Universidade do Minho
Escola de Economia e Gestão

Diogo Eduardo Machado Ferreira

Innovation and Productivity: Impact assessment of copromotion projects

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Diogo Ferreira

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Diogo Eduardo Machado Ferreira

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Resumo

Esta dissertação descreve, analisa e avalia os impactos dos projetos em copromoção, subsidiados por Fundos Europeus em Portugal, no período 2006 a 2019, relativos aos Quadros Financeiros Plurianuais QREN (2007-2013) e PT2020. O objetivo é avaliar econometricamente, através de um modelo de efeitos fixos, os impactos dos projetos em copromoção no desempenho das empresas, comparando-os com projetos individuais de I&D e avaliar de que forma as características dos consórcios afetam os resultados esperados.

O investimento em I&D é fundamental para o crescimento económico. No entanto, a existência de falhas de mercado pode conduzir a uma situação de subinvestimento e, consequentemente, a taxas de crescimento económico subóptimas. Dado que o desenvolvimento de projetos em copromoção pode ajudar as empresas a superar falhas de mercado, as políticas públicas têm vindo a apostar na formação destas parcerias. Todavia, não há consenso sobre os efeitos destas iniciativas no desempenho das empresas, variando os impactos com as características dos consórcios.

Os resultados desta dissertação sugerem que os projetos em copromoção têm efeitos positivos na produtividade das empresas, principalmente nas micro e pequenas empresas, e que superam os benefícios dos projetos empresariais individuais. No entanto, para o nível de vendas e das exportações, os projetos individuais parecem ter vantagem, sendo os efeitos ao nível do emprego semelhantes. Os impactos nas pequenas empresas parecem ser sensíveis às características do consórcio em que desenvolvem o projeto de I&D. Em suma, um número mais elevado de parceiros diminui os benefícios do projeto para todos os tipos de empresas, com mais intensidade para as menores, e os ganhos de produtividade das empresas mais pequenas são reduzidos nas parcerias com entidades mais produtivas. Contrariamente, as grandes empresas, ao nível das exportações, beneficiam mais ao fazerem parcerias com empresas maiores e mais exportadoras.

Palavras-chave: fundos europeus; I&D; produtividade; projetos em copromoção.

Abstract

This dissertation describes, analyzes, and evaluates the impacts of projects in copromotion, subsidized by European Funds in Portugal, in the period 2006 to 2019, related to the Multiannual Financial Frameworks QREN (2007-2013) and PT2020. The objective is to econometrically evaluate, through a fixed-effects model, the impacts of copromotion projects on firms' performance, comparing them with individual R&D projects and evaluating how the characteristics of the consortiums affect the expected results.

Investment in R&D is essential for economic growth. However, the existence of market failures can lead to underinvestment and, consequently, to suboptimal economic growth rates. Given that the undertaking of copromotion projects can help companies overcome market failures, public policies have been focusing on the formation of these partnerships. However, there is no consensus on the effects of these initiatives on the performance of companies, with the impacts varying with the characteristics of the consortiums.

The results of this dissertation suggest that copromotion projects have positive effects on the productivity of companies, especially in micro and small firms, and that they outweigh the benefits of individual business projects. However, for the level of sales and exports, individual projects seem to have an advantage, with similar employment effects. The impacts on small companies seem to be sensitive to the characteristics of the consortium in which they develop the R&D project. In short, a higher number of partners reduces the benefits of the project for all types of firms, more intensely for the smaller ones, and the productivity gains of smaller companies are reduced in partnerships with more productive entities. In contrast, large corporations, in terms of exports, benefit more from partnering with larger and more exporting companies.

Keywords: copromotion projects; European funds; productivity; R&D.

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1. Introduction

Investment in R&D (Research and Development) is fundamental as a driver of competitiveness, productivity, and economic growth (Romer, 1990; Aghion and Howitt, 1998; Bayona-Sáez & García-Marco, 2010; Bellucci et al., 2016; Cin et al., 2017). However, due to market failures, the socially desirable level of innovation is not equal to the equilibrium level of the markets, providing a rationale for public subsidies (Bloom et al., 2019; Bryan and Williams, 2021; Teichgraeber & Van Reenen, 2022).

In fact, R&D investments are uncertain and associated with a higher risk of failure (Feldman & Kelley, 2003; Bayona-Sáez & García-Marco, 2010). Additionally, in the case of micro-sized firms, SMEs (small and medium enterprises) and new entrants have financial constraints for these types of investments, due to asymmetric information and a higher risk of default (Fazzari et al., 1988; Beck and Demirguc-Kunt, 2006; Freel, 2007; Alessandrini et al., 2010; Czarnitzki & Hottenrott, 2011; Cin et al., 2017). Moreover, R&D is a non-rival good (its use by a company will not prevent its use by others), and so it may lead to potential knowledge spillovers where other companies will benefit from others' innovation efforts (Katz, 1986; Feldman & Kelley, 2003; Belderbos et al, 2004; Crespi et al., 2020), worsening the underinvestment problem.

To overcome these market failures, governments intervene in the market by issuing policies to incentivize the socially desirable investment in R&D and promote the consequent spillovers, hoping that it will create positive externalities for the rest of the economy (Grossman and Helpman, 1991; Aghion and Howitt, 1990; Aguiar & Gagnepain, 2017; Cin et al., 2017). Policies aimed to support R&D are seen as crucial for regional development, with the OECD Innovation Strategy (OECD., 2010) recognizing the role of innovative policies in sustaining innovation-induced productivity. The European Union has also acknowledged R&D as one of its priorities (De Blasio et al., 2015) and has launched a series of programs, whose goal is to raise the productivity and competitiveness within European firms through R&D (Teichgraeber & Van Reenen, 2022).

However, public intervention in these activities is not a consensual solution, being the main arguments against the following: it has a substitution effect rather than a complementary one; the possibility of negligence regarding public money, which would not happen if the funds were private; the increase in R&D costs; and even the possibility of the government being inefficient on the allocation of resources among the research fields (Bayona-Sáez & García-Marco, 2010).

The biggest concern about the efficacy of public subsidies lies in the answer to the question: what would be the behavior of the firms if they had not received the subsidies? The possibility of a crowding-

out effect, that is, of the subsidy acting as a substitute for private investment, leads to situations where projects that are being financed by public resources would be carried out even without the awarded incentives (Brown et al., 1995; Wallsten, 2000; Barajas et al., 2012). This crowding-out phenomenon happens because public capital presents a lower cost to every firm. However, the literature is not unanimous in recognizing the presence of this effect (De Blasio et al., 2015; Cin et al., 2017).

Several authors find evidence pointing out to the crowding-out problem (Wallsten, 2000; Sissoko, 2011; De Blasio et al., 2015), other studies do not perceive any signs of this phenomenon (Feldman & Kelley, 2003; Duguet, 2004; González et al., 2005; González & Pazó, 2008; Santos, 2019) and there is even evidence of a partial-effect (Czarnitzki & Lopes-Bento, 2013). For instance, there are findings showing that it occurs more in bigger firms, whilst small ones carry out the investment that they couldn't without public support (Pavitt, 1998; Lach, 2002; Görg & Strobl, 2007).

Concerning the policy toolkit to increase research and innovation, Tether (2002) lists several restrictions to R&D that cooperation between firms and between firms and the scientific and technological system may help to overcome: the inherent risk of innovation; financial constraints; bureaucratic obstacles; and lack of market/technologies/customers information. R&D collaborations have been increasing recently and are now an important component of the innovation process (Tether, 2002; Aschhoff & Schmidt, 2008). R&D collaborations may be beneficial to the economy as a whole by diminishing the costs of innovation and spreading knowledge more easily and effectively, through internal and voluntary spillovers (Katz, 1986; Combs & Link, 2003; Bellucci et al., 2016)[1].

The European Union has been encouraging explicitly the formation of partnerships in R&D projects (Aschhoff & Schmidt, 2008; Amoroso et al., 2018). Back in the early 1980s, there were already European policies that aimed to promote research partnerships to support the technology sectors and their international competitiveness. Since then, the policies have been upgraded, with financial raises, better coordination, and a more central role to industry-university collaboration (Galán-Muros et al., 2017; Aguiar & Gagnepain, 2017).

In Portugal, R&D partnerships have also been supported by the government with European funds. In the last two multiannual financial frameworks (NSRF - National Strategic Reference Framework; and PT2020 - Partnership Agreement), projects in co-promotion were financed by European funds, within the scope of the System of Incentives for Research and Technology Development (SI I&DT) to increase the investment in R&I to enhance firm's competitivity.

[1] According to Crespi et al. (2020), research collaborations are the preferable way to produce spillovers.

Being these projects in copromotion financed by public resources it is important to assess their impacts on the economy. However, the effects arising from public policies for R&D are not easy to measure and the results in the literature are ambiguous. There are some difficulties to collect the needed data to study the impacts and, the impacts in themselves, are hard to isolate.

This study will look to deepen the question raised by Alexandre (2021), who, for the first time, studied the impact of copromotion projects on the performance of Portuguese firms. The research questions of the present study are:

1) What are the impacts of co-promotion projects on firm performance and how do they compare to the impacts of individual projects?
2) How does the composition of the consortium affect the impacts on company performance?

To answer the proposed questions, this work will use 3 distinct datasets, provided by COMPETE, Agência Nacional de Inovação (ANI), and Portugal Statistics (INE). The first two entities presented relevant information regarding the copromotion projects carried out in Portugal, while the latter provides firm-level information. By linking the three databases, it will be possible to construct a panel dataset from 2006 to 2019 and use it to answer the research questions through a fixed-effects approach.

To the best of our knowledge, this study will be the first to evaluate the possible existence of diffusion spillovers and the impact of the consortiums in Portuguese R&D joint ventures promoted by the European Funds, while deepening on the economic impacts of participating in partnerships for R&D.

The estimations carried out later in this dissertation indicate more benefits related to the participation in copromotion projects for smaller firms. Comparing this modality with the individual projects undertaken, the first only are more beneficial in productivity terms while individual projects offer more positive impacts on sales and exports (both modalities have a similar effect on employment). When considering the characteristics of the consortium, they seem to be more relevant for smaller firms. In particular, for smaller companies, more members, within the partnership, has a negative effect on the outcomes, and the bigger the difference to the most productive firm within the consortium, the smaller will be the productivity gains. These findings suggest that micro and small Portuguese firms are the main beneficiaries of copromotion projects, but the benefits seem to hinge on the type of consortium in which they belong.

The remainder of the dissertation is structured as follows. Section 2 presents a review of the literature on subsidies for R&D. Section 3 presents the data and the descriptive statistics while presenting an

overview of the copromotion projects that were undertaken in Portugal. Section 4 presents the empirical strategy and discusses the results. Section 5 concludes with some final remarks.

2 Literature Review

As mentioned in the Introduction, projects in copromotion may be a good strategy to overcome some market failures connected to investment in R&D. Firms tend to engage in projects in copromotion to reduce the risks associated with innovation; share costs and avoid wasteful duplications of research; overcome financial obstacles and constraints; and look for external resources (being them monetary or knowledge-based) otherwise unreachable (Katz, 1986; Tether, 2002; Feldman & Kelley, 2003; Barajas et al., 2012; Alexandre et al., 2021).

Although projects in copromotion may mitigate underinvestment in R&D, they also entail additional costs. Entities participating in such undertakings are susceptible to increased management costs, problems of free-riding, or time to build up the needed trust in the partner (Benfratello & Sembenelli, 2002; Feldman & Kelley, 2003; Barajas et al., 2012; Crespi et al., 2020). On the other hand, some of the potential spillovers are only achievable through intangibles, and thus, it requires networks with a good organization in order to transfer knowledge from one organization to another, hence, the externalities may be compromised by coordination failures. Therefore, coordination is key in copromotion projects, and firms will only engage in a partnership when the expected gains outweigh the costs (Aschhoff & Schmidt, 2008; Crespi et al., 2020).

Those results suggest that participation in research collaborations is not random and depends on numerous variables. Several studies report that larger firms are associated with a higher probability of being awarded incentives, as well as having higher performances and production capacity, in terms of wages per employee, tangible fixed assets, or being located within a high-intensity export region (see, for example, Tether, 2002; Feldman & Kelley, 2003; Bayona-Sáez & García-Marco, 2010; Hud and Hussinger, 2015; Aguiar & Gagnepain, 2017; Santos, 2019). On this matter, large-sized firms benefit from being more capable to bear the fixed costs associated with R&D projects, they meet the bureaucratic demands of the application more easily (Blanes & Busom, 2004; Czarnitzki & Hussinger, 2004), and also have the additional incentive to participate so they can monitor the latest innovations (Aguiar & Gagnepain, 2007). However, some evidence state that larger firms are less willing to participate and apply for joint ventures, to not share knowledge with their smaller competitors (Röller et al., 2007; Barajas et al., 2012).

Blanes & Busom (2004) and Aguiar & Gagnepain (2007) argue that government institutions may also prefer large-sized companies, as they are associated with higher rates of success regarding R&D. This practice of the government is acknowledged as picking the winner's approach, that is, supporting projects with a higher associated rate of success, and, where the firms have past experiences with public funding,

where even rejected firms take advantage of their application knowledge, to apply for future calls with better submissions (Barajas et al., 2012).

Hud and Hussinger (2015) also found that younger firms have better chances of getting their projects approved as they are more prone to innovate (Czarnitzki and Lopes-Bento, 2014), while Feldman & Kelley (2003) argue that riskier projects and new partnerships are more prone to be approved.

Regarding the constitution of the partnerships and their probability of getting supported, projects with participants already embedded in research networks and/or more prone to diffuse their knowledge should be favored, as they present a higher expected return in terms of new knowledge and spillovers (Feldman & Kelley, 2003). In this sense, the same author states that the participation in projects in copromotion, with either other firms or universities, allows the participants to be part of networks with other agents of the innovation system and to enjoy spillovers arising from other applicants, in the future. However, other scholars warn that firms engaging with higher education institutions tend to be larger in size, as they are more aware of their innovative capabilities, have more absorptive capacity, and have the resources needed to withhold the partnerships (Tether, 2002; Freitas et al., 2013).

Some authors have pointed out cultural and cognitive differences between universities and firms as barriers to the existence of more partnerships, yet they also emphasize how industry-university collaboration projects are a way to solve conflicts that may arise as a result of those differences (Lee, 2000; Lam, 2011). OECD supports as well, a higher proximity between innovative institutions and industry to facilitate knowledge and technology transfers stating that the current relationships need to improve (e.g., OECD, 2010).

For the actual effects arising from R&D research, there is evidence stating that, in fact, the knowledge spillovers produced lead to improvements in productivity (Basant & Fikkert, 1996; Coe & Helpman, 1995; Adams & Jaffe, 1996; Sissoko, 2011; Cin et al., 2017; Crespi et al., 2020). Cin et al. (2017) propose some explanations found in the literature for the productivity increments detected such as “cost-sharing, risk sharing, and the inducement of external investment through the provision of qualitative information to investors to facilitate decision making”. In its study regarding Korean SMEs and the impact of R&D on their performance, between 2000 and 2007, Cin et al. (2017) notices gains among both the treated and the untreated firms that were close to the firsts in geographical terms. Crespi et al. (2020), in an analysis regarding R&D grants for firms in Chile, conclude that those effects are not linear, and a significant mass of treated firms is needed to produce spillovers. On the other hand, also according to Crespi et al. (2020),

programs that are too large may generate a business-stealing effect instead of a positive externality, so, there are saturation points that need to be considered in the policy design.

Several authors have concluded that copromotion projects have a positive impact on productivity growth (e.g., Benfratello & Sembenelli, 2002; Belderbos et al., 2004; Aguiar & Gagnepain, 2017). However, those impacts are dependent on firms' characteristics: the magnitude of the impact decreases for more productive firms (Benfratello & Sembenelli, 2002; Sissoko, 2011); on the other hand, companies that partner with foreign multinationals present more gains (Belderbos et al., 2004).

However, the literature is not unanimous on the impact of copromotion projects on firms' productivity. Cannone & Ugheto (2014), when evaluating public supports for R&D in Italy, found no evidence of any additional impact of joint ventures on productivity. Barajas et al. (2012), even though they also do not discover any direct effect of being part of joint ventures on labor productivity, found an indirect effect through intangible fixed assets by employee, that will generate productivity growth. Subsidized firms may present inefficiencies regarding productivity levels since increases in employment affect positively the decision of awarding the funds. For that reason, as found in Bernini & Pellegrini (2011), firms tend to commit to employment levels above their optimal level to receive the funds, which ultimately will negatively impact their productivity. Santos (2019) corroborates that result as it found that non-subsidized firms in Portugal increased more their labor productivity when compared with the awarded firms. Moreover, some studies find that private R&D leads to higher returns when compared to publicly funded R&D (Griliches & Lichtenberg, 1984; Lichtenberg & Siegel, 1991), and those projects perform better results concerning productivity as well (Billings et al., 2004).

Additionally, supports for investment in R&D and research partnerships are not limited to productivity effects. Innovation is also considered a driver of employment (OECD, 2010) with Bellucci et al. (2016) and Santos (2019) concluding that subsidized firms employ more people than the non-treated ones. However, and to reflect the lack of consensus within the literature, Sissoko (2011) is not able to find out consistent evidence on the relationship between subsidies and employment.

In general, R&D subsidies lead to an increase in investment and innovation levels (see, for example, Feldman & Kelley, 2003; Cannone & Ughetto, 2014; Bronzini & Iachini, 2014; Bellucci et al., 2016; Cin et al., 2017; Santos, 2019; Crespi et al., 2020). However, those increments in private R&D investments are not synonymous with positive effects on productivity or economic growth (Hall & Maffiolo, 2008). On the other hand, some authors also find that R&D subsidies do not lead to the increment of investment (De Blasio et al., 2015) with Bronzini & Iachini (2014) arguing that, even though small firms indeed

increase their investment level due to the awarded subsidies, no evidence supports the same impact for large companies.

There is a wide range of studies that support that subsidies to small-sized firms result in more benefits compared with the ones registered for larger companies, along several dimensions (Busom, 2000; Lach, 2002; Hyytinen & Toivanen, 2005; Lööf & Heshmati, 2005; González & Pazó, 2008; Bronzini & Iachini, 2014). The logic behind those differences relates to the previously mentioned financial constraints faced by smaller firms, and, with the attribution of subsidies to R&D, the government successfully reduces those constraints, leading small firms to undertake projects that they would not otherwise (Criscuolo et al., 2019).

Bellucci et al. (2016), comparing the effects of copromotion projects with the impacts of individual undertakings on Italian SMEs, between 2003 and 2012, find that public subsidies for research in copromotion projects are less effective than the resources allocated to individual research projects. According to the results of those authors, individual projects present clear effects on investments and employment, while copromotion projects showed weaker and mixed effects, such as lower growth in employment and a negative impact on investment. Crespi et al. (2020), by comparing also individual and joint research projects in Chile, conclude that the benefits are broadly similar. Bellucci et al. (2016) warn for the possible presence of free-riding, moral hazard, and selection drawbacks in 'imposed' partnerships that need to be accounted on the designing of public policies that may affect the final impacts.

The literature has been quite unanimous that the effects of R&D partnerships will differ depending on the type of cooperation and partners (Belderbos et al., 2004). There is evidence that more market-oriented partnerships lead to a higher probability of better economic effects among the participants. Benfratello & Sembenelli (2002) and Bayona-Sáez & García-Marco (2010) analyzed the Eureka program, which promotes R&D partnerships with a more market-oriented purpose, and found positive effects of the projects on firms' profitability, one year past the completion of the venture and a significant effect on labor productivity.

Concerning the characteristics of the partnerships, consortiums with suppliers look for cost reductions, by assuring the quality and improvements on the inputs while partnerships with competitors are more prone to generate incremental innovations and lead to productivity increases through cost-sharing (Belderbos et al., 2004). Aschhoff & Schmidt (2008) add that collaborations held between competitors and firms within the same sector achieve cost reductions as they significantly impact the production process. However, these types of collaborations may raise anti-competitive behaviors (Tether, 2002).

Partnerships with customers increase the chances of acceptance by the market, as companies are more aware of their preferences, which is even more relevant when considering novel products that are being introduced to the market (Belderbos et al., 2004). These partnerships with other industry actors lead to research on more marketable knowledge (Aguiar & Gagnepain, 2017).

We expect that partnerships between firms involving small and large companies have a higher potential for innovation diffusion and, thus, for generating positive externalities for smaller-sized firms. Although those types of arrangements have been increasing through the years (Alvarez & Barney, 2001; Rothkegel et al., 2006), their pursuit is often problematic, facing trust-based issues, lack of cooperation, and opportunistic behaviors (Das & Teng, 1998; Hancké, 1998). According to Sawers et al. (2008), there is a major vulnerability concern from SMEs regarding large-sized firms, regarding the possibility of knowledge appropriation. Some authors report cases of firms felting exploited and facing bankruptcy upon the end of partnerships with large companies (Alvarez & Barney, 2001). On the other hand, Rothkegel et al. (2006), with the support of other authors, recognizes also the existence of successful partnerships when they are based on trust and compatible goals (see, for example, Ring & Van de Ven, 1994; Child, 2001).

Concerning partnerships with institutions from the scientific field, several studies present evidence of a positive effect of relationships with universities and research centers on the sales volume, arising from the creation of new products (Lööf & Heshmati, 2002; Belderbos et al., 2004; Aschhoff & Schmidt, 2008; Lööf & Broström, 2008). The new products enable firms to enter new and different markets or market segments. Moreover, firms by allying themselves with universities and other research entities may benefit from economies of scale, access to incremental knowledge, more technical expertise and so, more impactful findings (Feldman & Kelley, 2003; Argyres & Silverman, 2004). D'Este & Perkmann (2011), however, emphasize the possible conflict of interests, where universities are more oriented to basic research, while firms intend to primarily commercialize the output of their research. Yet, as referred by Belderbos et al. (2004), the role of universities, and competitors to some extent, on projects in copromotion, are essential to generate radical innovations and novel products for the market. Also, partnerships with universities are associated with productivity gains as a consequence of more effective public spillovers (Belderbos et al., 2004).

Recent evidence suggests that SMEs benefit more than larger firms from collaborations with universities (García-Vega & Vicente-Chirivella, 2020; Spanos, 2021), though most of the partnerships formed with universities are composed by large companies (Alexandre et al., 2021). As stated by

Motohashi (2005), large firms look largely for R&D collaborations while SMEs only engage in research partnerships during the final product stage. Until then, their preference lies in technical consulting. Freitas et al. (2013), explains this phenomenon to the fact that small-sized companies have a preference for more personal contacts with university academics, while, conversely, larger firms look for more institutional partnerships, with departments or even TTOs, for instance, which are easier to process for the higher education institutions (see, also on this issue, Alexandre et al., 2021).

The referred TTOs are considered one type of intermediary institutions, which are entities that have a central role in the innovation system and diffusion of knowledge. They bridge the existent gaps between academia and industry, and, consequently, their optimization has become a crucial guideline in technology policy (Wright et al., 2008; Alexandre et al., 2021). They also aim to reduce the transfer costs for firms, ensure that agents have conditions of appropriability, and foster trust between them (Etzkowitz & Klofsten, 2005; Vries et al., 2019).

The main idea is that these intermediary entities are of particular benefit for SMEs, as they possess higher barriers regarding knowledge acquisition, however, the literature on intermediary institutions is scarce (Giarreta, 2014; Alexandre et al., 2021). The current findings support the conclusions that these institutions are important to build trust, particularly for SMEs, helping them overcome spatial and non-spatial barriers between them and the universities, and are also considered effective in their purpose of transferring knowledge (Fernandez-Esquinas et al., 2011; Giarreta, 2014; Villani et al., 2017).

3 Copromotion projects in NSRF and PT2020

As referred previously, projects in copromotion are a tool granted in the frameworks approved by the Portuguese republic that is funded by European funds, namely through the ERDF (European Regional Development Fund). The frameworks in study are the National Strategic Reference Framework (NSRF), which regulated the use of the community funds between 2007 and 2013, and the Partnership Agreement Portugal 2020 (PT2020) in the period 2014-2021. Each program includes three distinct systems of incentives for three distinct areas, namely SI Qualification; SI Innovation; and SI I&DT, with projects in copromotion being a modality of projects funded by SI I&DT.

The main goal of the SI I&DT is to increase the investment in R&I (Research and Innovation) and enhance firm's competitiveness, by promoting partnerships between them and entities from the STS (Scientific and Technological System), growing knowledge-intensive activities, create value based on innovation, develop new products and services (especially in activities of greater technological and knowledge intensity) and increase national participation in international R&I programs and initiatives (Ordinance No. 1462/2007; Ordinance No. 57-A/2015).

The projects in copromotion are classified as such when performed in partnerships between companies or companies and entities of the scientific and technological system to promote the development of R&D activities through the complementarity of competencies or common interests, leading to the potentiation of synergies, cost, and risk-sharing.

During NSRF, projects in copromotion were a modality that only included R&DT firm projects, while, for PT2020, the modality of projects in co-promotion starts to comprise five typologies in total: R&D firms projects; demonstration projects; industrial property protection; internationalization of R&D; and mobilizing programs. Within these typologies, firms would choose in which modality they would like to apply, be it with individual or copromotion projects (the mobilizing programs were the unique type that required appliances in copromotion).

3.1 Data

The dataset used to study the copromotion projects undertaken in Portugal was built with two databases, one delivered by Compete and the other by ANI (Agência Nacional de Inovação). Both provide all relevant information regarding projects of SI I&DT from NSRF (2007-2013) and PT2020 (2014-2021). They present information on all projects of the system of incentives, being them approved or rejected, carried out individually or in copromotion. The information for each project is also very rich, containing

all the involved entities, including firms and entities from the STS, the monetary worth of the project (in terms of investment and subsidies), the activity sector, and the technological area within the scope of the project, all the details regarding the application and also details on the technical bodies responsible for the application, evaluation, financing, and oversight of the project.

The information from those two datasets was then merged with the Integrated Business Accounts System (SCIE, "Sistema de Contas Integradas das Empresas", INE, Statistics Portugal, 2018), which is a very rich firm-level database with yearly information of all the reported Portuguese firms' balance sheets, between 2006 and 2019. From SCIE, it was retrieved firm-level data on the average worker productivity, the average wage per worker, the number of total workers, the tangible and intangible assets, the dimension and age of the firm, and, finally, the level of exports and total sales. Given that SCIE only has data until 2019, and its information is paramount to the analysis, it will only be considered in this dissertation the period until 2019. This implies that 505 approved projects in copromotion, referring to 2020 and 2021, are not considered. We will only consider projects undertaken in mainland Portugal.

The following two subsections will present, first, descriptive statistics that characterize the copromotion projects carried out in Portugal between 2007 and 2019 as well as the entities involved in them. Second, we will characterize the probability of firms having copromotion projects and how their approval might vary given their characteristics.

3.2 Descriptive Statistics

Table 1 presents an overview of copromotion projects developed in NSRF and PT2020. Across the two frameworks, there were 1,240 entities involved (with 326 carrying out projects both in PT2020 and NSRF) across 1,224 projects in copromotion. These projects summed up to 1,421 million euros in total investment, from which, 805 million euros were subsidized by European funds.

PT2020 awards almost two times more incentives with fewer projects. Moreover, on average, during PT2020, each project received 107% more incentives, and, at the median, the value of the supports increased by 56%, showing that the projects in PT2020 were significantly larger.

Additionally, PT2020 also presents more entities involved and bigger projects in terms of members (in NSRF, 48% of the projects had 2 members by project and 27% had 3, while in PT2020 35% of the undertakings had 3 members and projects with 2 entities accounted for 33% of the total).

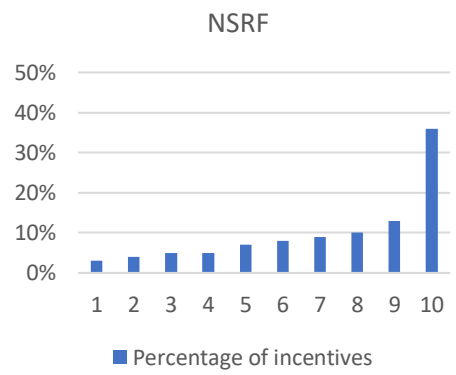
Table 1 *- Characterization of projects in copromotion supported by the ERDF in NSRF and PT2020, mainland Portugal*

	NSRF (2007-2013)	PT2020 (2014-2019)
Number of projects	637	587
Entities:		
Firms	652	725
Entities from the STS	86	103
Members by project		
Average	3.28	3.81
Mode	2	3
Standard deviation	3.12	4.35
Min.	1	2
P10	2	2
Median (P50)	3	3
P90	5	5
Max.	39	47
Total of incentives (M €)	276,97	527,70
Average (th €)	434,8	899,0
Standard deviation (th €)	563,2	1 944,9
Min (th €)	40,3	107,7
P10 (th €)	145,8	263,5
Median (P50) (th €)	317,7	495,7
P90 (th €)	700,0	1 104,1
Max (th €)	6 455,9	21 073,8

Source: Own computations using data provided by Compete.

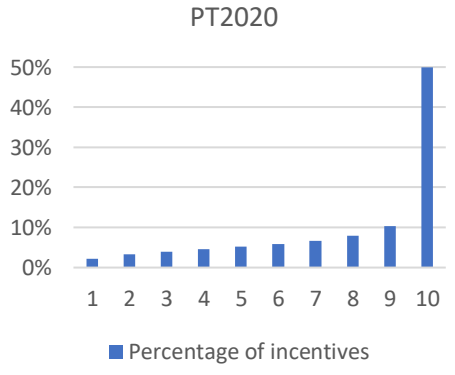
Graphs 1 and 2 illustrate how the funds are distributed across the deciles of the projects. The figures show a concentration of incentives in the top decile, which increased from NSRF to PT2020. In NSRF, the 10th decile receives 36% of the funds attributed in NSRF, and in PT2020 it received 50% of the incentives.

Figure 1 *- Decile distribution of incentives by project in NSRF*



Source: Own computations using data provided by Compete.

Figure 2 *- Decile distribution of incentives by project in PT2020*



Source: Own computations using data provided by Compete.

3.2.1 Characterization of the firms in copromotion projects

Of all the firms involved, 258 (23% of the total) had projects both in NSRF and PT2020. However, the number of firms in PT2020 increased by 11%, by 2019.

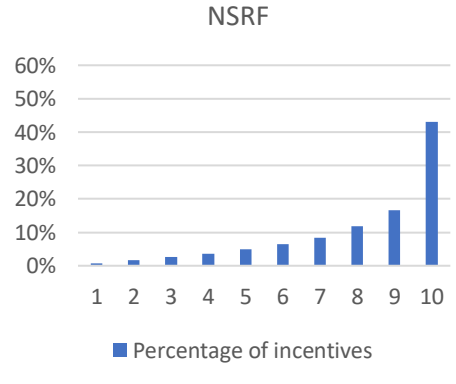
Table 2 *- Characterization of the participation of firms in projects in copromotion, supported by the ERDF in NSRF and PT2020*

	NSRF (2007-2013)	PT2020 (2014-2019)
Firms	652	725
Projects participation		
Average	1.72	1.61
Mode	1	1
Standard deviation	1.58	1.23
Min.	1	1
P10	1	1
Median (P50)	1	1
P90	3	3
Max.	14	9
Total of incentives (M €)	151,73	289,61
Average (th €)	232,72	399,46
Standard deviation (th €)	364,24	1 726,65
Min (th €)	0	0
P10 (th €)	30,12	39,58
Median (P50) (th €)	128,94	177,47
P90 (th €)	501,98	707,37
Max (th €)	5 644,08	44 530,78

Note: P10 stands for percentile 10 (likewise for the other statistics). Min and Max represent the minimum and the maximum, respectively. Source: Own computations using data provided by Compete.

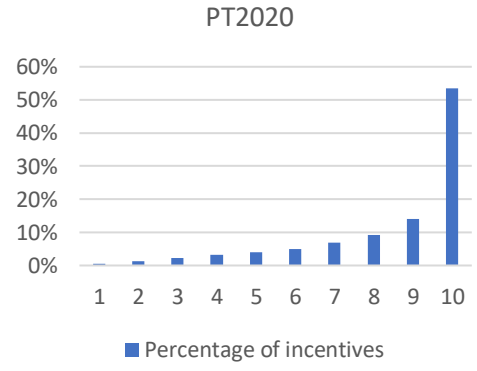
In PT2020, the average amount of incentives received by firms increased by 72%, in comparison to NSRF. Yet, at the median, the incentives increased by 38%, less than the average, pointing to a larger share of incentives being attributed to the most subsidized companies, in PT2020.

Figure 3 *- Decile distribution of incentives by firms in NSRF*



Source: Own computations using data provided by Compete.

Figure 4 *- Decile distribution of incentives by firms in PT2020*



Source: Own computations using data provided by Compete.

Figures 3 and 4 show the decile distribution of funds by the involved firms. The figures reveal a concentration of funds in the top 10% of most subsidized companies and confirm a higher concentration during PT2020, with an increase of 11 p.p, going from 43% to 54% of the total funds.

Table 3 *- Distributions of projects in copromotion by firm size, in NSRF and PT2020*

	NSRF (2007-2013)				PT2020 (2014-2019)			
	Firms	Projects	Incentives	Investment	Firms	Projects	Incentives	Investment
Micro	24 %	23 %	19%	15 %	19 %	14 %	11 %	8 %
Small	26 %	24 %	27%	22 %	27 %	26 %	21 %	18 %
Medium	25 %	22 %	22%	22 %	31 %	31 %	25 %	23 %
Large	25 %	31 %	32%	41 %	23 %	29 %	43 %	51 %
TOTAL	100 %	100 %	100%	100 %	100 %	100 %	100 %	100%

Source: Own computations using data provided by Compete.

Table 3 shows a balanced distribution of firms by size in NSRF, which is more unbalanced in PT2020, with more small and medium firms involved compared to micro and large ones. Yet, larger firms get a bigger share of the projects and the awarded incentives. Larger firms are also the ones with more investment made, which consequently leads to them receiving more funds. It is also noticeable the increase in the share of funds awarded to medium and larger firms in PT2020.

3.2.2 Characterization of the entities from the STS in copromotion projects

STS entities are understood to be all non-profit research and development organizations in the State, higher education, and private institutions sectors. However, even among these entities, there are different types of institutions. This dissertation defines 3 categories to better understand the scope of the actors: (1), Higher education institutions; (2), Interfaces; and (3), all the other entities not included in the two previous classifications (here we include research centers, independent laboratories; etc).

Below we will dedicate a subsection to each type of institution. However, we will in a first step analyze all the entities from the STS together. Table 4 presents the main metrics of these entities, following the structure used for the characterization of the firms. The number of research institutions increased from 86 to 103, from NSRF to PT2020 (an increase of 20%), with 69 entities participating in both frameworks.

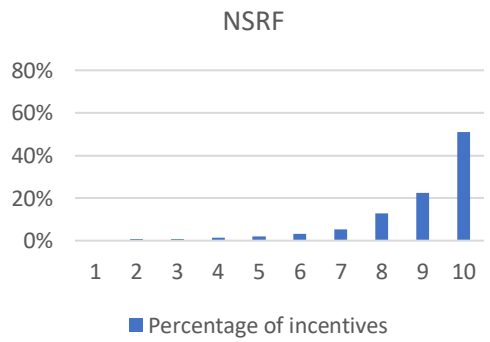
Table 4 *- Characterization of the participation of entities from the STS in projects in copromotion, supported by the ERDF in NSRF and PT2020*

	NSRF (2007-2013)	PT2020 (2014-2019)
Entities from the STS	86	103
Higher education institutions	26	27
Interfaces	23	25
Others	37	51
Projects participation		
Average	11.10	10.36
Mode	1	1
Standard deviation	17.59	17.02
Min.	1	1
P10	1	1
Median (P50)	4	4
P90	25	29
Max.	95	88
Total of incentives (M €)	125,24	238,08
Average (th €)	1 456,25	2 311,42
Standard deviation (th €)	2 398,11	6 368,27
Min (th €)	18,91	15,77
P10 (th €)	68,27	58,26
Median (P50) (th €)	344,64	336,94
P90 (th €)	4 056,92	5 180,74
Max (th €)	10 967,32	54 110,16

Note: P10 stands for percentile 10 (likewise for the other statistics). Min and Max represent the minimum and the maximum, respectively. Source: Own computations using data provided by Compete.

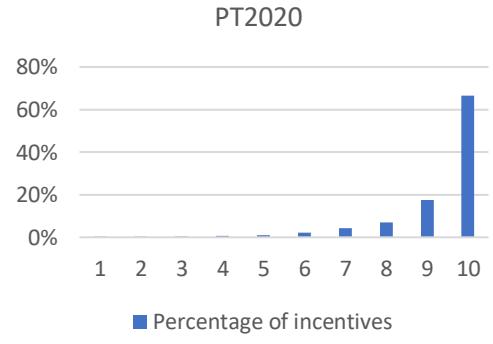
On average, entities from the STS received 59% more incentives in PT2020, however, at the median, the increase was not proportional, as it actually decreased. On the other hand, the percentile 90 increased by 28% and the maximum became 5 times larger. The stability in the percentile 10 and an increase of the standard deviation points to a concentration of funds in a small group of entities in PT2020.

Figure 5 *- Decile distribution of incentives by entities from the STS in NSRF*



Source: Own computations using data provided by Compete.

Figure 6 *- Decile distribution of incentives by entities from the STS in PT2020*



Source: Own computations using data provided by Compete.

Figures 5 and 6 reinforce the concentration of incentives in the higher deciles and a significant increase of 16 p.p. in the percentage of funds credited to the 10% most subsidized institutions.

Characterization of the higher education institutions

Higher education institutions (HEI) represent 31% of all the entities from the STS involved in copromotion projects. Table 5 presents the statistics regarding the projects with the participation of these entities. Higher education institutions were part of 64% and 71% of the projects, received 22% and 31% of all the incentives awarded, and invested 23% and 27% of the total, in NSRF and PT2020, respectively.

Table 5 *- Characterization of the participation of universities and polytechnics in projects in copromotion, supported by the ERDF in NSRF and PT2020*

	NSRF (2007-2013)	**PT2020 (2014-2019)**
Number of projects	407	416
Projects participation		
Average	20.50	22.59
Mode	1	3
Standard deviation	27.39	44.48
Min.	1	1
P10	1	1
Median (P50)	6	11
P90	68	79
Max.	95	88
Total of incentives (M €)	61,95	163,84
Average (th €)	2 382,70	6 068,30
Standard deviation (th €)	3 392,81	11 473,68
Min (th €)	20,55	26,32
P10 (th €)	87,24	143,62
Median (P50) (th €)	618,36	1 432,08
P90 (th €)	8 238,77	21 304,15
Max (th €)	10 967,32	54 110,16

Note: P10 stands for percentile 10 (likewise for the other statistics). Min and Max represent the minimum and the maximum, respectively.
Source: Own computations using data provided by Compete.

On average, HEI participated in more projects in PT2020 compared to NSRF (while in NSRF 16 entities participated in a single project, in PT2020 only 3 participated in just one). The increased importance of these institutions is also shown through the incentives received (on average, they received 2.5 times more, and the median became 2.3 times higher).

Table 6 *- Distribution of firms involved in projects that include higher education institutions by size, in NSRF and PT2020*

	Micro	Small	Medium	Large	TOTAL
NSRF	25 %	26 %	24 %	25 %	100 %
PT2020	19 %	27 %	31 %	23 %	100 %

Source: Own computations using data provided by Compete.

Tables 19 show the distribution of firms by their size through the different groups of firms. It is represented a balanced distribution, with a decrease in the weight of micro-companies and an increase for medium, on these partnerships during PT2020.

Characterization of the intermediary organizations

As referred previously, the Portuguese government recognized 31 intermediary institutions, classifying them as "interfaces". Interfaces are entities recognized by ANI, that act in the intermediate space of the innovation system, developing and promoting innovation by facilitating the transfer of knowledge from higher education institutions to the industry. This sub-section will give information regarding the interfaces involved in copromotion projects following the same structure used previously for higher education institutions.

From the 31 recognized interfaces, 26 got involved in at least one project in copromotion and 22 of them had projects in both frameworks. In terms of projects, NSRF interfaces were involved in 39% and 43% of the projects, were awarded 19% and 7% of all the incentives, and were responsible for 15% and 12% of the total investment, in NSRF and PT2020 respectively as they represent 22% of all the involved entities of the STS.

From Table 7, we perceive that, until 2019, the activity of interfaces regarding projects in copromotion was relatively similar to what was recorded during NSRF, with small variations in the average incentives awarded and the medians. These entities also participated in roughly the same number of projects in NSRF and PT2020.

Table 7 *- Characterization of the participation of interfaces in projects in copromotion, supported by the ERDF in NSRF and PT2020, mainland Portugal*

	NSRF (2007-2013)	PT2020 (2014-2019)
Number of projects	246	251
Projects participation		
Average	14	13.44
Mode	3	2 / 3 / 15
Standard deviation	10.19	10.16
Min.	1	1
P10	3	2
Median (P50)	13	12
P90	30	30
Max.	37	34
Total of incentives (M €)	52,91	61,87
Average (th €)	2 300,22	2 474,94
Standard deviation (th €)	2 207,65	2 132,13
Min (th €)	100,49	92,97
P10 (th €)	192,54	162,53
Median (P50) (th €)	1 600,84	2 233,66
P90 (th €)	4 475,19	5 906,74
Max (th €)	8 264,48	6 796,88

Note: P10 stands for percentile 10 (likewise for the other statistics). Min and Max represent the minimum and the maximum, respectively.
Source: Own computations using data provided by Compete.

Table 8 reflects a tendency for more partnerships between larger firms and interfaces, with a smaller share attributed to micro firms compared to the observed values for higher education institutions. This table appears to support the argument of Freitas et al. (2013), who states that larger firms look more for institutional partnerships with intermediary organizations.

Table 8 *- Distribution of firms involved with interfaces by size, in NSRF and PT2020*

	Micro	Small	Medium	Large	TOTAL
NSRF	19 %	27 %	27 %	27 %	100 %
PT2020	17 %	26 %	32 %	25 %	100 %

Source: Own computations using data provided by Compete.

3.2.3 The composition of consortiums

As discussed above, some studies show how different partnerships affect the impacts of the subsidies (see e.g. Belderbos et al., 2004; Aschhoff & Schmidt, 2008). This subsection will dwell on the characteristics of the consortiums funded by NSRF and PT2020, providing a detailed description of their composition in terms of firms' characteristics and the participation of the different entities of the STC.

Firstly, Table 9 presents the share of projects with some particular characteristics, such as the presence of micro or large-sized firms in the consortium; the presence of an exporter firm; having multiple firms or entities from the STS in the partnership; among others.

Table 9 *- Characterization of projects by their consortiums in % of the total, for NSRF and PT2020*

	NSRF	PT2020
	% of Total	% of Total
Project with Micro Firm	33%	28%
Project with Large Firm	28%	27%
Project with an exporter firm	81%	89%
Project with firms with R&D employees	54%	53%
Project with more than 1 firm	39%	46%
Project with more than 1 entity from the STS	35%	53%
Projects with firms from more than 1 district	33%	34%

Source: Own computations using data provided by ANI merged with SCIE.

From Table 9, it is clear how in PT2020, compared to NSRF, the number of projects with both multiple firms and entities from the STS increased, especially regarding the latter. It is also possible to perceive an increase in projects with an exporter firm, with a large share of projects having the presence of at least one exporter firm, and, on the contrary, a small decrease for projects with micro firms.

Table 10 *- Characterization of partnerships including only one firm, in % of the total, by size, in NSRF and PT2020*

NSRF				
	Entities from the STS			**Total Projects**
	Interface	HEI	Other STS	
Micro	21%	73%	19%	78
Small	32%	69%	14%	118
Medium	37%	69%	11%	91
Large	40%	73%	10%	70
PT2020				
	Entities from the STS			**Total Projects**
	Interface	HEI	Other STS	
Micro	28%	85%	13%	39
Small	30%	75%	22%	93
Medium	45%	72%	19%	99
Large	40%	65%	11%	72

Source: Own computations using data provided by ANI merged with SCIE.

From the table above, regarding the projects, with just one firm within the consortium, it is noticeable how the presence of interfaces increases for larger firms. On the other hand, the higher education institutions, in PT2020, present a different trend, by being more present in projects with smaller firms. The number of projects involving just one micro firm presented a decrease of 50% from NSRF to PT2020.

Table 11 *- Characterization of partnerships with more than one firm, in % of the total, by size, in NSRF and PT2020*

NSRF								
	Firms				Entities from the STS			Total Projects
	Micro	Small	Medium	Large	Interface	HEI	Other STS	
Micro	21%	50%	34%	27%	48%	58%	14%	86
Small	27%	35%	43%	33%	51%	50%	14%	159
Medium	25%	58%	30%	32%	56%	56%	18%	118
Large	25%	57%	41%	29%	57%	53%	25%	93
PT2020								
	Firms				Entities from the STS			Total Projects
	Micro	Small	Medium	Large	Interface	HEI	Other STS	
Micro	18%	60%	52%	20%	46%	70%	22%	105
Small	39%	36%	47%	22%	45%	75%	23%	162
Medium	40%	55%	30%	27%	54%	68%	16%	139
Large	28%	48%	49%	29%	60%	65%	19%	75

Source: Own computations using data provided by ANI merged with SCIE.

Table 11, by evaluating partnerships involving more than one firm, illustrates how small firms are the most usual partner for firms of different sizes, then followed by medium companies. Concerning micro firms, their presence increased in projects with small and medium firms during PT2020, and, conversely to what was observed in Table 10, their total number of projects with multiple firms increased. Large firms, in PT2020, presented a trend of increased participation in partnerships with larger firms. For the partnerships with entities from the STS, as before, interfaces partner more with larger companies with a bigger presence of higher education institutions in the partnerships with smaller firms. These partnerships reinforce, once again, the explanation presented earlier by Freitas et al. (2013), regarding intermediary institutions and large firms.

Tables 12 and 13 will evaluate the consortiums on a firm-based analysis, by presenting some dispersion measures of the firm's characteristics within the same joint venture.

Table 12 *– Dispersion measures of characteristics of firms within the same project, in NSRF*

NSRF			
Dimension	**Firms by Project**	**Av. Ratio (Max./Min.)**	**Av. Standard Deviation**
Productivity (€)	2 Firms	2.63	59.13
	3 or 4 Firms	4.04	29.42
	5 Firms or more	6.78	21.04
Exports (€)	2 Firms	1 617.48	19 504,00*
	3 or 4 Firms	8 455.95	15 257,93*
	5 Firms or more	37 309.66	18 108,23*
Nº of workers (€)	2 Firms	47.79	258.15
	3 or 4 Firms	26.39	185.04
	5 Firms or more	107.00	186.76
Wage per Employee (€)	2 Firms	1.50	6 125.62
	3 or 4 Firms	2.21	10 955.76
	5 Firms or more	2.90	8 158.91

*Source: Own computations using data provided by ANI merged with SCIE. *Values in thousands.*

Table 13 *- Dispersion measures of characteristics of firms within the same project, in PT2020*

PT2020			
Dimension	**Firms by Project**	**Av. Ratio (Max./Min.)**	**Av. Standard Deviation**
Productivity (€)	2 Firms	2.47	27.96
	3 or 4 Firms	3.95	26.27
	5 Firms or more	9.79	23.99
Exports (€)	2 Firms	327.74	27 952.03*
	3 or 4 Firms	15 761.70	23 224.66*
	5 Firms or more	4 630.87	118 523.54*
Nº of workers (€)	2 Firms	15.34	165.90
	3 or 4 Firms	92.96	208.06
	5 Firms or more	203.87	268.54
Wage per Employee (€)	2 Firms	1.54	6 527.52
	3 or 4 Firms	2.21	7 328.65
	5 Firms or more	3.85	9 286.31

Note: P10 stands for percentile 10 (likewise for the other statistics). Min and Max represent the minimum and the maximum, respectively.

*Source: Own computations with using provided by ANI merged with SCIE. *Values in thousands.*

The two tables above analyze the consortiums created through dispersion measures, namely the ratio of the maximum over the minimum, and the standard deviation, of some variables. The goal is to understand how different were the companies that engaged in partnerships together and measure the variability of firms within the same project. What is acknowledgeable is that normally the higher the number of members in the consortium the higher will be the dispersion and differences between the

companies at the extremes, except for the productivity, where there is a trend of larger projects having more similar members in terms of productivity.

3.3 Participation and approval determinants

As acknowledged earlier, the participation in projects in copromotion is not random and varies depending on the characteristics of the firms. This subsection will present the characteristics not only for the candidate firms to copromotion projects (all the companies with approved or rejected projects) but also of candidate firms to individual projects and the characteristics of the entirety of the Portuguese business sector. After the comparison, it will be estimated how the probability of engaging in copromotion projects and having the projects approved may depend on some of those characteristics.

Table 14 reports the statistics for the first step of the analysis. It shows the characteristics of all the 3,272 firms that applied for at least one copromotion project, along with the same characteristics for the 3458 candidate firms for individual projects, and finally, for all the 269,848 firms from the Portuguese business sector in the year of 2019.

Companies that applied for R&D projects, be it individually or in copromotion are much larger than the average Portuguese firm. However, distinguishing between the two modalities, it is possible to perceive how companies that applied for copromotion projects are, on average, larger.

Table 14 *- Characteristics of all candidate firms for copromotion projects, individual projects, and of all firms from the Portuguese business sector, in the year 2019*

Firms involved in copromotion projects							
	Employees	Assets (€ th.)	Sales (€ th.)	Productivity (€ th.)	V.A. (€ th.)	Exports (€ th.)	Wage p/ Employee (€ th.)
Average	157.33	25 851,0	43 049,12	91,18	10 692,89	18 578,05	26,14
SD	501.64	197 470,02	302 473,04	1 055,09	52 926,48	158 942,36	12,72
P10	5	34,09	201,22	17,32	129,88	0	15,20
Median	41	1 266,76	4 502,70	34,48	1 717,73	741,95	23,86
P90	306	16 319,15	45 867,10	72,52	13 714,79	19 487,79	38,56
Firms involved in individual projects							
	Employees	Assets (€ th.)	Sales (€ th.)	Productivity (€ th.)	V.A. (€ th.)	Exports (€ th.)	Wage p/ Employee (€ th.)
Average	91.80	5 705,07	15 513,69	41,26	4 639,63	8 738,24	24,89
SD	232.22	23 812,46	61 396,64	35,50	17 090,86	53 198,29	11,30
P10	4	28,00	191,90	15,55	96,65	0	13,76

Median	29	741,02	2 667,19	32,98	996,83	417,27	22,68
P90	217	9 699,44	27 430,19	69,22	8 400,97	12 695,99	38,67
All firms from the Portuguese business sector							
	Employees	Assets (€ th.)	Sales (€ th.)	Productivity (€ th.)	V.A. (€ th.)	Exports (€ th.)	Wage p/ Employee (€ th.)
Average	10.59	534,68	1 316,92	30,16	336,56	283,81	14,61
SD	114.97	15 322,41	27 279,34	696,15	5 128,63	12 521,84	13,59
P10	1	0	27,67	5,94	9,64	0	6,47
Median	3	18,07	151,95	17,39	55,38	0	12,36
P90	15	411,87	1 351,02	46,85	404,65	39,72	24,22

Note: P10 stands for percentile 10 (likewise for the other statistics). Min and Max represent the minimum and the maximum, respectively. Source: Own computations using data provided by ANI merged with SCIE.

3.3.1 Characterization of the probability of firms having copromotion projects. a *probit* model analysis

The statistics presented in Table 14 suggest that copromotion applicants are larger and more productive. We will now use a limited dependent variable model to test that assessment. We will specifically use a *probit* estimator.

A *probit* model is an estimation procedure used for situations where there are only two possible outcomes, namely, $Y_i = 1$ or $Y_i = 0$. In this context, the model will estimate the probability of one of the events occurring (when $Y_i = 1$), where that probability is given by $P(Y_i = 1)$ and is calculated, by the maximum likelihood method and estimating the pseudo-R^2 (for measuring the explanatory capability of the model), through the following equation:

$$P(Y_I = 1|X_i) = F(x_i\beta) = \phi(x_i\beta) = \int_{-\infty}^{x_i\beta} \frac{1}{\sqrt{2\pi}} e^{\frac{1}{2}z^2} dt$$

where X_i is a vector that represents the independent variables that will affect the probability of $Y_i = 1$ occurring. In our case, X_i will include the firms' characteristics. In the equation, ϕ represents the normal distribution of the probability function, and it will relate the non-linear relationship between the explanatory variables and the outcome Y_i, and make sure that the estimated probability is restricted to the interval [0,1]. The parameters estimates have no direct interpretation in terms of magnitude. To quantify the relationship between the regressors and the dependent variable, we can calculate the marginal effects associated with each one of the explanatory variables through partial derivatives.

3.3.2 Case 1: Probability of applying for copromotion projects

The first model to be estimated will have $Y_i = 1$ when firm i has applied for a project in copromotion, 0 otherwise. As explanatory variables, we include the log of firm's level of productivity (measured by the average gross added value per worker), the log of the number of workers, the age of the company (it will also be included in the specification of model the age squared to assess if there are diminishing effects of firms' age) and their tangible and intangible assets, also in log. The economic activity sector and the district of the firm are also included in the model to control for sectorial and geographical specificities.[2] The second model will consider $Y_i = 1$ when firm i has an application for copromotion approved, 0 otherwise. The explanatory variables considered will be the same as for the first *probit* presented above, including, additionally, a dummy variable that will equal 1 for situations where a firm already has past experience in copromotion applications (if a company applied for a copromotion project in a prior year, it does not matter if the application was approved or rejected, it is considered that the firm has past experience, and the variable will equal 1).

The tables to be presented below will show the marginal effects of the independent variables, meaning that the values of each parameter represent the variation in the probability of an event occurring (in our case, for applying to a project in copromotion and having its application approved) for marginal variations of the regressors. In what follows, we estimate the marginal effects of firm's age at age 10 (as it is the median age of the sample of the first *probit* model) and, for the case of the past experience, the regressor presented shows the variation on the probability when the variable equals 1.

The marginal effects for 'applied for a project in copromotion', the first *probit* model, are presented in Table 15. These estimations rely on a sample of 4,043 firms that have applied for an R&D project. The application for funding could be approved or rejected in either modality (copromotion or individual), with 1,971 making up the group of companies that applied for copromotion projects. The considered candidates for individual projects are 2,898 firms with 826 having applied for both types. Each observation is considered in the year where the application was made or rejected.

[2] The statistical inference results show that their inclusion is indeed relevant to the estimation of the model.

Table 15 *– Firm probability of applying for Copromotion Projects (probit model)*

	M(1)	M(2)
Log Employment	0.155***	0.101***
	(0.020)	(0.022)
Log Productivity	0.115***	0.101***
	(0.024)	(0.026)
Age	0.006***	0.007***
	(0.002)	(0.003)
Log Intangible Assets	0.009***	0.0004
	(0.003)	(0.004)
Log Tangible Assets	-0.007	-0.012
	(0.008)	(0.009)
Observations	7145	6099
Pseudo-R^2	0.172	0.184
Log-likelihood	-4087.87	-3431.06

Notes: Robust standard errors in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. M(1) corresponds to the sample of all the 1971 firms 4043 firms that have applied for an R&D project. M(2) excludes from the sample 536 firms that had applications for both copromotion and individual projects, in the same year. The activity sector and the district are also included in the model as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

In model M(1), the estimation is for the entire sample of 4043 firms, while model M(2), as a robustness check, drops 536 observations that applied for both modalities in the same year. Looking at the estimation of the results, it is possible to conclude that companies that apply for copromotion projects are bigger, as they employ more workers, are more productive, and are older. It is possible to see through M(1) that, for companies 10% more productive, the probability of applying for a copromotion project increases by about 1.2 percentage points (p.p.), while for the employment, having 10% more employees increases that probability by 1,6 p.p.

These conclusions are sustained in both M(1) and M(2) with small variations in the coefficients. The intangible assets are an exception, being statistically significant in M(1), pointing that applicants for joint ventures have more value in intangible assets, it is statistically non-significant in M(2). The tangible assets of the firms seem to not be a determinant for the probability of a company applying for a project in copromotion.

3.3.3 Case 2: Probability of having an application for copromotion approved

The next estimation presented in Table 16 is comprised of only companies that applied for projects in copromotion, in the year of the application. We aim to explain the probability of having their project

approved depending on the characteristics of the firm. Model 1, M(1), has all the 1971 applicants, while in model 2, M(2); firms that had at least one project approved and another one rejected in the same year are not considered (a total of 216 firms).

Table 16 *– Firm probability of having an application for a project in Copromotion approved (probit model)*

	M(1)	M(2)
Log Employment	0.094***	0.066**
	(0.028)	(0.030)
Log Productivity	0.107***	0.089**
	(0.038)	(0.041)
Prior Applications	0.143**	0.012
	(0.060)	(0.064)
Age	0.003	0.006*
	(0.003)	(0.003)
Log Intangible Assets	0.008	0.005
	(0.005)	(0.006)
Log Tangible Assets	0.010	0.013
	(0.012)	(0.013)
Observations	3463	3147
Pseudo-R^2	0.155	0.168
Log-likelihood	-2027.03	-1793.12

Notes: Robust standard errors in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. M(1) corresponds to the sample of all the 1971 firms that applied for copromotion projects. M(2) excludes from the sample 216 firms that had both approved and rejected copromotion projects in the same year. The activity sector and the district are also included In the model as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

As seen before in Table 15, the number of workers and productivity appear as determinants in the approval of the projects. According to M(1), firms that have 10% more employees, as well as those that are 10% more productive, have a higher likelihood of being approved by about 1,1 p.p. and 0.9 p.p., respectively. The new variable, of having prior experience in applications for copromotion projects, has a very strong, and statistically significant at a 5% significance level, impact on the probability of having an application for a project in Copromotion approved. Prior experience is associated with a 14 p.p. increase in the chances of having their projects approved. This result is not statistically significant in M(2). The age of the company appears to only be impactful when we consider model 2, while neither the tangible nor the intangible assets affect the probabilities of having the project approved in both estimations presented in Table 16.

Summing up, the estimations presented in Table 15 confirm the expectations hinted from the statistics presented in Table 14, i.e., companies involved in projects in copromotion are larger and more productive compared to the candidate firms for individual projects. Among the first, the ones who have their projects approved are the also the larger and more productive ones, with some ambiguous effects dependent on their age and past experience with applications, supporting views of authors who believe that the management entities act according to a picking the winner's method, choosing firms with higher chances of success in their projects (Blanes & Busom, 2004; Aguiar & Gagnepain, 2007; Barajas et al., 2012).

4 Analysis of the determinants of firms' performance

The current chapter will tackle the research questions presented in the introduction, namely:

1) What are the impacts of co-promotion projects on firm performance and how do they compare to the impacts of individual projects?
2) How does the composition of the consortium affect the impacts on company performance?

Through the SCIE, it was possible to generate a rich panel dataset, from 2006 to 2019, with a total of 547,309 companies. To answer the proposed questions there are three possible approaches. It is possible to use an OLS (ordinary least squares) estimation if all the variables are observed, as it produces consistent estimates. However, for panel data, where the same individual is observed through time and, consequently, we have autocorrelation from different observations of the same individual, the OLS is not ideal, as it ignores this autocorrelation. Therefore, a Random Effects or a Fixed Effects model is preferable, as they take advantage of the longitudinal feature of our data.

Between those two approaches, the use of fixed effects is most likely preferred to a random-effects approach given the fact that, in order for a firm to participate in either a copromotion project or an individual one, it first needs to apply for it. This hints that the assignment to the treatment might not be not random, this is, there is a high chance of having unobserved heterogeneity correlated with the estimated covariates. Moreover, as shown in the *probit* regressions, even within the candidate firms, some of their characteristics influence the probability of having their projects approved by the managing entity, reinforcing the non-random odds of receiving the treatment. By using a Fixed Effects model, we are controlling for this unobserved heterogeneity and producing consistent estimates.

To fully attest that the Fixed Effects is the most efficient model to be estimated, for each research question is made a Hausman test, to verify the validity of this approach over the Random Effects. The Hausman test will assess if there is any correlation between the estimators and the error term, with the null hypothesis being that there is no correlation between them. Rejecting the null hypothesis means that the random-effects estimator is not adequate. The statistic underlying the Hausman test is defined as:

$$\omega = [b - \hat{\beta}]' [Var(b) - Var(\hat{\beta})]^{-1} [b - \widehat{\beta}] \sim \mathcal{X}^2_{(k)}$$

where k represents the number of elements in b, and, under the null hypothesis, b Is a consistent estimator and $\hat{\beta}$ Is an efficient estimator.

The models to be estimated will be in line with the following equation:

$$y_{it} = X_{it}\beta + \eta_i + \varepsilon_{i,t}$$

where y_{it} corresponds to the outcome variables we ought to measure for each firm i in period t and η_i are the time-invariant unobserved components of firm i. This term η_i can be estimated, it's a mean of all elements (observed and unobserved) that do not vary within firms and captures the unobserved heterogeneity associated with each unit under observation.

As outcome variables, we consider the average productivity per worker (calculated as before, for the estimation of the *probit* models), the total employment, and the reported volume of exports and sales. All the effects will be lagged by one year to account for a possible delay of the impact of projects in copromotion on the performance of the involved firms.

The estimation results, as well as the details on the inference, will be given in the following subsections. Firstly, it will be answered the question of which modality, between individual projects and in copromotion, presents the most advantages. Next, the final section of this chapter dwells on the evaluation of the diffusion potential within consortiums for certain characteristics of its members.

4.1 Research question 1 – Copromotion vs Individual application

Based on the assessment from the Hausman test, our preferred estimates will be the ones computed from the fixed-effects estimator. Given the structure of the autocorrelation and heteroskedasticity present in our data and econometric formulation of the model, we will report standard errors clustered at the firm level for the estimation of the determinants of having participated in a copromotion project or in an individual one. In the estimation of the first model, it will be only considered firms that applied for at least one project, within the SI I&DT. It could be for any of the modalities: copromotion or individually (it also includes companies that never carried out any R&D project but presented an application for it, even though it was rejected). Thus, it was removed from the sample all firms that never applied for any type of project regarding R&D, comprising the final sample of 4,043 companies (1,971 candidates for projects in copromotion and 2,898 applicants for individual projects).

In the first step, it will be estimated the results for the entirety of the sample, and then, it will be made four distinct estimations with each one assessing the regressors for the different firm sizes. The model is specified as follows:

$$Y_{i,t+1} = \beta_1 + \beta_2 TCoProm_{i,t} + \beta_3 TInd_{i,t} + \beta_3 TCoProm_{i,t} TInd_{i,t} + \beta_4 Tang.Assets_{i,t} + \beta_5 Intan.Assets_{i,t} + \sum_{j=6}^{7} \beta_j Z_{j,i,t} + \eta_i + \lambda_t + \varepsilon_{i,t}$$

The dependent variables represented by $Y_{i,t+1}$ are the logarithms of the average productivity per worker, of the sales and of the exporters of firm i, and also the number of workers, all in period $t+1$. The model also controls for the year, the activity sector, and the district of the firm, so it could account for a specific sector, geographical, and yearly shocks (a test for each of the three parameters prove that its inclusion is important to control for those shocks). The independent variables used are:

- $TCoProm_{i,t}$ - is a dummy variable that equals 1 in years where company i carried out a project in copromotion
- $TInd_{i,t}$ - is a dummy variable that equals 1 in years where company i carried out an individual
- $TCoProm_{i,t} TInd_{i,t}$ - represents the interaction of the previous two dummy variables and assesses the effects for firms that carried out both individual and copromotion projects in the same year.
- $Tang.Assets_{i,t}$ - is the logarithm of the value of the tangible assets of firm i in year t.[3]
- $Intan.Assets_{i,t}$ - is the logarithm of the value of the intangible assets of firm i in year t.[4]
- $Z_{j,i,t}$ – contains the effects attributed to the activity sector and the district of the firm: $ActivitySector_{i,t}$; $District_{i,t}$.
- η_i – captures the time-invariant characteristics of the firms
- λ_t– represents the effects from each period t
- $\varepsilon_{i,t}$ – represents the error term

The results for the first estimation are presented in Table 17, where the sample contains all the candidate firms for the SI ID&T. The first conclusion retrieved from Table 17 is that the projects in copromotion impact differently the various outcomes. Regarding productivity, while the undertaking of individual projects has no statistically significant effect, carrying out a copromotion project increases productivity by about 3% in the year immediately after the completion of the venture (at a significance level of 5%). Although carrying out individual projects has a positive effect, it is not statistically significant. For the employment, both types of undertakings have a positive impact, with an expected increase of 7% in employment in the year following the end of the project in either modality.

[3] Following the argument of Santos (2019), the tangible assets are used as control for the firm's productive capacity, as a proxy of its physical capital.

[4] Following the argument of Santos (2019), the intangible assets are used as control for the firm's innovative capacity, as a proxy for R&D activities).

Table 17 *- Impacts on Productivity, Employment, Exports, and Sales (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	0.029**	0.071***	0.024	0.053**
	(0.014)	(0.011)	(0.089)	(0.021)
TInd	0.013	0.074***	0.147**	0.068***
	(0.011)	(0.011)	(0.074)	(0.018)
TCoProm x TInd	-0.032	0.035	-0.014	0.019
	(0.027)	(0.023)	(0.175)	(0.038)
Intang. Assets	0.002**	0.009***	0.034***	0.011***
	(0.001)	(0.001)	(0.007)	(0.002)
Tang. Assets	0.014***	0.067***	0.165***	0.088***
	(0.003)	(0.004)	(0.020)	(0.007)
Observations	40139	40139	40139	40139
Firms	4169	4169	4169	4169

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations. using data provided by ANI merged with SCIE.

Looking at exports, the return to copromotion, although positive, is not statistically significant. For this outcome measure, the impact associated with individual projects is almost 15%. In terms of sales, the results point to a bigger impact, in the order of 2 p. p., of individual projects in comparison to joint ventures (with the firsts increasing sales by around 7% and the second being fixated at 5%, but only at a 5% significance level). Finally, carrying out individual and copromotion projects simultaneously has no evident impact on any performance measure considered in the models.

It is also important to highlight the significance that the assets have on the variation of the outcomes within companies involved in projects of the SI I&DT. Having higher productive and innovative capacities are linked to increases in the studied outcomes, except for the level of intangible assets that do not affect the productivity of the companies, at least in the year immediately following.

Next, it is presented four similar models, that make the same assessment but dividing the sample by firm size. For firms that increased or decreased in dimension along the period from 2006 to 2019, it is considered the mode of the dimension.

Table 18 *- Impacts on Productivity, Employment, Exports, and Sales for Micro Firms (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	0.090**	0.134***	0.063	0.013
	(0.042)	(0.028)	(0.238)	(0.075)
TInd	0.033	0.117***	0.087	0.072
	(0.029)	(0.024)	(0.173)	(0.049)
TCoProm x TInd	-0.169*	0.043	-1.042*	0.052
	(0.100)	(0.084)	(0.588)	(0.116)
Intang. Assets	0.004	0.009***	0.035**	0.014***
	(0.003)	(0.002)	(0.015)	(0.004)
Tang. Assets	0.013***	0.047***	0.117***	0.070***
	(0.004)	(0.004)	(0.024)	(0.009)
Observations	13288	13288	13288	13288
Firms	1780	1780	1780	1780

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

Table 19 *- Impacts on Productivity, Employment, Exports, and Sales for Small Firms (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	0.042*	0.079***	0.181	0.093***
	(0.024)	(0.018)	(0.165)	(0.029)
TInd	0.010	0.058***	0.241**	0.069***
	(0.016)	(0.014)	(0.121)	(0.023)
TCoProm x TInd	-0.020	0.064*	0.063	-0.008
	(0.046)	(0.035)	(0.333)	(0.064)
Intang. Assets	0.002*	0.007***	0.028**	0.009***
	(0.001)	(0.001)	(0.011)	(0.002)
Tang. Assets	0.024***	0.091***	0.291***	0.117***
	(0.006)	(0.008)	(0.043)	(0.013)
Observations	15145	15145	15145	15145
Firms	1390	1390	1390	1390

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

Table 20 *- Impacts on Productivity, Employment, Exports, and Sales for Medium Firms (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	0.008	0.012	-0.066	0.021
	(0.015)	(0.018)	(0.116)	(0.032)
TInd	0.009	0.025	0.023	0.033*
	(0.015)	(0.017)	(0.106)	(0.019)
TCoProm x TInd	-0.022	0.068*	0.253	0.052
	(0.033)	(0.036)	(0.194)	(0.046)
Intang. Assets	-0.0003	0.011***	0.029***	0.010***
	(0.001)	(0.002)	(0.011)	(0.003)
Tang. Assets	0.006	0.091***	0.195***	0.093***
	(0.009)	(0.021)	(0.061)	(0.023)
Observations	8749	8749	8749	8749
Firms	753	753	753	753

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

Table 21 *- Impacts on Productivity, Employment, Exports, and Sales for Large Firms (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	-0.061	0.008	-0.416**	-0.019
	(0.038)	(0.026)	(0.200)	(0.032)
TInd	-0.020	0.079**	0.047	0.066*
	(0.032)	(0.040)	(0.147)	(0.039)
TCoProm x TInd	0.082	-0.007	0.201	0.010
	(0.060)	(0.045)	(0.212)	(0.049)
Intang. Assets	0.004	0.009***	0.019	0.011***
	(0.003)	(0.003)	(0.018)	(0.004)
Tang. Assets	0.001	0.063***	-0.112	0.073***
	(0.012)	(0.019)	(0.103)	(0.022)
Observations	2957	2957	2957	2957
Firms	246	246	246	246

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

From the comparison of Tables 18 till 21, the main finding is that smaller firms (including micro and small ones) have more benefits attributed to their participation in projects in copromotion and individual

than larger firms (including medium and large companies). The same is observed for the assets, although to a lesser extent.

Micro firms are the type of company that benefits the most in terms of productivity and employment increases from participating in copromotion projects. From Table 18 one concludes that micro firms' labor productivity and employment increase by 9% and by 13%, respectively, following the participation in a co-promotion project. However, there are no significant effects regarding their exports and level of sales. For small firms, the increase in productivity and employment is lower (4% and 8% respectively). We now observe that participating in a joint venture seems to increase sales of these companies by 9%. Finally, the results do not show any significant benefit for medium and large benefits from participating in copromotion projects, with large firms even registering a decrease in the exports in the year following the project conclusion.

As previously stated, the impacts of higher productive and innovative capacity remain significant when explaining the evolution of the performance measure, but its impacts decrease the larger are the firms that we are considering. Making a distinction between modalities, in every parameter where the participation in copromotion projects is statistically significant, its impact is, normally, superior to the registered effect for participating in individual projects. The exceptions are the cases where the impact of copromotion is negative on the exports of large firms, and individual projects are not statistically significant and, in some cases, where individual projects lead to increases, and the copromotion modality is not statistically significant (which only is detected four times). Finally, copromotion projects appear to favor more smaller firms, while individual projects have more effects on larger ones in comparison. The results are in line with the literature by perceiving that, the benefits of engaging in copromotion projects are higher for smaller firms. Our results are also aligned in line with the study of Alexandre (2021) which recognizes that research joint ventures, carried out in Portugal, have bigger returns than individual undertakings, though, in our regressions that is only clear for micro and small companies. The results reported in Tables 18 to 21The tables presented before also recognize show that R&D investments are a driver of employment, therefore supporting the findings of other studies (OECD, 2010; Bellucci et al., 2016; Santos, 2019).

4.2 Research question 2 – Consortium effects on firms' performance

In the second research question, the aim is to test whether partnering with larger firms indeed provides positive externalities to smaller firms, by using a similar model, but with different independent variables.

The dependent variables will be the same: logarithms of productivity, exports, sales, and number of workers.

The independent variables include the number of partners that the firm had in that year, in order to control for possible coordination problems that could impact the final results. The way this firm's characteristic is measured is through 3 dummy variables, where the base group will be firms with active projects in copromotion with just one other partner, and the dummies will account for companies that were involved with two other entities, three or four partners and for companies that carried out projects with either five or more other entities.

To verify for possible diffusion's spillovers within the consortiums, it will be used four ratios, which measure the differences between the companies within the same projects so it can be possible to perceive how it may affect the outcomes. The ratios will measure differences in average productivity per worker, exports, number of workers, and average wage per employee (used as a proxy for the labor force qualifications). They will be calculated by dividing the values of each firm i by the maximum value of that performance measure within its partners.

Firms that participated in projects from both modalities, even though in different years are also dropped, because the focus of this estimation will be firms in joint ventures, and this way it is avoided possible lagged effects from other types of projects that could bias the results. As before, a Hausman test attested that a fixed-effects approach was preferable to random effects. It were also implemented tests for the statistical significance of control variables, namely the economic activity sector, the district, and the year, which proved that its inclusion in the model was relevant.

Firms that participated in projects from both modalities, even though in different years are also dropped, because the focus of this estimation will be firms in joint ventures, and this way it is avoided possible lagged effects from other types of projects that could bias the results. As before, a Hausman test attested that a fixed-effects approach was preferable to random effects. It was also done tests to control parameters, namely the activity sector, the district, and the year, which proved that its inclusion in the model was in fact relevant to isolating the causal effects.

Having said that, the sample used in the following estimations is composed of a total of 3785 firms, from which 2246 do not had any project approved, 968 carried out individual projects and 571 undertook copromotion projects. The model estimated is as follows:

$$Y_{i,t+1} = \beta_1 + \beta_2 TCoProm_{i,t} + \beta_3 TInd_{i,t} + \beta_3 Partners2_{i,t} + \beta_4 Partners3.4_{i,t} + \beta_3 Partners5plus_{i,t} + \sum_{j=4}^{7} \beta_j X_{j,i,t} + \sum_{j=8}^{9} \beta_j Z_{j,i,t} + \eta_i + \lambda_t + \varepsilon_{i,t}$$

where $Y_{i,t+1}$, $TCoProm_{i,t}$ and $TInd_{i,t}$ represent the same as before, however, the term of interaction between the last two is removed as, in this new sample, no company carries out different types of projects simultaneously. The newly introduced independent variables are:

- $Partners2_{i,t}$ – is a dummy variable that equals 1 if firm i partnered with 2 other entities in year t
- $Partners3.4_{i,t}$ – is a dummy variable that equals 1 if firm i partnered with 3 or 4 other entities in year t
- $Partners5plus_{i,t}$ – is a dummy variable that equals 1 if firm i partnered with 5 or more other entities in year t
- $X_{j,i,t}$ – represents the group of 4 ratios:
  $RProductivity_{i,t}$; $RExports_{i,t}$; $REmployment_{i,t}$; $RWageEmployee_{i,t}$.
- $Z_{j,i,t}$ – contains the effects attributed to the activity sector and the district of the firm:
  $ActivitySector_{i,t}$; $District_{i,t}$.
- η_i – captures the time-invariant characteristics of the firms
- λ_t– represents the effects from each period t
- $\varepsilon_{i,t}$ – represents the error term

Table 22 presents the results for the first estimation measuring the impacts of the consortiums on the outcomes variables. It appears that having fewer partners, in this case being part of the base group with just one partner, has more benefits. What we observe is all-around benefits attributed to the participation in copromotion projects that decrease for firms within projects with more than one other entity. However, it is not linear through all the estimations: regarding productivity, there are no disadvantages connected to having 3 or 4 partners or having just 2 for the export's outcomes. These results may point to the theory that more entities involved within the same project might generate coordination problems and affect the effectiveness of the research, as stated by Crespi et al. (2020). The effects on employment are independent of the number of partners, as they do not differ depending on the dimension of the project in terms of members.

Table 22 *- Consortium impacts on Productivity, Employment, Exports, and Sales (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	0.142***	0.133***	0.586**	0.289***
	(0.046)	(0.035)	(0.289)	(0.076)
TInd	0.016	0.114***	0.301***	0.119***
	(0.013)	(0.013)	(0.084)	(0.022)
Partners2	-0.142**	-0.052	-0.449	-0.318***
	(0.057)	(0.040)	(0.366)	(0.094)
Partners3.4	-0.078	-0.063	-1.004***	-0.262**
	(0.061)	(0.045)	(0.389)	(0.127)
Partners5plus	-0.135**	-0.058	-0.875***	-0.232***
	(0.053)	(0.042)	(0.331)	(0.087)
RProductivity	-0.011***	0.0004	0.002	-0.005
	(0.003)	(0.001)	(0.010)	(0.003)
RExports	-0.0000001	-0.000001**	-0.00001	-0.000002***
	(0.000001)	(0.000001)	(0.00001)	(0.000001)
REmployment	0.0001	0.00004**	-0.0003	0.0001**
	(0.0001)	(0.00002)	(0.0005)	(0.0001)
RWageEmployee	0.00002	0.0002	0.0002	-0.00003
	(0.0004)	(0.0001)	(0.001)	(0.0005)
Observations	34187	34187	34187	34187
Firms	3641	3641	3641	3641

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

From the first set of results, it appears that having fewer partners, in this case being part of the base group with just one partner, has more benefits. What we observe is all-around benefits attributed to the participation in copromotion projects that decrease for firms within projects with more than one other entity. However, it is not linear through all the estimations: regarding productivity, there are no disadvantages connected to having 3 or 4 partners or having just 2 for the export's outcomes. These results may point to the theory that more entities involved within the same project might generate coordination problems and affect the effectiveness of the research, as stated by Crespi et al. (2020). The effects on employment are independent of the number of partners, as they do not differ depending on the dimension of the project in terms of members.

Looking for the dispersion measures, we only see an impact of these differences on the average worker productivity. The results point to a decrease in the productivity gains for firms that partner with more productive companies. The minimum value for the ratios is 0, however, only for firms that do not undertake any copromotion projects. For those who are engaged in such ventures, the minimum value is 1 (when we are dividing the most productive firm of the consortium by itself), thus, when that happens, ceteris paribus, the project in copromotion increases the productivity of the company by 13% (0.142 – 0.011 x 100), however, the higher the ratio the fewer gains are expected, for instance, if a company is 3 times less productive than the most productive entity in the consortium, its expected gains are of 11%. These regressors might indicate that there is no diffusion of productive knowledge from the most productive firms to the lesser ones and that more similar companies in terms of productivity of their workers, align themselves better in this type of projects. For the rest of the measures, some of them are statistically significant, although they have no economic significance.

As before, it will now be presented an evaluation of the same consortium's effects but dividing the samples by firm size.

Table 23 *- Consortium impacts on Productivity, Employment, Exports, and Sales for Micro Firms (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	0.245**	0.287***	0.545	0.478**
	(0.105)	(0.073)	(0.436)	(0.199)
TInd	0.043	0.167***	0.325**	0.160***
	(0.032)	(0.028)	(0.166)	(0.056)
Partners2	-0.273**	-0.068	-0.962	-0.752***
	(0.132)	(0.080)	(0.613)	(0.272)
Partners3.4	-0.062	-0.146	-0.802	-0.414
	(0.153)	(0.096)	(0.732)	(0.300)
Partners5plus	-0.159	-0.180**	-0.926*	-0.461*
	(0.130)	(0.087)	(0.555)	(0.244)
RProductivity	-0.010***	-0.001	0.008	-0.006*
	(0.004)	(0.001)	(0.006)	(0.003)
RExports	-0.000004***	0.0000001	0.00001	-0.000004**
	(0.000001)	(0.000001)	(0.00002)	(0.000002)
REmployment	0.0001	0.00004*	-0.0003	0.0002**
	(0.0001)	(0.00002)	(0.0004)	(0.0001)

RWageEmployee	-0.00004	0.0003***	-0.001	0.00001
	(0.0004)	(0.0001)	(0.001)	(0.0005)
Observations	12385	12385	12385	12385
Firms	1675	1675	1675	1675

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

Table 24 *- Consortium impacts on Productivity, Employment, Exports, and Sales for Small Firms (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	0.120*	0.029	0.950*	0.036
	(0.072)	(0.055)	(0.495)	(0.128)
TInd	0.000	0.098***	0.327**	0.118***
	(0.017)	(0.018)	(0.139)	(0.028)
Partners2	-0.079	0.036	0.007	-0.048
	(0.098)	(0.061)	(0.726)	(0.116)
Partners3.4	-0.060	-0.004	-1.621**	-0.041
	(0.086)	(0.065)	(0.641)	(0.125)
Partners5plus	-0.096	0.031	-0.976*	-0.145
	(0.080)	(0.071)	(0.581)	(0.116)
RProductivity	-0.019*	0.010*	-0.055	-0.012
	(0.012)	(0.006)	(0.049)	(0.011)
RExports	-0.000000003	-0.000001	-0.00001	-0.000002***
	(0.000001)	(0.000001)	(0.00001)	(0.000001)
REmployment	0.0002	-0.002***	-0.008	-0.002
	(0.001)	(0.001)	(0.009)	(0.002)
RWageEmployee	0.022	0.019	0.170	0.140*
	(0.021)	(0.013)	(0.107)	(0.084)
Observations	12902	12902	12902	12902
Firms	1195	1195	1195	1195

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

Table 25 *- Consortium impacts on Productivity, Employment, Exports, and Sales for Medium Firms (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	0.059*	0.063	-0.452	0.189**
	(0.035)	(0.054)	(0.587)	(0.093)
TInd	0.015	0.028	0.067	0.029
	(0.020)	(0.024)	(0.137)	(0.025)
Partners2	-0.063	-0.092	0.192	-0.213**
	(0.051)	(0.064)	(0.631)	(0.099)
Partners3.4	-0.084	-0.037	0.118	-0.429
	(0.059)	(0.077)	(0.668)	(0.275)
Partners5plus	-0.088*	-0.048	-0.006	-0.138
	(0.047)	(0.064)	(0.670)	(0.101)
RProductivity	0.013	-0.023**	0.013	-0.004
	(0.008)	(0.011)	(0.060)	(0.017)
RExports	0.000003**	0.00001***	-0.00001	0.00001***
	(0.000001)	(0.000002)	(0.00001)	(0.000002)
REmployment	0.0001	-0.0004	0.0004	-0.001
	(0.002)	(0.002)	(0.009)	(0.003)
RWageEmployee	-0.008	0.026	0.117	-0.00002
	(0.014)	(0.017)	(0.142)	(0.023)
Observations	6909	6909	6909	6909
Firms	602	602	602	602

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

Table 26 *- Consortium impacts on Productivity, Employment, Exports, and Sales for Large Firms (Fixed Effects)*

	Productivity	Employment	Exports	Sales
TCoProm	-0.118	-0.075	-0.027	-0.007
	(0.239)	(0.059)	(0.265)	(0.128)
TInd	-0.000	0.129**	0.071	0.119**
	(0.033)	(0.057)	(0.202)	(0.056)
Partners2	-0.053	0.015	0.587	-0.030
	(0.294)	(0.067)	(0.659)	(0.136)
Partners3.4	0.008	-0.166	-0.731	-0.397*
	(0.270)	(0.142)	(0.628)	(0.204)
Partners5plus	-0.052	0.016	-1.220	-0.097
	(0.253)	(0.067)	(0.744)	(0.144)
RProductivity	0.004	-0.036	0.251	-0.011
	(0.032)	(0.036)	(0.177)	(0.024)
RExports	0.00003	0.00004	0.002***	-0.000004
	(0.0001)	(0.0001)	(0.0002)	(0.0001)
REmployment	-0.012	0.028	0.331*	0.007
	(0.011)	(0.017)	(0.191)	(0.012)
RWageEmployee	-0.010	0.075	-0.499	0.031
	(0.053)	(0.058)	(0.340)	(0.033)
Observations	1991	1991	1991	1991
Firms	169	169	169	169

Notes. Robust standard errors clustered at the form level in parentheses. Significance levels: *, 10%; **, 5%; ***, 1%. Each dependent variable is in logarithm. The model also includes the year, the activity sector, and the district as control variables.
Source: Own computations using data provided by ANI merged with SCIE.

By looking at Table 23 until Table 26, it is possible to notice that the composition of the consortiums impact mainly on smaller firms. As proof, the previously viewed negative impact of the productivity ratio is only statistically significant for micro and small firms (in the case of the latter, only at a 10% significance level). Even regarding the number of projects, the regressors are more significant for the smaller firms. Conversely, if we look at large firms, they in fact benefit from partnering with bigger and more exporting firms, as it leads to increases in their exportations in the year following the completion of the project.

The results lead to a conclusion that the composition of the consortium is more impactful in smaller companies (mainly in micro), as having to partner with a higher number and more capable companies in terms of performance reduces their expected gains from projects in copromotion. The larger the firm the

smaller the impact that the consortium has on the outcomes, and it may even have positive effects in terms of exportations. These findings look to be in line with the statement of Alvarez & Barney (2001), who argues that small firms are harmed in their performance by partnering with larger firms, however, the presented model only accounts for a simple diffusion measure and it would be hasty to withdraw such strong conclusion from a simplified model.

5 Concluding Remarks

This work studies the impacts of copromotion projects, funded by public subsidies, on firms' performance while also distinguishing the effects by the different firm sizes. Another addressed dimension refers to the composition and characteristics of the partnerships and how they affect the outcomes of copromotion projects. This investigation benefits from the use of a very rich dataset, comprising project and firm-level information, for the period 2006-2019, of the population of firms that has ever applied for an R&D project, be it individually or in copromotion.

The first conclusion of our empirical analysis suggests that the applicants to copromotion projects are larger than the individual applicants. Concerning the group of copromotion candidates, our estimates show that firms that have their projects approved tend to be larger and the more productive ones, corroborating the findings of Blanes & Busom (2004) and Aguiar & Gagnepain (2007).

Regarding the estimation of the impact on firms' performance, using a fixed-effects approach, the results point to positive effects of participating in copromotion projects on productivity, employment, and total sales. The analysis by firm size shows that smaller companies are the ones that benefit the most from participating in such projects, which is a finding in line with several works carried out thus far (see, e.g. Feldman & Kelley, 2003; Cannone & Ughetto, 2014; Bronzini & Iachini, 2014; Bellucci et al., 2016; Cin et al., 2017; Santos, 2019; Crespi et al., 2020). Comparing the copromotion modality with the individual one, the first is more impactful in the productivity of the firms while the latter presents more compared benefits in terms of exports and made sales. Alexandre (2021), in his study, concluded that, in Portugal, for a similar period, research joint ventures are associated with more benefits than individual projects. However, in this work, such superiority in all outcomes is only noticed for micro and small firms. The modality where companies carry out research projects alone presents more compared gains for larger firms.

Our empirical estimates also show that the composition and characteristics of consortiums are crucial for the impact on the outcomes of smaller firms, while larger ones are not so affected by the number or type of engaged partners. The results suggest that the number of members in the partnership has a negative impact on the outcomes of the copromotion project. This result may be explained by management and coordination costs associated with bigger networks, which harm the project. The possible diffusion of knowledge through the association of different sized firms is not perceived in our estimations, with even some negative effects arising, particularly in micro firms, by joining them with more productive firms. A possible explanation for these negative impacts might be related to coordination

issues, where more similar companies work together more easily than with firms that are more productive and have a very different production process. Another possible reasoning revolves around the argument of Alvarez & Barney (2001) which states that partnerships between small and large firms are not beneficial to the first. However, this issue deserves further investigation.

In fact, the results achieved in this work require further investigation as it presents several limitations. First, the models are lagged for only one period, and, as referred by Bayona-Sáez & García-Marco (2010) some projects might suffer from a period of delay before their impacts become clear in the firm performance. Hence, by only using one lag period, some effects might be overlooked. The specification of the consortiums is also very simple, as it only accounts for the number of members and some dispersion measures. The presence of exporting firms, the cooperation with specific entities from the SCT (such as intermediary organizations or higher education institutions), and the geographic location of the partners may also be relevant to explain the possible impacts on the outcomes. With that said, it is not correct to immediately conclude that partnerships between small and large firms are not optimal without further research. However, it is important to note that, as also supported by Bellucci et al. (2016), imposing partnerships between certain actors may not be the ideal approach, as trust is essential in such undertakings, mainly between small and large companies (Ring & Van de Ven, 1994; Child, 2001; Rothkegel et al., 2006). For future research, it would be interesting to deepen on the effects of the consortiums and make a more in-depth evaluation of them by using other methodologies, such as matching procedures, to better evaluate the different impacts of copromotion projects.

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