Cooperation Networks as a Driver of Sustainability-Oriented Innovation

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Abstract: Companies can contribute to sustainable development in a dynamic and globalized market, such as today’s, through Sustainability-Oriented Innovation (SOI). However, to do this implies meeting specific requirements and dealing with greater complexity because of the higher level of sophistication of cooperation networks for this kind of innovation. In this context, to meet the requirements demanded by SOI, Foreign Direct Investment (FDI) is considered fundamental. However, it is not known whether their capacity to focus more on heterogeneous knowledge sources, which, thanks to their cooperation networks, are broad and geographically diverse, would have a differential impact on SOIs. Through comparative analysis, this paper attempts to shed light on the possible network differences for companies, with and without FDI, looking to undertake SOI. It focuses on the knowledge framework and geographical scope stemming from cooperation for successfully undertaking sustainable developments. To this end, three networks had to be set up, which include diversity, scope, experience, and frequency of national, European, and global cooperation. The results lend strength to the theory that SOI is favored by European and global cooperation networks if companies have FDI, and by national networks if there is no foreign participation. For this, the role of absorptive capacity is key, understood as a joint analysis of R&D intensity and the skills and education of employees tasked with innovation, and the implementation of new organizational methods. Lastly, it is confirmed that having FDI allows companies to have qualified employees, and better methods and organizational practices in connection with an openness to innovation.

Keywords: sustainability-oriented innovation; foreign direct investment; cooperation networks; absorptive capacity

1. Introduction

In the last decade, the interest of both professionals and academics has focused on knowing how different open innovation partners can improve this Sustainability-Oriented Innovation (SOI). In this sense, SOI reflects the intention of the company to develop new products or services with scope in economic, environmental, and social sustainability [1–4].

Current literature, therefore, focuses on understanding how companies integrate a large number of actors in a sustainable context, in order to determine what the external links are within the diversity of options that allow them to undertake SOI [5,6].

However, this diversity means there is a lack of knowledge about how SOI benefits from external cooperation, as these multiple new perspectives of stakeholders are needed to rethink and redesign products, processes, and services that comply with the requirements of sustainable development [2,7].

In this regard, previous studies recognize the efficient and effective integration of clients, suppliers, and institutions, among other actors, as a key competence for companies to undertake SOI. In other words, the formation of partner networks plays an important role in the aforementioned redesign. As
a result, there is a need to use what the literature on inter-organizational cooperation, alliances, or networks can offer to carry out further research into SOI [6,8,9].

Despite the existence of a number of solid arguments that favor openness to developing SOI and the international recognition of the power of cooperation networks to boost SOI, relatively little is known about how this openness should come about and what its contribution would be. The question of what network links are, therefore, is open for future research; how these links can benefit SOI and their implications is an area yet to be explored [6,9,10].

To contribute to this emerging field on the research of sustainable networks, this document considers SOI as a process that deliberately seeks to make improvements in the economic, environmental, and social spheres, with the aim of exploring the relationship between reaching sustainable goals and participation in cooperation networks. These networks are those that provide sustainable and innovative solutions through the exchange or cooperative development of knowledge, by way of alliances between different external actors. So, the first research question is, does participating in cooperation networks encourage companies to carry out Sustainability-Oriented Innovation?

Recently, Foreign Direct Investment (FDI) (a company is considered as having FDI when foreign investment exceeds 10%) has been a driving force for sustainable development, allowing society to prosper, create knowledge, and be consistent and resilient to financing. Furthermore, it enhances the image in financial intermediation and the increase in credit, improves trust and increases local resources, is a good catalyst for internal investment, and enhances technology transfer and management capacity [11].

In this sense, FDI updates technologies with positive environmental effects [12]. In fact, it has environmental and social concerns, since economic performance is not the only result [13]. Hence, it covers any activity that is significant in creating value, such as obtaining knowledge [14]. Companies with external links, including access to FDI, seem to be more oriented towards innovation and towards sustainability objectives [7,15].

FDI looks to obtain strategic resources, setting companies apart in terms of how they cooperate, their capacity to invest in knowledge, and their technology. This implies that FDI researches and develops assets from different knowledge fields. However, they need to be integrated both internally and externally in the local innovation system. They are also different in terms of how their human capital interacts to obtain knowledge [16–20].

As regards the network links of companies with FDI, the literature recognizes the need to further understand the role of the characteristics of the network partners in innovation performance, when it comes to integrating multiple networks, as is the case for these companies. There needs to be further discussion on the relationships between networks and innovation when FDI comes from culturally different countries like Asia, Africa, or Latin America; research into how the strategic focus of innovation influences the creation of networks; and the alliance strategy needs to be the right one for mitigating the liability of foreignness [21–24].

This performance is influenced by various factors. The first is the diversity of intra and inter-organizational networks, which is determined by the similarities and differences between the partners of a network with respect to an attribute. Likewise, their similarities and differences with respect to technological knowledge, culture, and the institutional environment entail different levels of cognitive proximity. Secondly, operating within a set of multiple contexts, through networks, allows them to fuse the absorbed knowledge. Lastly, they have the capacity to obtain knowledge on a global level, given their different technological areas and competitive environments in which they operate, which is perhaps better for managing heterogeneous partnerships due to their structural characteristics, their diverse knowledge base, and their experience [21,22,24–28].

In summary, there seem to be arguments to suggest that companies with FDI, thanks to their cooperation networks, can focus more attention on knowledge sources that are heterogeneous, broad, and have greater geographical scope. Therefore, the second research question to consider is, will that network diversity have a differential impact on SOI?
Absorptive capacity is key for applying acquired knowledge to SOI. This capacity to absorb and use new knowledge sources is enhanced by the training and experience of human capital. In the case of companies with FDI, employees are more qualified as they interact across borders and therefore develop multicultural skills. In fact, these companies are better positioned than their national counterparts when it comes to translating the diversity of alliances into better innovation performance with a high level of human capital [29,30].

Moreover, having foreign ownership offers the company more specific assets in terms of the better practices typically found in other countries, more units that innovation can be applied to, and more incentives for making the effort to undertake innovation [31–33].

All of the above suggests that companies with FDI will have a superior absorptive capacity to drive the relationship between the geographical diversity of their external cooperation networks, which, in turn, will make them more likely to develop SOI. So the third research question is, can better SOI performance for companies with FDI be associated with greater absorptive capacity as compared with their national counterparts?

This paper intends to contribute, both empirically and theoretically, by way of a comparative analysis, providing a better understanding of the different channels for accessing knowledge for attaining SOI. To this end, three types of network will be analyzed (national, regional, and international), with a focus on the scope, diversity, experience, and frequency of their cooperation, and analyzing how these networks interact with companies’ absorptive capacity and sustainable goals, which guided their innovation. A comparative analysis will be used between companies with and without FDI to see if the sustainable innovation performance of companies with FDI is greater and determined by the formation of differentiated sustainable networks.

The document goes on to provide a section on theoretical precedents (Section 2) with an overall theoretical basis for undertaking SOI through cooperation networks (Section 2.1). Consequently, the literature is reviewed to justify the need to explore the differential effect on SOI of the diversity in cooperation networks of companies with FDI (Section 2.2) and the influence of absorptive capacity (Section 2.3) Then, the methodology is outlined (Section 3), with detailed information on the database (Section 3.1), identification, measurement, and relationship of the variables (Section 3.2), and the econometric methodology (Section 3.1). Following this, the results are presented empirically (Section 4). Finally, the study provides a discussion on the results (Section 5) and conclusions (Section 6).

2. Theoretical Framework

This section establishes what is considered to be SOI and how it relates to opening the process to different stakeholders and ends by exploring theoretical precedents, which may provide valuable information on the interaction between networks and SOI (Section 2.1). It continues with a literary review to establish the effect of diversity in the cooperation networks used by companies with FDI when it comes to achieving SOI (Section 2.2). Lastly, it establishes the role played by absorptive capacity in achieving SOI (Section 2.3).

2.1. SOI Openness through Cooperation Networks

After decades of research and entrepreneurial progress in sustainable development, innovation has recently surfaced as a convincing means for improving sustainability [4]. However, these innovations are riskier, as they encompass economic, social, and environmental aspects [2]. Hence, sustainable goals must guide companies’ innovative processes, with SOI as the end goal [34].

In this regard, SOI is the strategic orientation of innovation to develop commercial practices that are economically profitable, socially acceptable, and more environmentally friendly [3,35]. Therefore, SOI is used to refer to significantly improved or new services or products, which contribute to economic, environmental, and social sustainability [1].

SOI is often described as the cornerstone of proactive sustainability strategies. In fact, an orientation towards sustainability increases the likelihood of generating innovations in both products and
processes [5,36]. However, this innovation poses greater complexity due to the increased sophistication of the learning and innovation networks [37]. This poses a challenge that companies cannot address by themselves, pushing them to look beyond their borders in their search for knowledge [38]. Through this openness, companies can use knowledge management as an asset that promotes SOI [39]. Consequently, they create networks with diverse actors, which lead to innovative sustainable solutions through the exchange or cooperative development of knowledge [40].

The development of SOI is a participative process involving multiple actors. It presents particular features due to its multidimensional goals, uncertainty, and the compression of a larger number of direct stakeholders [40,41]. Additionally, preliminary studies on innovation confirm that the effectiveness of cooperation depends on the context. Extensive research is therefore required on how to incorporate external actors in a sustainable context, such as the one addressed in this paper, in the development of these SOI [42,43].

Below, therefore, is a review of the literature on companies’ openness to innovation in the specific context of sustainability (see Appendix A). This review shows that there is limited documented evidence on the incorporation of external actors through networks in innovative sustainable processes.

Within this review of the literature, there is a part focused on the intersection between networks and the sustainable business model. This interaction is how value is shaped, and confirms the fact that the development of sustainability leads companies to cooperate as a network [9,10]. Likewise, in this relationship, there are studies that establish that achieving sustainability is mediated by the influence of the network and moderated by the company’s innovative orientation. For their part, various authors consider responsible innovation to be one of the driving factors in openness to knowledge networks and a participative process in which there is knowledge exchange and continuous learning [37,40,44].

Along similar lines, there are scholars who explore how the creation of sustainable markets can be favored through network innovation, illustrating how sustainability can only be achieved through multilevel changes in how the stakeholders think and behave. In other words, by generating a beneficial environment for everyone [45]. Likewise, there are authors who suggest that the relational capacity for developing new ecological products should encompass the creation of cooperation networks with stakeholders throughout the supply chain and beyond, including the acquisition of specific technical knowledge in sustainability [38]. For Walter & Scholz [46], the integration of disparate stakeholder types (market and non-market) requires critical success conditions, such as, diversity, network density, and the use of knowledge integration methods.

Research into the relationship between cooperation networks and sustainability is scarce and scarcer still when the focus is on the development of SOI. The few existing studies which have explored the driving forces for sustainable innovation have not taken into account whether or not a proactive search for geographically diverse partners influences innovation to foster greater levels of SOI. However, this search must be distinguished from the management and integration of traditional stakeholders, whose needs and requirements with respect to the company in general are always a factor to be taken into account. The matter of how to approach the problems derived from integrating sustainability in innovation and the knowledge contributed by various external sources seems to require greater attention [2,47].

Likewise, previous studies have not clarified what the most efficient combination of internal and external factors are in companies to favor opening knowledge relationships with SOI [37]. The greater part of the debate today on sustainability-focused innovation through networks is aimed at macro-level cooperation, or limited to meso-level operations in the supply chain [45]. Empirical, qualitative, and quantitative studies are required, therefore, to confirm the relevance of openness to SOI [47]. Consequently, the following hypothesis has been formulated:

**Hypothesis 1 (H1).** There is better SOI performance when it is associated with participation in cooperation networks.
2.2. Cooperation Network Diversity of Companies with FDI

As has been established in the introduction, FDI helps companies to meet the requirements demanded by SOI. It represents an injection of capital, which is a necessary resource for the development of responsible innovation, given its greater investment needs. Furthermore, the specific and intrinsic advantages associated to foreign participation increase with knowledge gained through the interaction of diverse market and institutional sources. It should also be mentioned that companies are more innovative, as well as more sustainable, if there is bidirectional cooperation [1,11,15,48].

FDI is an optimal vehicle for expanding the creation of competences both geographically and technologically, for which companies use cooperative networks [18]. However, the effect on the innovation performance of the multiple network links of these companies stands out because of the diversity of intra and inter-organizational networks in relation to technological knowledge, culture, and the institutional environment or organizational culture, and because the companies operate within multiple contexts through networks which enable them to fuse the absorbed knowledge [26,49].

Lastly, this differentiation comes as a result of these companies’ capacity to obtain knowledge at the global level, given their different technological expertise and competitive environments in which they operate. They could also be better placed for managing heterogeneous partnerships due to their structural characteristics, their diverse knowledge base, and their experience. At the same time, however, these factors can generate new challenges, concerns, and tensions [21,22].

Operating within a group of multiple contexts, through networks, allows them to simultaneously balance and manage the evolution of these contexts, ideally as creators and providers of knowledge, thereby making them “centers of excellence” or “global innovators” [50,51]. They are also catalysts for the creation of local knowledge networks and are attractive partners, both for other national companies, and universities and research institutions, as they act as anchors in the local knowledge network and provide international quality standards [49,52]. These companies can compensate for the different operational contexts, avoiding dependencies, which limit access to resources or inefficient complementarities [53].

That is why international business scholars consider this double inclusion as a major source of skills, knowledge, and information, as it allows them to have different groups of resources and capacities, enhance technologies, strengthen learning and innovation, have greater social capital, control strategic resources, and consolidate their position with respect to future investment and policy negotiations. In other words, it constitutes a source of power. Lastly, this embeddedness increases inverse knowledge transfer, as it reduces motivational and cognitive problems, thanks to the aforementioned potential learning, diminishing costs, and because it facilitates knowledge development [30,54,55].

All in all, this duality poses a formidable organizational challenge, requires time and investment, generates concerns that companies might lose control, and may lead to an imbalance caused by under-incorporated or over-incorporated integration in one of the networks (internal or external). This, in turn, can lead to accessing widespread or redundant knowledge, situations of resource dependency, and a loss of negotiating power. Additionally, internal and external tensions may arise, creating problems of coordination, communication, and transfer; hence the need for a certain level of qualified human capital [23,30,49,54].

Moreover, having the capacity to obtain knowledge on a global level affords companies better access to diverse, new ideas from multiple market and cultural perspectives. A clear example is the capacity to modify new products or services, in line with the needs and preferences of global clients. The literature establishes that the geographical extension of cooperation inherently leads to better performance, in a scenario of overlapping partners, which benefits from the existence of a subsidiary in the same country as the external cooperation partner. This allows language, cultural, institutional, and social barriers to be overcome, and, therefore, relationships of trust to be developed. Therefore, the global reach and strategy will determine the advantage derived from using global knowledge networks, and will benefit from a more refined division, as corporate integration strengthens the influence of the focal company within its group, and external integration directly affects innovation [22,23,30,53,56,57].
Despite the aforementioned advantages, high levels of international geographical diversification mean dealing with the risk of diseconomies of scale, meeting the growing costs of coordinating the process of interactive learning, and inhibiting international knowledge transfer. Likewise, there can also be consequences of the location’s scientific and institutional wealth and the distances, which will, logically, affect innovation performance [22,23]. In this regard, Elia et al. [58] establish that companies with FDI are less innovative in alliances involving partners from other cultures.

In summary, FDI offers a privileged position, with access, through global networks, to heterogeneous knowledge, which is an asset. It also attracts strong and compatible partners, which are both more innovative and more sustainable, assuming there is bidirectional cooperation. This leads to the formulation of the second hypothesis:

**Hypothesis 2 (H2).** Cooperation network diversity has a differential impact on SOI.

### 2.3. Absorptive Capacity

A company will be more efficient in its use of acquired knowledge, through innovation networks, if its absorptive capacity is high, with staff training as a crucial factor in this respect [2]. This absorptive capacity is especially efficient when there are international partners, as this offers greater understanding and assimilation of knowledge of a different innovation system [59]. This should be highlighted as a complementary factor in the search for this knowledge, since mere exposure to it is not enough if the aim is to retain, reactivate, and apply it to products and processes [60].

Higher levels of internal human capital in these companies is seen to facilitate the transfer of internal knowledge and increase the positive impact of knowledge stemming from external cooperation [29]. This constitutes their absorptive capacity. In this regard, the proportion of highly qualified employees and organizational training increases the socialization of external knowledge, with positive effects on sustainable innovation [61]. Staff with R&D skills offer companies an advantage, as these are not easy skills to transmit. As a consequence, certain studies have looked at human capital in terms of the internalization of external knowledge [62]. There are very few empirical studies, however, which take the characteristics of human capital into account [63,64].

Given that absorptive capacity is key for applying acquired knowledge to SOI, and that there are studies that highlight how FDI is affected by the skills and education of the human capital, it is interesting to observe how it influences sustainable innovative development.

In this context, there are discrepancies in previous literature when it comes to innovation performance. There are authors who believe that it is shown to be more efficient from a work perspective, as firms can trust the human capital associated with the use of knowledge sources and the organizational capacities of the parent companies [22,65]. In fact, companies with FDI are better positioned than their national counterparts when it comes to translating the diversity of alliances into better innovation performance with a high level of human capital [30]. However, for O’Regan et al. [66], their absorptive capacity when operating in the host country is weakened, because these companies can also develop their absorptive capacity when they integrate with other subsidiaries from other countries and the head offices.

The capacity to absorb and use new knowledge sources is enhanced by the training and experience of human capital [67]. Since employees from companies with FDI are more qualified, by interacting across borders and developing multicultural skills, they will have a superior absorptive capacity, which, in turn, will make them more likely to develop SOI [29].

Moreover, having foreign ownership offers the company more specific assets, not just when it comes to knowledge and technology, but also in terms of the better practices typically found in other countries, more units that innovation can be applied to, and more incentives for making the effort to undertake innovation [31–33].
However, to the best of our knowledge, the literature has not addressed how companies with FDI use their absorptive capacity to drive the relationship between the geographical diversities of their external cooperation networks and their SOI performance. This leads us to formulate the third hypothesis:

**Hypothesis 3 (H3).** Better SOI performance of companies with FDI can be associated with greater absorptive capacity.

To test the hypotheses, this work contributes an empirical analysis based on the open framework of conventional innovation, to understand the relationship of geographically diverse innovation networks with sustainable goals that have guided innovation. This valuable knowledge is developed adding a dynamic and micro perspective, studying the aforementioned relationship over time.

### 3. Methodology

#### 3.1. Database and Sample

For the study, data have been used from the Technological Innovation Panel (PITEC), which monitors innovation activities, providing anonymized data for both foreign and national companies located in Spain. From the annual data contained in the panel, the period 2009–2016 has been used for this study.

This database has been used because it allows for the study of companies’ dynamic behavior [68]. Monitoring the information on the same companies over time is necessary, given that there is evidence that knowledge networks change over time [37]. PITEC data have been identified as being representative of the geographical distribution of foreign subsidiaries inside the host country [63]. The survey is not biased, because its aim is not to gather information on sustainability issues [69]. This allows us to study cooperations in R&D in the last three periods [70]. Lastly, PITEC contemplates regions like Europe; the United States; China and India; and other countries, which allows us to address geographical diversity in cooperation [71].

The study is focused on Spain, because there is a high number of investments by companies with FDI in R&D, demonstrating its integration in our country [72]. Furthermore, it can serve as a guide for other countries like Spain, which are neither advanced nor behind in R&D [73,74]. There is also a wealth of information provided by PITEC as compared with the information offered by EU CIS countries for other countries on Europe’s borders [57]. Additionally, among Spanish companies, there is increasing technological interaction with diverse and geographically dispersed actors [59]. Lastly, the growing importance of sustainable issues makes it an interesting environment to investigate SOI [3].

#### 3.2. Identification, Measurement, and Relationship of the Variables

This section presents the definitions and measurements of the variables for this study. For more information, see Appendices B and C.

##### 3.2.1. Sustainability-Oriented Innovation (SOI)

Innovation is considered to be SOI if it has been guided by sustainable goals. This is why “sustainable goal indicators” are incorporated as a qualifier, constructed based on a broad review of the literature. This allows these processes to be assessed taking into account the sustainability goals, which have guided the companies towards innovation (See review of [48]).

These goals, which have oriented the company to innovate, provide three sub-constructions for both groups:
- Sustainable Economic Goal Indicator, which includes a wide range of products or services, penetration in new markets, greater participation in these, and greater production or service capacity.
- Sustainable Environmental Goal Indicator, determined by less material and energy per unit produced, less environmental impact, and compliance with the requisites of environmental regulations.
- Sustainable Social Goal Indicator, which looks for better quality in terms of goods or services, improvements in the health and safety of employees, increasing or maintaining the number of jobs.

Innovation goals: In the database, companies are asked: “During this year and last year, the innovation activity undertaken in your company may have been guided by different goals. Indicate the level of importance of the following goals”. For each of the goals, the company can respond that the importance of the effect is high, medium, or low, or that this factor was not experienced. We construct fictitious variables, which take a value of one if any of the corresponding goals, outlined below, are of great importance, and zero if this importance is low or null.

Although this data is self-reported, it is commonly used in the literature [41,75,76]. Therefore, if the innovative activity undertaken by the company is oriented by the three aforementioned goals (economic, environmental, and social), the innovation will be considered as sustainability-oriented.

Therefore, the dependent variable is a dummy variable, which takes a value of 1 if the company reports that the innovation activity undertaken has been oriented simultaneously by economic, environmental, and social goals, and 0 if not.

3.2.2. Networks

Companies face a considerable challenge in the development of SOI, as sustainability needs to be understood and integrated within the innovative process [38]. In this context, cooperation with each of the potential partners can affect the different sustainable areas. This implies that a diverse range of paths can be taken to achieve sustainability [4].

Network participation is especially important, so that, through sustainability, value is generated beyond the confines of the organization. This is why companies around the world recognize cooperation networks as a driver of sustainable innovation. This requires the inclusion of multiple values (social, environmental, and economic), the promotion of knowledge management, and open innovation [9,10,39].

Bearing in mind that obtaining knowledge of the networks depends on strategic choices, and that the network types determine the benefits that the companies could obtain from cooperation, geographically different networks are believed to have an unequal effect on companies’ sustainable innovation performance [22,59,77].

Consequently, a national cooperation network is considered to be any whose cooperations are restricted to within Spanish borders, a European cooperation network would include cooperations within Europe, and a global cooperation network includes cooperations that extend their links to the US, China, India, or other countries.

Each network considers the scope, diversity, and experience of the company’s cooperation partners. The first dimension, scope, is the number of different types of knowledge (domains) between the company and the partners involved. This domain could be contributed by market sources (providers, clients, competitors, consultors) and/or institutional sources (universities or other higher education institutions, public research institutions, and technology centers). Recent research has placed an emphasis on the need to consider factors beyond geographical distance, with scope emerging as a notion of cognitive proximity. The greater the scope, the greater the cognitive distance, and the less risk there is of information redundancy. However, there will likely be more communication issues and conflicts between partners contributing homogeneous knowledge [23,37,78].

The second dimension, diversity, describes the heterogeneity of the partners. A distinction is drawn between providers, clients, competitors, consultants, universities, or other higher education
institutions, public research institutions, and technology centers. Here, unlike with the previous dimension, the capacity to form alliances with different partners is included, but whether or not the cooperation will yield different knowledge is not. For example, a company can cooperate with providers, clients, competitors, and consultants, showing itself to be highly diverse, but will only obtain knowledge of the market, i.e., its scope will be reduced [30,62,79,80].

Lastly, the experience describes the habits of the alliance between the focal company and its partners. PITEC includes information about whether or not companies that participate in innovation cooperate with different kinds of partners, measured over three-year periods (PITEC data provide interesting information on all activities undertaken by companies over three-year periods, in other words, the activities undertaken during the reference year and the two previous ones). This dimension has been included, given that companies with experience are more likely to efficiently manage highly diverse alliances [81,82].

Thus, the national network encompasses cooperations of at least three years between different Spanish partners, who contribute market and institutional knowledge. The European network encompasses cooperations of at least three years between different European partners, who contribute market and institutional knowledge. The global network encompasses cooperations of at least three years between different partners from the US, China, India, or other countries, who contribute market and institutional knowledge.

**Cooperation network** is therefore a categorical variable, which takes a value of 1 if the company is not in any cooperation network, 2 if it is in a national cooperation network, 3 if it is in a European network, and 4 if it is in a global network.

### 3.2.3. Absorptive Capacity

The literature on absorptive capacity indicates that intensity, staff skill, and management practices to transfer and disseminate external knowledge are key to assimilating and applying new knowledge in a company’s innovation processes [83,84].

We needed to distinguish between a company’s capacity to assess external information, and assessing its capacity to use it, given the multidimensional nature of knowledge [85].

With respect to its capacity to assess external information, a new variable is produced, Staff, which brings together intensity and the company staff’s skill and education levels, using principal component analysis. In Appendix D, the Cronbach’s alpha demonstrates the reliability of the scale. The factor analysis is valid because the amount of explained variance exceeded 50%, the weighting factors of all the items in each scale exceeded 0.5, and the reliability when presenting a Cronbach’s alpha greater than 0.7 [78,86–89].

However, unlike the previous literature, this only takes into account employees tasked exclusively with developing a company’s R&D activities. This kind of employee increases the capacity to absorb and apply new knowledge in a company’s innovation processes. They also facilitate the exchange of knowledge within the organization and offer a greater capacity to find, integrate, and use new tacit knowledge [62,70].

Finally, the use of information dimension is measured using two different fictitious variables. The first, regarding whether or not companies introduced new business practices in terms of how they organize work or procedures, and the second, if said companies implemented new models for managing external relations with other companies or public institutions. This is because the implementation of open innovation for sustainability requires specific organizational capacities, which are different to those that a company might already possess, and knowledge integration methods [46,61,78,90].

Absorptive capacity is included in the model with the following variables:

- **Staff**: Principal component, which includes intensity, skill, and education of full-time R&D staff.
- **New methods**: Dummy variable which takes a value of 1 if the company has put into practice new methods for managing external relations with other companies or public institutions during the three-year period which ends in the reference year, and 0 if not.
- New practices: Dummy variable which takes a value of 1 if the company has undertaken new business practices in the organization of work or procedures during the three-year period that ends in the reference year, and 0 if not.

3.2.4. Control Variables

Firstly, we controlled for company size, distinguishing between large companies and SMEs [91]. The tensions between firm size and sustainability goals can be better understood by studying the strategies of these businesses [1,15,92].

Furthermore, there are discrepancies between the effects of company size when it comes to establishing external partnerships. There are authors who establish that bigger companies are less likely to need to form external partnerships, as they have more resources and can generate the necessary knowledge internally [78]. Others, however, consider them more likely to need R&D collaboration with different kinds of partners [88]. Lastly, in the case of foreign participation, there are studies that argue that the benefits of alliance networks are subject to the liability of foreignness, especially in smaller companies [21]. Size is a categorical variable, which takes a value of 1 if it is a micro company, 2 if it is a small company, 3 if it is a medium-size company, and 4 if it is a large company.

Secondly, we controlled for age, which can have an influence, given that more experience probably means a greater accumulation of knowledge, although it can also become a source of inertia. This knowledge enables adaptation, as well as the introduction of new developments in products and processes [93]. There is disagreement in terms of its effect on sustainable innovation, although there are studies that find that older companies are better or currently place more emphasis on integrating sustainability issues, others establish that this is not an indicator for sustainable innovation [3,38]. In addition, age does not seem to influence geographical diversification and company performance [71]. Age is a categorical variable, which takes a value of 1 if the company is less than 5 years old, 2 if it is between 5 and 15 years old, and 3 if it is more than 15 years old.

Thirdly, we controlled for sectoral heterogeneity. For this, we took into account the level of technological intensity of the sector in which the company operates, and determined whether it was a high, medium, or low-technology sector [23]. While the need to access external resources is common to companies in all sectors, the need to collaborate with external agents is even more evident in the technology sectors [94]. Preliminary studies have demonstrated that sectoral dynamics are relevant for companies’ sustainable behavior [3,15]. Lastly, FDI in Spain is distributed across the three technological sector levels [57]. Sector is a categorical variable, which takes a value of 1 if the company belongs to a low-technology sector, 2 if it belongs to a medium-technology sector, and 3 if it belongs to a high-technology sector.

Fourthly, we controlled for export activity, as this can enable a company to better understand foreign cultures and related commercial practices, familiarize itself with possible foreign partners, and come in contact with foreign technological knowledge which can improve innovation performance. This process can imply establishing R&D collaborations with foreign companies to have broader access to locally integrated knowledge [78,86]. Other analyses have focused on how exports influence the propensity to carry out sustainable innovation [33]. To avoid the rest of the multinational network investing immeasurable efforts in research, the subsidiaries that are most active in research export more, thus avoiding their research efforts benefiting the local economy and not the global markets [95]. Exports is a dummy variable, which takes a value of 1 if the company sells on a geographical market other than the national one, and 0 if not.

Fifthly, we controlled for whether employees have received internal or external training, specifically focused on the development or introduction of new or significantly improved products or processes. Training can enable employees to better understand processes and practices at company level and is more beneficial than investing in technology. Providing employees with professional training generates performance benefits in the form of SOI results [2,78,96]. Training is a dummy variable, which takes a
value of 1 if the company carries out internal or external training aimed specifically at the development or introduction of new or significantly improved products or processes, and 0 if not.

Lastly, we controlled for whether the company has received public financial support during the current year for its innovation activities [23,97]. In this regard, a large part of public funding is directed at stimulating cooperation between companies, and between companies and public institutions [55]. Governments with local, national, and supranational funds can help to counter a lack of funding, which is often mentioned as an obstacle to sustainable innovation [1]. Public funding is a dummy variable, which takes a value of 1 if the company has received EU, regional, or local funding for innovation projects.

3.3. Specification of the Model

Given that SOI is a dummy variable, which takes a value of 1 if the company reports that the innovation activity undertaken has been oriented simultaneously by economic, environmental, and social goals, and 0 if not, a binary logistic regression model has been used [41,98,99].

The likelihood that a company’s innovation is guided by sustainability is calculated using a logistic cumulative distribution function, where the conditional probability has the following form:

\[ P_i = P_r(Y = 1|X_i) = \int_{-\infty}^{\beta X_i} q(z)dz = \frac{1}{1+e^{-z}} \]  

(1)

where the binary logistic regression model is the logarithm of the odds ratio:

\[ L_i = \ln \left[ \frac{P_i}{1-P_i} \right] = z_i \]  

(2)

The model expressed in its general form:

\[ \text{SOI}_{it} = \ln \left[ \frac{P_i}{1-P_i} \right] = \alpha_0 + \sum_{a=1}^{4} \alpha_a N_{ait} + \theta_b ST_{bit} + \lambda_c NM_{cit} + \eta_d NP_{dit} + \sum_{e=1}^{3} \gamma_e SI_{eit} + \sum_{f=1}^{3} \kappa_f A_{fit} + \sum_{g=1}^{4} \beta_g S_{git} + \delta_h X_{kit} + \mu_j T_{jit} + \varphi_k PF_{kit} \]  

(3)

Lastly, as has already been mentioned, the Equation (3) has been estimated for two groups, FDI and NFDI.

\[ \text{SOI}_{it}(FDI) = \ln \left[ \frac{P_i}{1-P_i} \right] = \alpha_0 + \sum_{a=1}^{4} \alpha_a N_{ait} + \theta_b ST_{bit} + \lambda_c NM_{cit} + \eta_d NP_{dit} + \sum_{e=1}^{3} \gamma_e SI_{eit} + \sum_{f=1}^{3} \kappa_f A_{fit} + \sum_{g=1}^{4} \beta_g S_{git} + \delta_h X_{kit} + \mu_j T_{jit} + \varphi_k PF_{kit} \]  

(4)

\[ \text{SOI}_{it}(NFDI) = \ln \left[ \frac{P_i}{1-P_i} \right] = \alpha_0 + \sum_{a=1}^{4} \alpha_a N_{ait} + \theta_b ST_{bit} + \lambda_c NM_{cit} + \eta_d NP_{dit} + \sum_{e=1}^{3} \gamma_e SI_{eit} + \sum_{f=1}^{3} \kappa_f A_{fit} + \sum_{g=1}^{4} \beta_g S_{git} + \delta_h X_{kit} + \mu_j T_{jit} + \varphi_k PF_{kit} \]  

(5)

4. Results

As noted above, for the proposed study, a binary logistic regression model has been used to obtain the predicted likelihood that each type of company, with and without foreign participation, will perform SOI. Although equation (3) represents a logit panel, it could not be estimated as such due to a lack of intragroup heterogeneity, making efficient estimation of the fixed effects and random effects impossible. It
was therefore decided to treat the panel as a grouped binary logistic regression. Table 1 shows the results obtained for the two groups, allowing for a comparative analysis and an analysis of the resulting common and disparate effects. Appendix E shows the sensitivity analysis and model specification.

Table 1. Results of the binary logistic regression model.

| Dependent Variable | FDI | NFDI |
|--------------------|-----|------|
| SOI                | β   | Odds Ratio | β | Odds Ratio |
| Constant           | −3.78 | 0.02 | −3.39 | 0.03 |
| **COOPERATION NETWORK** |
| National Cooperation Network (N1) | 0.05 | 1.05 | 0.15 ** | 1.17 |
| European Cooperation Network (N2) | 0.18 * | 1.19 | 0.03 | 1.03 |
| Global Cooperation Network (N3) | 0.16 * | 1.17 | −0.03 | 0.96 |
| **ABSORPTIVE CAPACITY** |
| Staff (ST)          | 0.35 ** | 1.41 | 0.33 ** | 1.39 |
| New methods (NM)    | 0.24 ** | 1.27 | 0.46 ** | 1.58 |
| New practices (NP)  | 0.47 ** | 1.60 | 0.96 ** | 1.75 |
| **CONTROL VARIABLES** |
| Small company (S1)  | −0.15 | 0.86 | 0.14 ** | 1.15 |
| Medium-size company (S2) | 0.13 | 1.13 | 0.16 ** | 1.17 |
| Large company (S3)  | 0.25 ** | 1.28 | 0.14 ** | 1.15 |
| **REFERENCE CATEGORY: LESS THAN 5 YEARS OLD (A1)** |
| Between 5 and 15 years old (A2) | 0.07 | 1.07 | −0.15 | 0.86 |
| More than 15 years old (A3) | 0.46 * | 1.59 | −0.06 | 0.95 |
| **REFERENCE CATEGORY: LOW-TECHNOLOGY SECTOR (S1)** |
| Medium-Technology Sector (S2) | 0.16 ** | 1.18 | 0.17 ** | 1.19 |
| High-Technology Sector (S3) | 0.46 | 1.59 | 0.11 * | 1.12 |
| Export (X)          | 0.69 ** | 1.99 | 0.63 ** | 1.88 |
| Training (T)        | 0.19 * | 1.21 | 0.39 ** | 1.48 |
| Public Funding (PF) | 0.27 ** | 1.31 | 0.38 ** | 1.47 |
| **Number of cases** | 11,842 | 57,158 |
| Omnibus test        | 794.56 (16) | 0.00 | 3792.15 (16) | 0.00 |
| Nagelkerke’s R²     | 0.15 | 0.16 |
| Hosmer-Lemeshow test | 37.70 (8) | 0.00 | 242.31 (8) | 0.00 |

Source: Prepared by the authors. Note: **, *** significant coefficients up to 5% and 1%, respectively.

Table 1 presents the results of the binary logistic regression, taking innovation oriented by sustainable goals as a dependent variable. The coefficients (β) and odds ratio are reported for each of the independent variables, the categorical variables being treated with the deviation contrast, so that each category, except the reference category, is compared with the average of the rest of the categories. The Odds Ratio columns allow us to quantify by what percentage SOI increases for each explanatory variable when the other variables remain constant, the value 1 being the point of comparison.

The results show that the comparative analysis offers patterns that are common to companies with and without FDI. Interesting ideas arise regarding the effects of the controls included in our econometric specification.

Firstly, the results highlight the role of exports in undertaking SOI. Thus, exporting companies are 99% and 88% more likely to undertake SOI if they have foreign participation and if they do not have it, respectively. This suggests that selling outside of the country provides an incentive for innovation to be guided by sustainable goals.
Likewise, it is observed that the provision of local/regional/national/international funding increases the likelihood of undertaking SOI. Therefore, companies with public financial assistance are 31% and 47% more likely to carry out SOI, if they have FDI or do not have it, respectively. This would suggest the effectiveness of subsidiaries in driving said innovations, and that companies without foreign participation need greater public support to undertake SOI.

Thirdly, it can be observed how internal or external staff training, in companies without and with foreign participation, has an influence. Staff training for the latter increases their chances of undertaking SOI by 48%, while these increase by 21% for the former. This indicates that companies without FDI should provide more training for their employees, to allow them to better understand the processes and practices that favor openness to new ideas and new knowledge creation.

Taking into account the general characteristics of the companies, the results offer a different description depending on whether or not there is foreign participation. In the case that there is FDI, the companies that, generally speaking, are more prone to undertaking SOI are large companies that operate in a highly technological sector and which are over 15 years old. However, if they do not have foreign participation, the companies most prone to undertaking SOI are medium-size companies from a medium-technology sector, for which the company’s age has no influence.

Looking at the focus of the study, the results show that achieving SOI requires participation in cooperation networks. However, once you focus on the different types of cooperation networks, this effect is different. It can be seen that companies with FDI are 19% and 17% more likely to achieve SOI, through European and global cooperation networks, respectively. If there is not foreign participation, whether or not a company achieves SOI is linked exclusively to its participation in a national cooperation network. If this is the case, the likelihood of SOI increases by 17%. This considerable difference reflects a capacity to focus more on heterogeneous, broad, and geographically diverse knowledge sources, which is associated with FDI.

As regards the role of absorptive capacity, the model reflects its influence on the likelihood of undertaking SOI. This indicates that the joint analysis of R&D intensity and the skills and education of the employees tasked with innovation has a positive effect on the probability of SOI. This shows that high levels of human capital are significant, but that specific organizational capacities are also needed, such as the introduction of new methods of external relations management and work organization practices.

In this regard, the analysis shows that companies with FDI are 41% more likely to carry out SOI if they have R&D intensive, skilled, and educated staff. This probability of success increases by 27% if the company improves how it manages external relations, and by 60% if it improves its business practices in work organization (for example, the management of the supply chain or knowledge management systems).

Companies without foreign participation will increase their likelihood of achieving SOI by 39% if they have qualified staff, by 58% if they improve how they manage external relations, and by 75% if they improve business practices in work organization. This suggests that companies without FDI have employees that are less skilled, and that they have to improve their organizational capacities.

In general, the results support the arguments of our three hypotheses. The first hypothesis is supported because the outcomes show the global recognition of the potential that cooperation networks have to drive sustainable innovation, for both types of companies. However, once you focus on the different types of cooperation networks, this effect is different. It can be seen that companies with FDI have the capacity to focus more on heterogeneous, broad, and geographically diverse knowledge sources, which is associated with the second hypothesis. Lastly, the results confirm that having foreign ownership allows companies to have qualified staff and greater assets thanks to better methods and organizational practices related with openness to innovation. Thus, the third hypothesis is compatible, since the role of absorptive capacity in companies with FDI, which is superior to that of their national counterparts, is key. Absorptive capacity must be understood as a joint analysis of R&D intensity, the skills and education of the employees tasked with innovation, together with specific organizational capacities.
5. Discussion

Recently, sustainable innovation has been at the top of the agenda of many companies. However, there is a gap in the literature on the diversity of paths and the different combinations of resources that lead companies to develop SOI, which would show how open innovation can be essential in a context of sustainable innovation. There is a growing tendency to associate cooperation networks with this kind of innovation [1,2,4,37,39].

One of the purposes of this study, since it is focused on initiating processes of Sustainability-Oriented Innovation, was to provide an answer to whether or not participating in cooperation networks makes companies more prone to undertaking SOI.

This line of reasoning directly echoes the findings of this study, regarding the evidence that cooperation networks help companies to achieve sustainability goals. Networks favor the attainment of sustainable and innovative solutions through the exchange and cooperative development of knowledge, confirming the first hypothesis [9,37,40].

These SOI networks are national cooperations for medium-size companies without foreign participation in a medium-technology sector. Contrary to recent literature, it can be seen that these companies’ SOI performance is only strengthened through national networks [59,77].

This might be due to cognitive restrictions in the processing of excessively geographically diverse knowledge entries [50]. No benefits have been found to compensate for the challenges posed by the cultural diversity entailed in exposure to new cognitive frameworks. This would suggest that this kind of company strengthens its SOI with strategies focused on the supply of external knowledge.

Although one would expect open innovation methods to be used primarily in high-technology sectors, there seems to be a trend towards sectoral diversification. This result is consistent with the idea that the need to collaborate with external agents is all the more evident in technological sectors [94].

The fact that the results are focused on medium-size companies confirms that the participation of this kind of company in sustainable innovations entails cooperation with external partners to cover the possible lack of resources [1]. It is therefore consistent with studies that establish that it is more feasible that larger firms do not need to form external partnerships, as they have more resources to generate the necessary knowledge internally [78].

Lastly, the results obtained regarding company age are in line with the opinion that this does not have an influence on SOI and does not intervene in a company’s geographical diversification and performance [3,38,71].

However, when there is FDI, these cooperation networks are European and global, which gives us an affirmative response to the second question posed by this study and confirms the second hypothesis. Therefore, companies with FDI have a differential impact on SOI, due to the diversity of their cooperation networks.

The results are consistent with the opinion that companies with FDI benefit from operating in different countries, which gives them access to different resources, geographically dispersed knowledge sources, and learning opportunities [16,24].

Unexpectedly, the results of this study indicated that, although high levels of geographical scope were associated with high performance levels in sustainable innovation, geographical scope on a national level does not influence the capacity of companies with FDI to undertake SOI.

This suggests that this kind of company, unlike its national counterparts, improves its SOI with strategies based on diversity in the external knowledge supply from diverse geographical locations. This confirms the idea that external knowledge search strategies differ between both types of company, which is a result of their knowledge complementarities [72,74].

This could be due to the nature of their own mandates, the corporate strategy, Spain’s scientific and institutional wealth, and the distance between the origin of the FDI and Spain [18,22,28]. Moreover, it is important to bear in mind that within the group of companies with FDI operating in Spain, those that create competition with local partnerships are in the minority [68]. Another possible explanation is that this type of company is more oriented towards technologies for global use. Furthermore, this
study does not take into account the FDI entry modes, which can influence partnerships with local companies [74].

In line with recent studies, companies with FDI that are most prone to undertaking SOI are, generally speaking, large companies that operate in a high-technology sector and which are more than 15 years old, since this type of company overcomes the liability of foreignness [19,21]. This paper shows how companies involved in SOI partnerships, both with and without FDI, must be aware that for SOI to take place, it is important they sell on external markets, train their employees, and obtain public funding.

The importance of public funding is consistent with the idea that this is an instrument to stimulate and combat a lack of funding, which is often mentioned as an obstacle to the development of sustainable innovation [1]. However, the fact that its importance is greater in companies without foreign participation confirms the fact that FDI is a necessary injection of capital for the development of responsible innovation [48].

In previous studies, benefits can be observed from training employees to prepare them for the implementation of sustainable innovations [2,78,96]. Although the importance of exporting when it comes to SOI is common to both kinds of company, contrary to what one might think, it allows companies without foreign participation to be more prone to SOI, but it does not encourage them to become more familiar with foreign partners with whom they can create alliances. It is confirmed that research-intensive companies with FDI are exporters, which avoids their research efforts benefiting the local economy rather than the global markets. Evidence of this is that the national cooperation network is not significant, but exports are [78,86,95].

Finally, the importance of absorptive capacity in achieving SOI is observed as a common factor, given that the knowledge required for this is more complex [2]. The results reveal the significance of the different dimensions of absorptive capacity. It is not just human capital that is important, but also organizational capacities, which can increase the socialization of external knowledge.

These findings support previous work on the importance of R&D intensity and the skills and education of employees tasked with innovation [78,86,87,89]. Since the implementation of open innovation for sustainability requires specific organizational capacities and knowledge integration methods [46,61,78,90].

This explanation stems from the difference in knowledge contributed by the different partners, because of the different motives that lead companies to innovate and because of the partners’ structural proximity. The need is made evident for practices and organizational methods designed for the cooperation process and knowledge dissemination [61,78].

However, there are significant differences in the quantification of the effect of absorptive capacity, depending on whether or not there is foreign participation, supporting the third hypothesis. The findings confirm the idea that companies with FDI are more work efficient, as they can rely on human capital that is highly qualified, due to employees’ needs to develop multicultural skills and interact across borders. This, therefore, places these companies in a better position for translating alliance diversity into enhanced innovation performance [29,30,66].

Moreover, having foreign ownership entails incorporating the better practices and organizational methods typically found in other countries [31–33]. This is evidenced by the fact that implementing new organizational methods, which the company has not used before, affects SOI less than it does for its national counterparts.

6. Conclusions

This study emerges from a growing interest in how to incorporate external actors in the development of SOI. Firstly, it builds on the literature that establishes that a proactive search for geographically diverse partners influences sustainable innovation. Secondly, it further develops the literature that supports FDI’s contribution of knowledge through interaction with diverse market and institutional sources, making companies with FDI more innovative and sustainable. Lastly, it
contributes to the literature that establishes that companies with FDI are better positioned than their national counterparts when it comes to translating the diversity of alliances into better innovation performance with a high level of absorptive capacity.

This comparative study arises from these three premises, with the aim of finding out if participating in cooperation networks makes companies more prone to undertaking SOI, if the network diversity of companies with FDI has a differential impact, and if the superior SOI performance of companies with FDI can be associated with their greater absorptive capacity, as compared with their national counterparts.

This paper provides considerable evidence that cooperative development through cooperation networks including diverse external stakeholders has positive effects on SOI. The network links of companies with FDI have a differential impact on SOI because cooperative development is undertaken through European and global cooperation networks, while their national counterparts use a national cooperation network. To address the integration of sustainability, a high absorptive capacity is required. Similarly, both companies need to train their employees and obtain public funding. Finally, the capacity of companies with FDI to obtain knowledge on a global level and better manage heterogeneous partnerships with improved SOI performance is a result of having highly qualified human capital, which has developed multicultural skills and interacted across borders, and the better practices and organizational methods typically found in other countries. It is confirmed that FDI is a necessary injection of capital for the development of SOI, and leads research-intensive companies to seek benefits from global markets. From a theoretical perspective, this is a pioneering study, in that it offers a review of the literature with the aim of integrating sustainable innovation concepts, foreign direct investment, cooperation networks, and absorptive capacity.

This study complements the previous literature by adding a new vision, which shows how the geographical scope of networks, through the different global regions, provides access to heterogeneous knowledge, which plays an important role in SOI. It contributes to the literature on organizational learning, and complements previous studies, which reveal the performance implications of FDI. It extends the knowledge-based view, as it compares companies with foreign and national participation, which operate in the same country, and discusses how they differ in terms of their local and global knowledge. Lastly, it contributes to the coevolution of companies with FDI in multiple contexts, demonstrating empirically that SOI can be affected by way of different networks, without necessarily having a role in the local knowledge network.

From an empirical point of view, this study contributes quantitative research focused on testing the effect of geographically dispersed networks, taking into account major locations for R&D generation, like the US, India, Europe, and China. To do this, three types of network have been constructed, which include the diversity, scope, and experience of cooperation. Furthermore, a principal component has been constructed to attain a value for external information, which gathers the intensity, skill level, and education of company employees tasked with innovation.

From a managerial perspective, the findings obtained can help managers to reconcile openness to innovation in a sustainable context. It can enable them to choose the right alliance strategy and obtain their external knowledge supply through strategies with a geographically diverse focus or national location. In addition, both SMEs and large companies from technological sectors are provided with an efficient combination of internal and external factors for driving SOI. Lastly, this paper provides recommendations regarding how to strengthen the capacity to absorb external knowledge, for which staff training and the introduction of organizational practices are greatly beneficial.

Both from the findings obtained and the aforementioned limitations arise future lines of research. The sample is limited to companies located in Spain. To generalize the results, data from other regions would be needed. Due to the availability of data, a broad range of regions was analyzed, making it impossible to observe the weight of each country. With the aim of providing a more detailed analysis on how and why geographical scope has an influence, it would be interesting to gather country-level information on where companies are specifically connected. In addition, given the lack of region-by-region data in the PITEC survey, a more broken-down analysis on this level has yet to be
undertaken. This model has not taken into account the modes of ownership, alliances, or acquisitions, which might be influential in the network construction of companies with FDI. It is recommendable that the model has a higher proportion of continuous variables than dummy variables. PITEC has these kinds of variables, but this paper aims to distinguish between large companies and SMEs in order to better understand the tensions between firm size, age, and sustainability goals, by studying the strategies of these businesses. Furthermore, these companies in Spain undertake R&D in different regions to their national counterparts, and so it would be interesting to look at location factors in the construction of alliances to achieve SOI. Lastly, the study does not have data to measure the motivation or mandates of companies with FDI in Spain. There is therefore no way of confirming whether these companies are more focused on harnessing skills or serving the national market. It would be interesting to see studies undertaken that consider this factor.

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Appendix A

Table A1. Networks-sustainability relationship.

| Authors                  | Purpose                                                                 | Network                                                                 | Results                                                                                           | Methodology     |
|--------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------|
| Rossignoli & Lionzo, 2018 [9] | Offers evidence on how forms of interdependencies arising within the network drive changes in the business model by focusing on value proposition; value capture; and value creation and delivery. | Network formed by manufacturing companies and service companies. | The evidence shows that networks help achieve sustainability goals by solving the problem of resource dependency; however, new resource dependencies on network partners, and the network itself, are seen to emerge. | Case study analysis. |
| Oskam et al., 2018 [10] | Analyze how business modeling and networking interact over time. | Network construction based on the different stages of the sustainable innovation model (ideation, conception, start-up of the business, initial growth, and continuous growth), as well as the type (existing or expansion), purpose (technological and innovation, supply, marketing, and reputation), and strength of the link (strong or weak). | Networking helps to refine and improve the overall business model, and, in turn, an improved business model spurs expansion of the network. We identify five micro-level processes through which value shaping occurs. Value shaping is particularly relevant for Sustainability-Oriented Innovations, to help clarify all the types of financial, social, and environmental value to which a business model may contribute. | Two case studies. |
Table A1. Cont.

| Authors                             | Purpose                                                                                                                                                                                                 | Network                                                                                                                                  | Results                                                                                                                                                                                                 | Methodology                                                                 |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Van Geenhuizen & Ye, 2014 [37]      | Elucidates ways in which small high-technology companies, through using open knowledge networks, may contribute to sustainability transitions.                                                                 | Open knowledge networks that use two dimensions, the capacity of openness (breadth and depth), and the diversity of openness (distinction of local vs. regional partners), assigning weights to three variables of strength, contact frequency, duration of the relationship, and emotional intensity. | Responsible innovation drives openness regarding capacity (knowledge domains) and diversity (knowledge partners), among other factors. However, the results on the growth of spin-offs point to a negative influence on the diversity of openness, which requires a “selective opening” with respect to the types of network partners. | Quantitative exploratory approach and case study.                           |
| De Clercq et al., 2018 [44]         | Drawing from research on strategic choice, this study investigates the relationship between market turbulence and firms' sustainable behavior, in the context of sustainability-related institutional adversity. | This construct was evaluated by the degree to which respondents maintained close personal relationships with network partners.            | The study shows that market turbulence enhances sustainable company behavior through the development of strong network relationships. Furthermore, the mediating effect of network embeddedness is particularly salient among firms that exhibit a stronger innovative orientation. | Regression analysis.                                                      |
| Dangelico et al., 2013 [38]         | Integrate environmental issues into the development of new products.                                                                                                                                 | Network built by the intensity of formal collaborations undertaken for the development of new products with suppliers of materials and processes and with customers. | Collaboration networks have a significant effect on green manufacturing. External knowledge links have a significant positive effect on green manufacturing.                                                | Two-step regression analysis.                                             |
| De Kraker et al., 2013 [40]         | Presents a first exploration of the potential of social network software to support learning networks for sustainable development.                                                                      | An intraregional learning network. An interregional learning network of Regional Centers of Expertise on Education for Sustainable Development. | Supporting learning for sustainable development with social network software is technically feasible and can be functionally effective. However, it appears that designers of social software support for such learning networks are also faced with fundamental tensions, which concern the degree of mixing private and professional life, learning networks and social networks, face-to-face and virtual interactions, top-down and bottom-up control, hierarchical and emergent structure. | Functional and technical design of a social network platform in constant interaction with potential users and testing of a prototype in two small-scale pilots, but in real-life scenarios. |
**Table A1. Cont.**

| Authors | Purpose | Network | Results | Methodology |
|---------|---------|---------|---------|-------------|
| Antikainen et al., 2013 [45] | Explore how the shaping of sustainable markets can be facilitated through network innovation. For example, how sustainable markets can be defined through collaboration and joint innovation involving multiple actors at various levels. | In the case of furniture markets, the innovation network considered the interests of consumers, retailers, and a manufacturing company. In the case of travel, the interests of consumers and a service provider. In the case of local food markets, a large retailer, a hypermarket, and its local producers. In addition, in the workshops, a group of researchers participated in the SHAPE project (Shaping Sustainable Markets). | Instead of changing the attitude of consumers, changing behavior by offering better sustainable products with a reasonable reward is a key issue to direct consumption towards more sustainable products and services. | Multi-methodological case study. |

Walter & Scholz, 2006 [46] | Connect industrial ecology research with social sciences. These ‘sustainable innovation networks’ are local and transient cooperations between a small but diverse group of agents from a wide range of organizations, which present an innovative sociotechnical innovation. | Network built taking into account diversity (Public Administration, Companies, NGOs, Public, Experts), density (unidirectional or bidirectional communication), knowledge integration method (scientific disciplines, systems, perspectives/interests, ways of thinking), and evaluation of performance (efficiency of the media and the network). | Social network theory can provide tools to analyze and understand sustainable innovation networks, including in industrial ecology. Critical success conditions for sustainable innovation networks are identified. | Five case studies. |

Source: Prepared by the authors.

**Appendix B**

**Table A2. Concept, items, and author.**

| Concept | Item | Authors |
|---------|------|---------|
| ECONOMIC SUSTAINABILITY GOAL | Wider range of goods or services | [48] |
| | Penetration in new markets | |
| | Higher market share | |
| | Increased production or service capacity | |
| ENVIRONMENTAL SUSTAINABILITY GOAL | Less material per unit produced | |
| | Lower environmental impact | |
| | Compliance with environmental regulatory requirements | |
| SOCIAL SUSTAINABILITY GOAL | Higher quality of goods or services | |
| | Improvement in the health and safety of employees | |
| | Increase in total employment | |
| | Increase in skilled employment | |
| | Job maintenance | |
Table A2. Cont.

| Concept          | Item                                                                 | Authors                                                                 |
|------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|
| NATIONAL NETWORK | Diversity: Number of Spanish partners it cooperates with.            |                                                                        |
|                  | Scope: Number of knowledge domains contributed by Spanish partners.  |                                                                        |
|                  | Experience: Years cooperating with Spanish partners.                 |                                                                        |
| EUROPEAN NETWORK | Diversity: Number of European partners it cooperates with.           | [4,9,10,22,30,37–39,59,62,77–82]                                       |
|                  | Scope: Number of knowledge domains contributed by European partners. |                                                                        |
|                  | Experience: Years cooperating with European partners.                |                                                                        |
| GLOBAL NETWORK   | Diversity: Number of partners it cooperates with from the rest of the world. |                                                                        |
|                  | Scope: Number of knowledge domains contributed by partners from the rest of the world. |                                                                        |
|                  | Experience: Years cooperating with partners with the rest of the world. |                                                                        |
|                  | STAFF: Principal component that includes:                            |                                                                        |
|                  | • R&D intensity: Percentage of full-time, internal R&D staff         |                                                                        |
|                  | • Skill: Percentage of full-time researchers and technicians         |                                                                        |
|                  | • Education: Percentage of full-time R&D staff holding PhDs or degrees |                                                                        |
|                  | New business practices in work organization or company procedures.   |                                                                        |
|                  | New methods for managing external relations with other companies or public institutions |                                                                        |
| CONTROL VARIABLES| Company size: Micro, small, medium, and large                        |                                                                        |
|                  | Company age: Fewer than 5 years, between 5 and 15 years, and more than 15 years. |                                                                        |
|                  | Technological sector: High, medium, and low                          |                                                                        |
|                  | Export: Sold in markets other than the national one                  |                                                                        |
|                  | Training: Internal or external, focused on developing new or significantly improved products or processes. | [1–3,21,23,33,38,58,59,71,78,86,88,91–97]                              |
|                  | Public Funding: Financial support from Local or Regional Governments, and/or State Administration and/or the European Union |                                                                        |
| Source: Prepared by the authors. |

Appendix C

Table A3. Role of each variable in the equation and its construction.

| Role in the Equation | Name of Variable | Construction of Variable |
|----------------------|------------------|--------------------------|
| DEPENDENT VARIABLE   | SUSTAINABILITY ORIENTED INNOVATION (SOI<sub>t</sub>) | Fictitious variable, which takes a value of 1 if the company reports that the innovation activity undertaken has been oriented simultaneously by economic, environmental, and social goals, and 0 if not. |
| COOPERATION NETWORK  | NETWORK (Na)     | Categorical variable, which takes a value of 0 if the company is not in any cooperation network, 1 if it is in a national cooperation network, 2 if it is in a European network, and 3 if it is in a global network. |
|                      | STAFF (ST<sub>St</sub>) | Principal component, which includes intensity, skill, and education of full-time R&D staff. |
| ABSORPTIVE CAPACITY  | NEW METHODS (NM<sub>Na</sub>) | Fictitious variable, which takes a value of 1 if the company has put into practice new methods for managing external relations with other companies or public institutions during the three-year period which ends in the reference year, and 0 if not. |
|                      | NEW PRACTICES (NP<sub>Na</sub>) | Fictitious variable, which takes a value of 1 if the company has undertaken new business practices in the organization of work or procedures during the three-year period that ends in the reference year, and 0 if not. |
Table A3. Cont.

| Role in the Equation | Name of Variable | Construction of Variable |
|----------------------|------------------|--------------------------|
| **SIZE (SL_{it})**   | Categorical variable, which takes a value of 1 if it is a micro company, 2 if it is a small company, 3 if it is a medium-size company, and 4 if it is a large company. |
| **AGE (A_{it})**     | Categorical variable, which takes a value of 1 if the company is less than 5 years old, 2 if it is between 5 and 15 years old, and 3 if it is more than 15 years old. |
| **SECTOR (S_{it})**  | Categorical variable, which takes a value of 1 if the company belongs to a low-technology sector, 2 if it belongs to a medium-technology sector, and 3 if it belongs to a high-technology sector. |
| **EXPORT (X_{uit})** | Fictitious variable, which takes a value of 1 if the company sells on a geographical market other than the national one, and 0 if not. |
| **TRAINING (T_{it})**| Fictitious variable, which takes a value of 1 if the company carries out internal or external training aimed specifically at the development or introduction of new or significantly improved products or processes, and 0 if not. |
| **PUBLIC FUNDING (PF_{iut})** | Fictitious variable, which takes a value of 1 if the company received EU, regional, or local funding for innovation projects. |

Source: Prepared by the authors.

Appendix D

Table A4. Validity and reliability results from the factor analysis of the main staff components.

| Factor | Items | Factor Structure Matrix | Explained Variance |
|--------|-------|-------------------------|--------------------|
| **STAFF** | R&D Intensity: Percentage of full-time internal R&D staff | 0.655 | 0.744 |
| | Skill: Percentage of full-time researchers and technicians | 0.933 | 0.924 |
| | Education: Percentage of full-time, internal R&D staff holding PhDs or degrees | 0.915 | 0.909 |
| | Kaiser-Meyer-Olkin Measure of Sampling Adequacy | 0.590 | 0.639 |
| | Cronbach’s Alpha | 0.776 | 0.811 |
| | **Kaiser-Meyer-Olkin Measure of Sampling Adequacy** | 0.590 | 0.639 |

Source: Prepared by the authors.

Appendix E

Table A5. FDI (Foreign Direct Investment) model classification table.

| NO SOI | SOI | Correct Percentage |
|--------|-----|--------------------|
| NO SOI | 7531 | 3270 | 69.7 |
| SOI | 349 | 692 | 66.5 |

Overall Percentage: 69.4%

Source: Prepared by the authors.

In the table above, it can be seen that the model would correctly classify 692 cases (out of 1041) SOI = 1 (Y = 1). Its sensitivity would therefore be 66.5% (692/1041). It would also correctly classify 7531 as NO SOI (Y = 0) out of 10,801, meaning the model specificity is 69.7% (7531/10,801). Overall, it has correctly classified 69.4% of the cases ((692 + 7531)/11,842).
### Table A6. NFDI model classification table.

|                | NO SOI | SOI  | Correct Percentage |
|----------------|--------|------|--------------------|
| SOI            | 38,593 | 14,376 | 72.9               |
| NO SOI         | 1396   | 2793  | 66.7               |
| **Overall Percentage:** | 72.4% |       |                    |

Source: Prepared by the authors.

In the table above, it can be seen that the model would correctly classify 2793 cases (out of 4189) \( \text{SOI} = 1 \) (Y = 1). Its sensitivity would therefore be 66.7% (2793/4189). It would also correctly classify 38,593 as NO SOI (Y = 0) out of 52,969, meaning the model specificity is 72.9% (38,593/52,969). Overall, it has correctly classified 72.9% of the cases \((2793 + 38,593)/57,158\).

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