Gabinete de Estratégia e Estudos

REPÚBLICA PORTUGUESA
ECONOMIA E MAR

GEE Paper

173

Julho de 2023

R&D subsidies and Portuguese firms' performance: A longitudinal firm-level study

Inês Ferraz Teixeira | Aurora A.C. Teixeira | Luís Delfim Santos

Gabinete de Estratégia e Estudos da Economia e do Mar
Office for Strategy and Studies of Economy and Maritime Affairs
Avenida da República, n.º 79 - 1069-218 Lisboa, Portugal
www.gee.gov.pt
ISSN (online): 1647-6212

R&D subsidies and Portuguese firms' performance: A longitudinal firm-level study [1]

Inês Ferraz Teixeira[2], Aurora A.C. Teixeira[3], Luís Delfim Santos[4]

Abstract

The present study analyses the impact of subsidies to Research and Development (R&D), more specifically, the impact of QREN (Quadro de Referência Estratégico Nacional)'s Sistema de Incentivos à Investigação e Desenvolvimento Tecnológico nas Empresa (SI I&DT QREN), on the performance of firms.

A relatively wide range of studies explores the relationship between subsidies to R&D and firms' performance. Nevertheless, no consensus has been reached. Furthermore, the literature that analyses the impact of R&D subsidies in non-market-centred and moderate innovative economies like Portugal is quite scarce and limited.

The information used in this empirical study concerns the period between 2008-2017, and it was collected from the Operational Competitiveness Programme (COMPETE) included in QREN and complemented with economic and financial data gathered from the Annual System of Iberian Balances (SABI) database.

We compared the performance of firms that in 2014 succeeded in obtaining subsidies to R&D with similar firms that did not receive subsidies. Resorting to information on a set of relevant variables in the period before obtaining the subsidy (2008-2013), we established a trustable comparison group using the Propensity Score Matching (PSM). Then, based on the Average Treatment Effect on the Treated (ATT), we compared firms that received subsidies with those that did not use outcome variables of 2017 (three years after the subsidy), most notably employment, labour productivity, operational results, and exports.

Results show that firms that received a public subsidy to R&D three years after receiving the subsidy have higher employment levels and export propensity than those that did not. Notwithstanding, no statistically significant differences were encountered in terms of labour productivity or overall financial performance.

JEL Classification: C31, L25, O32

Keywords: R&D subsidies; firms' performance; propensity score matching; Portugal

Note: ***This article is sole responsibility of the authors and do not necessarily reflect the positions of GEE or the Portuguese Ministry of Economy and Maritime Affairs*.**

[1] Award-winning work by the Call for Papers on the "Impact of Science on Economy and Society in Portugal: Investment, scientific employment and knowledge enhancement", a partnership between the Office for Strategy and Studies of the Ministry of Economy and Maritime Affairs (GEE) and the Foundation for Science and Technology (FCT).

[2] Faculdade de Economia, Universidade do Porto & KU Leuven; ines.ferrazteixeira@kuleuven.be

[3] CEF.UP, Faculdade de Economia, Universidade do Porto & INESC TEC; ateixeira@fep.up.pt

[4] Faculdade de Economia, Universidade do Porto; luisd@fep.up.pt

1. Introduction

Technology development and innovation are central aspects of competitiveness and long-term growth in today's economies (Romer, 1990; Vanino et al., 2019). R&D, in particular, emerges as a key factor for the sustained long-run growth of firms and to their competitive position (Vanino et al., 2019). Indeed, as stated earlier by Schumpeter (1934), growth is the consequence of strategic efforts by firms in developing R&D projects.

R&D activities are expected to increase social benefits, which may even surpass private benefits, leading to underinvestment in a free market (Arrow, 1972). In this context, governments tend to devise policies that aim to promote R&D projects and help firms overcome difficulties that may arise (Cunningham et al., 2012). The reasoning behind an R&D policy is not only to correct the market failure mentioned by Arrow (1972) and enhance national firms' competitiveness (Kim et al., 2016). Following this line of thought, innovation-oriented economies have been implementing national and/or regional policies that are materialized in (i) direct involvement of governmental institutions or (ii) the attribution of tax and financial incentives to private businesses' R&D activities (Duch et al., 2009; Silva et al., 2017).

The discussion about the pertinence and efficacy of governmental support to R&D and technological innovation has always been a topic of controversy (Duch et al., 2009; Cunningham et al., 2012; Criscuolo et al., 2019; Vanino et al., 2019). Studies that analysed the impact of publicly funded R&D activities on firm performance are numerous and resort to both qualitative (e.g., Lenihan & Hart, 2004; PACEC, 2009) and quantitative (e.g., Karhunen & Huovari, 2015; Vanino et al., 2019) methodologies. Those that use quantitative micro economic analyses seek to assess the impact of subsidies on the performance of the granted firms (Duch et al., 2009; Karhunen & Huovari, 2015; De Balasio et al., 2015; Bellucci et al., 2016; Cin et al., 2017; Furman et al., 2017; Vanino et al., 2019; Criscuolo et al., 2019). However, their results are somewhat contradictory. Some studies (e.g., Duch et al., 2009; Karhunen & Huovari, 2015; Vanino et al., 2019) evidence the existence of a positive relationship between R&D public-funding and firms' employment and turnover growth, regardless the size and sector of the firm. While others, for example, Criscuolo et al. (2019), have found that subsidies to R&D projects impact positively employment only in small firms. Furthermore, when performance is measured by labour productivity, Karhunen & Huovari (2015) showed that in the five-year period after the subsidy is granted the effect of the subsidy on labour productivity is not significant and it is negative in the two-year period after the subsidy year. Whereas Duch et al. (2009) demonstrated that in the year of conclusion of the publicly funded R&D project the labour productivity increased. When performance is proxied by the survival of the firms, Cin et al. (2017) evidenced that R&D subsidies positively impact the survival of firms, whereas Wang et al. (2017) obtained results that showed no significant effects.

Another aspect that seems to be common among empirical evidence is that research focuses mainly on public R&D policies that take place in market-centred-economies that are considered relatively efficient. That is the case of the study made by Basit et al. (2018), which assesses the impact of R&D grants on non-technological firms of the service sector in Germany. Their results show that public R&D funds have a positive impact on marketing and organizational innovation, which in turn affects positively the performance of firms. Furthermore, most of the studies mentioned above took place in leading innovative countries such as Finland (Karhunen & Huovari, 2015) and South Korea (Cin et al., 2017), or in emerging economies such as China (Wang et al., 2017).

Even though there are plenty of studies made on this topic, less attention is paid to moderate innovative countries, such as Portugal. Although Duch et al. (2009) have studied a sample of Spanish firms – hence, have analysed a country like Portugal in terms of innovation –, the firms considered were located only in the region of Catalunya.

The present study provides a comprehensive analysis of the effects of public R&D support on the performance of Portuguese firms. Furthermore, it analyses both the Services and Manufacturing sectors, all the extent of Portuguese territory. To do so, we compare firms' performance across different sectors, regions, and industries. Secondly, we use longitudinal data on firm performance and subsidy attribution so that we can evaluate the relationship between participating in R&D funded programmes and the firm's growth in the short term.

This paper addresses two research questions: 1) What are the determinants for a firm to receive a public subsidy to R&D?; and 2) Do R&D subsidies positively impact the performance of the recipient firms?

More specifically, we concentrate our efforts on understanding the extent to which subsidies to R&D projects – in particular, the SI I&DT[5] QREN – have impacted the performance of firms. Using a PSM technique (Duch et al., 2009; Vanino et al., 2019), we assess performance differences between subsidized firms and a matched comparing group of firms that have not been granted a subsidy, based on their probability of being a participant in such programmes. Thus, the treatment effect of public R&D subsidies and the governance of such funds is estimated through the comparison of their performance before and after the project participation. Our study considers factors such as the size, age, past performance, past productivity, human and physical capital in order to consider the effect of firm heterogeneity on the self-selection of firms into publicly supported R&D activities.

This paper is structured as follows. After this Introduction, Section 2 comprises the relevant literature on the topic. Section 3 gives an overview of the methodology adopted and disclosures information about the dataset. Section 4 presents and discusses the empirical results. Finally, in Conclusions the main contributions of the present study are summarised, and the policy implications, limitations and paths for future research are discussed.

[5] SI I&DT – Sistema de Incentivos à Investigação e Desenvolvimento Tecnológico, henceforth "R&TD – QREN".

2. Literature Review

2.1 Why is R&D public policy important?

The argument behind public intervention asserts that social returns to R&D activities are greater than private returns making market allocation of these resources sub-optimal (Arrow, 1972; Dutch et al., 2009). Economic theory highlights the inefficiency of markets as the main supporting argument for public funding of research projects (Duch et al., 2009). The literature gives emphasis to two market failures: imperfect appropriability of knowledge and capital market limitations (Silva et al., 2017).

The first market failure mentioned refers to the fact that knowledge – the main output of R&D projects – possesses the nature of a public good, which leads private R&D spending to be lower than the socially optimal level (Arrow, 1972). The positive externalities that emerge cause knowledge to be appropriated not only by whom has created it (firms which incur in costs to produce it) but also by other firms (who have not invested at all) (Arrow, 1972; Silva et al., 2017). As a consequence, it is expected that companies underinvest in R&D because they cannot utterly appropriate its results and, so, fully benefit from its profits – under these circumstances, private R&D will systematically be lower than the socially optimal level (Arrow, 1972). Empirical studies have demonstrated that social returns to R&D activities are higher than private ones, in the presence of positive externalities (Griliches, 1991; Jones & Williams, 1998; Elder & Fagerber, 2017).

Nonetheless, there is legal protection for firms that invest in R&D, preventing research outputs from becoming common, for example, through the emission of patents (Basit et al., 2018). This instrument guarantees that, by a given period of time, the firm owns the right to use exclusively the knowledge created. Indeed, patents serve as a reward to innovating firms and, obviously, encourage potential innovators to allocate resources to R&D. The trade-off between the benefit of more R&D and the cost associated with temporary monopoly power is pointed as the optimal choice for a patent length (Duch et al., 2009). Literature justifies the existence of legal protection arguing that the welfare loss of long patents is not significant compared to the social cost of choosing to short a patent (Nordhaus, 1969). Nevertheless, Arrow (1972) defends that legal protection cannot completely convert intangible knowledge into an excludable and entirely appropriable good. In addition, preventing the diffusion of knowledge reduces the efficiency and the quantity of R&D projects, once knowledge concerns both: the output of research and the input for future studies (Arrow, 1972). This argument is also supported by Gallini & Wright (1990) and Matutes et al. (1996), whose studies have concluded that expanding the period of a patent slows down the rate of introduction of innovations and restricts the diffusion of new findings.

The second market failure mentioned – capital market limitations – is originated by the difference between the private rate of return and the cost of external capital (Silva et al., 2017). Whenever firms do not have enough financial autonomy to perform R&D activities, they can fund them through external capital. However, asymmetric information on the predicted outcome and sunk costs in R&D investment undermine the access to external funding. Even though researchers have much more information about the potential success of the R&D process than investors, typically, they are reluctant to provide details about it, because they fear external appropriability of their work (Hall, 2002). Moreover, the intangible nature of knowledge makes it difficult to serve as a collateral to secure a loan (Zúñiga-Vicente et al., 2014). This is in line with the Real Options Theory which states that investment and uncertainty are negatively related, the higher the uncertainty, the higher the risk (and the cost of capital), hence, uncertainty influences economic agents to decrease investment in fixed capital (Pindyck, 1991).

Despite the emergence of venture capital formation and other forms of early-stage capital as a solution for the absence of external funding of R&D activities, some limitations still come to light. In some cases, minimum investment is required and, if too high, it might be problematic for SME (small and medium enterprises) and start-ups (Silva et al., 2017).

To conclude, the main premise behind the rationale for Public R&D Policies relies on the presence of market failures, with most scholars arguing that solely private initiatives would not meet the desirable social level of R&D activities.

2.2 R&D policy instruments

Government R&D policy instruments are often in the form of direct public funding of firms R&D (e.g., subsidies or public procurement) and tax credits.

Using subsidies, government can select projects with higher expected social rates of return. However, due to information asymmetries, it might be difficult for public agencies to recognize which R&D projects will impact more positively social returns and which ones of these are less likely to be developed only by private initiatives (Socorro, 2007). In this perspective, the risk that public funding will crowd-out private expenditures in R&D is considerable (David et al., 2000). For this reason, the allocation of public funding is of maximum importance. When badly allocated, subsidies may end up discouraging private investment in R&D activities. Indeed, the crowding out effect is probably the major concern associated to this policy instrument. Plenty of authors make an allusion on this issue, as is the case of David et al. (2000) and Dai & Cheng (2015). They defend that a firm's own R&D spending in innovation may be partially or utterly crowd out by government subsidies. In the same vein, several empirical studies have shown that private R&D investment and public funding may have a substitutive or complementary relationship (Guellec & Van Pottelsberghe De La Potterie, 2003). Furthermore, even if used in projects likely to generate high social return, government funds may be inefficiently allocated into irrelevant activities, for instance, raising wages, acquiring unnecessary machines or hiring needless employees (David et al., 2000).

In addition, existing empirical literature suggests that a potential selection bias in the public funds allocation is a real issue (David et al., 2000). As politicians might be more concerned with maximizing their political goals than in potentialize economic efficiency, resources might be misused (Bergström, 2000). Hence, public funds may end up financing R&D activities that result in higher private returns and, so, crowding out private investment in R&D (David et al., 2000). In this perspective, subsidies can turn out to be the most inefficient and costly policy (Fischer & Newell, 2008).

Besides direct funding, tax incentives are also a means to boost private financed R&D activities. Whereas subsidies increase the private marginal rate of return of R&D investment, tax incentives decrease the marginal cost of R&D (David et al., 2000), thus, there is not a priori a crowding out effect (Hall & Van Reenen, 2000). Furthermore, tax incentives have the advantage of being more impartial in terms of the nature of firms that benefit from it. Moreover, the projects and the amount of R&D expenditure is determined by private firms (David et al., 2000). Consequently, tax incentives are an option that minimizes the discriminatory selection of public agencies. Nonetheless, this advantage can be considered a weakness, in the sense that it is socially desirable to direct R&D towards research with high spillover effects. This is unlikely to occur since private firms tend to use tax credits to first finance projects with the highest rate of return, which are not necessarily the ones with highest social return (Hall, 1993). Another limitation of this policy instrument, which may constitute an argument against authors who believe tax credits diminishes biased selection, is that once only firms with profits can benefit from it, start-ups and small business might not have access to it (Silva et al., 2017). Therefore, tax credit does not appear to be the most effective tool for the correction of the capital market failure (Guellec & Van Pottelsberghe De La Potterie, 2003).

In conclusion, operationalising the R&D policy is a hard task and it is crucial to access whether its instruments are being efficiently allocated.

2.3 The determinants of the attribution of a R&D subsidy

A central topic of investigation that arises is the allocation process of public R&D funds. The main question is whether there is a potential selection bias or whether the grants are attributed randomly. There are some studies that highlight some key determinants of the participation in a R&D subsidy programme, including firm’s size, number of qualified workers, past experience in participating in R&D programmes, firms’ property structure, exports intensity and the technology intensity of the sector where the firm operates.

According to the literature, one of the most significant variables is the size of the firm. Frequently, larger firms tend do have a higher probability of receiving a subsidy (Herrera & Nieto, 2008). On one hand, larger firms typically have a R&D department or laboratory, which enables them to develop more robust R&D projects that are in line with the requirements of the public agencies. On the other hand, it might be harder for smaller firms to apply to such subsidy programmes since they usually have fragile R&D management capacity (Herrera &

Nieto, 2008). Though, Busom (2000) has found that smaller firms may be more prone to receive a subsidy once public agencies may want to support them in the first place due to their limited access to credit.

Another factor that seems to positively influence the propensity to receive a subsidy is the firms' percentage of qualified employees (Blanes & Busom, 2004). Indeed, literature shows that the more qualified workers a firm has, the more likely it is for the firm to see its absorptive capacity grow. Thus, it is expected that a larger share of qualified employees will contribute positively for the creation of more profitable and disruptive R&D studies (Aschhoff, 2010). Therefore, when making an application for a public R&D subsidy, presenting as critical resources for the project highly qualified workers increases the chances of the firm to get the project approved.

Some authors, such as Aschhoff (2010), argue that having received a R&D subsidy in the past may impact positively the chance of being subsidized again. In line with the thought that past experience in R&D may be determinant for receiving a subsidy, some authors use the firm's age as a proxy of its experience (e.g., González et al., 2005).

Property structure is another variable that has been pointed out by scholars as a feature that influences the probability of being attributed a subsidy. For instance, Duch et al. (2009) have presented empirical evidence for the fact that if a shareholder owns more than 25% of the total number of a firm's shares, then the chance of it receiving a subsidy increases. Also, most studies show that foreign ownership reduces the propensity to receive a subsidy, whereas some degree of public ownership increases it (e.g. Herrera & Nieto, 2008).

Export intensity, capital and intermediate inputs of production of the firms were also found to positively affect the probability of receiving a subsidy (e.g. Duch et al., 2009; Aschhoff, 2010).

The intensity of R&D activities differs across industries for the fact that each is exposed to different technological opportunities and to different expectations of demand growth (Silva et al., 2017). In this view, many studies try to control for sector or industry differences on the awarding of a subsidy. In fact, industry characteristics influence the public agencies decision on the attribution of a grant, once they may want to enhance R&D activities in specific fields or industries (Busom, 2000). It is important to mentioned that studies' conclusions on this matter vary according to sample used. Nonetheless, there seems to be moderate evidence that low-technology industries have lower odds of receiving a R&D subsidy when compared to high-technology ones (Busom, 2000; Herrera & Nieto, 2008).

2.4 Mechanisms through which R&D subsidies policy impacts on firms' performance

The present study intends to assess the effects of R&D public policies on the performance of firms. We use as a basis-root for our study the efficient resource-based management performance theories (see Figure 1): Firm Growth Theory (Penrose, 1959); Resource Based

View (Barney, 1991); the Dynamic Capabilities (Teece et al., 1997), and Institution-Based View (Peng, 2002).

2.4.1 Firm Growth Theory

The Firm Growth Theory (FGT) was developed by Penrose (1959). According to it, a firm comprises a group of resources that can be combined in such different ways that originate creative and original products/services. In their turn, such distinctive products/services make the firm unique and foster the different productive and performance opportunities it possesses (Burvill et al., 2018). The ongoing creation of new resources enables a firm to increase its activity, and this can only be accomplished if new knowledge is continually generated (Nason & Wiklund, 2018). FGT asserts that firms' economic value is a consequence of both the creative combination and usage of resources and the action of human capital involved in the productive process. Indeed, the latter is the factor responsible for the promotion of a dynamic atmosphere which stimulates the formation of productive opportunities and the rise of firm's innovation and growth (Coad & Guenther, 2014). Moreover, for a firm to develop successful R&D activities, it must possess specialized human resources and, simultaneously, a highly coordinated organization capable of receiving new knowledge (Savino et al., 2017).

Another important aspect is the continuous maintenance of firms' competences and knowledge to protect their competitive advantages (Lockett et al., 2011). Patent licensing is a mean through which a firm may defend its intellectual property and eliminate competition. Nonetheless, intellectual property measures are only effective for a determined period of time, thus, this advantage is likely to be lost at a certain point (Burvill et al., 2018).

Therefore, to protect and maximize competitive advantage a firm must continuously develop activities intended to innovate and renew the economic value of its resources. In this sense, we can infer that efforts made upon R&D projects might be the first step to be taken, since there are strong evidence on the positive relationship between the generation of new knowledge and the creation of innovation in both high and low intensive R&D/technological firms (Love & Roper, 2015). Here is where R&D policies assume an important role by providing financial support or fiscal tax burden relief to firms which invest in such risky activities. In fact, the existence of R&D policies is supported by the assumption that R&D developed within firms, stimulates (directly or indirectly) innovation resulting in the production of new products, services and/or processes (Cunningham et al., 2012) – see Figure 1.

2.4.2 Resource Based View (RBV)

The Resource Based View (RBV), developed by Barney (1991), constitutes an extension of Penrose's theory. It considers firms to be a group of tangible and intangible resources which, depending on how they are managed, may originate strengths or weaknesses (Schellenberg et al., 2018). In other words, a firm's resources are the origin of its competitive advantage and, consequently, are responsible for performance growth. However, this is only true if the resources are valuable, rare, inimitable, and non-substitutable (Ratten & Tajeddini, 2017). While value and rarity of resources enable firms to create new economic value, inimitability and non-substitutability allow the firm to retain profits related to such resources and prevent the erosion of its market power overtime (Nason & Wiklund, 2018). For instance, Burvil et al. (2018) stresses the importance of the firm's human capital's competences as a resource to create new knowledge, which will ultimately lead to a sustained increase of the firm's profit and performance by strengthening its competitive advantage.

Considering the cost of R&D activities as well as the uncertainty associated with its outcome, R&D policies emerge as propellant of such projects. Often, receiving public support is decisive for a firm to engage in R&D. Indeed, public R&D supported firms see their liquidity and their financial slack increasing, which helps them to surpass innovation risk and encourages them to undertake uncertain R&D projects (Zona, 2012) – see Figure 1.

2.4.3 Dynamic Capabilities

The Dynamic Capabilities theory (Teece et al., 1997) claims that firms develop learning processes that adapt to the market changes and emphasizes the key role of innovation in the creation of competitive advantage (Teece, 2017). The fundamental idea underlying this view is that the efficient combination of existing firm-specific capabilities (competences and resources) and their development, deployment and protection, can be a source of advantage in a fast-changing environment. Indeed, through the development of management capabilities and difficult-to-imitate combinations of organizational, functional, and technological skills, firms capture entrepreneurial rents by promoting the rise of competitive advantages (Teece et al., 1997).

Accordingly, this approach supports the importance of R&D activities since those are the basis of product and process development, intellectual property, technology transfer and human resource and organizational learning. In this sense, R&D activities constitute a competitive factor for the firms because they originate the knowledge that serves as a basis for innovations and differentiation (Love & Roper, 2015). Therefore, the higher the investment in such activities, the greater the chances of accessing and absorbing knowledge (Love & Roper, 2105). However, considering knowledge characteristics (Section 2.1.), the resulting externalities make R&D activities less appealing for firms. In such circumstances, R&D policies play a crucial role in addressing underinvestment in R&D by private business (Arrow, 1972) – see Figure 1.

2.4.4 Institution Based View

With the realization that institutions are more than just background conditions, the Institution Based View (IBV) has arisen and was mostly developed by Peng (2002). Several authors have attempted to define the term institution, for instance, Douglas North (1990, p. 3) defined it as "the humanly devised constraints that structure human interaction", and W.

Richard Scott (1995, p. 33) viewed this concept as "regulative, normative, and cognitive structures and activities that provide stability and meaning to social behavior". The same author defends that the main function of institutions is to reduce uncertainty and offer significance by establishing the boundaries of what is legitimate and set the norms of behaviour.

IBV treats institutions as independent variables and considers strategic choices to be an outcome of the dynamic interaction between institutions and organizations (Peng, 2002). According to Jarzabkowski (2008), managers are confronted with formal and informal constraints imposed by certain institutional frameworks. Consequently, their strategic choices are driven by such restrictions and not only by industry conditions and firm capabilities. Therefore, IBV argues that even when a firm cannot defeat competition by cost or differentiation it can still do so by the means of nonmarket political intervention (Oliver & Holzinger, 2008).

The case of Japanese pharmaceutical industry is a good example of how impactful the institutional framework may be to managers' and industries' behaviour (Peng et a., 2009). The success of innovative Japanese electronics and automobile products have made Japanese firms to be considered innovative worldwide. However, there is not any Japanese pharmaceutical firm among the world-class innovative pharmaceutical firms (Peng et al., 2009). The reason for that is institutional (Peng et al., 2009). According to Mahlich (2010), the Japanese health care system does not incentive the launch of innovative new medicines, since it does not reward firms for such accomplishment. Even though the government negotiates medicines' prices with firms, once fixed, it is not allowed to rise prices during the shelf life of the product. Therefore, if the prices are stable and, simultaneously, economies of scale decrease production costs, then the highest profits come from old medicines and not new ones (Peng et al., 2009). Hence, Japanese pharmaceutical firms have little benefit in investing in R&D (Peng et al., 2009). This is a good illustration of how policies to R&D may influence firm's disposition to undertake R&D activities. In an institutional context where favourable conditions for the development of R&D are secured, managers feel encouraged to engage in such activities (Cunningham et al., 2012).

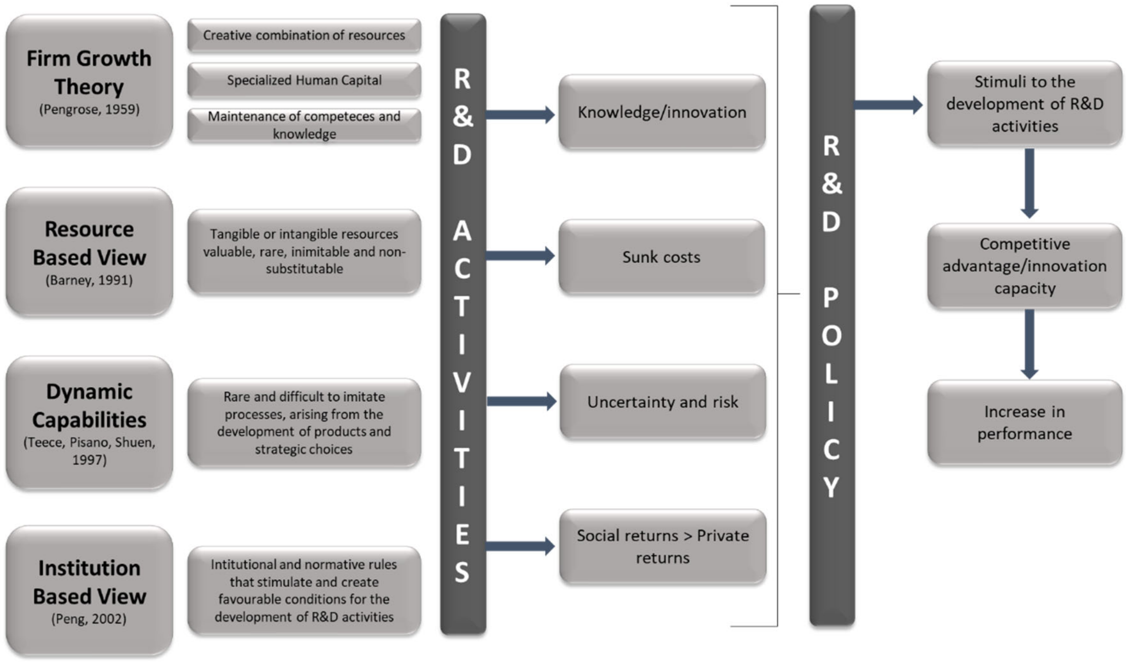

Figure 1: Theoretical Framework

Source: Own elaboration.

Most scholars agree that firms' innovation performance can improve thanks to governmental incentives on R&D – see Figure 1. Along this study, we have identified the most relevant arguments that support this thesis. First, these incentives enhance the engagement in R&D and potential innovation outputs by reducing the firms' costs on the development of such activities (Fischer & Newell, 2008). Secondly, government funds (tax credits or subsidies) may promote firms' additional R&D investments (Koga, 2003; Kobayashi, 2014). Thirdly, technological opportunities and projects with high risk might not be developed by firms if they did not have access and help from the innovation policy programmes (Guellec & Van Pottelsberghe De La Potterie, 2003). Additionally, firms that benefit from this innovation policy instruments are perceived as high-quality and competitive firms and, obviously, this is reflected on their investments, their access to credit and their partnerships. Consequently, this positive signalling stimulates and creates favourable conditions for even more innovations to be generated (Zhang & Guan, 2018).

2.4.5 Empirical evidence on the impact of R&D policy on firms' performance

There is an extensive literature that points innovation as a fundamental element for the dynamic competition of markets (Love & Roper, 2015) and for the performance and survival of firms (Savino et al., 2017). As a matter of fact, innovative firms present, on average, greater levels of growth, efficiency and profits when compared to non-innovative ones (Love & Roper, 2105). This might be a result of the firm's increased market value and, thus, competitive advantages (Savino et al., 2017).

In general, the range of studies on this topic (see Table 1) has identified a positive role of R&D policies on firms' employment growth (e.g., Karhunen & Huovari, 2015; Criscuolo et al., 2019; Vanino et al.,2019), value added (e.g., Duch et al., 2009), exports (e.g., Cunningham et al., 2012) and access to external capital (e.g., Meuleman & De Maeseneire, 2012). In fact, PACEC (2009) reported 6000-9000 net additional jobs in firms which have participated in the SMART programme. Furthermore, Almus & Czarnitzki (2003) indicate that firms that received public funds may hire R&D staff, which in turn raises their levels of employment.

Literature on the additionally effect of R&D direct support (Cunningham et al., 2012) also identifies the growth of value added as a measure of the impact of R&D subsidies on the firm's financial performance (Duch et.al, 2009). According to the previous author, on average, firms that receive subsidies show a faster value-added growth rate.

Additionally, according to Cunningham et al. (2012), the intensity of exports of a firm is positively related with the reception of R&D funds. The rationale for public R&D support is also associated with the competitive edge of firms operating in international markets which are pressured to increase exports and, hence, increase activities and jobs. In the same vein, there is empirical evidence that shows R&D publicly financed firms present higher levels of exports when compared to similar firms which have not been given any grant (Duch et al., 2009).

Some scholars have also studied the effect of R&D subsidies on the access to external capital and have discovered that, in some cases, it transmits a positive signal to the markets. Indeed, firms that are granted with subsidies are seen as better-quality firms and this image mitigates the effect of product market uncertainty (Czarnitzki & Toole, 2007). As shown by Meuleman & De Maeseneire (2012), in Belgium, R&D subsidies attribution influences positively the access of firms to long term-debt. Likewise, the work of Feldman & Kelley (2006) suggests that venture capital formation for US firms participating in the Advanced Technology Program were enhanced by R&D public grants. Regarding the relationship between R&D grants and firms' productivity, results are not clear cut, with some studies finding no productivity increase (e.g., Karhunen & Huovari, 2015).

Although empirical evidence mainly supports that R&D policies increase the overall performance of firms, it is also important to underline that some researchers have found that there is a risk of distortion of the organizations' drive to participate in R&D projects, resulting in a misallocation of resources to activities that are not market oriented neither socially desirable (Guellec & Van Pottelsberghe De La Potterie, 2003; Kung et al., 2016). Moreover, there is a time gap between the reception of subsidies and firm's R&D spending (Guellec & Van Pottelsberghe De La Potterie, 2003) that might compromise the firm's strategy.

Table 1: Synthesis of the studies that evaluates the impact of R&D subsidies on firms' performance

Authors	Country of Study	Type of subsidy	Sample period	Methodology	Measures of performance	Estimated Effects
Vanino, Roper & Becker (2019)	United Kingdom	Publicly-funded research Councils	2006-2016	Propensity score matching approach	Employment	+++
					Turnover	+++
Duch, Montolio & Mediavilla (2009)	Spain	R&D Subsidies in Catalunya	2000-2002	Propensity score matching approach	Value-added	+++
Karhunen & Huovari (2015)	Finland	Fund to support R&D to SMEs	2002-2012	Combined matching and difference-in differences	Labour productivity	Effect in 5 years: 0 Effect in 2 years: -
					Employment	+++
Belluci, Pennachio & Zazzaro (2016)	Italy	Regional research and innovation subsidies for collaborative research projects between SMEs and universities	2003-2012	Difference-in-differences propensity score matching	Firm' sales	0
					Firm's profitability (return on equity)	Short-term: - Medium-term: +
Cin, Kim, & Vonortas (2017)	Korea	Government R&D subsidy programme	2000-2007	Difference-in-differences	Survival	+++
Wang, Li & Furman (2017)	China	Innofund programme (grant applications for R&D publicly funded projects)	2005-2010	Linear probability models Regression discontinuity design	Firm survival (by 2015)	0
					Equity investment received from venture capital or private equity firm by 2015	0
Criscuolo, Martin & Overman (2019)	United Kingdom	Regional selective assistance programme (RSA)	1997-2004	Firm level regressions (OLS, reduced form, first stage, instrumental variables)	Employment (manufacturing in logs)	+++ (small firms only)
					Capital investment (in logs)	+++
					Output (in logs)	+++
					Total factor productivity (in logs)	0
De Blasio, Fantino & Pellegrini (2015)	Italy	Fund for technological innovation, funding projects of R&D	2001-2007	Regression continuity design	Sales (in logs)	0
					Financial conditions	0
					Assets	++
					Return on assets	0

Meuleman & De Maeseneire (2012)	Belgium	Belgium, IWT - Flanders' SME Innovation Programme	1995-2004	Econometric analysis of IWT supported	External financing events	++
Almus & Czarnitzki (2003)	Germany	R&D Subsidies in East Germany	1994-1998	Econometric analysis (non-parametric matching technique)	R&D spending	++
Czarnitzki & Toole (2007)	Germany	Germany, no particular programme	1994-2000	Econometric analysis	Product market uncertainty	+++
Guellec & Van Pottelsberghe De La Potterie (2003)	17 OCDE countries	No particular programme	1983-1996	Econometric analysis	Private R&D expenditure	+++
Feldman & Kelley (2006)	United States of America	U.S. Advanced Technology Program at NIST	1998	Multivariate logit regression applied to data collected through a survey	New funding	++
PACEC (2009)	United Kingdom	Grant for R&D/SMART	1998-2008	Survey and interviews	Gross value added	++
					Employment	++
Savino, Petruzzeli & Albino (2017)	Several	Various R&D Subsidies Programmes	-	Review of empirical evidence	-	-
Cunningham, Gok & Laredo (2012)	Several	Various R&D Subsidies Programmes	-	Compendium of Evidence on the Effectiveness of Innovation Policy Intervention	-	-

Legend: +, ++ and +++ indicate positive and statistical significance at 90, 95 and 99 percent levels, respectively. – indicates negative and statistical significance at 90 percent level.
Source: Own elaboration.

3. Methodology considerations

3.1 Describing the Propensity Score Matching (PSM) technique and the econometric specification to be estimated

As mentioned in our earlier review of literature, receiving funds for a research project is very likely to be influenced by selection bias and endogenous factors which may affect allocation decisions and self-selection of firms into such programmes (Vanino et al., 2019). In this context, the referred experimental design is generally not a reasonable approach to be adopted when aiming at evaluating public programmes.

In order to surpass the selection bias, both Duch et al. (2009) and Vanino et al. (2019) have used in their studies an alternative method, the Propensity Score Matching (PSM) technique which makes possible the comparison of two groups of firms: those that have received public subsidy (treated firms), and those which did not (non-treated firms). The PSM technique creates an appropriate control group of non-treated firms, which is as similar as possible to the treated group, based on the probability of receiving a subsidy. After, through the Average Treatment effect on the Treated (ATT) model, the authors assess the differences in performance before and after the subsidy attribution. In other words, they estimate the differences in the outcome variables between treated and non-treated firms over the period in study.

We follow a similar method as these authors. Hence, we construct a control group that shows an ex-ante equal probability of being publicly funded in such a way that both treated and non-treated firms can be considered as if they had been randomly assigned.

Following Duch et al. (2009), and assuming receiving a subsidy as being the treatment effect, we define the main impact to be analysed as the expected effect of treatment for the treated population:

$$ATT = E\,(Y1 - Y0 \mid S=1) = E\,(Y1|S=1) - E\,(Y0 \mid S=1) \qquad [1]$$

where, Y1 is the outcome for firms which receive public subsidy and Y0 is the outcome for firms not exposed to the treatment. And, Si $\in \{0,1\}$ represents the participation of each firm (S=1 for treated firms, S=0 for non-treated firms).

In accordance with what we have referred earlier, receiving a public subsidy cannot be considered a random event and, thus, E (Y0 |S=1) is not observable and must be estimated since it represents the outcome that firms would experience whether they had not participated in the programme. To do so, we need to construct a control group that considers, as an alternative, the effect of no treatment on the outcome of similar firms that have not been subsidized (Vanino et al., 2019). In this sense, we apply the propensity score matching and we obtain a counterfactual sample of firms (the control group) by pairing each recipient firm with a non-treated one. It is important to highlight that, as stated by Rubin (1977), conditional independence between outcomes for non-recipient and treated firms is a necessary assumption, given that some characteristics (X) are observable. Accordingly, the control group contemplates firms which have not participate in the public programme and whose distribution of observed characteristics is as identical as possible to the ones of participating firms. This implies:

$$0 < \Pr(S=1 | X=\kappa) < 1 \qquad \text{for } \kappa \in X \qquad [2]$$

and assures that all treated firms have a counterpart in the control group.

If the vector X is highly dimensional, as is in this case, we may face an implementation problem. As a possible solution for this arising problem is the use of a scalar function that defines the probability of receiving treatment conditional on covariates (Rosenbaum & Rubin, 1983). This probability p(X) represents the propensity score (PS). Following this, the ATT is estimated by the matching method as:

$$ATT = E\{E[Y1 | S=1, p(X)] - E(Y0|S=0, p(X)| S=1)\} \qquad [3]$$

In this vein, equation [3] is a derivation of equation [1] which considers the requirement of having an adequate balancing of pre-treatment variables. Fulfilling this hypothesis will provide observations with the same PS that have the same distribution of observable characteristics independently of their treatment status (Duch et al., 2009).

Given the pre-treatment characteristics, the PS is defined as the conditional probability of receiving a subsidy. Thereby we estimate a probit model with the covariates estimation:

$$\Pr\{S=1|X\} = \Phi\{h(X)\} \qquad [4]$$

where Φ is the normal function and h(X) is an initial specification which includes all the covariates as linear terms.

After defining PS, we procced by matching the non-treated and treated observations given their estimated propensity score using Nearest Neighbour estimator (NNM). We build the match for each treated firm as a weighted average over the outcomes of non-participants, given that the weights depend on the distances between the computed PS. From this, we know that the weight is higher, as higher is the propensity similarity between firms. Then, we are finally able to estimate the average treatment of treated firms using Eq. [1].

Nonetheless, recent literature on propensity score matching technique highlights the existence of an alternative and "improved" model to estimate the average treatment effect on treated firms, the ATET. The main advantage of this alternative model is that it takes into consideration that propensity scores are estimated rather than known when calculating the standard errors[6]. In addition, while ATT model executes a simple nearest-neighbour matching with one neighbour, ATET model matches with all ties if there exist multiple observations with the same propensity score. Due to both the advantages mentioned and the addition of a Z-statistic, p-value and 95% confidence interval instead of just T-statistics on the outcome of

[6] SSCC – social science computing cooperative (Propensity score Matching in STATA using teffects), in https://www.ssc.wisc.edu/sscc/pubs/stata_psmatch.htm, last accessed on May 2023.

ATET model, we will perform it as well to assess the differences in the results obtained. The equation that defines this model is like equation [1]:

$$ATET = E\{E[Y1|\ S=1, p(X)] - E(Y0|S=0, p(X)|\ S=1)\} \quad [5]$$

Following the recommendation of Stuart (2010), and for the purpose of the ATT and ATET estimates, we considered the 5 nearest neighbours instead of considering only the nearest neighbour.

In respect to the dependent variable selected (performance), we consider four proxies: (i) labour productivity, (ii) number of employees, (iii) export activity, and (iv) firm's overall financial performance as reflected by the EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization). We then assess the evolution of each proxy between the years (t-5) and (t+3), that is the five-year period before receiving the subsidy and the three-year period after the subsidized project has been concluded. For that, we assume that specific effects for the firm and specific effects for the sector are fixed in the growth equation, hence, we do not represent them as a change variable.

In order to regulate the specific effects at the firm level, that is firm size and initial levels of competitiveness and positioning in the market, we take into account, besides the variable subsidy (a binary variable which assumes the value 1 if the firm received the R&D subsidy in 2014 and 0 otherwise), the average values (2008-2013) of a set of variables, most notably age, physical capital, human capital, R&D regional (NUTS III) intensity.

3.2 Data description

To estimate the impact of R&D subsidy programmes in the performance of firms, we have considered a sample of Portuguese firms which have had their projects approved under the so-called IS R&TD Individual Projects and IS R&TD Co-promotion Projects from the Operational Programme COMPETE QREN in 2014. We have chosen this year because it was the only year with projects approved after the economic crisis and TROIKA intervention in Portugal. Moreover, it permitted to have a three-year period after the subsidy and thus a reasonable time span for assessing the impact of the R&D subsidy.

The Operational Programme COMPETE is composed by three typologies of investment incentives – IS R&TD, IS SME Qualification and IS Innovation. We focus our analysis on the IS R&TD programme, in particular, the IS R&TD Individual Projects and IS R&TD Co-promotion Project. The main objective of this incentive is to increase firms' investment in Research and Innovation (R&I), in line with priority areas of research and innovation strategy for smart specialization, reinforcing the link between firms and entities of the R&I system and promoting the economic growth of knowledge-intensive activities and innovation-based value creation (POFC, 2015).

According to the COMPETE's Execution Report of 2014 (POFC, 2015)[7] IS R&TD Individual and Co-promotion Projects accounted 86% of the total incentive approved under this segment of COMPETE Programme.

Figure 2 depicts the framework of the Portuguese Incentive System in the period 2007-2014.

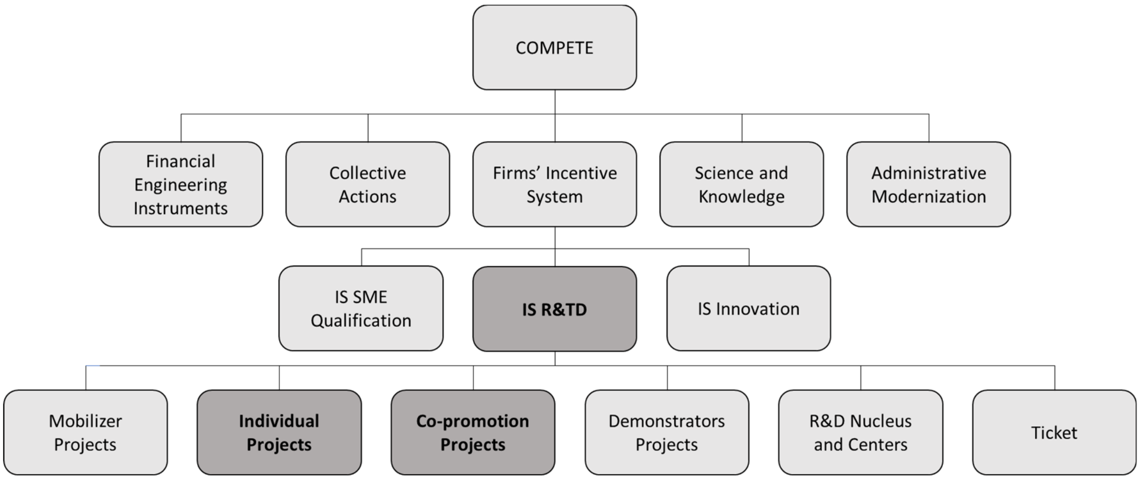

Figure 2: COMPETE QREN Programme framework

Source: Own elaboration based on information extracted from COMPETE QREN's website.

At COMPETE's website[8] we can find the list of all projects approved between 2007-2014. We selected the all the projects approved in 2014, that is, 108 projects from 104 different firms. The activities sectors with more projects approved in 2014 were "Consulting and computer programming and related activities" (EAC 62) and "Manufacture of metal products, except machinery and equipment" (EAC 25), presenting a relative weight of, respectively 18.3% and 8.7%.

Table 2: Sample distribution per activity sector

EAC (REV3)	Economic Activity Classification	Nº of firms	%
10	Food industries	5	4.8%
13	Textile manufacturing	7	6.7%
14	Garment industry	1	0.9%
15	Leather industry and leather products	3	2.9%
16	Wood and cork industries and their works, except furniture; manufacture of basketwork and straw	2	1.9%
20	Manufacture of chemicals and man-made fibers, except pharmaceuticals	5	4.8%
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	1	0.9%
22	Manufacture of rubber and plastic products	3	2.9%
23	Manufacture of other non-metallic mineral products	7	6.7%

7 http://www.pofc.qren.pt/compete/monitorizacao-e-avaliacao/relatorios-de-execucao/compete/entity/relatorio-de-execucao-compete--2014?fromlist=1, accessed in May 2023.

8 http://www.pofc.qren.pt, accessed in September 2019.

24	Basic metallurgical industries	1	0.9%
25	Manufacture of metal products, except machinery and equipment	9	8.7%
26	Manufacture of computer and communication equipment and electronic and optical products	5	4.8%
27	Manufacture of electrical equipment	1	0.9%
28	Manufacture of machinery and equipment n.e.c.	5	4.8%
29	Manufacture of motor vehicles, trailers, semi-trailers and motor vehicle components	7	6.7%
30	Manufacture of other transport equipment	2	1.9%
32	Other manufacturing industries	2	1.9%
33	Repair, maintenance and installation of machinery and equipment	1	0.9%
42	Civil Engineering	2	1.9%
58	Publishing activities	2	1.9%
62	Consulting and computer programming and related activities	19	18.3%
71	Architectural, engineering and related technical activities; testing and technical analysis activities	9	8.7%
72	Scientific research and development	3	2.9%
74	Other consultancy, scientific, technical and similar activities	1	0.9%
82	Administrative and support service activities provided to firms	1	0.9%

Source: Own elaboration.

Regarding the geographical distribution of the approved projects, 55% of the projects were presented by firms located in the North Region, 29% from Central Region, 15% from Metropolitan Lisbon Region and 1% from Alentejo Region (see Figure 3). Algarve Region did not register any approved project in the reference period.

Figure 3: Control group distribution per NUTS II regions

Source: Own elaboration.

Additionally, we built a control group. To do so, we considered the following criteria: i) firms that have not yet received any public financial support to R&D; and ii) firms operating in the same economic activity categories as the firms included in the treatment group.

We applied a proportion of 5 non-treated firms to each treated firm. We followed the procedure adopted by Duch et al. (2009), which makes our control sample more reliable and, hence, our estimation more robust. Thus, the control group includes 506 firms.

We proceeded with the construction of our database by extracting the relevant explanatory variables from the Annual System of Iberian Balances (SABI) database.[9]

We used data from two points in time i) before the subsidy: we considered the average of each variable five years before the subsidy was approved (i.e., the average of the variables for the period 2008 - 2013); and ii) after the subsidy: 2017, the most recent year with available data.

Table 3 presents the list of variables considered in the analysis.

Since we were not able to obtain all the relevant data for the treated firms, our treatment group is composed by 99 firms, meaning that we were able to cover 95% of all the firms that have had an approved project in 2014. The full database includes 605 observations, 16% of which are firms that received an R&D subsidy in 2014.

[9] SABI is a database website which displays financial end economic information on Iberian firms, in https://sabi.bvdinfo.com/, last accessed in November 2019.

Table 3: Descriptive statistics

Variables	Type	Definition	Unit	2008-2013				2017			
				Mean	Min	Max	Standard deviation	Mean	Min	Max	Standard deviation
S	Binary	1 if the firm has received a subsidy to R&D in 2014, and 0 otherwise	-	0.163	0	1	0.370	-	-	-	
Prod_L	Continuous	Labour Productivity (value added/number of employees)	Thousands of euros	36.4	105.6	839.2	46.6	41.6	-623.5	905.1	63.3
L	Continuous	Number of employees	Units	144.9	0	6481	351.6	168.8	1	2660	293.5
Exp	Binary	1 if the firm exports, and 0 otherwise	-	0.809	0	1	0.392	0.809	0	1	0.393
Fin	Continuous	Overall financial performance - EBITDA	Thousands of euros	1826.1	26045.1	107110.6	6285.9	3335.5	6181.9	175221.9	11768.3
VA	Continuous	Value Added	Thousands of euros	5399.8	4351.7	253200.1	14059.3	7629.1	-1941.4	179201.5	17008.1
K	Continuous	Physical Capital	Thousands of euros	5768.7	0	230783.6	18445.8	6888.2	0	181482.7	18052.5
HC	Continuous	Human capital - Average cost per employee	Thousands of euros	22.0	0	122.3	13.0	23.1	0	102.4	13.8
Age	Continuous	Firm's age in 2014	Units	22.2	0	149	17.0	-	-	-	
RD_I	Continuous	R&D regional intensity NUTS III (R&D regional expenditure/GDP)	Thousands of euros	0.144	0.019	0.766	0.160	0.142	0.018	0.835	0.151
ht_manuf	Binary	1 if the firm operates in a highly intensive technology manufacturing firm, and 0 otherwise	-	0.076	0	1	0.265	-	-	-	
hk_serv	Binary	1 if it the firm operates in an intensive knowledge services industry, and 0 otherwise	-	0.317	0	1	0.465	-	-	-	

Source: Own computations based on COMPETE and SABI.

Table 4 shows the differences in the evolution of treated and non-treated firms over the studied period. Treated firms are, on average, larger than untreated firms. The value added and overall financial performance, are, on average, lower in the case of non-treated firms. Treated firms are more likely to operate in international markets, that is, present higher export propensity. In contrast, labour productivity in 2017 was, on average, higher for firms which have not participated in the incentive programme. Moreover, this variable has, on average, increased for non-treated firms, whereas it has decreased in treated firms.

Furthermore, publicly funded firms tend to be slightly older than non-recipient ones and are, on average, located in regions with higher R&D intensity. Finally, firms receiving a R&D subsidy are more likely to belong to a highly technology intensive manufacturing sector.

Table 4: Descriptive statistics treated firms vs non-treated firms

Variable	2008-2013		2017		2008-2013		2017	
	Treated firms				Non-treated firms			
	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
S	99	1	99	1	506	0	506	0
Prod_L (average 2008-2013)	99	38.5	99	37.7	506	36.1	506	42.4
L (average 2008-2013)	99	255.9	99	251.2	506	123.2	506	152.7
Exp	99	0.9	-	-	-	-	506	0.8
Fin (average 2008-2013)	99	3909.8	99	4501.3	506	1418.4	506	3107.4
VA (average 2008-2013)	99	10632.2	99	11623.1	506	4376.1	506	6847.7
K (average 2008-2013)	99	9645.1	99	10708.6	506	5010.3	506	6140.7
HC (average 2008-2013)	99	24.2	99	26.9	506	21.5	506	22.4
Age	99	25.9	-	-	506	21.4	-	-
RD_I	99	0.160	99	0.149	506	0.100	506	0.100
ht_man	99	0.100	-	-	506	0.080	-	-
hk_serv	99	0.300	-	-	506	0.300	-	-

Source: Own computations based on COMPETE and SABI.

4. Empirical Analysis

4.1 Determinants for receiving a public subsidy to R&D

In this section we estimate the Propensity Score Matching (PSM) to answer our first research question, "What are the determinants for a firm to receive a public subsidy to R&D?".

Following the previous described methodological procedures, we use a bivariate probit model to estimate the PSM to investigate the variables that determine the propensity to be granted a public subsidy to R&D (see Table 5).

Table 5: Propensity Score Matching considering the 5 nearest neighbours, Probit regression (dependent variable: 1 if the firm received the R&D subsidy and 0 otherwise)

	Outcome variables			
	Labour Productivity (2017)	No. of employees (2017)	Exports (2017)	Financial performance (2017)
Age	-0.0092 (0.0095)	-0.0092 (0.0095)	-0.0082 (0.0091)	-0.0092 (0.0095)
Age^2	0.0002 (0.0001)	0.0002 (0.0001)	0.0002 (0.0001)	0.0001 (0.0001)
K (average 2008-2013)	0.00003 (0.00003)	0.00003 (0.0001)	0.00003 (0.00003)	0.00003 (0.00003)
Prod_L (average 2008-2013)	-0.0005 (0.0019)	-0.0005 (0.0019)	-0.0013 (0.0018)	-0.0005 (0.0019)
HC (average 2008-2013)	0.0056 (0.0060)	0.0056 (0.0060)	0.0111** (0.0055)	0.0056 (0.0060)
RD_I	0.3457 (0.3972)	0.3457 (0.3972)	0.3910 (0.3917)	0.3457 (0.3972)
Exp	0.6297*** (0.2187)	0.6297*** (0.2187)	-	0.6297*** (0.2187)
ht_man	0.0809 (0.2423)	0.0809 (0.2423)	0.0007 (0.2406)	0.0809 (0.2423)
hk_serv	0.1877 (0.1827)	0.1877 (0.1827)	-0.0577 (0.1603)	0.1877 (0.1827)
No. of observations	605	605	605	605
LR chi2	23.47 (0.005)	23.47 (0.005)	14.55 (0.069)	23.47 (0.005)

Legend: ***, **, * indicate statistical significance at 1%, 5% and 10% levels, respectively. Grey cells identify statistically significant estimates.
Source: Own computations based on data gathered from COMPETE and SABI.

In this model we include as explanatory variables the age, square of the age, past average (2008-2013) physical capital, past average (2008-2013) labour productivity, past average (2008-2013) cost per employee as proxy for human capital, regional R&D intensity, and sector dummies (high technology manufacturing and knowledge intensive service). An export dummy was also included in the specifications for 2017 labour productivity, employment and financial performance.

Considering the explanatory variables, we use the age of the firm as a proxy to organizational capacity and experience and the square of age to verify if the propensity to receive a public subsidy to R&D increases with the age of the firm up to a certain point and afterwards decreases. However, their effect is found to be small and not very significant.

The same conclusion applies to other structure and market-related variables, such as the average labour productivity, cost per employee, and physical capital, as well as the regional R&D intensity (measured by the ratio of regional R&D expenditure in the total GDP). These findings are not in line with usual studies on this topic, as is the case of Herrera & Nieto (2008) which report that high-technology industries have better chances of receiving a subsidy, or the case of Dutch et al. (2009) which point past experience (measured by the age of the firm) statistically significant on the propensity to receive a subsidy to R&D in Spain.

In all the models, excluding the one using the 2017 exports as the outcome, the only variable emerging as statistically significant to explain the firm's propensity to receive a public subsidy to R&D is the export activity. This indicates that firms which operate in an external competition context are more likely to be publicly funded so that their internal and external competitiveness is reinforced. This is in line with the results reported by Duch et al. (2009). In the 2017 export outcome specification, human capital (proxy by the average wage cost per employee) is positive and significant. This conveys the idea that a firm that is endowed with high levels of human capital is most likely to receive an R&D public subsidy.

4.2 The impact of R&D public subsidies on firms' performance

To answer the second research question, "Do R&D subsidies impact positively the performance of the recipient firms?", we apply the Average Treatment on Treated firms. Specifically, we run this model for the four proxies of performance (outcome variable) we have defined: (i) labour productivity, (ii) number of employees, (iii) export activity, and (iv) overall financial performance.

Table 6 presents the results of the ATT model obtained for each outcome variable, using the standard tool for propensity score matching in Stata 14, the psmatch2 command. In view of the results presented in Table 6, we conclude that receiving a subsidy did not significantly impact on the 2017 labour productivity or overall financial performance of the recipient firms when matching them with a comparable control group of non-recipient firms. Notwithstanding, the estimations suggest that both for the unmatched and matched samples, firms that received a R&D subsidy in 2014 observed higher dynamics in terms of employment and exports.

Although empirical literature typically reports a positive effect of public R&D subsidy on the performance of the recipient firms, there are some studies that are in line with our results. For instance, Karhunen & Huovari (2015) measured performance by labour productivity in a sample of Finnish firms and concluded that in the five-year period after the subsidy the effect of the subsidy on firms' labour productivity was not significant, being negative in the two-year period after the subsidy was granted. Also, Criscuolo et al. (2019) found no significant effect of R&D grants in the total factor productivity. Moreover, other scholars such as Láredo et al. (2016) and Mohnen et al. (2017) have highlight that the cause-effect relationship between R&D policy and its impacts in terms of productivity and employment are uncertain.

Table 6: Average Treatment Effect on the Treated (ATT)

Variable	Sample	Treated	Controls	Difference	S.E.(*)	T-stat
Prod_L	Unmatched	37.750	42.355	-4.606	6.964	-0.66
	ATT	37.750	48.256	-10.507	8.518	-1.23
L	Unmatched	251.171	152.729	98.442	32.034	3.07
	ATT	251.171	181.189	69.982	48.035	1.46
Exp	Unmatched	0.919	0.789	0.131	0.043	3.05
	ATT	0.919	0.844	0.075	0.037	2.00
Fin	Unmatched	4501.263	3107.415	1393.847	1293.123	1.08
	ATT	4501.263	3751.087	750.176	1400.187	0.54

Notes: These estimations resort to the standard tool for propensity score matching in Stata 14, the psmatch2 command (*) S.E. does not consider that the propensity score is estimated. Grey cells identify statistically significant estimates.

Even when we estimate the average treatment on treated firms using the teffects psmatch command (see Table 7), the results reached are similar to the above. Indeed, the firms which received subsidies presented, three years after receiving the subsidy, a higher level of employment and a greater propensity to export; however, in terms of labour productivity and financial results no significant differences between R&D subsidy recipient and non-recipient firms emerge. Again, these results are partially in line with the literature. Several empirical studies report that R&D subsidies enhance employment and exports (see Duch et al., 2009; PACEC, 2009; Karhunen & Huovari, 2015; Criscuolo et al., 2019; Vanino et al., 2019) and have no significant impact on labour productivity (cf. Karhunen & Huovari, 2015) and financial conditions (De Blasio et al., 2015).

Table 7: Treatment-effects estimation (PSM, probit), Average Treatment on Treated (ATET)

Variable	Coef.	AI Robust Std. Error	z	P>|z|	[95% Conf. Interval]	
Prod_L	-10.507	7.560	-1.39	0.165	-25.323	4.310
L	69.981	31.964	2.19	0.029	7.332	132.631
Exp	0.075	0.362	2.06	0.039	0.004	0.146
Fin	750.176	1134.601	0.66	0.508	-1473.601	2973.954

Note: These estimations resort to the *teffects psmatch* command in Stata 14. Grey cells identify statistically significant estimates.
Source: Own computations based on data gathered from COMPETE and SABI.

5. Conclusion

In last three decades the role of R&D in economic performance has become a hot topic in policy makers' agenda and economic debates. This study aimed to contribute for this discussion by attempting to respond to the following research questions: 1) What are the determinants for a firm to receive a public subsidy to R&D?; and 2) Do public R&D subsidies impact positively the performance of the recipient firms?.

Our research approach differs from existent empirical literature because, even though there are plenty of studies about this topic, less attention is paid to moderate innovative countries, such as Portugal. Indeed, developing effective R&D policies is a demanding task, which requires a deep understanding of the context, namely the national R&D system into which the firms operate.

The present study used longitudinal firm-level data from Portugal to analyse the impact of public R&D subsidies on the performance of firms. To do so, we have compared firms' performance across different sectors, regions and industries. In concrete, we have analysed firms' performance differences between publicly funded R&D and non-subsidized firms in the period after and before the fund's allocation. For that we have used PSM technique to construct a trustable comparison group which consists in a matched sample of firms that present the same propensity to receive a public subsidy to R&D. Then, we applied Average Treatment Effect model to assess the firms' performance before and after the project execution. Thus, we were able not only to identify the determinants for receiving a public subsidy to R&D, but also to estimate the casual effect of subsidies to R&D on the performance of the granted firms.

Based on data from 605 firms over the period 2008-2017, our results indicate that firms that export and have higher human capital endowments are more likely to be attributed a public subsidy to R&D. Furthermore, the results suggest that subsidies to R&D positively affect firms' performance in terms of employment and export activity which is in line with some relevant empirical literature (e.g., Duch et al., 2009; PACEC, 2009; Karhunen & Huovari, 2015; Criscuolo et al., 2019; Vanino et al., 2019). With respect to labour productivity and overall financial conditions, no significant differences emerged between treated and non-treated firms, as reported by Karhunen & Huovari (2015) and De Blasio et al. (2015).

Our results have some important implications. Policy makers should withdraw from our research that the societal effects of R&D subsidies on productivity growth and jobs creation are not granted (Larédo et al., 2016; Mohnen et al., 2017). Although they show a positive relationship between employment growth and propensity to export, financial conditions and labour productivity presented no significant improvement at least in the short run (three-year window). Evidently, a correct choice of policy instruments requires a deep understanding of the systemic bottlenecks that prevent their success, ranging from lack of interaction between business and I&I institutions, inadequate skills/ capabilities, or uncertainty about future demand (Elder & Fagerberg, 2017). In this sense, our results emphasise the importance of knowing deeply the national R&D context of a country when developing an effective R&D policy (Elder & Fagerberg, 2017). Notwithstanding, the positive and significant short run impact of public subsidies on firms' exports entails promising medium-long run impacts on innovation and productivity of firms. Indeed, some recent studies (e.g., Love & Roper, 2015; Petković et al., 2023) suggest that firms' export activity tend to raise their productivity and innovation performance. Therefore, Portuguese public policy authorities should persevere with active public policies aiming to support and foster firms' R&D activities even if their effects are not visible over the short term.

Even though our results are corroborated by other empirical studies, our analysis presents limitations that should be noted. First, while it is true that PSM can solve potential common support problems, it cannot completely isolate unobservable factors that influence grant allocation and post-grant performances. Second, the estimations obtained with this methodology are, naturally, dependent on the treated and control groups. Therefore, if the sample included in the analysis is not representative of the entire population, there is a risk of a potential biased estimation of the overall economic effect. Third, the temporal horizon being studied might not be sufficient to assess the real effect of public R&D subsidies on the performance of firms. Due to unavailability of more recent data, we have considered a lag of three years between the attribution of subsidy and its estimated impact. However, it is possible that its turnover effect regarding labour productivity and the overall financial conditions will only take place in a future period. Fourth, we have only analysed one instrument of R&D policy, which may not be representative of the impact of R&D policy on firms' performance in Portugal.

Following the limitations of our study, there are several lines of further research that can be carried out to improve and complement our analysis. To control for unobservable firm specific effects, making several periodical observations in the same firm (e.g., before, during and after receiving a subsidy for participants) might be a possible solution. Also, it could be advantageous to consider other type of variables, particularly those connected to firm's organizational characteristics, strategy, and markets. Lastly, studying another policy instrument that aims to enhance Portuguese R&D system would also be very interesting and relevant to provide a better picture of the results of the Portuguese R&D policy.

References

Almus, M., & Czarnitzki, D. (2003). The effects of public R&D subsidies on firms' innovation activities: the case of Eastern Germany. Journal of Business & Economic Statistics, 21(2), 226-236.

Arrow, K. J. (1972). Economic welfare and the allocation of resources for invention. In Readings in Industrial Economics (pp. 219-236). London: Palgrave.

Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99-120.

Basit, S. A., Kuhn, T., & Ahmed, M. (2018). The effect of government subsidy on non-technological innovation and firm performance in the service sector: Evidence from Germany. Business Systems Research Journal, 9(1), 118-137.

Bellucci, A., Pennacchio, L., & Zazzaro, A. (2016). Public subsidies for SME research and development: Empirical evaluation of collaborative versus individual place-based programs (No. 133). Money and Finance Research group (Mo. Fi. R.)-Univ. Politecnica Marche-Dept. Economic and Social Sciences.

Bergström, F. (2000). Capital subsidies and the performance of firms. Small Business Economics, 14(3), 183-193.

Blanes, J. V., & Busom, I. (2004). Who participates in R&D subsidy programs?: The case of Spanish manufacturing firms. Research Policy, 33(10), 1459-1476.

Burvill, S. M., Jones-Evans, D., & Rowlands, H. (2018). Reconceptualising the principles of Penrose's (1959) theory and the resource based view of the firm. Journal of Small Business and Enterprise Development, 25 (6), 930-959.

Busom, I. (2000). An empirical evaluation of the effects of R&D subsidies. Economics of Innovation and New Technology, 9(2), 111-148.

Cin, B. C., Kim, Y. J., & Vonortas, N. S. (2017). The impact of public R&D subsidy on small firm productivity: evidence from Korean SMEs. Small Business Economics, 48(2), 345-360.

Coad, A., & Guenther, C. (2014). Processes of firm growth and diversification: theory and evidence. Small Business Economics, 43(4), 857–871.

Criscuolo, C., Martin, R., Overman, H. G., & Van Reenen, J. (2019). Some causal effects of an industrial policy. American Economic Review, 109(1), 48-85.

Cunningham, P., Gök, A., & Laredo, P. (2012). Impact of Direct Support to R&D and Innovation in Firms. Part of the Compendium of Evidence on the Effectiveness of Innovation Policy Intervention, NESTA. (Compendium of Evidence on the Effectiveness of Innovation Policy Intervention, NESTA.). London: Nesta.

Czarnitzki, D., & Toole, A. A. (2007). Business R&D and the interplay of R&D subsidies and product market uncertainty. Review of Industrial Organization, 31(3), 169-181.

David, P. A., Hall, B. H., & Toole, A. A. (2000). Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. Research Policy, 29(4), 497-529.

De Blasio, G., Fantino, D., & Pellegrini, G. (2015). Evaluating the impact of innovation incentives: evidence from an unexpected shortage of funds. Industrial and Corporate Change, 24(6), 1285-1314.

Duch, N., Montolio, D., & Mediavilla, M. (2009). Evaluating the impact of public subsidies on a firm's performance: a two-stage quasi-experimental approach. Investigaciones Regionales-Journal of Regional Research, (16), 143-165.

Feldman, M. P., & Kelley, M. R. (2006). The ex ante assessment of knowledge spillovers: Government R&D policy, economic incentives and private firm behavior. Research Policy, 35(10), 1509-1521.

Fischer, C., & Newell, R. G. (2008). Environmental and technology policies for climate mitigation. Journal of Environmental Economics and Management, 55(2), 142-162.

Gallini, N. T., & Wright, B. D. (1990). Technology transfer under asymmetric information. The RAND Journal of Economics, 147-160.

González, X., Jaumandreu, J., & Pazó, C. (2005). Barriers to innovation and subsidy effectiveness. RAND Journal of Economics, 930-950.

Griliches, Z. (1991). The search for R&D spillovers, NBER Working Papers 3768, National Bureau of Economic Research, Inc.

Guellec, D., & Van Pottelsberghe De La Potterie, B. (2003). The impact of public R&D expenditure on business R&D. Economics of Innovation and New Technology, 12(3), 225-243.

Hall, B. H. (1993). R&D tax policy during the 1980s: success or failure? Tax Policy and the Economy, 7, 1-35.

Hall, B. H. (2002). The financing of research and development. Oxford Review of Economic Policy, 18(1), 35-51.

Hall, B., & Van Reenen, J. (2000). How effective are fiscal incentives for R&D? A review of the evidence. Research Policy, 29(4), 449-469.

Herrera, L., & Nieto, M. (2008). The national innovation policy effect according to firm location. Technovation, 28(8), 540-550.

Jarzabkowski, P. (2008). Shaping strategy as a structuration process. Academy of Management Journal, 51(4), 621-650.

Jones, C. I., & Williams, J. C. (1998). Measuring the social return to R&D. The Quarterly Journal of Economics, 113(4), 1119-1135.

Karhunen, H., & Huovari, J. (2015). R&D subsidies and productivity in SMEs. Small Business Economics, 45(4), 805-823.

Kim, S. J., Kim, E. M., Suh, Y., & Zheng, Z. (2016). The effect of service innovation on R&D activities and government support systems: the moderating role of government support systems in Korea, Journal of Open Innovation: Technology, Market, and Complexity, 2(5), 1-13.

Kobayashi, Y. (2014). Effect of R&D tax credits for SMEs in Japan: a microeconometric analysis focused on liquidity constraints. Small Business Economics, 42(2), 311-327.

Koga, T. (2003). Firm size and R&D tax incentives. Technovation, 23(7), 643-648.

Kung, C. C., Zhang, L., & Kong, F. (2016). How government subsidy leads to sustainable bioenergy development. Technological Forecasting and Social Change, 112, 275-284.

Larédo, P., Köhler, C., & Rammer, C. (2016). The impact of fiscal incentives for R & D. In Handbook of Innovation Policy Impact. Edward Elgar Publishing.

Lenihan, H., & Hart, M. (2004). The use of counterfactual scenarios as a means to assess policy deadweight: an Irish case study. Environment and planning C: government and policy, 22(6), 817-839.

Lockett, A., Wiklund, J., Per Davidsson, P. & Girma, S. (2011). Organic and acquisitive growth: re-examining, testing and extending Penrose's growth theory. Journal of Management Studies, 48(1), 48-74.

Love, J. H., & Roper, S. (2015). SME innovation, exporting and growth: A review of existing evidence. International Small Business Journal: Researching Entrepreneurship, 33(1), 28-48.

Mahlich, J. C. (2010). Patents and performance in the Japanese pharmaceutical industry: An institution-based view. Asia Pacific Journal of Management, 27(1), 99-113.

Matutes, C., Regibeau, P., & Rockett, K. (1996). Optimal patent design and the diffusion of innovations. The RAND Journal of Economics, 27(1), 60-83.

Meuleman, M., & De Maeseneire, W. (2012). Do R&D subsidies affect SMEs' access to external financing? Research Policy, 41(3), 580-591.

Mohnen, P., Vankan, A., & Verspagen, B. (2017). Evaluating the innovation box tax policy instrument in the Netherlands, 2007–13. Oxford Review of Economic Policy, 33(1), 141-156.

Nason, R. S., & Wiklund, J. (2018). An Assessment of Resource-Based Theorizing on Firm Growth and Suggestions for the Future. Journal of Management, 44(1), 32-60.

Nordhaus, W. D. (1969). Invention, Growth, and Welfare. A Theoretical Treatment of Technological Change, Cambridge: The MIT Press.

North, D. C. (1990). Institutions, Institutional Change and Economic Performance. UK: Cambridge University Press.

Oliver, C., & Holzinger, I. (2008). The effectiveness of strategic political management: A dynamic capabilities framework. Academy of Management Review, 33(2), 496-520.

PACEC, 2009. Evaluation of Grant for Research and Development & Smart. DIUS/LDA URN 09/1059, London.

Peng, M. W. (2002). Towards an Institution-Based View of Business Strategy. Asia Pacific Journal of Management, 19(2-3), 251–267.

Peng, M. W., Sun, S. L., Pinkham, B., & Chen, H. (2009). The institution-based view as a third leg for a strategy tripod. Academy of Management Perspectives, 23(3), 63-81.

Penrose, E. T. (1959). The growth of the firm—a case study: the Hercules Powder Firm. Business History Review, 34(1), 1-23.

Petković, S.; Rastoka, J.; Radicic, D. (2023). Impact of Innovation and Exports on Productivity: Are There Complementary Effects? Sustainability, 15, 7174

Pindyck, R. S. (1991). Irreversibility, uncertainty, and investment, Journal of Economic Literature, 29, 1110-1148.

Ratten, V., & Tajeddini, K. (2017). Innovativeness in family firms: an internationalization approach. Review of International Business and Strategy, 27(2), 217-230.

Romer, P. M. (1990). Endogenous technological change. Journal of political Economy, 98(5), Part 2), S71-S102.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. Biometrika, 70(1), 41-55.

Savino, T., Petruzzelli, A. M., & Albino, V. (2017). Search and Recombination Process to Innovate: A Review of the Empirical Evidence and a Research Agenda. International Journal of Management Reviews, 19(1), 54-75.

Schellenberg, M., Harker, M. J., & Jafari, A. (2018). International market entry mode–a systematic literature review. Journal of Strategic Marketing, 26(7), 601-627.

Schumpeter, J. A. (1934). The Theory of Economic Development. Cambridge, MA: Harvard University Press.

Scott, W. R. (1995). Institutions and Organizations. Thousand Oaks, CA: Sage.

Silva, A.M., Silva, S.T., Carneiro, A. (2017). Determinants of grant decisions in R&D subsidy programmes: Evidence from firms and S & T organisations in Portugal, Science and Public Policy, 44 (5), 683-697.

Socorro, M. P. (2007). Optimal technology policy under asymmetric information in a research joint venture. Journal of Economic Behavior & Organization, 62(1), 76-97.

Teece, D. J. (2017). Towards a capability theory of (innovating) firms: implications for management and policy. Cambridge Journal of Economics, 41(3), 693-720.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. Strategic Management Journal, 18(7), 509-533.

Vanino, E., Roper, S., & Becker, B. (2019). Knowledge to money: Assessing the business performance effects of publicly-funded R&D grants. Research Policy, 48(7), 1714-1737.

Wang, Y., Li, J., & Furman, J. L. (2017). Firm performance and state innovation funding: Evidence from China's Innofund program. Research Policy, 46(6), 1142-1161.

Zhang, J., & Guan, J. (2018). The time-varying impacts of government incentives on innovation. Technological Forecasting and Social Change, 135, 132-144.

Zona, F. (2012). Corporate investing as a response to economic downturn: Prospect theory, the behavioural agency model and the role of financial slack. British Journal of Management, 23, S42-S57.

Zúñiga-Vicente, J. Á., Alonso-Borrego, C., Forcadell, F. J., & Galán, J. I. (2014). Assessing the effect of public subsidies on firm R&D investment: a survey. Journal of Economic Surveys, 28(1), 36-67.

GEE Papers

28: Análise comparativa de sobrevivência empresarial: o caso da região Norte de Portugal
Elsa Sarmento | Alcina Nunes

29: Business creation in Portugal: Comparison between the World Bank data and Quadros de Pessoal
Elsa Sarmento | Alcina Nunes

30: The Ease of Doing Business Index as a tool for Investment location decisions
João Zambujal Oliveira | Ricardo Pinheiro Alves

31: The Politics of Growth: Can Lobbying Raise Growth and Welfare?
Paulo Júlio

32: The choice of transport technology in the presence of exports and FDI
José Pedro Ponte | Armando Garcia Pires

33: Tax Competition in an Expanding European Union
Ronald Davies | Johannes Voget

34: The usefulness of State trade missions for the internationalization of firms: an econometric analysis
Ana Paula Africano | Aurora Teixeira | André Caiado

35: The role of subsidies for exports: Evidence from Portuguese manufacturing firms
Armando Silva

36: Criação de empresas em Portugal e Espanha: análise comparativa com base nos dados do Banco Mundial
Elsa Sarmento | Alcina Nunes

37: Economic performance and international trade engagement: the case of Portuguese manufacturing firms
Armando Silva | Oscar Afonso | Ana Paula Africano

38: The importance of Intermediaries organizations in international R&D cooperation: an empirical multivariate study across Europe
Aurora Teixeira | Margarida Catarino

39: Financial constraints, exports and monetary integration - Financial constraints and exports: An analysis of Portuguese firms during the European monetary integration
Filipe Silva | Carlos Carreira

40: FDI and institutional reform in Portugal
Paulo Júlio | Ricardo Pinheiro-Alves | José Tavares

41: Evaluating the forecast quality of GDP components
Paulo Júlio | Pedro Esperança | João C. Fonseca

42: Assessing the Endogeneity of OCA conditions in EMU
Carlos Vieira | Isabel Vieira

43: Labor Adjustment Dynamics: An Application of System GMM
Pedro Esperança

44: Corporate taxes and the location of FDI in Europe using firm-level data
Tomás Silva | Sergio Lagoa

45: Public Debt Stabilization: Redistributive Delays versus Preemptive Anticipations
Paulo Júlio

46: Organizational Characteristics and Performance of Export Promotion Agencies: Portugal and Ireland compared
Inês Ferreira | Aurora Teixeira

47: Evaluating the forecast quality of GDP components: An application to G7
Paulo Júlio | Pedro Esperança

48: The influence of Doing Business' institutional variables in Foreign Direct Investment
Andreia Olival

49: Regional and Sectoral Foreign Direct Investment in Portugal since Joining the EU: A Dynamic Portrait
Irina Melo | Alexandra Lopes

50: Institutions and Firm Formation: an Empirical Analysis of Portuguese Municipalities
Simão Arouca

51: Youth Unemployment in Southern Europe
João Leão | Guida Nogueira

52: Financiamento da Economia Portuguesa: um Obstáculo ao Crescimento?
João Leão | Ana Martins | João Gonçalves

53: O Acordo de Parceria Transatlântica entre a UE e os EUA constitui uma ameaça ou uma oportunidade para a Economia Portuguesa?
João Leão | Guida Nogueira

54: Prescription Patterns of Pharmaceuticals
Ana Gonçalves

55: Economic Growth and the High Skilled: the Role of Scale Eects and of Barriers to Entry into the High Tech
Pedro Gil | Oscar Afonso | Paulo Brito

56: Finanças Públicas Portuguesas Sustentáveis no Estado Novo (1933-1974)?
Ricardo Ferraz

57: What Determines Firm-level Export Capacity? Evidence from Portuguese firms
Ana Gouveia | Ana Luisa Correia

58: The effect of developing countries' competition on regional labour markets in Portugal
Tiago Pereira

59: Fiscal Multipliers in the 21st century
Pedro Brinca | Hans Holter | Per Krusell | Laurence Malafry

60: Reallocation of Resources between Tradable and Non-Tradable Sectors in Portugal: Developing a new Identification Strategy for the Tradable Sector
Ana Fontoura Gouveia | Filipa Canas

61: Is the ECB unconventional monetary policy effective?
Inês Pereira

62: The Determinants of TFP Growth in the Portuguese Manufacturing Sector
Daniel Gonçalves | Ana Martins

63: Practical contribution for the assessment and monitoring of product market competition in the Portuguese Economy – estimation of price cost margins
Luis Folque

64: The impact of structural reforms of the judicial system: a survey
Ana Gouveia | Silvia Santos | Corinna Herber

65: The short-term impact of structural reforms on productivity growth: beyond direct effects
Ana Gouveia | Silvia Santos | Inês Gonçalves

66: Assessing the Competitiveness of the Portuguese Footwear Sector
Fábio Batista | José Matos | Miguel Matos

67: The empirics of agglomeration economies: the link with productivity
Ana Gouveia | Silvia Santos | Marli Fernandes

68: Determinants of the Portuguese GDP stagnation during the 2001-2014 period: an empirical investigation
Carlos Figueira

69: Short-run effects of product markets' deregulation: a more productive, more efficient and more resilient economy?
Ana Gouveia | Silvia Santos | Gustavo Monteiro

70: Portugal: a Paradox in Productivity
Ricardo Pinheiro Alves

71: Infrastructure Investment, Labor Productivity, and International Competitiveness: The Case of Portugal
Alfredo Pereira | Rui Pereira

72: Boom, Slump, Sudden stops, Recovery, and Policy Options. Portugal and the Euro
Olivier Blanchard | Pedro Portugal

73: Case Study: DBRS Sovereign Rating of Portugal. Analysis of Rating Methodology and Rating Decisions
Annika Luisa Hofmann | Miguel Ferreira | João Lampreia

74: For Whom the Bell Tolls: Road Safety Effects of Tolls on Uncongested SCUT Highways in Portugal
Alfredo Pereira | Rui Pereira | João Pereira dos Santos

75: Is All Infrastructure Investment Created Equal? The Case of Portugal
Alfredo Pereira | Rui Pereira

76: Why Virtuous Supply-Side Effects and Irrelevant Keynesian Effects are not Foregone Conclusions: What we Learn from an Industry-Level Analysis of Infrastructure Investments in Portugal
Alfredo Pereira | Rui Pereira

77: The Role of Gravity Models in Estimating the Economic Impact of Brexit
Graham Gudgin | Ken Coutts | Neil Gibson | Jordan Buchanan

78: Infrastructure Investment in Portugal and the Traded/Non-Traded Industry Mix
Alfredo Pereira | Rui Pereira

79: Goods and Factor Market Integration: A Quantitative Assessment of the EU Enlargement
Lorenzo Caliendo | Fernando Parro | Luca David Opromolla | Alessandro Sforza

80: Understanding productivity dynamics:a task taxonomy approach
Tiago Fonseca | Francisco Lima | Sonia C. Pereira

81: On the Effects of Infrastructure Investments on Industrial CO2 Emissions in Portugal
Alfredo Pereira | Rui Pereira

82: Assessing Competition With the Panzar-Rosse Model: An empirical analysis of European Union banking industry
Suzana Cristina Silva Andrade

83: Health Care Investments and Economic Performance in Portugal: An Industry Level Analysis
Alfredo Pereira | Rui Pereira | Pedro G. Rodrigues

84: Is deregulation of product and labour markets promoting employment and productivity? A difference-in-differences approach
Hugo Correia | Ana Fontoura Gouveia

85: Foreign acquisition and internal organization
Paulo Bastos | Natália P. Monteiro | Odd Rune Straume

86: Learning, Prices, and Firm Dynamics
Paulo Bastos | Daniel A. Dias | Olga A. Timoshenko

87: The Diffusion of Knowledge via Managers' Mobility
Giordano Mion | Luca David Opromolla | Alessandro Sforza

88: Empresas Zombie em Portugal - Os sectores não transacionáveis da Construção e dos Serviços
Gabriel Osório de Barros | Filipe Bento Caires | Dora Xarepe Pereira

89: Collective bargaining through the magnifying glass: A comparison between the Netherlands and Portugal
Alexander Hijzen | Pedro Martins | Jante Parlevliet

90: A Lower VAT Rate on Electricity in Portugal: Towards a Cleaner Environment, Better Economic Performance, and Less Inequality
Alfredo Pereira | Rui Manuel Pereira

91: Who Seeks Re-Election: Local Fiscal Restraints and Political Selection
Susana Peralta | João Pereira dos Santos

92: Assessing the Competitiveness of the Metalworking Sector
João Marinho | Pedro Carvalho

93: The efficiency of Portuguese Technology Transfer Offices and the importance of university characteristics
Aurora Teixeira | André Monteiro

94: Persistence in innovation and innovative behavior in unstable environments
Joana Costa | Anabela Botelho | Aurora Teixeira

95: The effect of entrepreneurial origin on firms' performance - The case of Portuguese academic spinoffs
Natália Barbosa | Ana Paula Faria

96: Absorptive Capacity and Firms' Generation of Innovation - Revisiting Zahra and George's Model
Dina Pereira | João Leitão

97: Innovations in digital government as business facilitators: implications for Portugal
João Martins | Linda Veiga

98: Innovation and the economic downturn: Insights from Portuguese firms
Hugo Pinto | Tiago Santos Pereira | Elvira Uyarra

99: European Funds and Firm Dynamics: Estimating Spillovers from Increased Access
João Pereira dos Santos | José Tavares

100: Corporate Leverage and Investment in Portugal
Ana Martins | José Henrique Gonçalves | João Mário Ferreira Duque

101: The effects of official and unofficial information on tax compliance
Filomena Garcia | Luca David Opromolla | Andrea Vezzulli | Rafael Marques

102: Competition effect on innovation and productivity - The Portuguese case
Anabela Santos | Michele Cincera | Paulo Neto | Maria Manuel Serrano

103: Measuring the Welfare of Intermediation in Vertical Markets
Javier D. Donna | Pedro Pereira | Tiago Pires | Andre Trindade

104: Of course Collusion Should be Prosecuted. But Maybe... Or (The case for international antitrust agreements)
Filomena Garcia | Jose Manuel Paz y Minõ | Gustavo Torrens

105: Product market competition and gender discrimination
Dudley Cooke | Ana P. Fernandes | Priscila Ferreira

106: Integration of Small Technology-Based Firms in Aeronautics
Anabela Reis | Joana Mendonça | Ligia Urbina

107: The Effects of Highway Tolls on Private Business Activity – Results from a Natural Experiment
João Pereira dos Santos | David B. Audretsch | Dirk Dohse

108: Competition and Firm Productivity: Evidence from Portugal
Pedro Carvalho

109: Do Exchange Traded Funds (ETFs) Outperform the Market? Evidence from the Portuguese Stock Index
Carlos Manuel Pinheiro | Hugo Hilário Varela

110: Assessing the Competitiveness of the Portuguese Chemical Sector
Ana Rita Marques | Cátia Silva

111: A General Equilibrium Theory of Occupational Choice under Optimistic Beliefs about Entrepreneurial Ability
Michele Dell'Era | Luca David Opromolla | Luis Santos-Pinto

112: O Mercado Segurador em Portugal: O Papel dos Gestores na Constituição de Provisões
Soraia de Sousa Bornett | Carlos Manuel Pinheiro

113: Exploring the implications of di erent loan-to-value macroprudential policy designs
Rita Basto | Sandra Gomes | Diana Lima

114: The Determinants of TFP Growth in the Portuguese Service Sector
Ana Martins | Tiago Domingues | Catarina Branco

115: Agglomeration and Industry Spillover Effects in the Aftermath of a Credit Shock
José Jorge | Joana Rocha

116: Entrepreneurial Human Capital and Firm Dynamics
Francisco Queiró

117: Global Value Chains and Vertical Specialization: The case of Portuguese Textiles and Shoes exports
Tiago Domingues

118: Firm heterogeneity and exports in Portugal: Identifying export potential
Frederico Oliveira Torres

149: The Determinants of Total Factor Productivity in the Portuguese Quaternary Sector
Paulo Matos | Pedro Neves

150: Os modelos Input-Output, a estrutura setorial das economias e o impacto da crise da COVID 19
Pedro N. Ramos | João Ferreira | Luís Cruz | Eduardo Barata

151: Public Expenditure and private firm performance: using religious denominations for causal inference
Henrique Alpalhão | Marta Lopes | João Santos| José Tavares

152: Employee Training and Firm Performance: Quasi-experimental evidence from the European Social Fund
Pedro S. Martins

153: Dream Jobs
Luca David Opromolla | Giordano Mion | Gianmarco I.P. Ottaviano

154: Minimum wage and financially distressed firms: another one bites the dust
F. Alexandre | P. Bação | J. Cerejeira | H. Costa | M. Portela

155: Do short-term rentals increase housing prices? Quasi-experimental evidence from Lisbon
Susana Peralta | João Pereira dos Santos | Duarte Gonçalves

156: Economic and social policies under EMU
Ricardo Pinheiro Alves

157: International Sourcing in Portuguese Companies - Evidence from Portuguese Micro Data
Ana Martins | Guida Nogueira | Eva Pereira

158: The Impact of R&D tax incentives in Portugal
Rita Bessone Basto | Ana Martins | Guida Nogueira

159: The Determinants of Competitiveness of the Portuguese Defense Industry
Roxanne Merenda

160: How is the Minimum Wage Shaping the Wage Distribution: Bite, Spillovers, and Wage Inequality
Carlos Oliveira

161: Macroeconomy Impacts of the Covid-19 Pandemic in Some European Union Countries: a Counterfactual Analysis
António Portugal Duarte | Fátima Sol Murta

162: Digital adoption and productivity: understanding micro drivers of the aggregate effect
Natália Barbosa | Ana Paula Faria

163: Job Creation and Destruction in the Digital Age: What about Portugal?
Anabela M. Santos | Javier Barbero Jimenez | Simone Salotti | Andrea Conte

164: Is digital government facilitating entrepreneurship? A comparative statics analysis.
Joana Costa | Luís Carvalho

165: Automation trends in Portugal: implications in productivity and employment
Marta Candeias | Nuno Boavida | António Brandão Moniz

166: Digital Technologies for Urban Greening Public Policies
Maria José Sousa

167: The impact of a rise in transportation costs on firm performance and behaviour
Catarina Branco | Dirk C. Dohse | João Pereira dos Santos | José Tavares

168: Outward FDI, restructuring, performance upgrading and resilience: Firm-level evidence from Portugal
Natália Barbosa

169: Firm adaptation in COVID-19 times: The case of Portuguese exporting firms
João Capella-Ramos | Romina Guri

170: Supporting small firms through recessions and recoveries
Diana Bonfim | Cláudia Custódio | Clara Raposo

171: The Credit Channel of Public Procurement
Ricardo Duque Gabriel

172: Autonomia Estratégica Aberta na União Europeia: desafios e oportunidades na era da tecnologia digital
Gabriel Osório de Barros | Catarina Castanheira Nunes

173: R&D subsidies and Portuguese firms' performance: A longitudinal firm-level study
Inês Ferraz Teixeira | Aurora A.C. Teixeira | Luís Delfim Santos