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Exploring Business Indicator Benefits in Andalusia: Engaging in European Funded Environmental Projects for Regions in Transition

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Abstract

Business innovation policies in the field of environmental technology in Andalusia are evaluated through the implementation of the ERDF-Innterconecta Programme, which was a unique instrument of innovation policies financed by the Structural Funds of the European Union aimed mainly at the Spanish autonomous communities with Convergence Objective. The proposed analysis seeks to identify the impact of this multiannual programme on the main business indicators of growth, performance and innovation. To this end, we have differentiated between projects aimed at improving the environment and sustainability, and those which have not introduced this objective. The Propensity Score Matching methodology has been selected to contrast the impact of the policy analysed in the selected business indicators. The conclusions offer disparate results for the indicators analysed.

Keywords: Sustainability; Environmental Innovation; R&D&I Policy Evaluation; Structural Funds; Regional Development ; Andalusia

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1 Introduction

The current challenges facing the economic system are creating a growing awareness of the orientation of innovation policies and the effects they have on society. In this sense, there is no doubt that a large part of the attractiveness of companies in the future will be marked by their respect for the environment. In this line, previous studies (Hu, Huang & Chen, 2020; Palmer & Truong, 2017) show the relationship between environmental innovations and competitiveness, and other benefits at the economic performance level (Rennings, Ziegler, Ankele & Hoffmann, 2006).

For this reason, the aim of this study is to assess the impact of European regional innovation policies on the business indicators in Andalusia. For this study, the involvement or not of companies in innovation projects related to environmental sustainability has been taken into account. To this end, the analysis carried out has focused on the study of a specific policy, the ERDF Innterconecta Programme, which was a unique instrument of innovation policies financed by the Structural Funds of the European Union and aimed at the Spanish Autonomous Communities belonging to the Convergence Objective. The EU allocated more than 2,000 million euros to the whole of Spain through the Technology Fund (TF) to reduce the weaknesses of the Science, Technology and Enterprise System (STES) and the gap between the most technologically backward regions and the most developed ones (Ministry of Economy and Finance, 2007). These resources were

later complemented through the Smart Growth Programme (SGP). In the overall funding package, part of the funds was earmarked to support environmental technology innovations. The proposed analysis aims to identify the results of this multi-annual programme with respect to environmental technologies in the Andalusian region. In this regard, it should be recalled that the programme under analysis mobilised a significant volume of resources for innovation from the end of the 2007-2013 programming period and during the first years of the following period, with implementation planned until 2020. This original and novel study addresses the microeconomic impact of a European business innovation programme. Furthermore, a regional perspective has been used in this work, differentiating the results obtained according to the variables observed for the companies participating in the projects financed by the policy analyzed. The fact of having chosen the companies participating in environmental innovative projects as the object of study conforms a new and original approach for this kind of *ex-post* business impact evaluation at regional level. The results obtained will make it possible to discern the differences between some companies and others and to model policies that are better adapted to the needs of the business fabric (*target policies*).

But an evaluation process is not without its difficulties, such as the choice of the appropriate measurement of policy effects, the measurement of the cost-benefits of the analysed programme and the causal attribution of policy impact. Nevertheless, the evaluation of an innovation policy should not lose sight of the complexity and multi-causality of the relationships involved, which can lead to a certain indeterminacy in the effects of the policy analysed.

This study is structured as follows: Section 2 briefly describes the importance of innovation in the environmental field and the role of the European Structural and Investment Funds (ESIF), and also explains the programme studied; Section 3 describes the methodology used, the data sources and the key data of the study; Section 4 analyses the implementation of the ERDF-Innterconecta programme in Andalusia, assessing the effect of these call for proposals on the main business indicators, and differentiating between projects that support innovation related to the environmental technology field and those that do not; Finally, section 5 draws the conclusions and recommendations derived from the study.

2 Literature review

Increasing social and business interest in sustainability is the starting point for the development of environmental innovation theories. Over time there have been different definitions for environmental innovation. Most of these refer to the use of processes, products and administrative or managerial forms to reduce environmental impact (Kemp & Arundel, 1998; Rennings, 2000; Rennings & Zwick, 2003; European Commission, 2008; Amores, Martín, Navas & Delgado, 2011; Ozusaglam, 2012). Nevertheless, a comprehensive review of the general literature dealing with technology innovation and commercialization strategies was undertaken to identify suitable theoretical constructs, and provide empirical support from which to develop this framework. From that review, it is apparent that the business results could be influenced by the type of innovation (Disruptive: affects a specific industry causing drastic and radical changes; Discontinuous: adds something or a new function to an existing concept; Sequential: innovations that require several prior inventions to be developed) being introduced into the market, and by the level of commercial risk (cost risk, product risk and market risk) (Walsh, 2012). But while there is no full consensus on the extent of the environmental innovation and eco-innovation concepts -see Prieto-Sandoval, Jaca & Ormazábal (2018), Cohen-Rosenthal (2000), or Kemp & Pearson (2007)-, it is generally accepted that environmental innovations differ from the rest in that (OECD, 2010): 1) They result in

reductions in environmental impact, 2) Their scope goes beyond the boundaries of the innovating organisation, including social phenomena that enable changes in institutional structures and existing regulations.

2.1 The importance of environmental innovations at business level

Environmental innovations are conditioned by the technological possibilities of firms and their ability to appropriate the benefits of innovative activity (Horbach, 2008), but also by other factors such as customer demand (Yalabik & Fairchild, 2011) and social demand. On the other hand, evolutionary approaches defend the importance of coordinating innovative agents (Dosi, 2012) and developing systemic conditions that favour the exchange of knowledge (Dosi & Nelson, 1994; Dosi, Marengo & Fagiolo, 2005; Sande-Veiga, 2020). Thus, for the latter, the generation of environmental innovations will require changes in production and consumption patterns supported by a socially and technically favourable environment (Faber & Frenken, 2009; Smith, Voß, & Grin, 2010; Pereira & Vence, 2020).

At the business level, environmental innovations could be defined like implementations and organisational changes focused on the environment, with implications for different areas and indicators, including business performance (Ambec & Lanoie, 2008) due to material reduction (Porter & Van der Linde, 1995), but also at the level of products, manufacturing processes and marketing of companies (Dias, Chiappetta & Vasconcellos, 2012), among others. For the last authors, these improvements can be merely incremental -they intensify the performance of something that already exists- or radical -they promote something totally new-, but their main objective is to reduce the environmental impacts of the company. More controversial is the case of the impact on employment. While some studies do not detect positive results of environmental innovation on this indicator (Wagner, Muuls, Martin & Colmer, 2014; Petrick & Wagner, 2014), others find moderately positive results when it comes to product (Rennings & Zwick, 2002; Rennings, Ziegler & Zwick, 2004) and process innovations (Horbach & Rennings, 2013), in the last case thanks to competitivity improvements. For some authors (Triguero, Cuerva & Álvarez-Aledo, 2017), this difference regarding employment results could be explained because the size of the companies moderates the positive role of eco-innovation on employment growth, while young firms not belonging to a group (eco-entrepreneurs) contribute more to employment growth than old firms belonging to a parent firm.

The concept of competitiveness and its relationship with environmental innovations is a relevant aspect (Atkinson, 2013). Previous studies (Shrivastava, 1995; Chen, Lai & Wen, 2006; Palmer & Truong, 2017; De Jesús, ten Caten, Jung, Navas & Cruz-Machado, 2018; Jacob, Florido & Aguiló, 2010; Gilli, Mazzanti & Nicolli, 2013) affirmed the relationship between environmental innovations and competitiveness. The business traceability of possible relationships between competitiveness and environmental innovations would be established on the basis of four concepts (Álvarez, Fernández & Romera, 2014): 1) The direct relationship with cost savings, actions on demand, technological training and reinforcement of environmental and business innovation strategies (Horbach, 2008; Pereira & Vence, 2012); 2) The possible increase in demand for manufactured products because they are greener and more valued by markets (Kesidou & Demirel, 2012; Lin, Tan & Geng, 2013); 3) The development of eco-innovative competences and collaborative networks between companies (Mazzanti and Zoboli, 2006), 4) Advances in sustainability management and the growing concern about aspects such as the reduction of the environmental footprint and the improvement of productivity.

2.2 Policy implications on Environmental Innovation

The Treaty of Maastricht (1992) first and the Treaty of Amsterdam (1999) subsequently established environmental protection as an objective of the Union by linking it to development. Both the Treaty on European Union (TEU) and the Treaty Establishing the European Community (TEC) underline the importance of respect for the principle of sustainable development by Member States when promoting the economic and social progress of their peoples. The Treaty on the Functioning of the European Union (TFEU) expressly states that the environment is an area of shared competence between the EU and the Member States (TFEU, Art. 4, 2012). Therefore, in a strategic context marked by the growing importance of environmental innovation, the EU has had to make a series of funding instruments available to territories and Member States, including the ESIF. In this context, the European environmental innovation support strategy seems to have made the EU more globally competitive (Eryigit & Özcüre, 2015).

At business level, access to ESIF has been shown to be an effective measure to boost environmental innovation (Cecere, Corrocher & Mancusi, 2020), emission reductions (Klemetsen, Rosendhal & Jakobsen, 2016), profits (Madaleno, Robaina, Ferreira Dias & Meireles, 2020), sales of green products (Vicianová, Jaďuďová, Hronec & Rolíková, 2017) and business performance in terms of productivity (Jaraite & De María; 2016) and innovation indicators (Sande-Veiga & Sande-Veiga, 2023). Recent research has also confirmed the relationship between investments in environmental technologies and business investments in eco-innovation (Scarpellinia, Marín-Vinuesa, Portillo-Tarragona & Moneva, 2018; Orlando, Ballestra, Scuotto, Pironti & Del Giudice, 2020). In contrast, Sergej (2016) concludes that funded companies do not obtain economic results that contribute to their competitiveness and sustainable development as a consequence of the lack of a clear territorial strategy, while the previous work of Sande-Veiga & Sande-Veiga (2023) does not confirm an impact of ESIF on business growth and performance indicators. According to Ghisetti & Pontoni (2015), only some types of policies have been shown to affect environmental innovation, in particular regulatory constraints, and according to Li (2014), also pressures from competition or large customers works. The innovative activities of private firms need to be coupled with government interventions that specifically address environmental and knowledge externalities, and promote and participate in green R&D investments to make new technologies competitive (Olmos, Ruester & Liong, 2012; Veugelers 2012). This would also benefit from business cooperation (De Marchi, 2012), as public funds for eco-innovation are generally perceived by these agents as complementary to other external sources of funding (Costa, García-Quevedo & Segarra, 2014).

In addition to Sande-Veiga´s research, previous studies of the Spanish case (Arranz, Arroyabe, Molina-García & De Arroyabe, 2019) highlight that the complexity of the eco-innovation process negatively affects the decision to develop eco-innovations. That´s not strange if we take into account studies like the conducted by Walsh (2012), who claims that commercialization of innovation in environmental technologies is influenced by two important market dimensions: market demand and producers (market-pull), and eco-sophistication of the market (technology-push). For Lo (2004), the main implication when analyzing the effectiveness of investment is that to what extent a relation between risk and reward exists, because it is unlikely to be stable over time. According to the last author, such a relation would be determined by the relative sizes and preferences of various populations in the market ecology, as well as institutional aspects such as the regulatory environment and tax laws. However, results suggest that institutions and organisations of the Spanish environment are making efforts to compensate these obstacles and provide incentives to develop eco-innovations. But the effects induced by an environmental innovation policy also depend on the nature of the instruments used (Ghisetti & Pontoni, 2015).

In addition, environmental innovation policies present a number of problems that need to be addressed in order to carry out eco-innovations. On the one hand, there is uncertainty about future market demand, coupled with uncertainty about the return on investment (Marin, Marzucchi & Zoboli, 2015). In terms of general policy formulation, Colombo, Pansera & Owen (2019) argue that the eco-innovation discourse in EU programmes has been mostly built around the notion of eco-efficiency. On the other hand, recent studies (Wielgórka & Szczepaniak, 2019) have pointed precisely to the lack of financing and access to credit, and also high implementation costs, as the main difficulties faced by SMEs in achieving eco-innovations.

In any case, as Arundel & Kemp (2009) and others (Johnstone & Hascic, 2008a; 2008b; Machiba 2008) argue, it would be necessary to devote more effort to the direct measurement of the results of eco-innovation through R&D indicators or patents achievements, as well as changes in resource efficiency and productivity. In general terms, data measurements are often done on an informal data basis (Kleinknecht *et al.*, 2002). It is precisely within this framework that the proposal of this paper fits, taking as a reference the indicators used in previous regional innovation impact studies such as Sande-Veiga & Vence (2021).

2.3 The Funds studied: the ERDF-Innterconecta programme in Andalusia

Andalusia (figure 1) is traditionally an agricultural area, but the service sector (particularly tourism, retail sales, and transportation) now predominates. The once booming construction sector (hit hard by the 2009 recession) was also important to the region's economy, while the industrial sector is less developed than most other regions in Spain. According to the Spanish National Statistics Institute (INE), the Gross Domestic Product (GDP) per capita in Andalusia remains the second lowest in Spain (only Extremadura lagging behind). The GDP of the autonomous community was around 160.74 billion euros in 2021, accounting for a sixth part of Spanish economic output. GDP per capita was 18,906 euros. During the European programming period 2007-2016, Andalusia was classified as an objective Convergence region in Europe, and modest innovator, as well as Galicia, Extremadura and Castilla La Mancha.

Figure 1. Andalusia, Spanish region in objective Transition
Source: Google Images (Creative Commons Lic.)

At the end of the period analysed, the Autonomous Community of Andalusia had a R&D expenditure in relation to GDP of 1.06%, far from the 3% target set by the European Union for this indicator. Specifically, internal R&D expenditure amounted to 1,703.53 million euro, with the business sector accounting for 592.43 million euro. The number of companies offering high-tech manufacturing and services in the autonomous region barely reached 500 at that date, while the number of workers involved in this type of company barely exceeded 4,000. Nevertheless, the moderate progress in innovation has allowed Andalusia to cease to be a Convergence Objective territory and to be considered as a region in Transition.

The ERDF-*Innterconecta* calls arose in the middle of the 2007-2013 programming period, in view of the low implementation that was being achieved by the TF (Sande-Veiga & Vence, 2019; Sande, 2024a). The birth of this programme was based on the premise of supporting large integrated experimental development projects of a public-private nature, of a strategic nature, and aimed at developing new technologies in technological areas with international economic projection. The aid granted until 2020 under this programme financed projects with no thematic limitation, on the condition that they fostered employment, were of a high technological level and promoted activities that favoured an increase in the added value of the participating companies (Ministry of Economy and Competitiveness, 2013). The SGP subsidized different areas: 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. The basic information on the *Innterconecta* programme is broken down below (table 1).

Table 1. ERDF-Innterconecta Programme descriptive data

	Technology fund	Smart growth
Assignment to Spain	262 M€	210 M€
Territorial distribution of the Funds	Andalusia 150 M€ Galicia: 105 M€ Extremadura: 7 M€ Castilla La Mancha: This autonomous community does not participate in the calls for proposals of the TF	Plurirregional
Subsided areas	All, as long as they stimulate employment and increase added value (Ministry of Economy and Competitiveness, 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 requirements	Formation of an Economic Interest Grouping (EIG) or Consortium	

	Technology fund	Smart growth
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	

Source: Own elaboration (Sande-Veiga, 2024b)

3 Methodology

In this section, the methodology of the study is firstly discussed and then presented. Secondly, we analyse the main data extracted from the projects carried out iin the *Innterconecta* calls for proposals in Andalusia. To this end, we will first synthesize the information on the economic value of the projects and the technological areas involved, as well as the type of participating agents and the networks they have established.

3.1 Description of the Methology

One of the main discussions when preparing this research has been the choice of the methodology. To solve this, at least three options were possible: the use of what is known as Propensity Score Matching (PSM) technique, the Coarsened Exact Matching (CEM) and the dose-response analysis. According to Iacus, King & Porro (2012), CEM is a Monotonoic Imbalance Bounding (MIB) matching method, which means that the balance between the treated and control groups is chosen by the user ex ante, rather than discovered through the usual laborious process of checking after the fact and repeatedly reestimating. For some authors (Blackwell, Iacus, King & Porro, 2009) CEM is faster, is easier to use and understand than other techniques. Nevertheless, according to recent research (Black, Lalkiya & Lerner, 2020), CEM drops substantially more observations, does so in non-obvious ways, can severely misidentify average treatment effects, and is much less precise than other methods, so the authors discourage to use CEM, in favour of other methodologies such as PSM. For methodologies such as dose-response it would have been necessary to know the exact amount that each business consortium has been subsidized with, which disincentive to use this option because of data availability.

The *Propensity Score Matching* (PSM) methodology has been used for the statistical analysis of the subsequent part of the study. This technique analyses the covariances between two groups of values: on the one hand, the companies not participating in the policy and, on the other, the participating companies. The mean of the values ($\bar{x}$) and the standard deviation (σ) are then studied, and covariances of both groups are calculated. In case the value of the standardized mean difference (or SMD), measured through the *d-index*, is greater than 0.1, imbalance would be observed, and we should apply the PSM. The propensity score was then estimated by applying a *logit* model in which the outcome variable is a binary variable indicating whether the policy was implemented or not, using the R software package *MatchIt*. Among the different methods to perform the *matching* (*exact matching, nearest neighbour, optimal matching, full matching and caliper matching*,...), we selected the *nearest neighbour*, as we considered it more appropriate to

match each individual in the treatment group with the individual in the control group that has the closest *propensity score*. We use the most common implementation of PS matching, in practice is one-by-one matching, in which pairs of treated and control units are formed (this info has been included in the methodology). Using one-by-one nearest neighbour PS matching =N(1)iC, one treated unit i ∈ T is matched to one control unit j ∈ C. That is, that individual is selected from the candidates pairing whose propensity score is the most similar to the propensity score of the individual to be paired in the case group. There is a one-to-one matching, in the former an element of the control group is used more than once. The values of the variables have been taken at the end of the period, as a result for these indicators. Once the test is completed, we include the *p-value*, which indicates whether there are significant differences between the group that participates in the policy and the group that does not.

For the purpose described, the different types of measures and actions financed under this programme and their effects on the main business indicators will be analysed. Following previous studies (Sande-Veiga & Sande-Veiga, 2023; Sande-Veiga, 2024c), the indicators selected to conduct the current impact study are revenue, gross added value (GAV), employment, profitability, profit for the year and investment in research and development (innovation). The importance of analyzing this group of indicators, related to business growth, company results and their accounting activation of innovative activity, is marked by the following aspects. Firstly, business growth is desirable for companies and innovation, since increasing size also allows increasing the capacity to absorb resources for innovation. Secondly, given that it is an expected result of innovation that companies generate greater added value, business results should be improved. Thirdly, if companies receive financing to innovate, it would seem logical (at least a priori) for them to record this type of activity in their accounting. From this point of view, it could be interesting to differentiate what happened between large and small companies. The limited number of projects aimed at environmental innovation put at risk a separate treatment of both types of companies with consistent results.

Notwithstanding the rigorous statistical study, the proposed impact measurement study has had to face some problems and limitations. Firstly, there is the problem of self-selection, arising from the companies' ability to choose whether or not to participate in the calls for proposals of the programme under analysis. Secondly, the problem of endogeneity has been addressed. The decision of public administrations when approving the programme has been an external trigger that has allowed firms to participate (García-Nicolás & Cantos, 2015). Finally, the results could have distorting biases in case there were governmental interests in the selection of funding to projects and companies (Martí, 2020). To isolate the effect of these problems, the use of the PSM statistical technique has been proposed which, by accounting for and analyzing covariance, allows the effect of a policy to be estimated. But PSM could have other problems, as King & Nielsen (2019) argue. For example Rubin (2008) recommends the use of that technique on completely randomized experiments, and many authors (Rosenbaum & Rubin, 1985; Stuart & Rubin, 2007) have recommended that all observations more than 1/4 of a standard deviation in the propensity scores be routinely callipered off. In addition, along the lines of the PSM paradox, Peikes, Moreno & Orzol (2008) have pointed to PSM requiring many more observations than they expected.

Nevertheless, and despite possible limitations, the use of the PSM methodology is the most appropriate for the present study, since other methodologies such as CEM drops substantially more observations, does so in non-obvious ways, can severely misidentify average treatment effects, and is much less precise than PSM according to recent research (Black, Lalkiya & Lerner, 2020).

3.2 Data sources and key data

For the development of the work, it has been necessary to collect and process quantitative and qualitative data from numerous sources in order to study and analyze the data on the implementation and effects of the TF. The data sources used, and their purpose are listed below (table 2).

Table 2. Data sources and objectives

Source	Sort of data	Objective
Ministry of Finance	Processed data	ESIF framework in Spain (SP) and Andalusia (And)
Ministry of Education and Science	Descriptive data analizados	Evolution of strategic indicators SP-And
National Statistical Institute (INE)	Descriptive data	Evolution of strategic indicators SP-And
Andalusian Statistical Institute (IECA)	Descriptive data	Evolution of strategic indicators SP-And
Eurostat	Descriptive data	Evolution of strategic indicators SP-And
Ministry of Finance (Junta Andalucia)	Data analyzed	Implementation of the Innterconecta programme in Andalusia
Centre for Industrial and Technological Developement	Data analyzed	Analysis of networks formed and impact Innterconecta
Ardan data base (CZF, Vigo)	Data analyzed	Impact analysis on business indicators

Source: Own elaboration

Regarding the key data of the study, the average amount of investment per company participating in the funded projects has been calculated as Total amount/Number of companies. The average budget of each of the 827 participating companies identified amounted to 639,679.85 €, while CDTI support covered almost half of this amount on average, with 302,406.91 €.

The technological areas to which the 337 companies participating in *Innterconecta* belong -that made up the sample used for the impact study- were analysed, and two types of activities are particularly relevant: industrial manufacturing activities (34.12%) and professional, scientific and technical activities (27.60%), which often correspond to consultancy and specialised services. The rest of the *Innterconecta* resources went mainly to the following technological areas: information and communication technologies (9.20%), retail and wholesale trade (8.90%) and construction (8.31%). On the other hand, due to Andalusia's productive specialisation companies from sectors such as energy and water supply, hotels and catering, and health and social activities have emerged as project participants. In all these thematic areas, projects related more directly or transversally to sustainability and environment have appeared, so it has been considered to compute the projects in the broad sense of their environmental participation and results.

Although the TF had mobilised more European resources in Andalusia than the SGP, the smaller size of the projects financed by the SGP has made it possible to maintain a similar level of business participation between the two operational programmes. As a result, around 1,500 companies have been able to carry out *Innterconecta*-funded projects (table 3).

Table 3. Approved projects and participating companies in Innterconecta-Andalusia

Calls for proposals	Approved Projects	Number of Companies	Requested Projects	Number of Companies
1st Reg. Call 2011	31	195	74	410
2nd Reg. Call 2013	41	211	59	255
3rd Call 2015*	131	511	269	946
4th Call 2016*	64	246	231	822
5th Call 2018*	67	229	N/A	N/A
Total general	334	1392	633	2433

Source: Own elaboration from CDTI and BOE data; *Note: Plurirregional

The average number of participating companies per project was 4.17, but it should be noted that the total number of actors is higher, also taking into account the participation of technology centres, universities and research organisations in the consortia. Almost a quarter of the participating companies were included in projects related to the environment (22.26%), the majority of them were SMEs (80%), while the rest were large companies (20%). The latter had a strong presence as leading companies in the projects (table 4).

Table 4. Descriptive statistics of the projects analyzed at the beginning of the period

Number of participating companies analyzed // Companies in environmental projects // Control sample		337	75	355
	Small and Medium Enterprises	247 (73.29%)	60 (80%)	345 (97.18%)
	Large Enterprises	90 (26.71%)	15 (20%)	10 (2.82%)
Number of companies per project	4.17			
Role in the projects	Leaders	63 (18.69%)	27 (36%)	-*
	Partners	274 (81.31%)	48 64%	-*
Role in innovation of participants // Control sample	Previously innovative (accountancy data)	10 (2.97%)	0 (0%)	3 (0.85%)
	Non-innovative (accountancy data)	327 (93.03%)	75 (100%)	352 (99.15%)
Sector of activity of the projects subsidized	Industrial manufacturing activities	34.12%		
	Scientific and technical activities	27.6%		
	ICT	9.2%		

Retail and wholesale trade	8.9%
Construction	8.31%
Other activities	11.87%

Source: Own elaboration based on ARDÁN and CDTI data; *Not applicable

4 Analysis of the impact of the ERDF Innterconecta calls for proposals in environmental projects in Andalusia

In what follows in this section, the information is structured to assess the impact of the ERDF-*Innterconecta* Programme on companies that have carried out projects related to environmental sustainability, analysing the results of the main indicators of the companies participating in environmental innovation projects with respect to the other technological fields.

Comparative evolution of indicators performance in companies participating and non-participating in *Innterconecta*

The Funds allocated through the ERDF-*Innterconecta* programme for the promotion of business innovation have been significant for the Convergence regions, and particularly in Andalusia. For this reason, the expected impact should be relevant (although it is true that part of the results can be assessed over a longer period of time). In order to characterise the impact of this programme in Andalusia, the behaviour of the main indicators of growth, performance and innovation of the companies participating in this programme has been analyzed, without ignoring the fact that the evolution shown by these companies is also influenced by other factors of the socio-economic context, such as the systemic crisis suffered, legislative changes, the multiple corporate business management strategies, and others.

This paper addresses the evolution of the following business indicators of the companies analyzed for the period 2007-2020: the first group includes indicators related to business growth [revenue, gross value added (GVA) and employment], the second group includes indicators of business performance [economic profitability and profit for the year], while the third group analyses the impact on innovation indicators [investment in research and development]. For this analysis, we have differentiated between companies involved in projects related to environmental innovation and sustainability (30) and those involved in other types of projects (73 regional in Andalusia, and 332 plurirregional). The projects objectives and description have been taken into account to discern the membership in this group of environmental innovation projects (table 5). For the analysis of the indicators we have taken the accounting information of the companies participating in *Innterconecta* obtained in raw form from the Ardán database.

Table 5. Data on the number of identified projects and participating companies in the sample related to environmental innovation and sustainability in Innterconecta in Andalusia

	Number of projects	Total Subsidy (€)	Number of companies
1st Call	6	18,615,753.00	14
2nd Call	5	5,849,603.27	18
3rd Call	8	7,143,268.9	21
4th Call	4	3,367,214.6	6
5th Call	7	5,741,018.00	18
Total	30	40,716,857.8	77

Source: Own elaboration based on CDTI data, official websites and national newspapers

Of the more than eight hundred Andalusian companies identified as participants in the regional and multi-regional Innterconecta calls for proposals, data were available for a total of 337 companies that received the policy support. To gain a deeper understanding of the impact of the Innterconecta programme on these companies, the evolution of its indicators was compared with a control sample (CS) of 355 Andalusian companies that have not participated in the policy, which was extracted from Ardán. Companies participating in environment-related projects (EP) were also compared with those that participated in non-environmental projects (NEP). In principle, environmentally innovative companies show positive aggregate and relative developments for only three indicators: number of employees, investment in research and investment in development (table 6). This information has also been confirmed by the graphical study (see figures 2 to 8).

Utilizing outcome indicators for the Difference-in-Differences (DiD) analysis allows assessing the impact of funding on the specific outcomes of interest. This combined approach can help address potential selection bias, control for confounders, and provide a robust estimation of the treatment effect. By comparing changes in outcomes over time between the funded and control groups, we estimate the causal effect of funding on these outcomes. DiD Effect has been calculated as follows = (Outcome in Treatment Group, Post-Intervention - Outcome in Treatment Group, Pre-Intervention) - (Outcome in Control Group, Post-Intervention - Outcome in Control Group, Pre-Intervention). A statistically significant and positive DiD effect would imply that the intervention (innovation funding) had a positive impact on the outcomes of interest. The results show that, in general, the outcomes for the treatment group did not improved more than those for the control group after the intervention (table 7).

4.1 Statistical analysis

In this paper we have used the *Propensity Score Matching* (PSM) methodology, which analyses the covariances between two groups of values: on the one hand, companies not participating in the policy and, on the other hand, participating companies.

First, the statistical study is disaggregated by groups and differentiating between the control sample and the companies that have participated in environmental innovation projects financed by *Innterconecta* (table 7). For both the control sample and the participating companies, we first calculate the number for which the matching has taken place. Next, we study the mean of the values ($\bar{x}$) and the standard deviation (σ). In case the value of the standardised mean difference

Table 6. Aggregate and relative evolution after the participation of companies in environmental innovation projects in Innterconecta with respect to the control sample (€,%)

Sample	Revenue	GVA	Employees	Profitability*	Result of the Year	Research Investment	Development Investment
EP	-15,595,094,157 (-44.19%)	-1,452,620,753 (-32.53%)	+4,637 (+20.47%)	-0.65 (-27.03%)	-1,435,289,961 (-71.01%)	+ 1,654,759.99 (+4,390.04%)	+ 35,750,041.28 (+69.62%)
CS	+8,722,662,171 (+218.91%)	+1,879,833,987 (+246.07%)	+36,414 (+282.52%)	+15.03 (206.74%)	+301,259,773 (+327.17%)	+11,858,348.55 (+3,217,755%)	+75,893,895.83 (+4,597,485.60%)
NEP	+16,887,062,213 (+87.40%)	+5,598,327,904 (+110.88%)	+15,830 (+15.65%)	+0.88 (+15.39%)	+425,704,566 (+16.53%)	+8,292,495.65 (+77.84%)	+301,140,692.20 (+12.32%)

Source: Own elaboration based on Ardán and CDTI data
*Note: %

Table 7. Outcome Indicators for DiD of the groups studied (€, %)

Sample	Revenue	GVA	Employees	Profitability*	Result of the Year	Research Investment	Development Investment
EP-CS	-232,505,468.10	-24,663,583.71	-40.75	-0.05	-19,985,818.56	-11,341.37	262,876.95
EP-CS (%)	-263.11%	-278.6%	-262.05%	-233.77%	-408.18%	-2,768,751.59%	-4,597,414.94%
EP-NEP	-83,577,638.73	-40,654,694.59	1.64	-0.01	-20,755,848.02	-9,466.94	-668,354.43
EP-NEP (%)	-119.93%	-143.4%	4.82%	-42.42%	-97.54%	-522,673.97%	37.54%

Source: Own elaboration based on Ardán and CDTI data
*Note: %

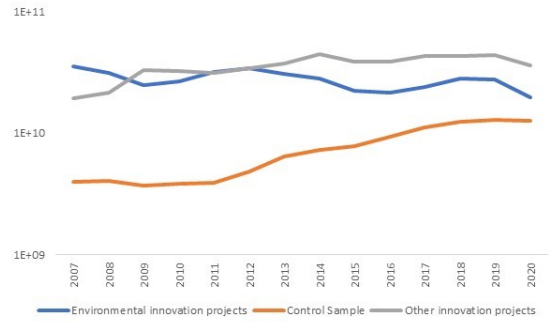

Figure 2. Comparative evolution of Revenue, participating and non-participating companies in environmental innovation projects, Innterconecta-Andalucía 2007-2020 (index 2007=100, log10(x))

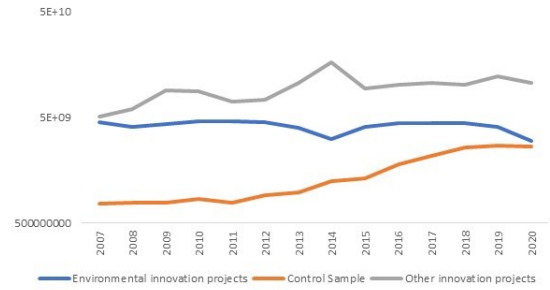

Figure 3. Comparative evolution of GVA, participating and non-participating companies in environmental innovation projects, Innterconecta-Andalucía 2007-2020 (index 2007=100, log10(x))

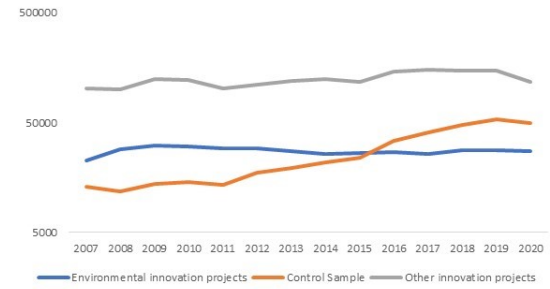

Figure 4. Comparative evolution of Employment, participating and non-participating companies in environmental innovation projects, Innterconecta-Andalucía 2007-2020 (index 2007=100, log10(x))

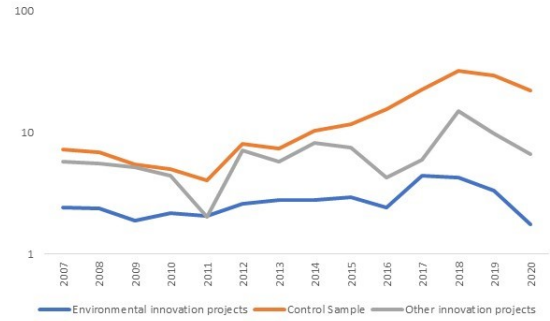

Figure 5. Comparative evolution of Profitability, participating and non-participating companies in environmental innovation projects, Innterconecta-Andalucía 2007-2020 (index 2007=100, log10(x))

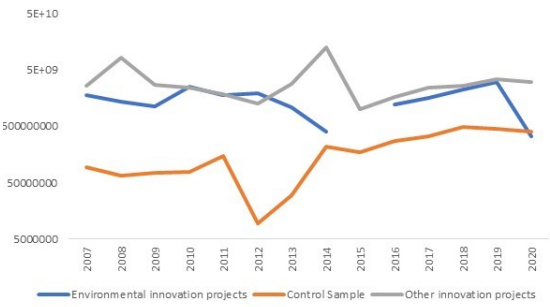

Figure 6. Comparative evolution of Result of the Year, participating and non-participating companies in environmental innovation projects, Innterconecta-Andalucía 2007-2020 (index 2007=100, log10(x))

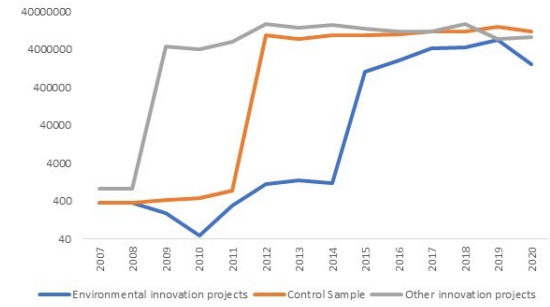

Figure 7. Comparative evolution of Research Investment, participating and non-participating companies in environmental innovation projects, Innterconecta-Andalucía 2007-2020 (index 2007=100, log10(x))

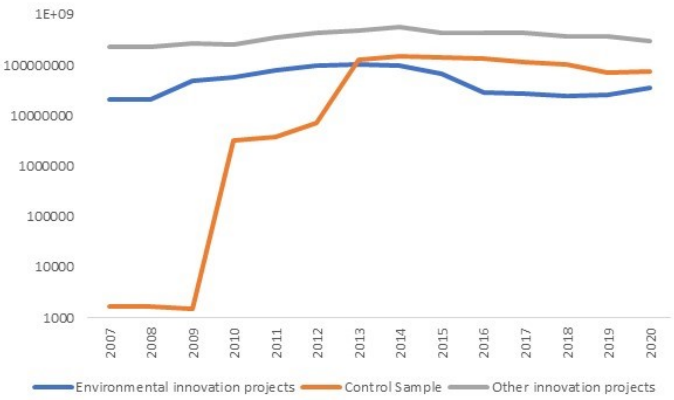

Figure 8. Comparative evolution of Development Investment, participating and non-participating companies in environmental innovation projects, Innterconecta-Andalucía 2007-2020 (index 2007=100, log10(x))

Source Figures 2 to 8: Own elaboration based on Ardán and CDTI data

(or SMD), measured through the *d-index*, is higher than 0.1, an imbalance would be observed, and we should apply the PSM. However, in order to provide more comprehensive information on the results, we have chosen to calculate the PSM also for those values whose d-index was lower than 0.1. The propensity score was then estimated by applying a *logit* model in which the outcome variable is a binary variable indicating whether the policy was implemented or not, using the R *MatchIt* software package. Among the different methods to perform the *matching* (*exact matching, nearest neighbour, optimal matching, full matching and calibre matching*,...), we selected *nearest neighbour*, as we considered it more appropriate to match each individual in the treatment group with the individual in the control group who has the closest propensity score. Once the test is completed, we include the *p-value*, which indicates whether there are significant differences between the group that participates in the policy and the group that does not. To complete the statistical information, the analysis has been extended to compare whether there are differences between the environmental innovation projects funded and other innovation projects under the same policy (table 8).

The results observed from the statistical analysis show a consistency in the results and a pattern of behaviour of the companies participating in the policy. Thus, the statistical test shows that funded companies participating in environmental or sustainability-related innovation projects performed better on four of the indicators (table 8): revenue, GVA, employment and profitability. This result has not been confirmed for the result of the year indicator. On the other hand, the availability of information and the low activation of investments in the companies' accounts, due to various regulatory factors and the previous crisis context (Sande-Veiga & Vence, 2021) has not allowed us to verify the existence or not of the impact of the policy for two of the indicators: investment in research and development.

Secondly, we performed the statistical test for all firms participating in the policy, differentiating between firms involved in other types of innovation projects and those involved in environmental innovation projects. The results again show consistency. The statistical analysis shows no differences in the impact for the indicators analysed according to the type of innovation project carried out (table 9).

Table 8. Results of the statistical analysis of firms related to environmental projects and the sample control, using PSM

	n_1	n_2	$\bar{x_1}$	$\bar{x_2}$	σ_1	σ_2	Index-d (DME)	p-valor
Revenue	20	29	290,407,388.70	49,948,378.48	420,054,859.37	55,223,517.25	0.803	0.0107
GVA	20	29	62,130,955.90	14,494,415.76	95,087,730	23,073,802.82	0.689	0.0165
Employment	20	29	989	260.55	1,421.77	312.29	0.708	0.0121
Profitability	20	29	0.02	0.05	0.06	0.11	0.352	0.0033
Result of the Year	20	29	-1,632,531.90	2,782,744.55	57,566,029.37	12,452,563.78	0.106	0.6000
Research Investment	1	1	1,406,198	1,406,198	NA	NA	NA	NA
Development Investment	4	1	459,227.45	65	917,848.41	NA	NA	NA

Source: Own elaboration using *R software*

Table 9. Results of the statistical analysis of firms related and not related to environmental projects, using PSM

	n_3	n_4	$\bar{x_3}$	$\bar{x_4}$	σ_3	σ_4	Index-d (DME)	p-valor
Revenue	176	56	205,730,382.13	351,713,269.09	893,554,268.85	1,497,817,530.42	0.118	0.9979
GVA	176	56	60,496,586.80	53,811,977.45	245,091,762.86	272,586,507.15	0.026	0.7577
Employment	176	56	668.50	487.41	1,980.32	731.34	0.121	0.9108
Profitability	176	56	0.04	0.03	0.14	0.08	0.057	0.9804
Result of the Year	176	56	17,055,422.26	6,007,590.14	191,602,025.04	168,462,489.15	0.061	0.7903
Research Investment	12	4	691,041.30	413,690.00	2,218,572.97	826220.09	0.166	0.9548
Development Investment	43	16	7,003,271.91	2,234,377.58	17,958,461.08	3,604,770.38	0.36	0.7696

Source: Own elaboration using *R software*

Below is a summary table listing the results observed for each of the groups analyzed: 1) Companies that have participated in environmental innovation projects (EP) relative to the control sample (CS), and 2) Companies that have participated in environmental innovation projects (EP) relative to companies that have participated in innovation projects that did not include environmental innovation (NEP) (table 10).

Table 10. Summary of the results of positive impact (+), or not demonstrated (=), for the companies participating in projects related to environmental innovation, by indicator

Sample	Revenue	GVA	Employees	Profitability	Result of the Year	Research Investment	Development Investment
EP-CS	+	+	+	+	=	NA	NA
EP-NEP	=	=	=	=	=	=	=

Source: Own elaboration

5 Conclusions

In this last section we will break down the conclusions into two parts. The first part presents the research findings, while the second part suggests a number of policy recommendations that can be inferred from the observed results.

5.1 Results

The *Innterconecta* Programme belonging to TF and SGP endowed with significant amounts of ESIF to promote technological development in Andalusia between 2011-2020. This availability of financial support raised expectations for the development of business innovation within the Andalusian Innovation System. However, some fields like the environmental did not receive a specific treatment in the programmes scheduled. Notwithstanding that, the positive results observed for several of the business indicators of companies participating in environmental innovation projects shows that support to projects focused on sustainability and environmental innovations, in addition to being necessary at an environmental level, also show positive results in various aspects.

In the chart study of the data, from 2011-2012 a slight improvement seems to be observed in the evolution of two indicators -research and development investment- of the companies participating in environmental projects, with respect to the control group of non-participating companies. This positive impact in terms of aggregate values would not be perceived for all the indicators analyzed, since for the rest of the indicators no impact is apparently visible in the graphic information.

Unlike the graphic information, it is clear from the statistical study that the results have generally been positive and consistent. Thus, while previous studies for other regions show lack of impact in growth indicators (Sande-Veiga, 2022) and a positive, albeit moderate, impact of the ESIF for innovation on the main innovation indicators of firms (Sande-Veiga & Vence, 2021), the present study does not confirm this general result. In fact, support for larger projects in Andalusia has led to an improvement in business growth indicators (revenue, GVA, employment) and profitability for the companies financed that participate in environmental innovation projects. This result would be in line with previous studies, such as the one carried out by Sande-Veiga & Sande-Veiga (2023).

5.2 Recommendations

Support for innovation through large projects financed in Andalusia has been positive in terms of business growth and profitability indicators. However, the results in terms of innovation indicators (in terms of their accounting activation) have been practically non-existent, if not nil. But this result could also be indicative that the Spanish accounting activation scheme for R&D would not be working properly.

As a consequence of the above results on the impact of business innovation policy on the environment in Andalusia, and in order to achieve greater efficiency in the results of R&D&I policies, specific lines of aid could have been implemented to support this technological field, also in response to the growing business and social demand at present. Similarly, financing smaller projects would have made it possible to address initiatives that would have responded to a greater extent to the possible investment needs of the smaller enterprises, particularly SMEs, which constituted a specific objective of the programme, and which make up a large part of the Andalusian business fabric. This would be in line with previous research such as that of Veryzer & Borja de Mozota (2005), which concludes that for practitioners, the article suggests how user-oriented design can improve new product development through its more grounded and comprehensive approach, along with the elevated appreciation of design challenges and heightened sense of possibilities for a product being developed. In this sense, we shouldn´t forget studies like those conducted by Cooper (2000; 1998) which highlight the convenience of approaching to radically new products, and disruptive or discontinuous innovations that change the dimensionality of the consumer decision.

In addition, more specific objectives could have been included in these innovation programs, which would facilitate the evaluation of the financing of the innovation ecosystem (for example, indicating the number of environmental innovation projects financed, the number of companies, technology centers and research organizations involved, or the expected sectoral impacts, etc.). Similarly, in order to more clearly promote the priority thematic areas defined in the regional Smart Specialization Strategy, a prior adaptation of the programs should be observed, thus facilitating greater alignment between policies and strategies while promoting a key aspect in the coming years, such as environmental innovation and sustainability.

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7 Appendix

Abreviations

CDTI - Centre for Industrial and Technological Development

CEM - Current Exposure Methodology

CS - Control Sample

DiD - Difference in Differences

EP - Environmental Projects

ERDF - European Regional Development Funds

ESIF - European Structural and Investment Funds

EU - European Union

GVA - Gross Value Added

GDP - Gross Domestic Products

INE - Spanish Statistical Institute

MIB - Monotonic Imbalance Bounding

NEP - Non-Environmental Projects

OECD - Organisation for Economic Co-operation and Development

PS - Propensity Score

PSM - Propensity Score Matching

R&D - Research and Development

R&D&I - Research, Development and Innovation

SGP - Smart Growth Programme

SMD- Standardised Mean Difference

SME- Small and Medium Enterprises

STES- Science, Technology and Enterprises System

TEC- Treaty establishing the European Community

TEU- Treaty on European Union

TF- Technology Fund

TFEU- Treaty on the Functioning of the European Union

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Diego Sande Veiga. Diego Sande Veiga is a lecturer and researcher in the Department of Applied Economics at the University of Santiago de Compostela. He is also a civil servant of the Xunta de Galicia (currently on leave). He holds a PhD in Economics and Business Studies. He has also taken master's and postgraduate courses in different areas. Diego is a member of the Research Group ICEDE (Innovation, Structural Change and Development) of the USC, and also collaborates with IGADI (Galician Institute of International Documentation). He is a member of the editorial board of the journal Tempo Exterior. He has visited various international universities, as well as participated in numerous conferences, and publishing several books and articles in scientific and technical journals. The author has received several research awards, among others, the Research Prize for works on employment (Council of Santiago de Compostela) or the Colmeiro Prize (Xunta de Galicia) to research works on Galician public administration. He has been collaborating with several media. His main areas of research are the study of the impact of European policies on regional innovation, the analysis of environmental and technological innovation policies, and other public policies.
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