*	*0.0081*	*0.3244*	*0.0018*
Baseline	−0.0745	−0.046	0.055*	0.111***	0.012
	0.254	0.402	*0.069*	*0.000*	*0.651*
ATE	0.131	0.161*	0.118	0.167	0.122**
	0.155	*0.063*	*0.103*	*0.103*	*0.038*
Observations	80	84	84	46	189
R-squared	0.514	0.285	0.260	0.221	0.362
Industry dummies	Yes	Yes	Yes	Yes	Yes

Notes: Dep variable is average annual growth rate in intangible ratio (2017–2021). Robust standard errors in parentheses. P-values in *italics*. The 'baseline' is the dependent variable's mean value for the control group, while ATE represents the average difference in outcomes between a treatment group and the control group.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

control group. This parameter was only marginally significant for Madrid and subsidized enterprises, suggesting that intangible assets grew moderately in this group of enterprises, but not in Barcelona or Seville.

An additional interpretation of the ATE findings involved analyzing the entire sample (4:1), which revealed that treated enterprises experience a 0.134 percentage point average annual growth rate in relative intangibles, compared with 0.012 percentage points for untreated enterprises. Consider one untreated and one treated enterprise, both with identical percentages of intangible assets accounting for one quarter of total assets in 2017 (a fair assumption considering the descriptive data in Table 3). By 2021, according to estimates, the treated enterprise sees its intangibles rise to 41.3 % of its assets, while the untreated enterprise sees its intangibles decrease to 26.2 % of its assets. This highlights a significant 15 % difference in the relative value of intangible assets for two enterprises starting at the same level. This underscores a notable increase in the value of patents, licenses and designs in the balance sheet in a period of just four years, which is attributable to treatment.

Collectively, the findings from Study 1 are consistent with the concept of policy additionality with regard to knowledge acquisition, and thus offer robust support for Hypothesis 1 and highlight significant differences between groups. The section below focuses on in-group disparities.

6.2. *Study 2: gaining know-how with networked financiers and collaborative systems*

Study 2 seeks to reveal optimal configurations for extracting more 'know-how' in terms of licenses, patents and industrial designs. The causal conditions consist of ordinal categorical-scale variables (e.g., crisp sets) and respond to Research Questions 1, 2a and 2b and Hypothesis 2.

Three conditions are dependent on the application: *BISInte*, reflecting the number of times an enterprise has applied for the 64Bis (1 to 5); *BISAlli*, denoting the number of Financiers across all applications (1 to 5); and *BISNetw*, which determines whether the Financier formed part of the enterprise's network ($v = 1$) or not ($v = 0$). There are also four variables indicating changes in the information source (Laursen and Salter, 2006): *INCMark* for market sources, *INCInst* for public research-based institutions such as universities, *INCOthe* for public non-research-based institutions and *INCSpec* for conferences and scientific publications. As previously discussed, the outcome variable *KNOAcq* takes three values: a decrease ($v = -1$), no change ($v = 0$) or an increase ($v = 1$) in know-how. The following equation illustrates the various combinations of causal conditions used to identify the necessary conditions for the outcome's occurrence:

$$KNOAcq = f(BISInte, BISAlli, BISNetw, INCMark, INCInst, INCOthe, INCSpec) \quad \text{(i)}$$

KNOAcq is calibrated on a 0-to-1 scale, where membership values reflect clear qualitative thresholds for increased knowledge acquisition. The crossover point, set at 0.5, represents cases where it makes sense to view enterprises as equally likely to belong to the set as not (e.g., enterprises reporting no change in knowledge acquisition). Full membership (1) corresponds to unambiguous improvement, while non-membership (0) indicates a decline in acquisition or its complete absence. To ascertain whether any of the seven conditions were necessary for knowledge acquisition, specific conditions were tested to see whether they consistently appeared as part of configurations leading to the outcome. This analysis reflects the configurational nature of QCA, where the presence or absence of conditions is assessed within the context of their interplay with other conditions. The results, as shown in Table 5, revealed that none of the conditions are trivial as their coverage scores are clearly different from 0. However, the consistency levels for each condition fell below the recommended 0.9 threshold (Ragin, 2009), suggesting that no single condition could independently account for the outcome. This underscores the configurational nature of fsQCA, where combinations of conditions must be considered in order to understand the conditions leading to knowledge acquisition. Thus, further analysis of conditional configurations and their interplay is required.

Causal combinations of conditions are evaluated according to their consistency score. Having qualitatively assessed the configurations in

Table 5
Necessity of conditions relative to knowledge acquisition occurrence.

Condition	*KNOAcq*		*~KNOAcq*	
	Consistency	Coverage	Consistency	Coverage
BISInte	0.168	0.728	0.238	0.368
~BISInte	0.854	0.759	0.824	0.261
BISAlli	0.195	0.538	0.252	0.410
~BISAlli	0.814	0.774	0.771	0.533
BISNetw	0.661	0.867	0.709	0.378
~BISNetw	0.339	0.715	0.291	0.318
INCMark	0.627	0.712	0.714	0.288
~INCMark	0.373	0.586	0.286	0.214
INCInst	0.407	0.632	0.667	0.368
~INCInst	0.593	0.833	0.333	0.167
INCOthe	0.492	0.659	0.714	0.341
~INCOthe	0.508	0.833	0.286	0.167
INCSpec	0.472	0.639	0.725	0.343
~INCSpec	0.528	0.831	0.275	0.165

Table 6
Complex, intermediate and parsimonious solutions results.

Outcome: Knowledge acquisition			
Model: $KNOAcq = f\,(BISInte, BISAlli, BISNetw, INCMark, INCInst, INCOthe, INCSpec)$			
Configurations	Unique coverage	Raw coverage	Consistency
Complex solution			
*~BISInte * BISNetw * INCInst * INCOthe * INCSpec*	0.344	0.438	0.986
*BISAlli * BISNetw*	0.267	0.364	0.934
*BISInte * BISNetw * ~INCMark * INCOthe*	0.200	0.300	0.912
Overall			
*KNOAcq = (~BISInte * BISNetw * INCInst * INCOthe * INCSpec) + (BISNetw * BISAlli) + (BISInte * BISNetw * ~INCMark * INCOthe)*		0.762	0.967
Intermediate solution			
*~BISInte * BISNetw * INCInst * INCOthe * INCSpec*	0.344	0.438	0.986
*BISAlli * BISNetw*	0.143	0.205	0.934
Overall			
*~BISInte * BISNetw * INCInst * INCOthe * INCSpec + BISAlli * BISNetw*		0.463	0.961
Parsimonious solution			
Overall			
BISNetw		0.643	0.643

Table 6 to establish an appropriate consistency threshold -usually above 0.800 (Rihoux and Ragin, 2008)-, a combination's score exceeding a 0.909 threshold is considered sufficient to cause the outcome. In this case, the outcome is assigned a value of 1 in the truth table (see Table A1). Conversely, combinations with a score below or equal to the threshold are deemed insufficient and receive an outcome value of 0. The results for the complex, intermediate and parsimonious solutions after applying these thresholds are presented in Table 6.

The complex solution reveals three distinct configurations leading to knowledge acquisition, exhibiting 0.762 coverage and 0.967 consistency. This detailed solution provides granular insights into the causal pathways contributing to knowledge acquisition- These include "*Publicly-Driven Basic Research*" enterprises, characterized by non-recurring applications (*~BISInte*), a network Financier (*BISNetw*) and public sources (*INCInst*, *INCOthe* and *INCSpec*); "*Privately-Driven Applied Research*" enterprises, which emphasizes the importance of network Financiers and multiple Financiers (*BISNetw * BISAlli*); and finally, "*Use-Inspired Basic Research*" enterprises, which highlight the relevance of multiple applications (*BISInte*) combined with the targeting of public non-research sources (*INCOthe*). The intermediate solution simplifies these configurations while retaining a strong theoretical foundation. By consolidating overlapping pathways, it focuses on two essential configurations: *Publicly-Driven Basic Research* and *Privately-Driven Applied Research*. This intermediate solution exhibits robust explanatory power, with 0.463 coverage and 0.961 consistency. Finally, the parsimonious solution provides the most streamlined explanation for knowledge acquisition, highlighting that the presence of a network Financier (*BISNetw*) is a core condition that accounts for the majority of cases.

To test our proposed research questions and hypothesis, we focus on the complex solution to capture the empirical diversity, and on the intermediate solution—commonly used for interpretation due to its balance between theoretical and empirical considerations (Schneider and Wagemann, 2012). These are presented in Table 7, where three causal configurations are identified. Research Question 1 seeks to analyze whether the presence of at least one Financier from the Developer's pre-existing network (*BISNetw*) constitutes a sufficient condition for knowledge acquisition. *BISNetw* consistently emerges as a condition in all configurations, and is the only variable included in the parsimonious solution. While *BISNetw* is not classified as a necessary condition across these configurations, its consistent role as a core condition indicates that its presence facilitates knowledge acquisition; nonetheless, it is not indispensable in all instances.

Research question 2a seeks to analyze whether the submission of multiple applications (*BISInte*) constitutes a sufficient condition for knowledge acquisition. The results present mixed evidence. Specifically, the absence of multiple applications (i.e., a single application) is a relevant supporting condition in Configuration 1, the variable is neutral

Table 7
Complex, Intermediate and Parsimonious solutions in fsQCA.

Outcome: Knowledge acquisition			
Complex solution			
Condition	Configuration 1	Configuration 2	Configuration 3
	Publicly-driven basic research	Privately-driven applied research	Use-inspired basic research
BISInte	⊗		●
BISAlli		●	
BISNetw	●	●	●
INCMark			⊗
INCInst	●		
INCOthe	●		●
INCSpec	●		

Outcome: Knowledge acquisition		
Intermediate solution		
Condition	Configuration 1	Configuration 2
	Publicly-driven basic research	Privately-driven applied research
BISInte	⊗	
BISAlli		●
BISNetw	●	●
INCMark		
INCInst	●	
INCOthe	●	
INCSpec	●	

Outcome: Knowledge acquisition	
Parsimonious solution	
Condition	Configuration 1
BISNetw	●

Notes: ● = presence of a condition (relevant in this configuration); ⊗ = absence of a condition (relevant in this configuration); blank space = "don't care" condition (i.e., presence or absence of the condition does not affect the outcome).

(i.e., neither present nor absent) in Configuration 2, and the presence of multiple applications is a supporting condition in Configuration 3. These inconsistencies suggest that the breadth of applications does not systematically lead to enhanced knowledge acquisition. The mixed results regarding the effect of multiple applications imply that, in practice, both arguments may coexist. Depending on the project's nature, a single application may contribute to knowledge acquisition when engaging with the public research-oriented sector as it can act as a catalyst, creating the "spark" for a collaborative system (Aversa et al., 2022). Conversely, persistence by means of multiple applications may lay out the conditions for gradual knowledge acquisition (Feldman et al., 2022).

Research question 2b posits that having multiple Financiers (*BISAlli*) constitutes a sufficient condition for knowledge acquisition. The findings reveal that this variable is part of a sufficient condition in Configuration 2, whereas it plays a neutral role in Configurations 1 and 3. Overall, these results suggest that the involvement of multiple partners may be neutral or positively associated with knowledge acquisition; however, it does not consistently emerge as a sufficient condition. The indifferent results in Configurations 1 and 3 may be attributed to the significance of coordination costs (Vivona et al., 2023; Wu et al., 2024), particularly in cases where partners from the public sector integrate into the collaborative system.

Hypothesis 2 posits that there are three distinct configurations linked to the innovation models proposed by Stokes (2011), reflecting a policy framework that facilitates the development of basic, use-inspired and applied research. The findings strongly and unequivocally support Hypothesis 4 as the complex solution[12] reveals three distinct configurational pathways for fostering collaborative systems.[13]

The first configuration, labeled *Publicly-Driven Basic Research*, is primarily driven by public sources of collaborative innovation such as universities, research centers, public institutions and conferences, while excluding market-based collaborative sources such as suppliers, clients, competitors, consultants and private R&D enterprises.

The second configuration, *Privately-Driven Applied Research*, emphasizes the role of private partners, such as Financiers in the 64Bis context. It shows that enterprises engaged in applied research benefit from a larger number of collaborative partners, which facilitates the acquisition of knowledge and capabilities required for market-oriented innovation.

The third configuration, referred to as *Use-Inspired Basic Research*, relies on multiple applications and public non-research-based institutions, reflecting a more experimental approach. This pathway leverages repeated interactions with the policy framework so as to foster ongoing user engagement and iterative innovation processes.

7. Conclusions

7.1. Key findings and research insights

Proper allocation of fiscal resources to promote private R&D investment is globally significant, given the societal benefits of innovation (Akcigit and Kerr, 2018; Arrow, 1972; Roper et al., 2013). Increasing demand for collaborative innovation stems from the growing specialization of scientific knowledge, which must be integrated into increasingly complex and diverse knowledge bases (Pintar and Scherngell, 2022; Stuart, 2000). Given the open nature of current innovation activities, which emphasize mutual learning, policies must promote collaboration alongside innovation in order to foster a sustained culture of cooperation (Haus-Reve et al., 2019; Nambisan et al., 2019). While fiscal policies such as R&D subsidies encourage the formation of consortia by requiring joint enterprise participation (Busom and Fernández-Ribas, 2008), they do not always achieve the desired outcomes because subsidies may fund projects that would have proceeded regardless, or replace R&D investments privately made by enterprises (Boeing, 2016).

Nevertheless, R&D subsidies are still considered an effective fiscal tool because they stimulate inter-enterprise collaboration, which tax incentives struggle to achieve due to their individualistic nature. This paper seeks to address this issue by offering insights into the introduction of a novel fiscal instrument in the province of Biscay, Basque Country: the 64Bis. This policy tool, in the form of tax credits, promotes inter- enterprise collaboration in R&D projects. The results suggest an alternative to traditional R&D subsidies, indicating that corporate collaboration can be promoted through more effective and efficient resource allocation, which aligns with the genuine innovation objectives of participant enterprises.

A two-stage study was conducted aimed at understanding the nuances of this tax incentive in relation to an increase in know-how. The approach resembles a quasi-natural experiment as it analyzes what occurs in a real-world setting with real incentives. The results from comparing 64Bis adopters with a statistically comparable set of non-64Bis adopters, using one-to-one matching, demonstrate that enterprises benefiting from this incentive increased their relative intangible assets to a greater extent than their counterparts. This confirms policy additionality and validates the tax incentive's efficacy at stimulating collaborative R&D. Furthermore, the fsQCA analysis reveals the presence of parallel pathways or configurational arrangements—publicly-driven basic research, privately-driven applied research, and use-inspired basic research—designed to optimize knowledge acquisition by enterprises utilizing this fiscal tool. Across all configurations, pre-existing networks consistently emerge as a sufficient condition for knowledge acquisition. However, neither the presence of multiple partners nor the submission of multiple applications systematically results in higher knowledge acquisition levels.

Overall, the results suggest that the implementation of the 64Bis initiative promotes collaborative R&D innovation and favors knowledge acquisition in collaborative innovation systems. These benefits account for the fiscal policy's positive effect and, above all, suggest the emergence of a breeding ground or primordial soup wherein a collaborative, inter-enterprise innovation ecosystem evolves (Aversa et al., 2022). These findings entail a number of important academic and policymaking implications for researchers, policymakers and other stakeholders.

7.2. Academic implications

This paper presents several significant academic implications. First, it shows that, since innovation has moved from a dyadic focus to a more networked approach, R&D tax incentives can be developed to support the context of a larger ecosystem (Crespi et al., 2016; Lokshin and Mohnen, 2013; Sterlacchini and Venturini, 2019). In this context, the study showcases a real case: the 64Bis fiscal policy in the Basque Country, used as a quasi-natural experiment to illustrate how a tax incentive can enhance the knowledge acquisition of participant enterprises. Second, the study provides a comprehensive description of this innovative tool and its key features, and emphasizes its capability to transfer tax credits, thereby promoting and facilitating the development of collaborative networks targeted at R&D projects (Brockman et al., 2018; Chesbrough et al., 2014; Xie and Wang, 2020). Considering that enterprises primarily benefit from taxable proceeds (as those failing to generate profitability cannot claim tax credit), the findings endorse the

[12] The intermediate solution consolidates the three configurations from the complex solution into two causal pathways, corresponding to the first two configurations. Moreover, the parsimonious solution identifies a core causal factor shared across all configurations: the presence of *BISNetw*, which consistently emerges as a core condition in all pathways.

[13] Our interpretation of the configurations, based on Stokes' (2011) model, assumes that enterprises in these three optimal configurations conduct basic, applied and user-inspired research, respectively. To verify this, one enterprise from each optimal configuration was analyzed in greater detail. The qualitative descriptions of these three cases can be found in Appendix Table A2, which clearly shows correspondence between the configuration and innovation type, thereby enhancing the analysis robustness.

idea that this policy instrument fosters more genuine inter-enterprise collaborations, with clear innovation objectives among the participant enterprises. This instrument also enables smaller enterprises to receive innovation support from tax credits, given the credit's transferable nature. Consequently, by making use of this fiscal tool, enterprises engaged in collaborative R&D attain a higher degree of knowledge acquisition compared with those not benefiting from this instrument (Ritala et al., 2023; Vanino et al., 2019). An experience effect was also observed as the use of the 64bis increased each year during the study, suggesting that even stronger effects may develop in the future.

The findings from the configurational analysis align with Stokes' (2011) seminal framework, which introduced a third R&D project category —Use-Inspired research— which complements the traditionally acknowledged basic and applied research categories. Moreover, and in contrast to the proximity paradox (Broekel and Boschma, 2012), the results highlight the critical importance of pre-existing networks prior to applying for the fiscal benefit in maximizing the advantages of collaborative R&D (Cipollone and Giordani, 2019). In this context, the findings show that enterprises with established contact networks reap greater benefits from the fiscal tool in terms of knowledge acquisition, and are more likely to establish, sustain and strengthen an innovation ecosystem (Chesbrough et al., 2014; Radziwon and Bogers, 2019).

7.3. Policymaking implications

Ken Arrow (1972) observed that the societal returns from innovation exceed the private returns the organization undertaking the innovation receives, hence a subsidy for innovation may be warranted. However, Arrow did not consider whether making the subsidy transferable would enable enhanced innovation participation and outcomes. The results suggest that there is value in making the innovation subsidy transferable, and doing so helps to promote collaborative innovation. The findings highlight the program's need to remain flexible, allowing the creation of different pathways according to the nature of the innovation being developed. Moreover, the findings can also be interpreted as a means to enhance the project screening process under the 64Bis initiative. These insights include the following four points:

First, the results suggest that external networks matched by third parties (e.g., consultancy firms) may not be the most effective approach for establishing collaborative innovation systems. Instead, allowing beneficiaries to leverage their existing networks could expedite collaboration and knowledge-sharing, given the pre-established confidence, degree of trust and psychological contracts. This suggests that when financial incentives are designed to encourage participation rather than active engagement, government agencies should minimize their reliance on intermediaries and consultancy firms when matching Developers with Financiers.

Second, providing the same Developers with repeated benefits, especially when Financiers remain unchanged, may not be advisable. The findings suggest that this policy should ideally be treated as a one-off measure because repeatedly awarding R&D incentives runs the risk of failure to advance innovation, thereby producing the so-called "mills" effect.[14] Developers participating in the 64Bis primarily aim to transfer their tax credits since they make negligible or negative profits. Prolonged reliance on this incentive without transitioning to profitability could indicate financial vulnerability.

Third, the presence of multiple Financiers during the application review process, particularly where at least one is known to the Developer, results in positive outcomes in terms of knowledge acquisition and ecosystem development.

Fourth, applying for the 64Bis with a single partner can be viable if the enterprise subsequently adds public partners such as universities and research centers. This approach encourages Developers to engage in R&D activities with public institutions at a more advanced stage.

Finally, the local nature of Developers and Financiers, who are both based and taxpayers in Biscay, highlights the regional focus of the policy and the networks. Similar initiatives to the 64Bis could therefore be effectively implemented regionally (in regions with fiscal privileges) or in smaller countries. Even in one region, use of the instrument grew significantly from its initial introduction, and continued to increase throughout the observation period. So, some patience is required in order to achieve sufficient results to sustain the instrument's use. However, a different approach may be needed in larger countries, possibly by awarding exclusivity for the development of free ports or other types of privileged geographical areas.

In summary, this research emphasizes that the 64Bis functions not only as a tax incentive for R&D investment but also promotes knowledge acquisition and ecosystem formation, albeit selectively. By combining the results from between-group and in-group comparisons, it is concluded that beneficiaries that significantly impact knowledge acquisition are those who develop new networks that stem, at least partially, from existing networks.

7.4. Limitations and future research avenues

The main limitation of this study lies in the very nature of the initiative 64Bis as it constitutes an unprecedented fiscal policy yet to be described in the academic literature, which raises numerous questions for future research. First, it must be emphasized that this policy tool pertains to the specific case of Biscay, which, as part of the autonomous community of the Basque Country, enjoys fiscal autonomy. This autonomy results in differences in taxation compared with the rest of Spain. Consequently, it would be pertinent to examine how this fiscal instrument could be adapted to diverse taxation systems, taking contextual factors into consideration such as industry, culture, governance and fiscal requirements.

Similarly, future research should focus on the inherent characteristics of industries in the Basque Country in order to identify the existing or pre-existing factors that have contributed to the establishment of innovation-oriented R&D collaborations. Subsequent studies should also elucidate similar existing or emerging national, regional or international fiscal policies so as to enable comparisons between different policy tools, and establish valid comparative criteria.

Finally, looking ahead, it is essential to assess the policy instrument over the long term to determine its true potential for fostering local ecosystems based on collaborative innovation, and to understand how such ecosystems might enhance regional competitiveness. Although recent research has made progress in this area (e.g., Guerrero and Siegel, 2024), there are still no established methods for evaluating the impact of public policies on the development of entrepreneurial or innovation ecosystems. This challenge remains highly complex, primarily due to the long-time horizons required for such systemic transitions to materialize.

CRediT authorship contribution statement

Ferran Vendrell-Herrero: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Oscar F. Bustinza:** Writing – original draft, Software, Methodology, Formal analysis, Data curation. **Mikel Larreina:** Writing – review & editing, Validation, Project administration. **Marco Opazo-Basaez:** Writing – original draft, Validation, Project administration, Conceptualization. **Henry Chesbrough:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

[14] There is a catch to this, recurring applications could be positive in terms of knowledge acquisition when research is use-inspired.

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Appendix A

Table A1
Truth table.

Number of cases	*BISInte*	*BISAlli*	*BISNetw*	*INCMark*	*INCInst*	*INCOthe*	*INCSpec*	*KNOAcq*	Consistency
1	0	1	1	0	0	0	0	1	1
6	0	1	0	0	1	1	1	1	0.986
2	0	1	0	0	1	1	1	1	0.960
1	1	1	0	0	0	1	0	1	0.912
1	1	0	0	0	0	1	0	1	0.909
3	1	1	0	1	1	1	1	0	0.600
1	0	1	0	0	0	0	0	0	0.500
3	0	1	0	1	0	0	0	0	0.333
1	0	1	1	0	0	0	1	0	0.333
4	0	1	0	0	0	0	0	0	0.282
2	0	1	1	0	1	1	1	0	0.250
1	0	1	1	1	0	0	0	0	0.250
1	0	1	0	0	0	1	0	0	0.050
1	0	1	0	0	0	0	1	0	0
1	0	1	0	0	1	0	0	0	0
3	0	1	0	1	0	0	1	0	0
1	0	1	0	1	0	1	0	0	0
1	0	1	0	1	0	1	1	0	0
1	0	1	0	1	1	0	1	0	0
3	0	1	0	1	1	1	0	0	0
1	0	1	1	0	0	1	1	0	0
1	1	1	0	0	0	0	0	0	0

Note: logical remainders not listed.

Table A2
Example of a Successful Knowledge-Transferring Enterprise per Configurational Pathway.

	Publicly-driven basic research	Privately-driven applied research	Use-inspired basic research
Enterprise name	Alpha	Beta	Gamma
Year of foundation	2020	1988	2002
Size	From 51 to 200 employees	From 201 to 500 employees	From 11 to 50 employees
Presence	Europe and Australia	Europe, Central America, South America, Australia and Japan	Europe, North America, South America, and Australia
Core industry	Industrial machinery manufacturing	Civil engineering	Telecommunications
Sector and business settings	Alfa emerged as a spinoff from two research and development centers focused on large-scale stationary decarbonization. The enterprise primarily operates in the maritime sector, with its main product being membranes designed for the reaction and separation processes of renewable hydrogen, aimed at decarbonizing the maritime sector.	Beta's main activities relate to the development of infrastructure projects, including railroads and roads, as well as water engineering, architecture, urban planning, environmental management, industry and energy. Its scope of action extends across the entire value chain of engineering, encompassing planning, design, construction and operation.	Gamma is a leading engineering company in the wireless telecommunications sector, specializing in the design of gateways for the Internet of Things (IoT). Specifically, the enterprise develops open platforms for system integrators and service providers across various sectors, including fleet management, AVL, telemetry and utilities.
Collaboration entities and domains	Alfa actively collaborates with universities, notably maintaining a close partnership with the Eindhoven University of Technology (TU/e). They have jointly developed projects primarily focused on theoretical aspects; idea generation and research prototyping. This collaboration has positioned Alfa as one of the most innovative and dynamic companies in the effective manipulation of key hydrogen carriers, such as ammonia and methanol.	Beta is characterized by its innovative capabilities, which it has strengthened through collaboration with enterprises from various industrial sectors to provide cost-effective and cutting-edge solutions. Over the last decade, the company has been part of and led a consortium of private enterprises focused on developing and testing leading innovations in the floating offshore wind energy sector.	Gamma collaborates directly with private enterprises to customize technological solutions. Once developed, these solutions provide Gamma with specific knowledge of complex industrial sectors. This expertise is then leveraged by the company as a foundation for its own innovations, which are subsequently launched onto the market through collaborations with public entities such as BEAZ—which provides feasibility analysis and

(*continued on next page*)

Table A2 (*continued*)

	Publicly-driven basic research	Privately-driven applied research	Use-inspired basic research
			assists with the market entry of the enterprise's new products.
64Bis involvement objective	R&D focused on exploring new types of palladium alloy membranes aimed at producing high-purity hydrogen.	R&D focused on the development of new Renewable Energy Generation Systems aimed at meeting the electricity supply needs of industrial parks.	R&D focused on developing telemetry systems aimed at industrial settings within Industry 4.0 and the Internet of Things (IoT).

Note: The three cases presented in this table aim to demonstrate the consistency between the sample enterprises and the categories established by Stokes (2011) that are adopted in the study. The information in this table has been obtained from the responses of enterprises to the questionnaire, and from information available on their respective websites.

Data availability

The data that has been used is confidential.

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