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The role of organizational innovation in the development of green innovations in Spanish firms

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ABSTRACT

An exploration of the links between organizational and green innovation has been the subject of an impressive quantity of literature during recent years. In this study, the ability of firms to refine their organizational practices in accordance with external developments has been considered, particularly in the context of the introduction of updated environmental regulations and advanced technologies, with the aim of surviving and competing globally. In this study, it was postulated that organizational innovation was one of the main drivers of green innovation at the level of the firm. Hence, the intention here was to study whether green innovation was affected when businesses adapted their environmental strategies in alignment with organizational structures. Moreover, the paper aimed to explore whether there was any major disproportion in green innovation between firms in dirty and in clean sectors. To address these main points, a two-step regression using the generalized method of moments (GMM) was run on data relating to organizational innovation factors and green innovation constructs at the level of the firm, this information being drawn from the Technological Innovation Panel (PITEC) database. These panel data, based on the Community Innovation Surveys (CIS) framework, were used to detect innovations in Spanish firms by investigating long-term relationships between variables to control for nonobservable heterogeneity. The principal findings confirm that the organizational innovation variables studied did promote green innovation and that the dirty sector firms were more likely to undertake green innovations than those in the cleaner sectors.

1. Introduction

Green innovation (GI) has been viewed as a driver of economic progress in recent years, during which, thanks to growing environmental challenges, there has been a surge of interest, and rapid development, in environmental matters (Sánchez-Sellero & Bataineh, 2022). Various environmental awareness forums, such as the Paris 2015 Agreement, have also stressed the need for individuals and businesses to reduce their environmental impacts (García-Marco, Zouaghi, & Sánchez, 2020). GI is a key strategic accelerator for achieving sustainable development, incorporating, as it does, technological innovation in energy conservation, the avoidance of pollution, and waste recycling (El-Kassar & Singh, 2019). In this way, it improves the efficiency of resource use, reduces costs, and protects the environment (Su, Xu, Lin, Chen, Liu, & Xu., 2020). This leads to a win-win approach as it alleviates contradictions between rapid economic expansion and environmental considerations (Song, Wang, & Ma, 2020).

Firms must assess their own abilities, the capacities of their suppliers, and government regulations, as well as organizational, technological, and environmental challenges when implementing green technologies (Weng, Chen, & Chen, 2015). These can help them achieve a balance between the benefits and the costs of GI, as well as increasing productivity (Chen, Lai, & Wen, 2006). Thus, if a GI is to be financially worthwhile, it requires the appropriate capabilities to address internal and external resources, and thus may reach out into various different domains, such as products, processes, and organization (Vasileiou, Georgantzis, Attanasi, & Llerena, 2022). To go into more detail, green product innovation refers to the use of materials that have a lower environmental impact, requiring less energy and fewer resources, as well as providing environmentally friendly products that are simple to recycle, reuse, or decompose. Green process innovation brings efficiency by reducing the use of raw materials and the production of hazardous

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substances and waste, as well as minimizing the consumption of electricity, water, and oil (Singh, Del Giudice, Chiappetta Jabbour, Latan, & Sohal, 2022). Finally, the green organizational innovation covers the creation of new and valuable ideas for green products, processes, services, and behaviors, which can strengthen business models and shift management attitudes toward establishing a green organizational identity (Song & Yu, 2018). According to some studies, green organizational innovation reflects an observance of managerial norms and environmental regulations (Borsatto & Amui, 2019; Hojnik & Ruzzier, 2016), so that investing in green innovations can boost an ecological organizational identity, environmental commitments, and legitimacy (Chang & Chen, 2013).

For the work being reported here, use was made of the PITEC dataset, which has been employed to detect innovation in Spanish firms, but is not explicitly designed to measure GI (De Marchi, 2012; Sánchez-Sellero & Bataineh, 2022). However, it is difficult to make a clear distinction, specifically between GIs in products and those affecting processes, because both types can arise from large improvements in the environmental performance (Horbach, 2008). However, GI variables do involve reducing the use of materials and energy, improving health, safety and the environment, and adhering to environmental regulations. On other lines, exploratory variables were introduced to represent organizational innovations. The term "organizational innovation" primarily represents non technological types of innovation that require new or improved ways of organizing a firm's resources (Ramadani, Hisrich, Abazi-Alili, Dana, Panthi, & Abazi-Bexheti, 2019). These can boost productivity, delivery time, quality, and adaptability in businesses (García-Marco et al., 2020). Standing apart from any environmental issues, such as a process of effectively deploying innovative ideas in businesses, is referred to as organizational innovation (Song et al., 2020). This study followed Oslo Manual guidelines on the collecting, reporting, and using of data on innovation for the principal components of organizational innovation. These relate to the adoption of a new organizational approach in a company's practices, workplace arrangements, or external relations (OECD, 2005).

The following of an environmental strategy is a core incentive for developing human resources and organizational capabilities, gaining commercial advantages, and thus attaining higher financial returns (Etzion, 2007). Hence, achieving an efficient use of resources and enhancing productivity may be seen as the strategic orientation followed by firms taking an innovative approach (Stock & Zacharias, 2011). This occurs through facilitating the creation of new ideas, developing novel products or services, and introducing innovative organizational methods (Edeh, Obodoechi, & Ramos-Hidalgo, 2020).

Organizational innovation in an internal context can be crucial to the success of novel external approaches (Anzola-Román, Bayona-Sáez, & García-Marco, 2018). Firms that employ a proactive environmental management strategy win a positive reputation for themselves that can be seen as an intangible asset, making them more attractive to the most talented potential employees (Dai, Cantor, & Montabon, 2017). Organizational culture also has a substantial role in encouraging innovation activities (Gürlek & Tuna, 2018). It helps in avoiding uncertainty and ensuring survival and growth over the longer term by providing a clear environmental vision through modifying organizational practices (Chang, 2014).

It is widely held that firms require dynamic capabilities to adapt to changing environments and shape the ecosystems they occupy (Huang & Li, 2017). It follows that green performance is likely to be improved when firms adopt environmental management practices (such as incentive and training programs for employees), adhere to ecological policies, reduce pollution, and impose environmental standards on their suppliers (Theyel, 2000). Actions of this sort may be driven by external legal requirements as well as a company's internal conditions, such as its organizational culture and the resources available to it (Zhang, Sun, Yang, & Wang, 2020). This being so, businesses take into consideration various aspects when adopting GI, including public regulations, preferences of business owners, suppliers' capacities, customer demands and interests, as well as technological and organizational drivers (Weng et al., 2015). In particular, capabilities in technology and organization are the mainstays of firms' internal resources (Cai & Li, 2018).

Internal barriers to innovation that prevent companies from actively undertaking changes may be attributed to a lack of expertise, insufficient resources, or an ineffective organizational structure. Market-based barriers to innovation may arise from competitor rivalry or a lack of market demand for changes (Szambelan, Jiang, & Mauer, 2020). It can be seen that organizational ability plays an important role in any innovation process (Aboelmaged & Hashem, 2019). Consequently, organizational support is essential to enhance environmental performance as in this way the resources required for adopting green practices will be more easily available and employees will be motivated to implement green behavior (Lin & Ho, 2011). Successful innovation thus results from companies' distinctive resources and capabilities (Chang, 2014). In this way, the application of effective ecological strategies contributes to promoting an awareness of GI and improves organizational performance (Gürlek & Tuna, 2018).

The outcome is that the adoption of integrated strategies of organizational innovation to a large extent brings with it successful green strategies (Antonioli, Mancinelli, & Mazzanti, 2013) that make the best use of organizational resources and perform coordinated tasks for the purpose of increasing compliance and reducing waste (Cai & Li, 2018). Furthermore, organizational innovation increases firms' capacities to put in place environmental practices that improve their productivity and flexibility, as well as their responsiveness to the views of external stakeholders (García-Marco et al., 2020). This is reflected in a better environmental image, together with access to new markets and increased profits (Su et al., 2020). Moreover, it is believed that increasing their market share can greatly motivate organizations to follow customers' green demands and cooperate with external partners (Huang, Hu, Liu, Yu, & Yu, 2016).

Accordingly, this study offers a view of the possible nature of the interactions that arise when organizational innovations are implemented and their effects on GI, which may be of interest to practitioners and policymakers alike. The findings reveal some striking insights into the complementary nature of combining different innovative activities, as well as how each organizational innovation component affects GI separately.

These results may pave the way for various lines of research, attempting to fill gaps in the knowledge available by providing further empirical evidence about the relationship between the various components of organizational innovation and GI and by investigating whether there is a distinction between dirty and clean industries when it comes to the adoption of new, ecological methods. Hence, the main objective of this paper is to study the effects of fresh organizational approaches upon novel green activities and investigate whether dirty industries differ from those in the clean sectors in terms of ecological innovation.

To respond to this principal aim, the paper is structured as follows: Section 2 presents a review of the literature and lays out the research hypotheses; Section 3 explains the research methodology; Section 4 presents the main results and discussion; and Section 5 provides a conclusion.

2. Literature review and hypotheses

2.1. What is green innovation?

Green innovation refers to the adoption of organizational practices with the aim of developing environmentally friendly products and processes, enhancing the efficiency of resource use, and reducing environmental impacts (Singh, Del Giudice, Chierici, & Graziano, 2020). GI may include technical, organizational, and marketing changes (Kemp & Pearson, 2007), which require the introduction of internal green practices, such as environmental policies and new approaches that reduce production costs, and enhance operating and administrative efficiency (García-Marco et al., 2020; Sánchez-Sellero & Bataineh, 2022). GI can be classified as green product innovation, green process innovation, or green organizational innovation. The first, green product innovation, includes environmental improvements, such as recycling. The second, green process innovation, seeks to minimize energy consumption and maximize efficiency in the employment of resources (Xie, Huo, & Zou, 2019). Finally, green organizational innovation reflects the development of new ideas, behaviors, processes, and innovative management systems, which contribute to the reduction in environmental damage (Rennings, 2000). Companies can make better use of their resources while simultaneously reducing expenses, and this can heighten their recognition of the potential for green product innovations, all of which foster ecological organizational innovation (Song & Yu, 2018).

2.2. Organizational innovation and GI

Organizational innovation practices cover the entire range of specific changes and improvements in an organization's structure (García-Marco et al., 2020). They may involve new forms of administration, such as total quality management (Frondel, Horbach, & Rennings, 2007). They contribute to the development of new processes and critical managerial practices (Hecker & Ganter, 2016), which act as facilitators in enhancing a firm's innovation performance and strategic decision-making (Stock & Zacharias, 2011). Business model innovation relates to the fact that companies can take new approaches through developing their internal capabilities and resources (Zott & Amit, 2010). Resource-based theories see internal capital, such as human capital, organizational assets, and dynamic capabilities, as driving the practices of organizations and providing them with advantages, efficiency in the use of their materials, superior performance, and a more innovative stance (Galbreath, 2019).

Major organizational challenges concern the managing of boundaries with the environment, including externally generated uncertainties (Stock & Zacharias, 2011). Hence, organizational capabilities are faced with possible difficulties in the context in which a company operates if green organizational structures are to be developed (El-Kassar & Singh, 2019). Porter's hypothesis suggests that stringent environmental regulation can also stimulate overall innovation in enterprises, as well as specifically managerial and organizational changes (Porter, 1991). Consequently, firms seek to refine their strategies, resource management, and organizational structures to deal with uncertainty (Chang, 2014), and adopt practices within their organization aimed at gaining competitive advantages, and at achieving environmental sustainability (Tseng, Tan, & Siriban-Manalang, 2013). The overarching goal of corporate sustainable development is to reach economic, social, and environmental sustainability by incorporating these approaches into decision making. This is linked to the green theory that asserts that businesses should focus on ecological management methods and modern technology to offer environmentally friendly products and services (Abbas & Sağsan, 2019). To arrive at that point, enterprises put effort and organizational resources into exploiting new green products, and this in turn enhances their innovatory ecological performance (Song et al., 2020). The mere fact of having dynamic capabilities, and employing organizational and strategic routines, to reconfigure resources in a move to be more relevant gives businesses a competitive advantage (Singh et al., 2022). However, GI frequently triggers organizational change, for instance, when firms must adhere to stricter environmental regulations (Antonioli et al., 2013).

As defined by the Oslo Manual (OECD, 2005), there are three types of organizational innovation: new methods in the way in which procedures are organized, the assignment of work responsibilities and decision-making, and external relations with other firms or public institutions. Anzola-Román et al. (2018) and Cozzarin (2017) pointed to the importance of these organizational changes in enhancing technical innovations, such as product and process innovations. As noted by Hottenrott, Rexhäuser, and Veugelers (2016), companies that implement substantial new organizational arrangements are more likely to bring in GIs and hence increase productivity. Zhou, Shu, Jiang, and Gao (2019) also showed that organizational innovation as an internal incentive helps the adoption of new ecological approaches by increasing the efficiency of administrative and operating procedures, lowering the consumption of energy and materials, and eliminating environmental pollution. In turn, GIs may contribute to heightening a firms' environmental image, reflecting its organizational reputation, and thereby offering access to new markets and increasing returns (Fraj-Andrés, Martinez-Salinas, & Matute-Vallejo, 2009). Organizational change may thus complement the use of green technologies (Hottenrott et al., 2016), as well as stimulate GIs (Frondel et al., 2007).

2.2.1. The introduction of new organizational practices and GI

Organizational innovations in business practices involve implementing innovative processes to increase learning and knowledge exchange within the organization, which involves the deployment of innovative strategies for organizing routines, work procedures (OECD, 2005), and developing the practices of supply chain management (Vasileiou et al., 2022). Organizational changes, as one element in a process of innovation, generate technological novelties (Anzola-Román et al., 2018), which may entail redesigning processes and reassigning responsibilities within a company to enhance its environmental performance (Frondel et al., 2007). For example, El-Kassar and Singh (2019) revealed that businesses that have introduced new human resource practices achieve a more consistent competitive advantage by improving both environmental and the organizational performance.

Introduction of new practices also refers to the incorporation of creative ideas in an organizational setting to enhance procedures, practices, or products (Song & Yu, 2018). It can also develop absorptive capacity, which is considered a learning system that helps firms react to their external environment. This capacity enables firms to add new knowledge to their existing knowledge base, produce new knowledge from a novel combination of new and existing knowledge, and utilize this body of knowledge to innovate, particularly GIs (Galbreath, 2019). New approaches and venues for obtaining knowledge and other innovative inputs come from many sources, such as crowdsourcing ideas and solutions to several business concerns (OECD, 2018).

Cuerva, Triguero-Cano, and Córcoles (2014) point out that organizational capabilities enhance GIs as they found that the application of a quality management system increased the probability of GI on average by 34% in the firms they surveyed. Promoting novel changes in organizational structures is essential for GIs (Horbach, 2008) through implementation of a unified monitoring system for business activities comprising production, finance, strategy, and marketing (OECD, 2005). In consequence, it is not enough merely to embrace technological novelties to reach the highest levels of competitive advantage if this is done in a context of the absence of organizational changes (Anzola-Román et al., 2018). Likewise, Singh et al. (2020) pointed out that green transformation inspires employees to acquire new knowledge and engages them in green process and product innovation activities, facilitating the company to introduce green products to the market.

Consequently, the adoption of appropriate ecological strategies boosts innovatory ecological improvements in organizational performance and the diffusion of a green culture among company employees (Roespinoedji, Saudi, Hardika, & Rashid, 2019). In this regard, internal factors could motivate the organizational practices for more environmental sustainability (Galbreath, 2019) by redesigning processes that improve the environmental efficiency in manufacturing and operations (El-Kassar & Singh, 2019). Enterprises should thus utilize their organizational resources to enhance their GI performance (Song et al., 2020),

In this mainstream, the incorporation of a new organizational methods into a company's business practices contribute to apply green innovations by following innovative strategies for organizing routines and procedures for work productivity. Organizational change may thus complement the use of green technologies (Hottenrott et al., 2016) as well as stimulate GIs (Frondel et al., 2007). On the basis of these arguments and to capture the relationship between the introduction of new organizational practices and its effect on enhancing GI, we propose the following hypothesis.

Hypothesis 1. (H1): The introduction of new organizational practices is positively associated with green innovation.

2.2.2. New methods for organizing the workplace and GI

An orientation toward novel approaches is a strategy that has an impact on organizational innovation practices and serves as a key to developing and implementing programs that heighten the innovative posture of a company (Weng et al., 2015). This means that the implementation of certain organizational practices can contribute to the triggering of GIs (Singh et al., 2020). Organizational innovation with respect to the workplace organization provides the firm's employees with greater autonomy in decision-making while shaping their ideas. This can stand accomplished by decentralizing group activity and managerial control or forming formal or informal work teams in which individual workers have more flexible job duties (OECD, 2005). These practices thereby include introducing new methods in staff engagement, decentralizing decision-making, rotating staff among jobs, and training for innovation (García-Marco et al., 2020).

When it comes to overseeing the organizational changes required for GI, new methods of organizing work responsibilities and practices and decision-making in the workplace are typically effective in terms of overall performance and support the notion that a company's organizational investment is both profitable and productive (Vasileiou et al., 2022). Reorganizing the organizational structure in a manner that boosts employee involvement and skill base may be useful in creating an environment that absorbs and utilizes even more complicated kinds of innovation (Antonioli et al., 2013). Therefore, a choice of innovative methods relative to the engagement and involvement of employees in issue-solving and decision-making within companies is a vital aspect that can well increase their commitment to environmental issues. In particular, practices in respect of organizational innovations are one of the key human capital management factors in achieving environmental objectives (García-Marco et al., 2020).

The adoption of an integrated organizational strategy can lead to improved environmental performance. Consequently, a commitment from the top management and the motivation of employees to move toward ecological practices are prerequisites for the application of green schemes (Tang, Walsh, Lerner, Fitza, & Li, 2018). In this way, an advanced environmental strategy can help firms improve their organizational efficiency and obtain a competitive advantage in various areas of product development (Caracuel & Ortiz-de-Mandojana, 2013). The potential organizational benefits of green practices include reduced consumption of energy and natural resources, less waste and emission of pollutants, and an improved environmental and financial performance (Lin & Ho, 2011).

Acquiring environmental knowledge allows the transfer of environmental information by creating a workplace that lifts motivation, involvement, and employee retention (Arfi, Hikkerova, & Sahut, 2018). Consequently, companies have to take into consideration various organizational features such as new approaches, information flows within the firm, stakeholders' interests, and tendencies and perceptions among employees (Etzion, 2007). With this aim in mind, businesses should thus engage in organizational practices that will enhance the knowledge and skills of staff with regard to novel processes and actions (García-Marco et al., 2020). Hence, we formulate the following hypothesis.

Hypothesis 2. (H2): The definition of new methods for organizing the workplace is positively associated with green innovation.

2.2.3. New methods for improvement of relations with external partners and GI

Firms typically seek ideas for new products from several internal and external sources to develop product innovation (Bloch, 2007). Hence, organizations' relations with external partners are a source of learning and allow for the generation of new knowledge (Arfi et al., 2018). Putting forward innovative organizational methods in a firm's external relations requires the implementation of new ways of organizing relationships with other firms or public institution (OECD, 2005). The key advantage of sharing external knowledge through organizational practices is that it enables a firm to acquire new skills and information. As a result, a company that can stimulate an exchange of knowledge between groups or organizations is more likely to produce fresh ideas for establishing new business prospects that facilitate innovation (Arfi et al., 2018).

External networking can also provide opportunities to gain new skills and bring in advanced technology, as well as spread the costs and uncertainties of innovation among various entities (Sánchez-Sellero & Bataineh, 2022). Through these interactions, the organization combines its abilities with the specialized and complementary competencies of the network's other partners (Arfi et al., 2018), such as the establishment of new alliances with research organizations or clients, new ways of supplier integration, and primary outsourcing or subcontracting of business activities in production, procurement, and ancillary services (OECD, 2005). Thus, the feasibility of transferring useful information between partners will have an impact on a firm's approach to GI (Huang & Li, 2017).

In terms of organization, it has emerged that to generate GIs, businesses need to have more external partnerships (Messeni Petruzzelli, Maria Dangelico, Rotolo, & Albino, 2011). The building and managing of external relationships with stakeholders stimulate green activities through the exchange of new ideas and innovative practices (Zhou et al., 2019). A good connection with stakeholders is critical not only for an organization's survival but also for its legitimacy (Chang & Chen, 2013). Organizational innovations such as quality or supply chain management and connections with other firms are fundamental for energy-saving products, showing that novel articles can be introduced only in close collaboration with all the actors in the value chain. Consequently, partnerships of this sort are most favourable to GI (Cuerva et al., 2014).

Competitive industries have an incentive to innovate to take advantage of market benefits (Porter & Linde, 1995) and cope with strict environmental regulations (Brunnermeier & Cohen, 2003). Institutional theory also states that businesses need to amend their organizational practices in response to external forces involving regulations, standards, and attitudes (DiMaggio & Powell, 1983). Examples of these forces might be external pressures from customers, governments, competitors or similar groups, and expectations regarding professional norms or informal standards relating to values and stated moral commitments (Galbreath, 2019).

Overall, the presence of external and internal resources as varied as stakeholder pressure and organizational support is considered a crucial predecessor for corporate environmental responsibility and the adoption of green practices (Lee, Kim, & Kim, 2018). GIs are viewed as comprehensive, requiring a higher level of cooperation, and having stronger complementarities with network partners' operations (Arfi et al., 2018). Accordingly, delivering GI necessitates a greater degree of collaboration with external actors in addition to internal actors (Messeni Petruzzelli et al., 2011) by organizing collaborative creative initiatives with external partners and incorporating outside knowledge and other outside inputs into a firm's innovative activities (OECD, 2018). On the basis of the literature review provided above, the following hypothesis can be framed.

Hypothesis 3. (H3): An improvement in relations with partners outside the firm is positively associated with green innovation.

2.3. GI in clean as opposed to dirty industries

As a result of increasing environmental regulation, stakeholder pressures, and competition, firms need to be ready to deal with the changes that may be expected by investing in green projects, while still maintaining profits (Borsatto & Amui, 2019). This can lead to win-win situations, with higher profits but fewer environmental impacts (Porter & Linde, 1995). Furthermore, the pressures of competition stimulate enterprises to increase their market share and competitive advantages, as well as maintaining their environmental image through efficient production processes and the sparing use of materials and energy (Hojnik & Ruzzier, 2016). GI is more likely in industries that have considerable environmental impacts and strong pressures from stakeholders (Del Río, Peñasco, & Romero-Jordán, 2015).

In accordance with this trend, firms seen as being in dirty industries are those in sectors recognized as having the highest pollution intensities (Mani & Wheeler, 1998). They thus have a greater opportunity to seek benefits from environmental regulation by improving their use of resources and process controls. Furthermore, being subject to higher levels of environmental regulation, they may find that unit compliance costs are actually lower in comparison with industries that pollute less (Petroni, Bigliardi, & Galati, 2019). This is on the lines of the Porter hypothesis, which suggests that businesses that produce more pollution have greater opportunities to eliminate inefficiencies.

Hence, companies in dirty industries should naturally be more inclined to distinguish their activities through embracing green practices to enhance their corporate image in the marketplace by aligning with environmental protection rules, while responding to stakeholder pressure (Kunapatarawong & Martínez-Ros, 2016; Petroni et al., 2019). Using data from Spanish firms, García-Marco et al. (2020) and Kunapatarawong and Martínez-Ros (2016) made the claim that companies in dirty industries were more likely to apply GI activities in comparison with those in the clean sectors. On these grounds, the following hypothesis is proposed.

Hypothesis 4. (H4): Firms in dirty industries are more likely to engage in green innovation activities than those in the clean sectors.

3. Research methodology and data analysis

3.1. Data

The data used were drawn from the Spanish Technological Innovation Panel (PITEC) survey and covered the years 2003–2016. This database collects information on the innovatory actions of Spanish firms and provides useful information on their technological activities, of a quality suitable for academic research. The panel data are gathered in cooperation with the Spanish National Institute for Statistics (INE), the Spanish Foundation for Science and Technology (FECYT), and a group of academic experts by means of a standardized questionnaire.

This database offers details at the level of the individual firm, with over 460 variables for each of the 12,849 companies operating in 44 various areas of the economy, identified as clean and dirty sectors (see Appendix A). Such panel data allow the detection of long-term relationships between variables, as well as controls for nonobservable heterogeneity (Jové-Llopis & Segarra-Blasco, 2018). However, they do not specifically detect environmental issues. Nevertheless, this may actually help in avoiding respondents' over-reporting of green performance (Cainelli, De Marchi, & Grandinetti, 2015).

PITEC is based on the Community Innovation Survey (CIS) methodology and is widely used for research into innovation, particularly GI in Spanish firms (De Marchi, 2012; García-Marco et al., 2020). Every European Union (EU) Member State conducts its own CIS to detect innovative activities and provide information on the features of innovation activity at the level of individual businesses, which permits research into the innovation process and its economic benefits (OECD, 2018). Similar questionnaires have also been used for GI studies in other European countries (Horbach, 2008). This facilitates cross-country comparisons because of the use of similar datasets.

With regard to the methodology of classification adopted in this paper, it should be noted that PITEC data have been extensively used for research into innovation at the level of the firm in the Spanish economy. These data were acquired through information gathered between 2003 and 2016 about the performance of companies and their various environmental objectives. Adopting the line taken in work by García-Marco et al. (2020) and Kunapatarawong and Martínez-Ros (2016), this paper distinguishes between clean and dirty industries on the basis of levels of pollution and toxins discharged into the environment, as indicated in the Toxic Release Inventory and Environmental Protection Agency reports of 2017. This classification of industries is reported from the Spanish national catalog of economic activities (CNAE 2009), which is identical to the statistical classification of economic activities employed by the European Community (NACE Revision 2).

3.2. Measurement of variables

In this study, GI activities were taken to be the dependent variable. The independent variables were related to novel organizational arrangements. The control variables were the size of the firm, the time it had been operational, the extent of its research and development (R&D) work, and the degree to which it exported goods and services. The methods for measuring these variables are indicated below.

3.2.1. Dependent variables

In accordance with suggestions in the literature, several measures of different dimensions of GI were adopted (De Marchi, 2012; García-Marco et al., 2020; Sánchez-Sellero & Bataineh, 2022). The first, labeled PEGR, related to activities leading to the use of less energy, fewer raw materials, or both, per unit of output produced. The second, designated HSEGR, referred to actions intended to improve health, safety, and the environment. The final measure, entitled REGR, represented compliance with environmental and regulatory requirements. As the PITEC survey has been expanded with new variables and more detailed information over the years, variables providing similar information were consolidated into a consistent measurement for the period analyzed, 2003–2016. In fact, during the period 2003–2007, the survey recorded three GI variables, but for the period 2008–2016, these were increased to five. The questions that were asked for the survey between 2003 and 2007 investigated reductions in the use of materials and energy, improvements in environmental impacts, and compliance with regulations. Between 2008 and 2016, the questions addressed related to fewer raw materials per unit produced, less energy per unit produced, reduced environmental effects, improved health and safety, and compliance with environmental and regulatory requirements. To achieve consistency over time, the first and second questions in the list covering the second period were merged into a single variable, as were the third and fourth. Thereafter, the values for GI were coded with Fi gs. 0, 1, 2, and 3 to represent not applicable, low, medium, and high levels of green practices, respectively. Finally, averages were used for the merged or unified variables, so that they were classed as not applicable (0), low (0.5 or 1), medium (1.5 or 2), or high (2.5 or 3), respectively. An overall GI variable was established, expressing the totality of GI activities, its potential values ranging from 0 to 9.

This GI variable, moreover, could be used in scoring because GI = PEGR + HSEGR + REGR, which implies that GI had a minimum value of 0 and a maximum of 9, as each of the sub variables could be a figure lying between 0 and 3. The purpose of setting up such a GI statistic and studying it in the paper separately from the three main GI variables was to test whether there was any additive effect between these variables and those for organizational innovation.

3.2.2. Independent variables

Organizational innovation indicates the introduction of new methods in a firm's practices, workplace setup, or external relations (Anzola-Román et al., 2018; García-Marco et al., 2020; OECD, 2005).

This is in accordance with the PITEC survey, which enquires whether businesses have brought in any organizational novelties. The variables used to measure this were three in number. The first, ORG_INN1, referred to the introduction of new business practices or procedures, covering company re-engineering, knowledge management, lean production, and quality management. The second, ORG_INN2, represented the adoption of new methods for organizing work with the aim of achieving a better distribution of responsibilities and decision-making. It comprises the initial implementation of new approaches to employee responsibility, teamwork, decentralization, employee participation, and education. The final variable, ORG_INN3, is an expression of new methods of managing external relations, such as the forging of fresh alliances, partnerships, outsourcing, or subcontracting. ORG_INN1, ORG_INN2, and ORG_INN3 were all assigned a value of 1, if a company involved itself in an activity of the appropriate kind, and 0, otherwise.

3.3. Control variables

In order to separate signals from noise, various control variables were used in this study. The variable firm size (SIZE) indicated the number of employees. In general, larger companies are likely to make a better job of implementing GI because they have more capabilities (Sánchez-Sellero & Bataineh, 2022). The variable firm age (AGE) represented the number of years since the business in question had been established. As is common practice, both size and age were expressed logarithmically to stabilize their variance before running statistical analyses. The measure for research and development intensity (RD_INT) was the ratio between the number of employees working in the R&D department and the total staff. Research and development intensity improves the capabilities of businesses by simultaneously encouraging innovative ideas, adopting new technology, and integrating external knowledge (Díez-Vial & Fernández-Olmos, 2015; Sánchez-Sellero & Bataineh, 2022). The figure for export intensity (EXP) recorded the ratio of export sales to total sales. Finally, the Industry Type figure indicated whether a company operated in a clean or a dirty sector. If the enterprise was in a dirty industry, it was set at 0, if in a clean sector, at 1.

3.4. Data analysis

An analysis of panel data with dynamic structures has several advantages compared with static modeling, particularly with regard to the issues of heterogeneity and endogeneity, thanks to the introduction of instrumental and lagged variables. Nevertheless, even when generalized method of moments (GMM) estimation is adopted, dynamic panel models do suffer from some problems, including estimator instability, serial correlation, and weak instruments, which generally lead to overidentification in these models.

Taking as a basis the Arellano and Bover (1995) system of GMM with forward orthogonal deviations, Roodman (2009.a) addressed the limitations mentioned above by developing an Estimator feature in the Stata package allowing separate handling of endogeneity in dependent and independent variables, as also lags in levels and differences. This Estimator offers the possibility of carrying out an analysis in one or two stages, depending on the type of the weight matrix: homoscedastic or heteroscedastic. Because this Estimator is more suitable for a panel gathered from a short time span, given that it incorporates the instruments in levels, so as to reduce any loss of information, this paper adopts the two-step estimation proposed by Roodman (2009.a), particularly because the literature indicates that this is more efficient, owing to the use of a heteroscedastic matrix in this case (Lillo & Torrecillas, 2018).

To perform such an analysis using Stata, variables need to be categorized in the model as endogenous, predetermined (weakly exogenous), or exogenous. Moreover, to deal with the overidentification issue, Roodman (2009.b) proposed testing for the presence of excess instruments through Sargan and Hansen tests. However, in a two-step system for GMM, the Hansen test is preferable when checking for overidentification (Lillo & Torrecillas, 2018).

This paper adopted a mix of strategies, with a step-by-step process for model-building to avoid as far as possible any problem of overidentification by restricting lags in the dependent variable when introduced as a regressor in the model. It limited the use of lags when generating the instruments for endogenous variables and uses only in-level equations. After the estimation of each model, the two tests for overidentification were run, as was the Arellano and Bond test for serial autocorrelation.

Roodman (2009.b) stresses that in estimating dynamic models with panel data, T should ideally not exceed ten periods. In consequence, the analyses performed left out-of-account observations from the first four years, 2003–2006, to limit the time span of the data to only ten years, 2007–2016. This choice was also appealing because it minimized the number of automatically dropped dummy time variables arising from collinearity in the subsequent analyses. In fact, Kripfganz and Schwarz (2019) suggest that when time dummies or other variables are omitted because of collinearity, the computed degrees of freedom and p-values for the overidentification tests are incorrect. For each of the dependent variables, PEGR, HSEGR, REGR, and GI, the actions described below were taken.

A basic two-step dynamic panel data regression analysis was performed between the dependent variable and the regressors, these being the first lagged dependent variable and the organizational innovation variables (ORG_INN1, ORG_INN2 and ORG_INN3). Controls covered the type of industry (dirty or clean), time (dummy year variables), the size of the business concerned, and its age, export intensity, and the extent of its R&D work. In this basic two-stage model, the first lagged dependent variable was deemed endogenous, while firm size, firm age, export intensity and research and development intensity were considered as predetermined variables. The type of the industry and the organizational innovation variables (ORG_INN1, ORG_INN2, and ORG_INN3) were treated as exogenous. Hence, the internal instruments (GMM instruments) were the first lagged dependent variable, together with the size of the business, its age, the extent to which it exported, and the intensity of its R&D activities, while the external instruments (IV) were the type of industry and the organizational innovation variables ORG_INN1, ORG_INN2, and ORG_INN3.

In implementing GMM, instruments were generated for one to three lagged variables with the option of collapsing so as to limit the number of instruments, while the equation level is included in the IV structure. Estimates were corrected by the robust method to ensure the consistency of the estimators with regard to heteroscedasticity and autocorrelation, while use was made of the orthogonal method, needing transformation of forward orthogonal deviations instead of first differences. Thereafter, once the basic model had been estimated, tests were made for serial autocorrelation by the Arellano and Bond procedure for lags 1 to 3. If AR (1) was significant at a 5% level, with AR tests not significant for higher lags, then it was possible to proceed with the basic model. Otherwise, this model was re-estimated by adding in the lagged dependent variable 2 as a regressor, then repeating the Arellano and Bond test with the same rules, to check for higher serial autocorrelation before continuing the analyses. The objective at this stage was to deal with the problem of serial autocorrelation first, before moving on to test for overidentification.

Once the problem of serial autocorrelation was resolved, overidentification was checked for, basically with the Hansen test, as this is more suitable in the case of two-step GMM estimations. If the test was significant at the 5% level, then there was a problem of overidentification. In such a case, the last estimated model was re-estimated by introducing into the GMM system another lagged dependent variable as an instrument, after which there was a retest for overidentification. The recommendations put forward by Lillo and Torrecillas (2018) are that the p-value of the Hansen test should be equal to or greater than

0.05 and less than 0.8, while Roodman (2009.a) suggests an optimal value lying between 0.1 and 0.25. In this paper, the model was deemed to be free of any problem of overidentification whenever either of these two measures was fulfilled.

4. Results and discussion

All statistical analyses were performed using Stata 14, and the principal results are presented in Tables 1–4. Table 1 displays the characteristics of the data, indicating primarily that there were almost 180,000 observations relating to just under 13,000 Spanish businesses, of which 68.77% were in the dirty sector. At the level of the firm, the data are clearly unbalanced as it may be seen that the number of enterprises in the dirty industries was more than double those in the clean sectors.

Tables 2 and 3 present the descriptive statistics for the dependent, independent, and control variables. Even at first sight, the average values indicate that businesses in dirty industries are more likely to apply GIs than those in the clean sector. Whether an industry is clean or dirty, mean values indicate that companies apply GIs in an order of likelihood as follows: compliance with environmental and regulatory requirements; improvements in the health, safety, and environmental profile; and reduced use of materials and energy per unit produced. Adherence to environmental regulations is the green action most widely adopted as a response to stakeholder pressures and public policies on the environment. Strict regulations in this area can drive GIs, which lead to competitive advantages, through the overcoming of trade barriers in markets, which would otherwise exclude producers on the grounds of unsustainability or disregard for the environment. However, the average values noted for control variables were almost equal, whether enterprises were dirty or clean. It is noteworthy that the majority of Spanish firms, in both sectors, have tended to introduce organizational innovations at a level of around 67% for ORG_INN1, 67% for ORG_INN2, and 84% for ORG_INN3.

In contrast, Table 4 provides a correlation matrix and details of variance inflation factors (VIFs) to check for multicollinearity among the independent variables. The results overall indicate significant associations between independent variables and medium to low absolute correlations between every pair of variables. The fact that all the VIF figures are under 10, with tolerance values higher than 0.1, indicates that the model is not affected by any problems of multicollinearity.

Results for the two-step GMM adopted for dynamic panel data are shown in Table 5. Overall, the models presented in this table showed a good fit and no problems of serial correlation or overidentification, as demonstrated by Wald, AR, Sargan, and Hansen statistics, in accordance with the rules explained in the methodology and data analysis section.

Hypothesis 1 states that *the introduction of new organizational practices is positively associated with GI.* As shown in models 1, 2, and 3, there is support for this hypothesis, as the bringing in of new business practices to organize procedures has a positive association with GI actions ($\beta = 0.14$, 0.18, and 0.18; $p < 0.01$ in the three models).

Hypothesis 2 affirms that *the definition of new methods for organizing the workplace is positively associated with GI.* As is demonstrated by models 1, 2, and 3, there is support for this hypothesis because the introduction of new methods for organizing work responsibilities and taking decisions within the firm has a positive association with green innovatory activities ($\beta = 0.10$, 0.12, and 0.13; $p < 0.01$ in the three models).

Hypothesis 3 specifies that *an improvement in relations with partners outside the firm is positively associated with GI*. As can be seen from models 1, 2, and 3, there is support for this hypothesis, as *improved relations with external partners have a* positive association with GI activities ($\beta = 0.08$, 0.14, and 0.10; $p < 0.01$ in the three models).

Model 4 indicates that in general every organizational innovation is likely to promote GIs ($\beta = 0.30$, 0.50, and 0.35; $p < 0.01$). The organizational innovation components seem to be related to practically all green innovatory activities. These trigger major consequences in terms of productivity within businesses, these being fundamental to the innovation process. Companies are certainly encouraged to be innovative and to attain competitive advantages through changes in their organizational practices in response to regulatory requirements. Environmental regulations can in this way oblige enterprises to redesign the way they work to take advantage of cost-saving potentials (Rave, Goetzke, & Larch, 2011). As stated by institutional theory, firms should develop organizational practices and create new methods of designing products or processes to comply with regulatory requirements. The theory relates to the regulatory, social, and cultural influences that promote survival. As a consequence of growing environmental regulation, of stakeholder pressures, and of competition, businesses need to be ready to deal with foreseeable changes by investing in green projects, while at the same time maintaining profits. They must thus keep up to date with environmental regulations in such a way as to retain their competitive position in the market and to avoid penalties. This may also aid them in obtaining subsidies or tax deductions on the basis of their environmental performance.

Improved organizational structures help reduce the consumption of materials and energy, and optimize the use of resources, thus stimulating environmental innovations (Horbach, 2008). The outcome can be a reduction in costs, thanks to recycling and reducing waste, while simultaneously creating market differentiation for products (Caracuel & Ortiz-de-Mandojana, 2013). This makes it clear that the adoption of technological innovations is not sufficient in itself to maintain competitiveness as full benefits can be gained from them only if they are accompanied by organizational innovations. These latter include new ways of arranging the workplace and of coming to decisions, novel methods for coordinating tasks, and changes in the administration of the external relations of a company (Anzola-Román et al., 2018). Enterprises hence need to develop and align their environmental strategies and management practices at all points in the supply chain if their intention is the efficient adoption of GI practices (Dai et al., 2017). Organizational innovation strategies, such as introducing fresh approaches with regard to staff involvement, decentralization of decision-making, job rotation, and training for innovation, represent aspects of human capital management intended to meet environmental objectives (García-Marco et al., 2020). In view of the complexities of environmental issues, businesses intending to promote GIs would be well advised to form relationships with a range of outside parties (Messeni Petruzzelli et al., 2011). The managing of links with external partners stimulates green initiatives, thanks to the exchange of ideas and the acquisition of new skills. In addition, uncertainty can be spread over various participants, as can the risk of loss in green ventures. Overall, the results presented here are in line with other published work (Cuerva et al., 2014; Zhou et al., 2019; Singh et al.,2020, 2022).

Hypothesis 4 asserts that *firms in dirty industries are more likely to engage in GI activities than those in clean sectors*. As shown by models 1, 2, and 3, there is support for this hypothesis, as *companies in the dirty industries are more oriented toward green innovatory actions than businesses in the cleaner sectors* ($\beta = -0.13$, -0.13, and -0.15; $p < 0.01$ in the three models). On aggregate, model 4 also supports the hypothesis ($\beta = -0.35$, $p < 0.01$).

It will be recalled that the firms in dirty sectors were categorized as "0," while those in the clean industries were given the value "1." A check on the descriptive results revealed that the average figures for GI

Table 1
Characteristics of the PITEC data.

Type of sector	Firms freq.	Freq. (%)	Observations	Freq. (%)
Dirty	8,836	68.77	123,704	68.77
Clean	4,013	31.23	56,182	31.23
Total	12,849	100	179,886	100

Table 2
Descriptive statistics (control and green innovation variables).

Variables		*Dirty*		*Clean*		*Overall*	
		N	*Mean (Std.Dev)*	N	*Mean (Std.Dev)*	N	*Mean (Std.Dev)*
Green Innovation	*Less energy/material* per *production (PEGR)*	123,704	0.61 (0.94)	56,182	0.55 (0.88)	179,886	0.59 (0.92)
	Improvement of HSE (HSEGR)	123,704	0.69 (1.05)	56,182	0.62 (0.99)	179,886	0.67 (1.03)
	Compliance with environmental regulations (REGR)	123,704	0.73 (1.12)	56,182	0.70 (1.09)	179,886	0.72 (1.15)
	Green innovation (GI)	123,704	2.04 (2.89)	56,182	1.88 (2.67)	179,886	1.99 (2.82)
Control variables	*Firm Size*	83,072	4.06 (1.59)	50,632	4.42 (1.89)	133,704	4.19 (1.72)
	Firm age	123,704	1.04 (0.60)	56,182	1.27 (0.34)	179,886	1.11 (0.54)
	Export intensity	123,690	0.12 (0.24)	56,176	0.12 (0.25)	179,866	0.12 (0.24)
	RandD intensity	123,690	0.02 (0.06)	56,176	0.02 (0.08)	179,866	0.02 (0.07)

Table 3
Frequency analysis of the organizational innovation variables.

Organizational innovation variables		*Dirty*		*Clean*		*Overall*	
		Freq.	%	Freq.	%	Freq.	%
Introduction of new business practices for organizing procedures (ORG_INN1)	*No*	45,435	67.15	29,637	68	75,072	67.48
	Yes	22,226	32.85	13,948	32	36,174	32.52
	Total	67,661	100	43,585	100	111,246	100
Introduction of new methods of organizing work with the aim of a better distribution of responsibilities and decision-making (ORG_INN2)	*No*	45,049	66.58	29,337	67.31	74,386	66.87
	Yes	22,612	33.42	14,248	32.69	36,860	33.13
	Total	67,661	100	43,585	100	111,246	100
New methods of managing external relations with other companies or public institutions (ORG_INN3)	*No*	58,244	84.90	36,167	83.03	94,411	84.17
	Yes	10,361	15.10	7,390	16.97	17,751	15.83
	Total	68,605	100	43,557	100	112,162	100

Table 4
Matrix of correlations and VIF values.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	VIF	1/VIF
(1) ORG_INN1	1.000							1.912	0.523
(2) ORG_INN2	0.668	1.000						1.903	0.525
(3) ORG_INN3	0.445	0.445	1.000					1.317	0.759
(4) SIZE	0.140	0.152	0.092	1.000				1.081	0.925
(5) AGE	0.019	0.021	−0.029	0.212	1.000			1.066	0.938
(6) EXP	0.072	0.082	0.026	0.060	0.126	1.000		1.032	0.969
(7) RD_INT	0.059	0.060	0.063	−0.047	0.037	0.093	1.000	1.019	0.981

variables were always higher for enterprises belonging to a dirty sector than those for firms in the clean sectors. This points to a greater likelihood that businesses in dirty industries will apply GIs than those in clean industries, as a consequence of regulations or of new paradigms. In order to survive, dirty firms are obliged to innovate by going clean, while enterprises in the clean industries already fulfil the norms. Hence, when the models presented are checked, it becomes clear that coefficients are negative for the sector type. This is because a movement from dirty to clean (0–1) leads marginal GI variables to decrease by the amount of the coefficient, as it is negative and significant. In brief, businesses in a clean industry are naturally likely to have GIs already in place, while dirty enterprises find themselves having to take more actions in respect of the dependent variables of GI. This result supports hypothesis 4 and is in line with previous studies (García-Marco et al., 2020; Kunapatarawong & Martínez-Ros, 2016).

In respect of the control variables, the firm size showed a significant positive impact on GIs in all the models. This suggests that larger businesses adopt GI more effectively. The likelihood is that this is a consequence of their capacity to introduce environmentally friendly products and to make longer-term green investments. These findings are consistent with the literature (García-Marco et al., 2020; Kunapatarawong & Martínez-Ros, 2016). In contrast, the statistical analyses showed that the firm age had a small but significant negative effect on all GI activities. It seems clear that many newer enterprises achieve a better performance in applying green practices over the short term than do older firms in the same field. These new businesses would appear to innovate in order to survive using resources efficiently and complying with environmental regulations. Doing so might assist them in obtaining public subsidies or avoiding penalties. These findings are in accord with those from earlier studies (Del Río et al., 2015; Horbach, 2008).

Export intensity showed a significant positive relationship with GI activities. This probably reflects the availability of wider opportunities for exporting firms to improve their productivity because they can gain new technology and knowledge from abroad (García-Marco et al., 2020). Companies active in international markets show up as having an ability to innovate efficiently (Jové-Llopis & Segarra-Blasco, 2018Jové-Llopis & Segarra-Blasco, 2018), essentially because exporters have to adopt proactive environmental strategies related to green practices to compete internationally. Exporting also puts businesses in contact with regions that have strict regulations, where complying with yields a competitive advantage over their rivals.

Finally, research and development intensity had a moderate positive correlation with GIs. A solid involvement in R&D stimulates the creation of innovative ideas, the introduction of new technology, and the assimilation of knowledge gained from external sources. This goes to improve the capabilities of the companies concerned, while simultaneously assisting them to exchange knowledge, acquire new skills, and enhance resource efficiency. Similarly, the availability of internal R&D resources enhances GI, heightens competitiveness, and increases corporate growth (Sánchez-Sellero & Bataineh, 2022). Nevertheless,

Table 5
Dynamic panel data estimations with two-step system GMM.

Independent variables		Green innovation variables			
		Model 1	*Model 2*	*Model 3*	*Model 4*
		PEGR	*HSEGR*	*REGR*	*GI*
Control Variables	*Lagged one of the dependent variable (L1.)*	0.49*** (0.008)	0.49*** (0.009)	0.47*** (0.009)	0.51*** (0.009)
	Lagged two of the dependent variable (L2.)	0.11*** (0.009)	0.10*** (0.008)	0.09*** (0.01)	0.11*** (0.01)
	Sector type (dirty vs. clean)	−0.13*** (0.01)	−0.13*** (0.01)	−0.15*** (0.01)	−0.35*** (0.04)
	Firm size	0.06*** (0.01)	0.07** (0.02)	0.09*** (0.02)	0.19** (0.05)
	Firm age	−0.12* (0.05)	−0.13* (0.06)	−0.19* (0.07)	−0.32* (0.15)
	Export intensity	0.18*** (0.03)	0.13*** (0.03)	0.16*** (0.04)	0.47*** (0.10)
	R&D intensity	0.60*** (0.13)	0.87*** (0.15)	0.88*** (0.18)	2.46*** (0.43)
	Constant	0.11*** (0.03)	0.08** (0.04)	0.10** (0.04)	0.21** (0.10)
Organizational innovation	*Introduction of new business practices for organizing procedures (ORG_INN1)*	0.08*** (0.01)	0.10*** (0.01)	0.12*** (0.01)	0.30*** (0.03)
	Introduction of new methods of organizing work with the aim of a better distribution of responsibilities and decision-making (ORG_INN2)	0.14*** (0.01)	0.18*** (0.01)	0.18*** (0.02)	0.50*** (0.04)
	New methods of managing external relations with other companies or public institutions (ORG_INN3)	0.10*** (0.01)	0.12*** (0.01)	0.13*** (0.01)	0.35*** (0.04)
Post estimates	*Wald Chi2-Statistic*	73,052.52***	82,366.64***	68,780.45***	101,095.74***
	Arellado and Bond test for AR(1)	−2.84***	−2.55**	−2.49*	−2.71***
	Arellado and Bond test for AR(2)	1.70*	1.44	1.87*	1.26
	Sargan test of overid. Restrictions	13.86 (0.12)	3.16 (0.87)	3.22 (0.86)	3.09 (0.87)
	Hansen test of overid. Restrictions	13.28 (0.15)	4.83 (0.68)	5.29 (0.62)	4.70 (0.69)

i. Dependent variables are less energy per production (PEGR), improvement of HSE (HSEGR), compliance with environmental and regulatory requirements (REGR), and green innovation (GI). Yearly dummy variables from 2007 to 2009 were dropped from the models because of collinearity.
ii. Dynamic panel data estimations with two-step system GMM were performed with the collapse option for instruments lagged 1–3 including equation level, robust estimation, and forward orthogonal-deviations transformation.
iii. Numbers without brackets are the estimated coefficients or test statistics, whereas numbers between brackets represent the standard errors of the estimated coefficients or the p-values in the case of Sargan and Hansen tests.
iv. * indicates a significance at 0.10 level, ** significance at 0.05 level, and *** significance at 0.01 level.

variations in the results of the study are an outcome of the impact of various different factors on the effects of R&D intensity upon environmental innovation, such as an enterprise's financial position and its relationships with stakeholders (Triguero, Cuerva, & Álvarez-Aledo, 2017).

5. Conclusion

Pressures from stakeholders and legislation can bring companies to refine their internal capabilities to deal with uncertainty by adapting their organizational structures, withstanding external challenges by adjusting their capacity to absorb them, changing strategies, improving resource efficiency, and spreading a green culture among their employees. It is clear that organizational innovation encompasses a broad range of diverse disciplines and phenomena, particularly in the light of global competition, with countries taking up an orientation toward green economies and sustainability. On the basis of the Porter hypothesis, areas with appreciable competition have an incentive to innovate to take advantage of market benefits and face up to strict environmental regulations worldwide by addressing public pressures on environmental issues, changes in demand, and customer awareness.

It would appear that despite the extensive literature on the relationship between organizational and GIs, the effects of the various components of organizational innovation upon green innovatory actions have not been widely addressed. This paper explores persistence in GIs over time. It thus contributes to a better understanding of the general context of the phenomenon of innovation, particularly the relationship between the different types of organizational innovatory practices, in particular those relating to changes, both internal and external in origin, and their impact on the adoption of GIs. As a response to organizational changes and institutional pressures, organizations incorporate GI practices into their structures to enhance their performance by differentiating their products and promoting the process efficiency, thus achieving competitive advantage. Accordingly, in line with the institutional theory, this paper draws upon the necessary theoretical basis for grasping the role of institutions in influencing green strategies and entitling the investigation of connections to organizational innovations. In addition, this paper determines whether organizational novelties are more likely to bring into play green innovatory actions as a function of the type of the industry, clean or dirty.

The data were derived from PITEC panel data for Spanish firms in all industries from 2003 to 2016, allowing tests to be made for associations between variables over the longer term, with controls for nonobservable heterogeneity. Finally, the paper addresses the existing research gaps in terms of the econometric methodology using the two-step system GMM with instrumental and lagged variables that help dealing with the issues of heterogeneity and endogeneity in estimation.

In consequence, this paper may help fill a gap in the literature by providing more empirical evidence about the relationship between organizational and GIs and detecting any differences between clean and dirty sectors with regard to the introduction of new environmental practices. Such a connection may encourage researchers, decision-makers, and stakeholders to refine their strategies. The setting of proactive environmental company policies undoubtedly leads to competitive advantages and better financial performance, as well as minimizing the risks and uncertainty of investing in green projects.

Using the rich PITEC dataset derived from the CIS, the paper provides an extensive empirical analysis of a large sample, amounting to some 13,000 Spanish businesses, through the application of two-step GMM estimation to panel data at the level of the firm, involving forty-four industries and running for over fourteen years. The results obtained provide novel insights for the knowledge base covering the main drivers for GIs and how internal capabilities are brought into play. Essentially, the key outcomes may be summed up as indicating that all organizational innovation components affect the adoption of GIs. These organizational actions include the introduction of new business practices for organizing procedures, an improved distribution of responsibilities and decision-making, and the managing of external relations with partners. Moreover, all these activities showed a positive relationship with GI actions. It was also noted that the dirty sectors were more likely to adopt GIs than were the clean ones because of their need to be more innovative in general and as a reflection of potential pressures and the imposition of environmental regulations.

The findings of this study have several managerial and policy implications. Green practices can help firms achieve cost savings, access new markets, and promote process efficiency, all of which impact positively on financial status. The consequence is that decision-makers should pay more attention to institutional factors influencing GIs. This requires the updating of their organizational practices and the putting of more effort into the careful use of their corporate resources and into the introduction of new, environmentally friendly products to attain objectives for sustainability. It is important to bring institutional regulations up to date and develop organizational practices in response to local and international pressures on environmental issues. Additionally, external collaboration should be developed and more should be invested in R&D as this may help businesses to exchange knowledge, acquire new skills, and bring in new clean technology or establish novel green patents. This supports institutional theory with regard to the part played by developing organizational capabilities in product differentiation and in gaining competitive advantages. On the other hand, local governments can offer subsidies for enterprises that demonstrate their commitment, hence stimulating green investments, particularly in dirtier industries, and can protect patent rights for GIs.

As with any research, this paper has its limitations. The PITEC dataset does not take into account certain aspects of green activities, primarily environmental managerial matters such as supply chain administration, human resource management, and green R&D. Moreover, it lacks details of financial ratios that would allow measurement of the effects of innovation upon performance. Furthermore, it would be of greater interest to base the classification of sectors on characteristics at the level of individual firms rather than on features of environmental performance throughout a whole industry or sector. However, the unavailability of data covering all the companies for the full time span of the study led to the procedure followed by previous studies being adopted.

Future researchers have several issues available for consideration. It would be feasible to include the effects of organizational culture and identity upon the adoption of GIs and to consider proactive environmental strategies and how they may affect financial performance. Moreover, if more detailed data on the characteristics of companies become accessible, future research could explore new ways of classifying sectors.

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Appendix A

Table A1

Sector classification	Sector type	Freq.	Percent
Dirty	Agriculture, Forestry and Fishing	1456	1.35
	Extractive industries	532	0.49
	Petroleum industry	42	0.04
	Food, Beverages and Tobacco	7742	7.20
	Textile	1904	1.77
	Leather and Footwear	448	0.42
	Wood and Cork	686	0.64
	Pulp and Paper	1064	0.99
	Graphic Arts and Reproduction	798	0.74
	Chemicals	6006	5.58
	Pharmaceutical	1722	1.60
	Rubber and Plastics	3626	3.37
	Nonmetallic mineral products	2758	2.56
	Metallurgy	1694	1.57
	Metal	5726	5.32
	Computer, Electronic and Optical Products	2604	2.42
	Electrical products	2492	2.32
	Vehicles	2954	2.75
	Shipbuilding	182	0.17
	Spaceship and airplanes	196	0.18
	Furniture	1302	1.21
	Energy and Water	854	0.79
	Waste management	994	0.92
	Construction	3598	3.35
Clean	Clothing and fur industry	686	0.64
	Machinery and Equipment	6790	6.31
	Transport equipment	280	0.26
	Other manufacturing activities	1414	1.31
	Machinery repair	966	0.9
	Commerce	9758	9.07
	Warehousing	2590	2.41
	Accommodation	2030	1.89
	Telecommunications	476	0.44
	Information technology	5978	5.56
	Other Information and Communication Services	1960	1.82
	Finance and insurance	2086	1.94
	Real estate activities	1288	1.2
	RD services	2380	2.21
	Other activities	8106	7.54
	Administrative services	4704	4.37
	Education	476	0.44
	Health and social services	2562	2.38
	Arts, recreations, and entertainment	658	0.61
	Other services	994	0.92

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