



# Is there an impact of the Structural Funds in innovation on business performance? Analysis through the ERDF-Innterconecta programme in Andalusia

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**Abstract** Andalusia, a Spanish Autonomous Community with a Convergence objective under the European Union, has had to manage a relevant volume of European resources for regional innovation throughout the last two European Programming periods, namely 2007–2013 and 2014–2020. For this reason, studying the impact on business results of European Funds for innovation is key to understanding the policy effects. This is why the ERDF-Innterconecta programme (the largest programme financed to support business innovation in Spain), belonging to the Technology Fund and the Smart Growth Programme, is analyzed. The proposed analysis seeks to identify whether there has been an impact of the subsidies on Andalusian companies. In this sense, two indicators have been studied: annual results and profitability. To this end, the beneficiary companies have been studied according to their size, participation in innovation and role in the financed projects, which constitutes an original research approach. The study shows poor results for the participating companies, which would indicate a wide margin for improvement in the planning and execution of these policies.

**Keywords** Structural Funds · Policy impact analysis · Regional innovation policies · Business performance · Large enterprises and SMEs

**JEL Codes** L53 · R58 · O38

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## Abbreviations

CEM	Coarsened Exact Matching
CDTI	Centre for Industrial and Technological Development (Spain)
ERDF	European and Regional Development Funds
ESIF	European and Structural Investment Funds
EU	European Union
GDP	Gross Domestic Product
INE	Spanish Statistical Institute
LE	Large Enterprises
MIB	Monotonic Imbalance Bounding
PSM	Propensity Score Matching
RI	Research Investment
R&D	Research and Development
R&D&I	Research and Development and Innovation
SGP	Smart Growth Programme
SME	Small and Medium Enterprises
TF	Technology Fund

## 1 Introduction

The Spanish Autonomous Communities with a Convergence objective were affected by the budgetary reduction of the European Structural Funds (ESIF) that began in the 2007–2013 programme period. This policy measure, taken after the deep financial crisis, was particularly relevant, since the ESIF has been a key financial instrument in efforts to combat inequalities in business development between territories. Despite the progressive cuts to this type of European resource, new business innovation policies were launched in Spain. These policies were financed initially by the so-called Technology Fund 2007–2013 (TF) —a business innovation policy targeting Convergence Objective territories— and subsequently by the so-called Smart Growth Operational Programme (SGP) 2014–2020, which had objectives similar to its predecessor. The TF and the SGP have mobilised more than €6 billion euros in total for Spain, of which more than €1 billion have been allocated to Andalusia. Among the calls for business innovation, Innterconecta stands out, having provided several hundred million euros to support large business innovation projects of various themes (ranging between €1 million and €5 million) for which forming a consortium of companies with public-private collaboration was required. These funds have been managed by a vast network of intermediary organisations, with the Spanish Centre for Technological and Industrial Development (CDTI) playing a key role.

It is necessary to point out that the Andalusian business fabric is mainly conformed by small and medium enterprises (SMEs). It is generally agreed that these companies need to generate economies of scale to increase their size and activity, but they also need to improve the use and attraction of public resources. In this context, this study aims to analyze the extent to which the planning, design and execution of the business research, development and innovation (R&D&I) programme financed by the TF and the SGP had a positive impact on business results of Andalusian firms.

To achieve this objective, the study focuses on the characteristics of the beneficiary companies and their role in the projects. In particular, the ERDF-Innterconecta calls for proposals were selected for this study, because they have been the most important business innovation policy implemented in the territory. This policy belonged to the TF and the SGP, and it specifically targeted business projects in which support for innovative SMEs was prioritised. This programme was in force during the last decade, and for this reason, why we have chosen it to analyze the evolution of the companies across the corresponding programme periods.

Although the academic literature analysing the results and the impact of European Funds on Spanish companies has grown in recent years (Sande and Vence 2019, 2021; Sande 2022a, b, 2024a, b, d; Sande and Sande 2023; Segarra-Blasco 2018; Moral and Paniagua 2016), the need to promote further research on the effects of these resources in the Andalusian Autonomous Community motivated this original and novel study, which carry out this research, a microeconomic perspective was adopted, differentiating the results obtained according to the characteristics of the firms participating in the policy studies. In this way, the observed results will help detect the differences among firms to model target policies.

The structure of the article is as follows: the second section reviews the literature on the importance of the ESIF and innovation policies and their influence on business performance, while also analysing the role of the TF and the SGP; the third section outlines and justifies the methodology used for the analysis, and describes the key data of the study; the fourth section assesses the results of the ERDF-Innterconecta programme of the TF and the SGP using the main business performance indicators in Andalusia, distinguishing companies according to the characteristics described; finally, the last section presents conclusions and recommendations for innovation policies based on the results obtained.

## **2 Improving business performance through Structural Funds and the description of the Erd-Interconecta call for proposals**

The European Union has recently planned different policies aimed at promoting business R&D&I, which have mainly been implemented both at the national and regional levels. In the case of Spain and Andalusia, the implementation of these policies is still urgent, especially if we bear in mind that these territories are still far from achieving the European Union's targets for investment in innovation, set at 3% of Gross Domestic Product (GDP).

In this sense, recent literature has shown in recent years that in order to achieve growth it is necessary to have a system that facilitates interactions between the different agents that make up regional innovation systems (Sande 2020; Rodríguez-Pose and Crescenzi 2008; Asheim et al. 2011; Uyarra et al. 2017; Fagerberg et al. 2018). Bearing in mind that companies are a key element of these systems, the aim of this article is to demonstrate the existence (or not) of the impact of these policies on the results of the participating companies, paying special attention to SMEs, since they constitute most of the private entities in the Andalusian productive fabric.

## 2.1 Literature review

Collaboration and interaction between firms have been shown to be a key element for collective innovative learning (Haus-Reve et al. 2019; González-Benito et al. 2016; Bjerke and Johansson 2015; Isaksen 2001; Cooke 2002; Freeman 2008). In this sense, the possibility of accumulating experience among different business agents is a key factor in improving the technological capabilities of territories (Ahn et al. 2015; Asheim et al. 2016). For this reason, it is logical to analyze the impact of the policies implemented at the regional level, particularly considering their characteristics and context. With this aim in mind, this paper reviews several key aspects of the policies implemented in Andalusia, a peripheral region of Spain: the impact of European policies on business performance, the impact of ESIFs according to the size and participation in innovation of firms, and the relevance of supporting SMEs.

Support through the ESIF for financing technological innovation has shown mixed results over time. For instance, literature exists defending positive results of technological innovation policies for the business sector (Le and Jaffe 2017; Bronzini and Piselli 2016; Musyck and Reid 2007), while other studies show moderately positive results in peripheral contexts, or even non-existent results in some cases (Sande 2022a; Blasio et al. 2015) as a consequence of the general design of the policies, and sometimes as a result of the leakage of resources to other territories (Sande 2024c).

When analysing the results of various studies on the relationship between business innovation and business performance, Bernini and Pellegrini (2011) found that subsidised firms improve their production indicators compared to non-subsidised firms. Furthermore, for other authors (Arbindane and Tarasova 2018; Henriques and Viseu 2022) the activities financed by the ESIF would also increase the productivity of companies, as well as business performance and competitiveness (Belussi et al. 2010). According to the latter study, the greatest contribution of activities financed by European Union (EU) funds comes from those implemented for the stimulation of entrepreneurial activity and the provision of entrepreneurship in the regions, such as expanding external markets, business incubators, and investment support for micro and SMEs in particularly supported territories. In any case, the existence of an ecosystem with collaboration between companies is essential to achieve positive results (Sande 2020; Burrus et al. 2018; Turkina et al. 2019).

On the other hand, authors such Bachtrögler and Hammer (2018) have found mixed effects of structural funds, reporting little evidence of additional positive effects on total factor productivity for firms benefiting from funding. But for Vojtovič (2016) and Sande (2022a) argues that firms financed with ESIFs do not achieve economic performance that contributes to their competitiveness, as their outcomes are similar to those obtained by firms without financial support. A possible explanation for these results may lie in the low absorption capacity of firms in peripheral territories for financing resources as they are mainly small and do not have the necessary organisational, capital and human resources (Sande 2020; Sande and Vence 2019).

In any case, it is worth noting the difficulty of measuring the effects of structural policies in times of economic crisis or recession (Fitoussi and Saraceno 2010; Camagni and Capello 2017), which explains why some studies could show different

results. In similar contexts, other authors (Di Caro and Fratesi 2022) distinguish between cases of effective, ineffective, triggering and marginal regional policies with European Funds, concluding that ineffective policies should learn from those that are effective. To increase the difficulty, the literature dealing with the different effects of European resources on regional innovation depending on firm's size and role in the projects is not very abundant. Despite this, there are some studies conducted in recent years that focus on the differences observed between firms according to their size but pertain to non-Andalusian regions (Herrera and Sánchez-González 2013; Seclen-Luna et al. 2021). For example, some studies (Santamaría and Nieto 2009; Blaschke et al. 2021) suggest that medium-sized firms could reduce their innovation gap relative to larger firms. Recently, an article has been published working on some aspects related to the importance of companies' size in Andalusia, but this article has focused mainly on business growth indicators finding positive results for larger companies (Sande 2024a).

Using the PSM statistical technique, recent studies have found different effects of the ESIF. For instance, while some studies have found that large enterprises have absorbed part of the expected impact intended for SMEs (Segarra-Blasco 2018; Sande 2022b, 2024a), others agree that it is medium-sized enterprises that have benefited the most in some indicators. In any case, firm size is a key factor, as other authors agree (Benkovskis et al. 2019).

It should not be forgotten that, in order to foster innovation and business growth, the preconditions of regional innovation systems are key aspects (Rodríguez-Pose and Wilkie 2016; Vechkinzova et al. 2019). Despite SMEs' difficulties in absorbing ESIF (lack of specialised human resources, knowledge, infrastructure and others) SMEs are one of the most important actors in creating the conditions for structural change at the systemic level (Asheim et al. 2003; Radziwon et al. 2017; Alhusen and Bennat 2021).

Despite the importance of supporting business R&D&I, and SMEs (endogenous systemic agents), the results of the policies in terms of impact for SMEs have been controversial. For instance, some studies show no effectiveness of the programme implemented (Gouveia et al. 2021), even in terms of competitiveness (Čadil et al. 2017). Conversely, other studies (Pirnea and Caldararu 2012) link the existence of results to the quality of knowledge management, Henriques and Viseu (2022) show only moderate results because of public financing. Similarly, other studies show a more moderate impact (Lewandowska et al. 2021), or positive for medium-sized enterprises but none for micro-SMEs (Sande 2022a). Nevertheless, studies tend to show positive effects of European policies on SMEs innovation (Romero et al. 2010; Piątkowski 2020; Henriques et al. 2022), including both public and private financing (Banai et al. 2020), and investments in eco-innovations (Demirel and Danisman 2019). Supporting such enterprises is therefore key for innovation ecosystems and the creation of sustainable dynamics at the systemic level (Vuorinen and Mereuta 2020).

## 2.2 The funds object of study

The European Council approved an additional allocation of ERDF resources for Spain to promote business R&D&I in the Convergence Objective regions. During the middle of the first decade of the century, the European Council supported the existence of a programme dedicated to the promotion of business R&D&I (Ministry of Economy and Finance 2007), called the Technology Fund (TF). Based on its positive results, its coherence over time, and its contribution to regional cohesion, authorities decided to ensure the continuity of this programme for business innovation with the SGP (Ministry de Finance and Public Administrations 2014) (Table 11 in the Appendix). The approval of these operational programmes was driven by the objectives set by the Lisbon strategy in 2005. On the one hand, this strategy aimed to raise R&D&I investment to 3% of GDP and, on the other hand, to achieve two new objectives before the start of the 2007–2013 programme period: (a) the development of research, education and innovation, and (b) the promotion of innovation policy.

**Table 1** ERDF-Innterconecta calls for proposals, description. (Source: Own elaboration, taken from Innterconecta calls for proposals)

	Technology fund	Smart growth
Assignment to Spain	262 M€	210 M€
Territorial distribution Funds	Andalusia 150 M€ Galicia: 105 M€ Extremadura: 7 M€ Castilla La Mancha: Don't participate	Plurirregional
Subsidised areas	All, as long as they stimulate employment and increase added value (Ministry of Economy and Competitivity 2013)	Health, demographic change and well-being, food safety and quality; safe, efficient and clean energy, smart, sustainable and integrated transport; action on climate change; social change and innovations, digital economy and society; security, safety and defence
Dimension and Amounts subsidised in the projects (Andalusia)	Up to 5 M€	Between 1–4 M€
Project re-requirements	Formation of an Economic Interest Grouping (EIG) or Consortium	
Projects duration	Two- and three-year projects (Ministry of Science and Innovation 2012)	
Objectives	Support for large R&D projects Increasing business R&D expenditure Use of existing infrastructures Mobilisation of SMEs Greater involvement of stakeholders and promotion of innovative culture Internationalisation of innovation Experimental development and cooperation between companies	

**Table 2** ERDF-Innterconecta main data, by calls for proposals. (Source: Own elaboration based on ARDÁN and CDTI data)

	1st Call	2nd Call	3rd Call	4th Call	5th Call
Requested projects	74	59	269	231	NA*
Approved projects	31	41	131	64	67
Companies requesting	410	255	946	822	NA*
Approved companies	195	211	511	246	229

\*Note: Plurirregional, data for requested projects not available for 2018

Following this contextualization, the ERDF-Innterconecta is a line of funding that seeks public-private collaboration through direct subsidies on a competitive basis to support strategic and large-scale business projects for experimental development and industrial research, with the aim of developing innovative technologies in areas with international economic potential. The key data of the programme and its five calls for proposals are shown below (Table 1).

Having described the main data of the programme, it is necessary to ask whether there are notable differences in the outcomes of participating companies in the policy analyzed. Furthermore, in view of the diversity of companies participating in the projects financed, it is worth asking whether these results vary according to the role they have played in the projects and their size (usually related to their role). In this context, analysing a policy such as the Innterconecta programme may be an appropriate choice to carry out the proposed analysis.

### 3 Methodology of the study

This section has a twofold objective. The first part introduces the methodology employed in the current research, while the second part highlights key information regarding the data analyzed.

#### 3.1 Discussion of the methodology and description of the PSM technique

One of the main debates when preparing this research has been the choice of methodology. To address this challenge, at least three options were considered the use of what is known as the *Propensity Score Matching* (PSM), *Coarsened Exact Matching* (CEM) and *dose-response* analysis. According to Iacus et al. (2012), CEM is a Monotonic Imbalance Bounding (MIB) matching method, which means that the balance between the treated and control groups is chosen by the user in advance, rather than discovered through the usual iterative process of checking after the fact and repeatedly reestimating. This implies that adjusting the imbalance on one variable does not affect on the maximum imbalance of any other variable.

For some authors (Blackwell et al. 2009) CEM is faster, easier to use and understand, requires fewer assumptions, is more easily automated, and possesses more attractive statistical properties for many applications than do existing matching methods. Nevertheless, according to recent research (Black et al. 2020), CEM excludes substantially more observations, does so in non-obvious ways, can severely misiden-

tify average treatment effects, and is much less precise than other methods. As a result, the authors discourage the use of CEM in favour of other methodologies such as PSM. At the same time, the use of methodologies such as *dose-response* is preferable for continuous variables. Continuous variables differ from discrete variables in that they cannot be measured exactly; their observed value depends on the precision of the measuring instruments. However, in the present case it is possible to know the amount that each business consortium received in subsidies, but not the value received by each individual company, which makes the use of this approach less feasible.

Consequently, the PSM technique was chosen, as it makes it possible to estimate the effect of a policy on a set of agents by analyzing the covariance of the observed values. This technique, which was originally used in the medical field to find out whether the application of a certain treatment (or medicine) to a patient was successful, allows the values obtained for the variables in the two treatment groups to be compared. Through the analysis of the covariances between the two groups, this technique also makes it possible to discern the existence of differences between the treatment groups because of their participation in a policy. For this purpose, this methodology requires the analysis of the results of two samples: on the one hand, a sample of companies that participated in the policy analyzed and a control sample of companies that did not. The results of the test enable verification of whether the null hypothesis is satisfied and, therefore, whether the policy influenced the results observed for the companies' receiving subsidies.

If the value of the standardised mean difference (SMD) of each of the study groups exceeds 0.1, an imbalance is observed and the PSM is applied. In this study, the observed value is  $\text{index-d} > 0.1$ , so we estimate the *propensity score* by applying a *logit* model in which the outcome variable is a binary variable indicating whether a certain policy has been applied. For this analysis, the R software, *MatchIt package*, was used.

There are different methods for performing the matching (*exact matching, nearest neighbour, optimal matching, full matching and calliper matching ...*), among them we select the *nearest neighbour*. The *nearest neighbour* method matches each individual in the treatment group with the individual in the control group that has the closest propensity score. This study uses the most common implementation of PSM: one-to-one matching, where pairs of treated and control units are formed (this info has been included in the methodology). Using one-to-one *nearest neighbour* PSM=N (1) iC, one treated unit  $i \in T$  is matched to one control unit  $j \in C$ . The pairing is based on selection the individual from the candidates whose *propensity score* is closest to that of the individual in the treatment group. In the former case, an element of the control group is used more than once. If instead of an element of the comparison group, all those with a close PS are used, the estimates use the information available is better and they are more stable. The counterpart is that if the same element of the comparison group is used too many times could increase sampling error. Among the matching algorithms most used in practice and one of those that produces the best results is the so-called *nearest neighbour* matching. This matching technique consists of choosing from the comparison group the element with the closest *propensity score* (ANNI 2023). Other forms of matching such

as *calliper* or *radius* are used with poor samples (this is not the case), or they carry out matchings between more disparate units (e.g. *kernel*) (Rodríguez 2012).

For the analysis, the values of the variables were taken at the end of the period under study. Once the test is completed, the *p-value* was included; if *p-value* < 0.05, this implies significant differences between the two groups.

### 3.2 Main data

This research analyzes the evolution of key economic indicators related to business results during the period 2007–2020. The indicators selected were results of the year (account 129 of the Spanish chart of accounts) and company profitability (efficiency of the company in the use of its assets to generate profits). These indicators were chosen because innovation projects are expected to increase productivity, which would, in turn, improve both results of the year and company profitability.

This paper incorporates a large amount of quantitative data extracted from multiple sources, conferring a strong empirical component to the work. Among these sources, R&D information pertinent to the regional context (presence of large/small companies, innovative position in Europe, etc.) was obtained from official bodies such as the National Statistics Institute (INE), the Andalusian Regional Government's Department of Finance, the Ministry of Finance, Eurostat and the European Administration. Additional data on the participating companies were sourced from the Centre for Technological and Industrial Development (CDTI) and from planning bodies consulted during the research process, including corporate name and identification number. Data constructed with information obtained from the planning bodies during the research process have also been used. Finally, data on economic and financial performance indicators of the companies participating in Innterconecta were also used, obtained through the ARDÁN business information service of the Vigo Free Trade Zone Consortium. It means that Ardán has provided information on the evolution of the indicators of the companies analyzed for the requested period.

Cross-referencing these data with qualitative information from innovation agents (firms, business financial directors, innovation technicians, etc.) and conducting statistical analysis using the *Propensity Score Matching* (PSM) technique enabled us to achieve the research objectives.

The total number of directly participating companies was 1392, of which 827 could be identified (some companies participated in multiple projects). Information in ARDAN was available for 337 of them, from which general data were extracted for this study. Companies with more than 250 employees in 2007 —at the start of the European programming period— were classified as Large Enterprises (LE). This study focuses on the analysis of the main results indicators of a sample of 337 Andalusian companies that participated in the ERDF-Innterconecta programme for this Autonomous Community. This sample has been compared to another group of 355 Andalusian companies that did not participate in the programme. The value of the number of observations may vary for each indicator depending on the availability of information in the Ardán database, but the sample size remains significant. The control sample has been selected by the Ardán business service, considering a random sample of Andalusian companies that have not participated in the policy.

**Table 3** Descriptive statistics of the projects analyzed at the beginning of the period. (Source: Own elaboration based on ARDÁN and CDTI data)

Number of participating companies analyzed// Control sample	Companies analyzed // Control Sample	337	355
	Small and Medium Enterprises	247 (73.29%)	345 (97.18%)
	Large Enterprises	90 (26.71%)	10 (2.82%)
Number of companies per project	4.17		
Role in the projects (participating companies)	Leaders	63 (18.69%)	
	Partners	274 (81.31%)	
Role in innovation of participants//Control sample	Previously innovative (accountancy data)	10 (2.97%)	3 (0.85%)
	Non-innovative (accountancy data)	327 (93.03%)	352 (99.15%)
Sector of activity of the projects subsidised	Industrial manufacturing activities	34.12%	
	Scientific and technical activities	27.60%	
	ICT	9.20%	
	Retail and wholesale trade	8.90%	
	Construction	8.31%	
	Other activities	11.87%	

This will allow determining if there exist a better behaviour in these indicators for the companies participating in the policy or if, on the contrary, the behaviour is like other groups of companies that have not received financing through this policy.

The total number of projects approved in the five Innterconecta calls for proposals analyzed was 334, although over 600 projects were submitted. The number of applicant companies exceeded twice the final number of participants (Table 2). The average planned budget per company was €639,679.85, but CDTI funding covered only around half of this amount, averaging €302,406.91.

The average number of participating companies per project was 4.17. Almost three quarters (247) of the participants were SMEs (73.29%), and the remaining quarter (90) were LE (26.71%). The LEs have played a relevant role leading the projects and managing resources. The business role in innovation has also been considered, distinguishing between the 63 leading companies (18.69%) and the 274 partners (81.31%), as well as between the 327 companies that did not innovate in 2011 (93.03%) and the 10 that did innovate (2.97%) the same year. The companies have been grouped together considering this distinction between leaders/partner and innovative/non-innovative companies. In addition, information published in the official bulletins of each call has been used, which has been cross-referenced with the information requested from CDTI. The accounting data of the companies (data provided by Ardán) were useful to group the companies based on whether they were previously innovative or not.

The technological areas in which the 337 analyzed companies participated included industrial manufacturing activities (34.12%) and professional, scientific and technical activities (27.60%), which are typically associated to consultancy activi-

ties and specialised services. The remaining Innterconecta resources went to the ICT sector (9.20%), retail and wholesale trade (8.90%) and construction (8.31%).

The business networks formed through this policy are characterised by significant participation from ICT and technical consultancy companies, which are present in nearly all the projects. Additional participation came from companies in sectors aligned with Andalusia's productive specialisations, such as commerce, hotels and catering, fishing and wood industries. Below is also a table of descriptive statistics in relation to the composition of projects and participating companies (Table 3).

Geographical proximity, a key factor for business innovation (Cardamone 2018), was also examined. Participating companies are primarily concentrated in Seville, but also mainly in Malaga and Cordoba, and to a lesser extent in Jaen, with limited participation from other Andalusian territories. The analysis also identified Spanish companies outside Andalusia participating in the policy. The analysis also identified Spanish companies outside Andalusia participating in the policy (Fig. 1).

#### 4 Analysis of the application of the Erdf-Innterconecta in Andalusia on the performance of innovative enterprises

This section breaks down the information into two parts: the first part is a general study of the Innterconecta programme data which analyzes aspects such the size and characteristics of the projects approved, and the networks formed; the second part evaluates the main business results indicators of the companies participating in the policy evaluated according to companies' size, participation in innovation and role in the projects.



**Fig. 1** Spatial location of the companies participating in the Innterconecta programme in Andalusia, by registered office. (Source: Own elaboration based on ARDÁN data)

**Table 4** Aggregate change and relative impact on the main business results indicators of the companies participating in Innterconecta, by size and role, 2007–2020 (€, %). (Source: Own elaboration based on ARDÁN and CDTI data)

Relative impact size and role	Number of Companies	Aggregate change		Relative impact	
		Results of the Year (€)	Profitability (%)	Results of the Year (%)	Profitability (%)
LE > 250 employees	90	-1,042,765,341	-2.46	-24.43	-59.47
SME < 250 > 50 employees	89	+26,746,345	+0.94	+41.36	+33.64
SME > 50 employees	158	+6,433,601	+2.21	+43.10	+182.87
RI = 0 (2007)	327	-994,819,552	+0.47	-23.0	+6.10
RI > 0 (2007)	10	-14,765,843	-0.23	-64.16	-51.20
Leaders	63	-669,405,757	-1.82	-25.36	-5.90
Partners	274	-340,179,638	+2.08	-19.11	+134.13
Companies Andalucía	337	-1,009,585,395	+0.24	-23.22	+2.93

**Table 5** Aggregate change and relative impact on the main business results indicators of the control sample, by size and role, 2007–2020 (€, %). (Source: Own elaboration based on ARDÁN and CDTI data)

Relative impact size and role	Number of Companies	Aggregate change		Relative impact	
		Results of the Year (€)	Profitability (%)	Results of the Year (%)	Profitability (%)
LE > 250 employees	10	+22,364,396	-0.51	+95.89	-94.42
SME < 250 > 50 employees	54	+129,186,220	+0.11	+278.45	+3.95
SME > 50 employees	291	+149,709,157	+15.43	+669.42	+381.95
RI = 0 (2007)	352	+304,038,308	+14.94	+346.21	+210.59
RI > 0 (2007)	3	-2,778,535	+0.08	-65.17	+45.67
Control Sample	355	+301,259,773	15.02	+327.16	+206.74

#### 4.1 Comparative evolution of the business results indicators of the companies participating in Innterconecta in Andalucía

The volume of funds mobilised by the Innterconecta calls for proposals in Andalucía has been significant, leading authorities to expect important results in terms of the policy's impact on the region's business fabric. In order to assess this impact, the behaviour of the main performance indicators of the companies participating in the policy has been analyzed. To this end, factors such as the size of the companies and their role in innovation and in the projects subsidised have been taken into account. Regarding the period of analysis, it should be noted that the coincidence in several years with the so-called Great Recession, together with the existence of other public policies, as well as other factors such as regulatory changes in company accounting, or the different management strategies of each company, may have influenced the

**Table 6** Statistical analysis of Results of the Year using PSM. (Source: Own elaboration using R software)

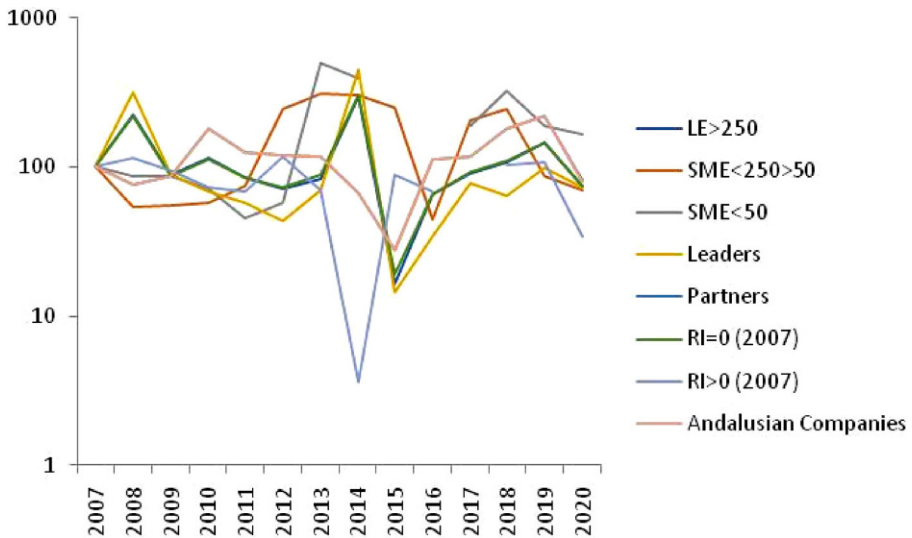
	$n_1$	$n_2$	$\bar{X}_1$	$\bar{X}_2$	$\sigma_1$	$\sigma_2$	Index-d (SMD)	p-value
LE > 250 employees	337	76	1,167,185.86	42,439,452.95	8,040,657.56	324,540,911.33	0.180	0.2985
SME < 250 > 50 employees	337	73	1,167,185.86	1,252,345.37	8,040,657.56	5,231,968.13	0.013	0.7732
SME < 50 employees	337	83	1,167,185.86	257,346.13	8,040,657.56	1,072,928.78	0.159	0.9855
RI = 0 (2007)	337	224	1,167,185.86	14,869,003.87	8,040,657.56	189,273,715.95	0.102	0.2915
RI > 0 (2007)	337	8	1,167,185.86	940,312.38	8,040,657.56	5,024,401.19	0.034	0.8298
Leaders	337	51	1,167,185.86	38,620,135.63	8,040,657.56	332,555,635.62	0.159	0.4555
Partners	337	182	1,167,185.86	7,519,889.97	8,040,657.56	7,519,889.97	0.077	0.4752

evolution of the values observed. Nonetheless, these cyclical factors do not detract from the solid results obtained for the indicators analyzed.

To analyze the comparative evolution of the indicators, data from 337 entities were used. Of these participating companies, 72.29% were SMEs (247) and 26.71% LEs (90). To further analyze the data according to the characteristics of the companies, we also considered the differences between the leading companies (18.69% or 63), and the partners (81.31%, or 274), as well as between the 93.03% of companies that did not innovate in 2007 (327) and those that did innovate (2.97% or 10). Again, the control sample of 355 Andalusian firms not participating in the policy was considered as a reference.

On the one hand, Table 4 shows the descriptive statistics for the aggregated variation produced in each of the variables based on the size and role of the firms participating in the policy. Only smaller SMEs show a positive evolution in the two previously selected variables (results of the year and productivity). The partner companies and previous non-innovators (in accounting terms) show positive values only in the case of profitability. The rest of the companies perform worse than the control sample. On the other hand, Table 5 shows the aggregate variation for the control sample. The values observed confirm a positive evolution for SMEs and previous non-innovator firms. LEs display growth for results of the year, while previous innovators show a positive trend in profitability.

To summarize, since the launch of the Innterconecta programme, it is evident that the evolution of the indicators analyzed varies from one group to another. Considering the evolution data, only SMEs appear able to translate these results into better performance for these variables.



**Fig. 2** Comparative evolution of results or the year of companies participating in Innterconecta-Andalusia 2007–2020, by size and company role (index 2007= 100, log 10 (x)). (Source: Own elaboration based on data from ARDÁN and CDTI)

In order to elucidate more precisely what has happened with the application of the Innterconecta programme, the behavior of the performance indicators analyzed is graphically illustrated below for the identified groups. The form chosen for the presentation of the data is base 100, since it clearly identifies behavioural differences. It was deemed appropriate to represent these figures on a base 10 logarithmic scale, offering more precise information on their evolution over time. To calculate the values initially in base 100, in the specific cases in which the initial data for 2007 is zero, the first positive value of the series has been taken. At this point it should be remembered that, by definition, of the logarithmic base does not allow negative values or values that are zero to be represented, which, in some cases, may lead to discontinuities in the lines or in the graphical absence of any value. These values have also been compared with those obtained for the Andalusian companies in the control sample for which information is available.

In general terms, the data for the two selected variables does not exhibit favourable behaviour throughout the period studied for companies adhering to the policy. On an initial approximation, it can be observed that the results differ slightly by indicator. The size of the companies participating in Innterconecta does not seem to be a key factor for a greater absorption of resources, with the exception of SMEs. The results remain largely inconclusive when focusing on the distinction between leading and associated companies. In general, these groups exhibit poorer performance compared to the control sample. Concentrating on the results obtained for companies already innovative ( $RI > 0$  in 2007) and new innovators ( $RI = 0$  in 2007), we once again observe negative trends.

## 4.2 Statistical analysis

This section analyzes the indicators selected for this study: results of the year and productivity. Statistical data for each of these indicators were taken, represented, described and analyzed.

### 4.2.1 Impact on results of the year by type of firm

In general terms, the different groups of companies analyzed have not shown a positive evolution in the first indicator in absolute terms for the period analyzed. However, it should be noted that a break in their evolution was observed in several years (2014–2016) due to the deep financial crisis suffered during that time.

The LEs (−25.64%), medium sized companies (−29.55%) and small sized companies (+66.65%) show differentiated results for this indicator, with SMEs apparently taking greater advantage of the funds. The results are also negative for leading companies (−25.19%) and partners (−65.53%), as well as for companies that had not previously innovated (−26.63%) and those that had (−19.05%). These results suggest a low incidence depending on the latter characteristics, in contrast to the case of business size. All companies (except SMEs) obtained worse results during the period than those observed in the control sample (−19.91%) (Fig. 2).

To test the existence of significant differences between the behaviour of companies participating and not participating in the policy, we performed a statistical

test for this indicator using the PSM methodology on the total set of companies for which data were available. For this test, the number of companies in the control sample with available data (from the Ardán database) was  $n_1 = 337$ , while the total number of companies participating in Innterconecta took on different  $n_2$  values depending on the study group and data availability from the Ardán database (Table 6). The mean of the values for the first sample was  $\bar{x}_1 = \text{€}1,167,185.86$  and its standard deviation  $\sigma_1 = \text{€}8,040,657.56$ , while for the companies that received resources from the innovation policy, the mean  $\bar{x}_2$  and the standard deviation  $\sigma_2$  were higher, except for previously innovative companies and SMEs.

If the value of the standardised mean difference (SMD) for any study group exceeds 0.1, an imbalance is observed, triggering the need to apply PSM. In this case the observed value is index-d Revenue  $> 0.1$ . Accordingly, we estimate the propensity score by applying a logit model, where the outcome variable is a binary, indicating whether (or not) a specific policy was applied. We used the R software, MatchIt package, and among the available methods to perform the matching (*exact matching, nearest neighbour, optimal matching, full matching and calliper matching ...*), we select the *nearest neighbour* method. The *nearest neighbour* method pairs each individual in the treatment group with the individual in the control group that has the closest propensity score. Once the test was completed, we included the *p-value*, which, if  $< 0.05$ , implies significant differences between the two groups. Regression statistics, including the *t-difference (t-test)*, the degree of freedom (*df*) value and the confidence interval of the regression ( $Ci_1$  and  $Ci_2$ ) were also included (Table 7). The results show that participation in the policy did not have a significant impact on this indicator for Andalusian companies.

#### 4.2.2 Impact on profitability by type of firm

Small sized companies showed the greatest relative growth in this indicator (+183.563%), followed by medium sized companies (+8.32%). In contrast, large companies experienced a negative evolution of the indicator (−59.46%). Leading companies also increased their investments (+1.61%) while partners failed to achieve positive results (−56.88%). Regarding the evolution of the companies according to

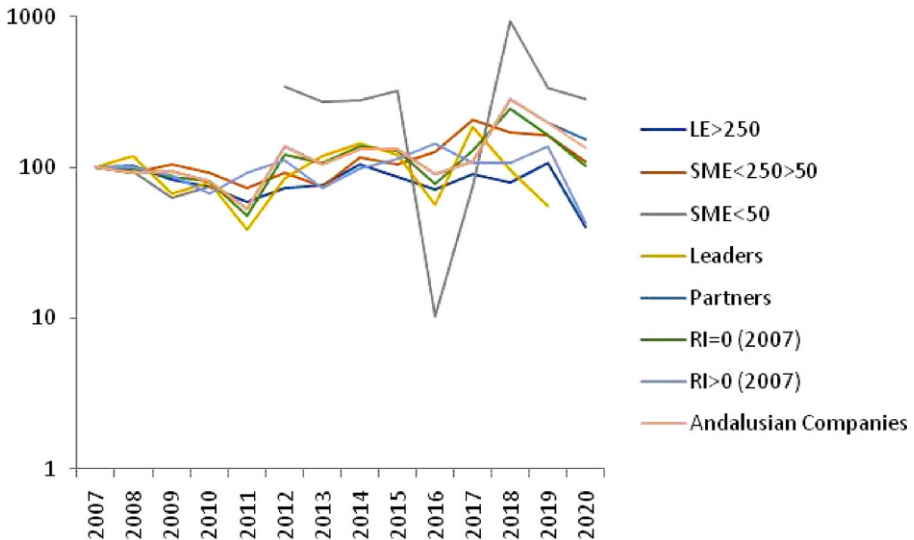
**Table 7** Statistics of the regression of the Results of the Year indicator, using PSM. (Source: Own elaboration using R software)

	<i>t-difference</i>	<i>Df</i>	<i>Confidence intervals</i>		<i>Sample estimates: Mean of x</i>
			$Ci_1$	$Ci_2$	
LE > 250 employees	1.0470	75	−35,314,585	113,558,642	39,122,028
SME < 250 > 50 employees	0.2892	72	−1,366,330	1,830,120	231,895.30
SME < 50 employees	−0.0183	82	−322,745.70	316,885.20	−2930.22
RI = 0 (2007)	1.0574	223	−11,568,738	38,356,892	13,394,077
RI > 0 (2007)	−0.2232	7	−5,157,238	4,267,690	−444,774
Leaders	0.7521	50	−58,724,243	129,027,732	35,151,745
Partners	0.7155	181	−10,793,313	23,073,067	6,139,877

their participation in innovation, those that were not innovating in 2007 ( $RI=0$ ) experienced the worst evolution in the period analyzed ( $-129.73\%$ ), while the evolution was positive ( $+54.76\%$ ) for companies that had been innovating in that initial year ( $RI>0$ ). For the control sample, the evolution was also positive ( $+34.13\%$ ) (Fig. 3).

We performed the statistical test for investment in development using the same methodology described above. The number of companies in the control sample with activated data in their accounting for investment in development was  $n_3=337$ , while for the total number of Innterconecta participants, different  $n_4$  values were observed depending on the study and data availability (Table 8). The mean of the values for the first sample was  $\bar{x}_3=0.07$  and its standard deviation  $\sigma_3=0.13$ , while for the companies that received resources from the innovation policy the mean  $\bar{x}_4$  was lower, and the standard deviation  $\sigma_4$  varied across cases. The value of the standardised mean difference (SMD) was  $index-d>0.1$  in all cases, indicating an imbalance that required the reapplication of PSM. Once the test was completed, we included the *p-value*, which again highlighted the absence of positive results for the companies participating in this policy. Regression statistics, including the *t-difference* (*t-test*), the degree of freedom (*df*) value and the confidence interval of the regression, were also reported (Table 9).

Below is a summary table listing the results observed for each of the indicators of business results analyzed, distinguishing companies by size and by role within the projects (Table 10). The observed results show that the impact of the policy has not been relevant for the group of subsidized companies in terms of business performance and productivity. This finding is important, as it underscores the need to develop better indicators and formulate policy recommendations for the future.



**Fig. 3** Comparative evolution of profitability of companies participating in Innterconecta-Andalusia 2007–2020, by size and companies' role (index 2007 = 100, log 10 (x)). (Source: Own elaboration based on data from ARDÁN and CDTI)

**Table 8** Results of the statistical analysis of Profitability using PSM. (Source: Own elaboration using software R)

	$n_3$	$n_4$	$\bar{x}_3$	$\bar{x}_4$	$\sigma_3$	$\sigma_4$	<i>Index-d</i> (SMD)	<i>p-value</i>
LE > 250 employees	337	76	0.07	0.02	0.13	0.10	0.4390	0.9771
SME < 250 > 50 employees	337	73	0.07	0.05	0.13	0.12	0.1200	0.9589
SME < 50 employees	337	83	0.07	0.04	0.13	0.16	0.1730	0.8190
RI = 0 (2007)	337	224	0.07	0.04	0.13	0.13	0.2290	0.6918
RI > 0 (2007)	337	8	0.07	0.02	0.13	0.15	0.3170	0.9665
Leaders	337	51	0.07	0.00	0.13	0.10	0.5350	0.9248
Partners	337	182	0.07	0.04	0.13	0.13	0.1600	0.7967

## 5 Policy implications and recommendations

Evaluating business performance and European policies is a complex task that presents additional difficulties due to the context in which they occur. These difficulties include not only the choice of an appropriate methodology for measuring the impact of policy on business actors, but also the causal attribution of observed outcomes. Such challenges could lead one to think that there is a certain degree of indeterminacy in the results. Therefore, a rigorous analysis of the impact of these policies should necessarily involve a degree of caution when interpreting the data and extrapolating them to other territories. In view of the above, it is deemed appropriate to differentiate the conclusions between practical and policy considerations.

### 5.1 Practical implications

In view of the results obtained, the average size of the projects approved in Innterconecta (approximately €4–5 million) does not appear to have had a clear impact on the results of the Andalusian companies that have participated in this programme.

Specifically, regarding the impact on the main business results indicators for the companies participating in Innterconecta, the graphical analysis shows some differences between the outcomes for a larger and smaller companies. Indeed, SMEs seem to show the greatest impact on the two indicators analyzed, while this improvement is absent for larger companies. For the leading and partner companies in the projects, as well as for companies that had not previously innovated and those that had, the graphical results are generally negative, except for profitability for LEs and previously innovative firms. However, the results of the statistical test confirm that there has not been a significant impact on the indicators analyzed for the companies participating in this policy.

Notwithstanding the completeness and rigor of the statistical study, the current study has faced some problems and limitations. First, there is the self-selection problem, which arises from the companies' ability to choose whether or not to participate in the calls for proposals under the programme being analyzed. Second, the

**Table 9** Statistics of the regression of the Profitability indicator, using PSM. (Source: Own elaboration using *R software*)

	<i>t-difference</i>	<i>Df</i>	<i>Confidence intervals</i>		<i>Sample estimates: Mean of x</i>
			<i>Ci<sub>3</sub></i>	<i>Ci<sub>4</sub></i>	
LE > 250 employees	-0.0288	75	-0.03328349	0.032336130	-0.00047368
SME < 250 > 50 employees	-0.0517	72	-0.03806427	0.036138240	-0.00096301
SME < 50 employees	-0.2296	82	-0.04934489	0.039132840	-0.00510602
RI = 0 (2007)	-0.39696	223	-0.02702342	0.017966181	-0.00453080
RI > 0 (2007)	0.0435	7	-0.16530500	0.171505000	0.00310000
Leaders	-0.0949	50	-0.04559129	0.041477560	-0.00205686
Partners	-0.2580	181	-0.02990481	0.022988320	-0.00345824

problem of endogeneity has been addressed: the decision by public administrations to approve the programme has served as an external trigger enabling firms to participate (Nicolás and Cantos 2016). Lastly, the results could be influenced by distorting biases if there were governmental interests affecting the selection of projects and companies receiving funds (Martí2020). To isolate the effect of these problems, the use of the PSM statistical technique was proposed. However, PSM could have other problems, as King and Nielsen (2019) argue. For example, Peikes et al. (2008) suggests that PSM requires many more observations than initially expected. Of course, there is also a risk of extrapolating these results to all territories. In each case, the characteristics of each regional innovation system should be taken into account, in addition to contextual factors, the behaviour of the various agents, and the specific attributes of the policies implemented, among others.

## 5.2 Policy recommendations

Expectations for the improvement of business innovation in Andalusia were high following the implementation of the Innterconecta programme, which was allocated almost 500 million euros. However, the management and application of these resources have led to modest results relative to the objectives formulated. When referring to management problems, we mean issues such as delays in the implementation of the execution of the funds due to their own dynamics, the generalist design of the policies (not always adapted to the specific needs of each territory), the extensive network of intermediate bodies involved in the execution of the resources (many of which did not have previous experience in executing this type of funds, which has resulted in the leading role of CDTI), or the learning curve faced by administrations involved in the design and execution of target policies.

On the one hand, and in view of the indicators analyzed, it is not possible to affirm, for example, that the policy achieved significant growth in mobilizing SMEs, even though these companies were one of the specific objectives of the programme. On the contrary, LEs and project leaders (primarily LEs) received most of the funds but do not show evidence of proportional results. On the other hand, a positive aspect of this policy's implementation, though not an initial specific objective, could

**Table 10** Summary of the results of positive impact (+), or not demonstrated (=) of the analyzed policy, by indicator. (Source: Own elaboration)

	LE > 250 employees	SME < 250 > 50 employees	SME < 50 employees	RI = 0 (2011)	RI > 0 (2011)	Leaders	Partners
Results of the year	=	=	=	=	=	=	=
Profitability	=	=	=	=	=	=	=

\*Note: values close to the confirmation limit

be that companies without prior innovation activity have leveraged the resources to achieve higher level of capitalisation.

In view of the above results, it can be argued that the objectives of the policy have not been fully met. To address this, the size of supported projects and the roles played by partner companies in collaborative projects could be optimized. Policies should be reformulated to ensure that smaller companies develop a greater capacity to absorb the impact of the funds.

Finally, for the future, it would be advisable to continue working on developing more precise indicators for innovation programmes and calls for proposals. Such improvements would enable more detailed analyses of the impact of these policies on the business fabric, differentiating the results by the characteristics of the agents involved. This differentiation would help assess the effects of fund application across various dimensions.

## 6 Appendix

**Table 11** Description of the Technology Fund and the Smart Growth Programme. (Source: Own elaboration based on the Operative Programme)

	Technology Fund	Smart Growth
Assignment to Spain	2248.45 M€	3939.18 M€
Assignment to Andalusia	976.80 M€	1612 M€*
Territorial distribution Funds	70% for Obj. Convergence regions (Andalusia, Galicia, Extremadura and Castilla La Mancha) 15% for Phasing-in regions (growth effect) 10% for Competitiveness Objective regions 5% for Phasing-out regions (statistical effect)	Plurirregional
Objectives	Articulate and integrate the Spanish R&D&I system with the regional innovation systems Promote business innovation, especially in SMEs in Convergence Objective regions Support the transfer of research results to companies Widen the base of the S-C-T-E by attracting SMEs to R&D&I Promote gender equality in R&D&I	Promoting R&D&I  Improving the use, quality and access to Information and Communication Technologies (ICT)  Improve the communication and competitiveness of SMEs  –  –
Subsidied actions	Vertebrate the innovation system, incorporating SMEs into innovative activity Create and consolidate Technology and Research Centres oriented towards relations with companies Promote the transfer of research from PRIs to companies Attract SMEs and other agents to innovation and research activity	Capacity building for the development of R&D&I activities supported by competitive scientific infrastructures at European and international level Stimulating and fostering capacities for the implementation of business R&D&I projects Promoting the incorporation of researchers and R&D&I personnel and fostering mobility between public sector personnel and the business fabric, as well as the creation of high added value employment

\*Note: Total forecast expenditure (Boscá et al. 2016)

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