Absorptive capacity and relationship learning mechanisms as complementary drivers of green innovation performance

ABSORPTIVE CAPACITY AND RELATIONSHIP LEARNING MECHANISMS AS COMPLEMENTARY DRIVERS OF GREEN INNOVATION PERFORMANCE

POST-PRINTS

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Abstract

Purpose:

This paper explores in depth how internal and external knowledge-based drivers actually affect the firms' green innovation performance. Subsequently, this study analyzes the relationships between absorptive capacity –internal knowledge-based driver–, relationship learning –external knowledge-based driver– and green (also called environmental) innovation performance.

Design/methodology/approach:

This study relies on a sample of 112 firms belonging to the Spanish automotive components manufacturing sector and uses partial least squares (PLS) path modeling to test the hypotheses proposed.

Findings:

The empirical results show that both absorptive capacity and relationship learning exert a significant positive effect on the dependent variable and that relationship learning moderates the link between absorptive capacity and green innovation performance.

Research limitations:

This paper presents some limitations as the particular sector (i.e., the ACMS) and geographical context (Spain). For this reason, researchers must be thoughtful while generalizing these results to distinct scenarios.

Practical implications:

Managers should devote more time and resources to reinforce their absorptive capacity as an important strategic tool to generate new knowledge and hence foster green innovation performance in manufacturing industries.

Social implications:

The paper shows the importance of encourage decision-makers to cultivate and rely on relationship learning mechanisms with their main stakeholders, to acquire the necessary information and knowledge that might be valuable in the maturity of green innovations.
Originality/Value:
This study proposes that relationship learning plays a moderating role in the relationship between absorptive capacity and green innovation performance.

Keywords: Absorptive capacity; green innovation performance; relationship learning; partial least squares.

1. Introduction

In the last two decades, enterprises and society in general became increasingly concerned about environmental issues and the human beings' activities footprint on the earth. Consequently, many firms have made a significant effort to foster green practices, gradually changing their strategies and operations in order to comply with this global environmental concern (Chang, 2011). In this line, companies are introducing innovative products or services, production processes, or business methods aiming to reduce environmental damage, pollution (on water, air, soil, noise), and other negative impacts (Kemp and Pontoglio, 2007), being recognized as a principal mechanism to mitigate or avoid environmental damage supporting firms and society to undertake environmental sustainability (Aragón-Correa, 1998; Pérez-Valls *et al*., 2015; Chen and Chang, 2013). Several contributions support that the introduction of green innovations do not come necessarily to the advantage of economic benefits. Indeed, it might represent a prerequisite for the attainment of competitive advantages (Dale, 2007) – especially when it comes to product innovations (Chang, 2011) – and a reinforcement for their survival opportunities (Laforet, 2009), as it can increase the firm's productivity by reducing costs and/or enable to develop new market opportunities, support differentiation strategies and improve corporate image (Orsato, 2006).

However, developing green innovations – also called environmental innovations – is not an easy task, given their specificities with respect to other innovations (Horbach, 2008; De Marchi, 2012), which spur critical managerial problems for firms interested in effectively reducing their environmental footprint. As reported by Cainelli *et al*. (2015),

such sub-group of innovations, in fact, entails a high degree of novelty, uncertainty and requires a great variety of resources; more often than for developing other innovations, firms need to go beyond their existing industrial knowledge-base and explore new external knowledge sources. Indeed, a large number of studies have reported the (distinctive) relevance of the collaboration with stakeholders for the effective introduction of environmental innovations (e.g., De Marchi, 2012, Cainelli *et al*, 2015; Marzucchi and Montresor, 2017). Less is known, however, about the role of the internal firm's capability to be effectively able to tap into such relevant knowledge flows and to transform them in products or services to meet environmental concerns.

To address this gap in the literature, this study investigates the ability of the firms to learn from external sources as a key antecedent of the successful implementation of green innovation. More specifically, we focus on two constitutive elements of such internal capability: the absorptive capacity, intended as the ability to internally convert knowledge developed by stakeholders into new products, services or processes (Cohen and Levinthal, 1990); and relationship learning, being the ability to share information and knowledge with supply chain partners (Leal-Rodríguez *et al*., 2013).

Therefore, this study aims to respond to the following research questions: (i) To what extent are knowledge-based capabilities, such as absorptive capacity and relationship learning, supporting firm's green innovation performance? (ii) Might the fostering relationship learning mechanisms reinforce the role of absorptive capacity to support the development of green innovations at firms? Hence, the main purpose of this work is to explore in depth how internal and external knowledge-based drivers actually affect the firms' green innovation performance. Subsequently, this paper analyzes the relationships between absorptive capacity (AC) –internal knowledge-based driver– relationship learning (RL) –external knowledge-based driver–, and green innovation performance (GIP). Furthermore, it aims to assess whether the RL construct acts as a moderating variable on the AC-GIP link.

This paper sheds light upon the scarcely developed topic comprising the identification of key, firm's level, capabilities that drive green innovation performance, providing several contributions to the literature. The existing literature regarding this issue often characterizes for providing qualitative insights in the form of case studies and

knowledge grounded on experts' advice, but fails to provide empirical evidence based on data from a sample of firms. Besides, while the majority of the studies investigating the firms' drivers of green innovations have employed general and limited empirical measures of the firms' capacity to absorb external knowledge and transforming it to innovative purposes (such as the presence of an internal R&D department) (e.g., De Marchi and Grandinetti, 2013; Ghisetti *et al.*, 2015) our analysis is grounded on an original dataset with detailed information on firms' practices. Another source of novelty in this study roots in the research setting. As green innovations dynamics may vary deeply from one industry to the other (Oltra and Jean, 2009) and from country to country (Horbach *et al*., 2013), this research work focuses on the automotive components manufacturing sector (ACMS) in Spain. Considering for the impact on the environment in terms of air pollution and resource and energy usage, firms in this industry are increasingly scrutinized from stakeholders at large for their environmental performance (Shatouri *et al*., 2013), as emerged in the 'dieselgate' that involved Volkswagen (Fracarolli & Lee, 2016). In this context, the development of more efficient and sustainable products or services is particularly relevant and case study analyzes support that the absorptive capacity of companies support diversified green innovation approach (Williander, 2007). According to Segarra-Oña *et al.* (2014), Spanish automotive companies focused on products and processes innovativeness tend to be more motivated by environmental issues. This means that firms which seek higher operational flexibility –in order to reduce labor costs per unit, increase production capacity, or to reduce energy consumption per unit when they are looking for new innovations– are more willing to adopt an environmental orientation.

Thus, this paper aims at providing a framework useful both for academics and practitioners that intend to explore knowledge-based practices that may lead firms to enhance their green innovation performance. In the following, we first review the literature and support the hypotheses proposed. The third section describes the empirical setting. The fourth section brings the empirical results of the study. Finally, the fifth section discusses the main points arising from the analysis.

2. Theory and hypotheses

2.1. Green innovation performance

Innovation is commonly understood as the introduction of new products, services, or processes that comprise a certain degree (radical or incremental) of organizational change (Ashok *et al*., 2014). Following Beise and Rennings (2005), green innovations is defined as new or improved practices, processes, techniques, systems and products to prevent or minimize environmental damages, involving energy-saving and pollution-prevention so as green product designs or configurations that facilitate waste recycling or corporate environmental management, and might include both radical or incremental improvements of the existing practices (e.g., Chen *et al.,* 2014). Albort-Morant *et al*. (2017, p. 3) define green innovation (GI) as "a type of innovation whose main objective is to mitigate or avoid environmental damage while protecting the environment and enabling companies to satisfy new consumer demands, create value, and increase yields". The literature focusing on technological innovations often distinguishes between "product innovation" and "process innovation" (e.g., Chen *et al*., 2006). Green product innovation consists in improving the product's design and features to minimize its negative environmental impact. Green process innovation involves any change or adjustment within the manufacturing process that contributes to decrease the negative environmental damage during any of the production stages – materials acquisition, manufacturing, delivery (Klassen and Whybank, 1999). Firms might modify their activities to take on just few or many of these environmental challenges; different GI performance – i.e., how many sustainability elements they tackle via the introduction of several GIs, or put differently, how much sustainability is at the core of their innovation activities – different strategies will be needed to put in place to achieve them (De Marchi and Grandinetti, 2013; Ghisetti *et al.,* 2015). Following this discussion, this paper conceptualizes GIP as the firm's endeavor in greening their activity that is channeled through the development and application of innovative practices that involve more sustainable products and processes.

Nowadays, firms are willing to strive for rising green innovations (Molina-Azorín *et al.*, 2009). Therefore, green innovation is an important tool that can help firms and society to undertake environmental sustainability (Chen and Chang, 2013), and plays a crucial role for firms willing to face the challenges of green and environmental consciousness while obtaining competitive advantage and business performance (Chang, 2011; Chen *et al*., 2012). Green innovation can enhance business performance at the time that permits meeting the ecological needs shared by the firm and its stakeholders –

customers, partners, governments and society in general. On the other hand, green innovation may hinder imitation opportunities, generating barriers to other competitors, and allowing developers to obtain competitive advantages based on green innovation (Chang, 2011).

A key element emerging from the studies that have focused on green innovations is that their development requires firms to master knowledge based being often diverse from their traditional domain and being multifaceted (Carrillo-Hermosilla *et al*., 2010), representing often a technological frontier. Indeed, very often companies willing to reduce emissions along the life cycle of the products or to improve recyclability are required to combine a wide variety of resources and capabilities, often external, and collaborating on innovation with a variety of external stakeholders, especially suppliers, universities or knowledge intensive business services (KIBS) gets even more important than for other innovations (De Marchi, 2012; Cainelli *et al*., 2015). The ability to learn from them and develop a common language becomes, therefore, crucial to allow the effective introduction in the market on new, green, technologies.

2.2. Absorptive capacity and green innovation performance

The concept of absorptive capacity (AC) was firstly coined by Cohen and Levinthal (1990), and has been subject to a significant development on its conceptualization and measurement since then (Lane *et al.,* 2006). Cohen and Levinthal (1990) defined absorptive capacity as the organization's ability to recognize the value of acquiring, assimilating and applying new external knowledge. Furthermore, they suggested that absorptive capacity involves the firm's ability to link and integrate this new external knowledge with its previous knowledge-base. In a review of the literature on key dimensions of absorptive capacity, Zahra and George (2002) reconceptualize and extend the concept of absorptive capacity initially proposed by Cohen and Levinthal (1990). According to these authors, AC is defined as a set of dynamic organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge. In particular, Zahra and George (2002) propose that absorptive capacity involves two general subsets or dimensions i) *potential absorptive capacity* (PACAP), which comprises knowledge acquisition and assimilation processes, and hence provides companies with enough strategic flexibility and independence to adapt and advance in a

continuously and rapidly changing environment; ii) *realized absorptive capacity* (RACAP), which includes knowledge transformation and exploitation, and encompasses the attainment of new insights and consequences from the combination of existing and newly acquired knowledge into firms' operations.

Absorptive capacity represents an important part of the firm's ability to create new knowledge (Cohen and Levinthal, 1990; Lane *et al.,* 2006; Wales *et al.,* 2013), and helps companies to introduce external knowledge that will allow the development of new products/services and ideas (Newey and Zahra, 2009) differentiating the firm from their competitors (Jansen et al., 2006; García-Zamora *et al.,* 2013), and gives firms a potential advantage in terms of knowledge acquisition (Wales *et al.,* 2013). Leal-Rodriguez *et al.* (2013) assess the relationship between absorptive capacity and innovation and reveal that innovation outcomes are to a great extent the result of the firm's efforts and investment in knowledge.

Considering for the characteristics of environmental innovations, we support that absorptive capacity, is particularly important to effectively develop them. Our view is in line with Gluch *et al.* (2009) that shapes absorptive capacity as an organizational capability that might enhance green innovation outcomes. Through these processes and routines the firm might learn to cope with and solve environmental problems. Indeed, the adoption of green innovation practices involves handling extensive quantities of knowledge both internal and external to the organization, often coming from different domains. This newly acquired external knowledge needs to be assimilated, combined with prior related internal knowledge and finally transformed. Thus, organizations need to develop the capacity to absorb new knowledge in order to facilitate such practices (Hashim *et al.,* 2015).

Several studies have addressed the link between absorptive capacity and green innovation (Gluch *et al*., 2009; Delmas *et al*., 2011; Hashim *et al.,* 2015), suggesting that the broad adoption and diffusion of green innovations (i.e., electric engine development; hybrid and hydrogen-based vehicles; sustainable tires that minimize friction and saves fuel; and the use of vegetable fibers in composite materials) requires that top management actively promote a knowledge-intensive and innovation-driven organizational culture. Focusing on a broad set of manufacturing activities, De Marchi

and Grandinetti (2013) further suggest that companies that are introducing a wide array of innovations to reduce environmental impacts – what we named green innovation performance (GIP) – are those that have a structured department, internal to the firm, devoted to the research and development of new technological solutions, being indeed the proxy used in the empirical literature to capture AC capabilities.
Therefore, we hypothesize:

H1: Absorptive capacity positively relates to green innovation performance.

2.3. Relationship learning and green innovation performance

Fostering strong relationships and business partnerships along with the corporate distinct stakeholders can lead to creating value for both parts and enhance their competitive advantages (Vargo and Lusch, 2004). For this reason, companies should devote time and resources to build and carry out collaborations with specific partners that will provide in turn mutual increased value, considering both for primary (customers, suppliers, employees, financiers, communities) and secondary (government, competitors, media, special interest and consumer advocate groups) stakeholders (Freeman *et al.,* 2007). Likewise, Ashok *et al*. (2016) define collaboration as the joint generation of value by a company and its main partners, which comprises exchange, sharing and co-development and found that investments in KM practices are fundamental in order to extract value from external knowledge for process innovation.

Upholding a context for relationship learning might conduct firms to extract and capture all the valuable relationship-based knowledge. The studies from Hallen *et al.* (1991) and Hakansson and Snehota (1995) were the first to conceptualize relationship learning (RL) as an organizational capability consistent with the interaction perspective on relationships building. Selnes and Sallis (2003, p. 81) define the concept of relationship learning as "a joint activity in which two parties strive to create more value together than they would create individually or with other partners". Cheung, Myers and Mentzer (2011, p. 1062) refer to relationship learning as "a joint activity between a supplier and a buyer in which two parties share information, which is jointly interpreted and integrated into a shared relationship-domain-specific memory that changes the likelihood of potential relationship-specific behavior". Other works argue that relationship learning is a joint activity between the organization and one or more parts –

supplier, customer, partner, etc. – in which the purpose is to share information (Leal-Rodriguez *et al*., 2014). RL is a multidimensional construct shaped by three first order reflective constructs, namely information sharing – exchange of information between the firm and one or more interested parties (Selnes and Sallis, 2003); joint sensemaking – the development of knowledge, insight, and associations between past actions, the effectiveness of these actions, and future actions (Fiol and Lyles, 1985); and knowledge integration – the combination of cooperation (alignment of interests) and coordination (alignment of actions) between firms and multiple parts (Gulati *et al.,* 2005). Together, these three variables define a general framework that shapes the context in which knowledge sharing takes place between transmitter and receiver (Leal-Rodriguez *et al*., 2014).

The companies' ability to foster and take advantage of RL mechanism may favor a strategy of coopetition that might lead them to competitive advantages and business performance enhancement. Through relationship learning there can be also reached some strategic goals such as the distribution of risks and the outsourcing of some functions within the value-chain (Gulati *et al.,* 2000).

The building and establishment of collaborative networks between companies and stakeholders is fundamental in innovation development processes (Bossink, 2002). Firms can therefore generate strategic alliances, joint ventures, inter-firm networks, R&D consortia, benchmarking experiences and other partnerships in order to learn best practices from their stakeholders (Doz *et al.,* 2000). According to Huang and Rice (2012), fostering openness in product and process innovation brings substantial advantages that essentially deal with value co-creation benefits (i.e., a more fluid transfer of complementary expertise and resources between parts, the development of deeper and broader firms' knowledge bases, the access to external specialized know-how that the firms may lack to overcome existing technological deficiencies and the sharing of risks, research costs and rewards among collaborators). Thus, those firms that actively rely on partnerships and collaborations might be able to successfully innovate by sharing complementary resources and capabilities (Powell, 1998). This view is also supported by Ashok *et al*. (2016), whose empirical results obtained from a sample of 166 knowledge intensive business service (KIBS) firms reveal that collaboration with end users favors incremental process innovation.

In light of the theory of resource dependence (Pfeffer and Salancik, 1978), organizations build collaborative relationships in order to respond to uncertainty and consequently, being able to organize their resources. Therefore, companies should facilitate the exchange of information with different customers and suppliers to increase their knowledge base, skills and competitiveness through common learning mechanisms, and updating their behavior accordingly. Due to the complexity of the process, relationships may change accordingly to the distinct parts' learning capability. Therefore, RL might be particularly relevant in the context of green innovation, characterized by high level of complexity and uncertainty and where collaboration with external partners is particularly relevant (De Marchi, 2012, Cainelli *et al*., 2015).

As we suggest in paragraph 2.1, the development of green innovative products and processes is not only dependent of internal resources but also of a broad set of knowledge-related capabilities, in line with prior research that highlights the existence of positive and significant relationships between fostering of collaboration and knowledge sharing among employees and developing a proactive environmental strategy within organizations (Aragón-Correa *et al*., 2013). De Marchi (2012) states that R&D cooperation with suppliers promotes environmental innovation to a greater extent than other kind of innovation. This feature is driven by the high complexity inherent to environmental innovations, which may only be tackled by blending a joint set of specialists' knowledge and competencies that are necessarily spread among distinct organizations (De Marchi and Grandinetti, 2013). In order to address the complexity underlying the pursue of a proactive innovative approach towards minimizing environmental impacts, firms are hence required to establish and maintain narrow cooperative ties with the distinct actors shaping their value network.

This is especially true as environmental or green issues do not represent the core business for most companies, so they often lack from the necessary knowledge and capabilities to foster green innovations (Cainelli *et al.* 2015). For instance, within the ACM sector, if a firm is willing to decrease its environmental impact, sustaining cooperation relationships with other firms in the product's value chain is vital (Petruzzelli *et al*., 2011). Furthermore, the complexity of environmental issues entails that organizations need to build an intense and broad network of connections with their

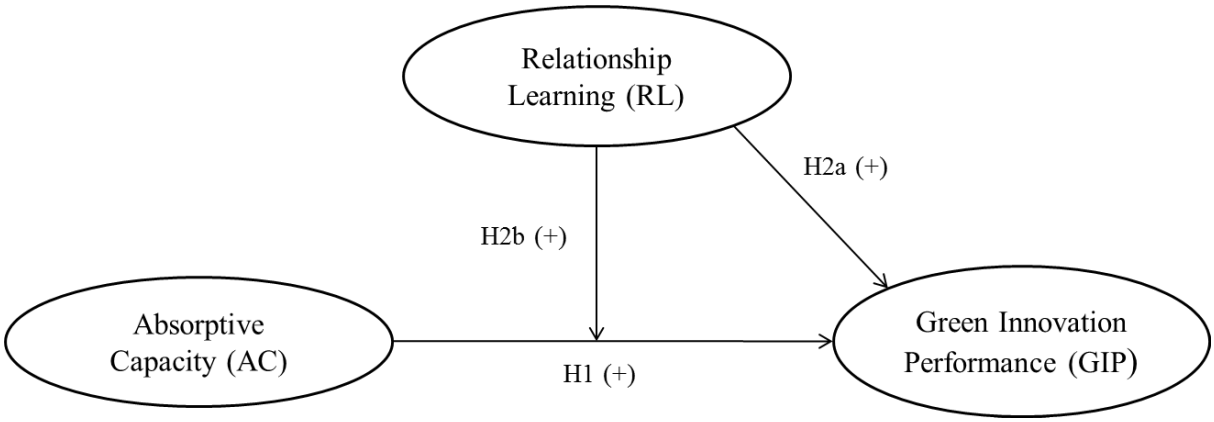
stakeholders (Ngai *et al.,* 2008). These stakeholders appear as a source of environmental knowledge and abilities external to the firm's domain. The collaboration and the knowledge exchange with external stakeholders will favor fruitful green innovation performance (Albort-Morant *et al.,* 2016).

All in all, relationship learning might be an important antecedent of green innovation performance because it joins an activity between the company and one or more parts which purpose is sharing information (in line with Leal-Rodríguez *et al*., 2014). Unlike other related literature that models AC as a variable that mediates the link between external collaboration and innovation performance (i.e, Foss *et al*., 2011; Ashok *et al*., 2016), this paper models RL as a moderator variable in the AC-GIP link. The reason underlying this decision roots on the particularities of the innovation type and of the industry context selected, where firms maintain and strengthen narrow links between each other, which may lead them to enhance GIP. If these companies failed to foster such relationships, the AC-GIP tie might be weakened, given that most of the knowledge required to develop this kind of innovations may be possessed by other members involved within the value chain. Hence, we posit the following hypotheses:

H2a: Relationship learning relates positively to green innovation performance.
H2b: Relationship learning positively moderates (reinforcing) the relationship between absorptive capacity and green innovation performance.

Figure I summarizes the research model we are proposing to investigate, modeling the relationships between absorptive capacity, relationship learning and green innovation performance.

Figure I. Research model and hypotheses.



3. Method

3.1. Sector overview

In order to verify the relevance of absorptive capacity and relationship learning on firms' green innovation performance we perform an empirical analysis on the car industry in Spain, considering both for car manufacturing companies and fabricants of components (ACM). The relevance of this empirical setting for the analysis proposed is multifold. Firstly, environmental innovation is getting a hot topic for this industry. Indeed, this sector is an example of success due to its great dynamism and capacity to generate growth within an economic environment as complex as the current one, however, it contributes significantly to environmental pollution. Ecological awareness has been supported by the introduction of environmental legislation (Sâuer *et al.,* 2012).

Companies are indeed working to reduce residual production, reduce the use of hazardous substances in new process and products, design and produce pieces that facilitate reusing and recycling, and develop the integration of recycled materials (Gerrard and Kandlikarb, 2007), i.e., to introduce green innovations (see e.g. Williander, 2007). Furthermore, the relationship between firms belonging to the ACM industry and their main clients – the major automobile manufacturers – is very knowledge-intensive, as the fabrication of such products and services is highly customized and dependent on the customer's particularities and technical requirements.

In this context, relationship learning plays a key role, since it contributes to develop and promote the learning capabilities of targeted customer-supplier relationships (Selnes and Sallis, 2003). Customer and supplier allow sharing information about a topic, which

facilitates the acquisition, assimilation, transformation and exploitation of external knowledge between two or more parties. Hence, the cooperation with other customers or suppliers in product's value chain becomes fundamental (Petruzzelli *et al*., 2011).

The automotive industry is a strategic sector of the Spanish economy. According to the annual memory of the Spanish Association of manufacturers of vehicles and trucks (SAMVT), the momentum generated by vehicle manufacturers is transforming the automotive sector into a key element for the country's economic and social development. The Spanish automotive sector is also an international benchmark, ranking 2nd among car manufacturers in Europe and 8th worldwide, having 9 vehicle manufactures. The production of vehicles in Spain experienced a sharp increase (13.7%) in 2015, with a total of 2,733,201 units. With regard to passenger cars, the largest line by volume, there was a 17.6% increase, with a total of 2,202,348 cars manufactured. (ANFAC, 2015).

3.2. Data collection and sample

This study is based on original survey data collected from a sample of Spanish firms belonging to the automotive components manufacturing industry, built from a list of Sernauto – the Spanish association of automotive equipment and components manufacturers. Starting from the universe of (906 firms), we identified 387 that met our selection criteria (being innovation intensive companies that make an extensive use of external knowledge and maintain strong relationships of interdependence in supply chains). We made telephone calls to identify the directors or chief officers and seek their assistance in the reception and distribution of questionnaires to the managers of their project teams. Each informant then received a packet including a cover letter, the survey, and a postage-paid reply envelope. Informants who did not reply to the initial survey within 3 weeks were identified and were mailed a second set of survey materials. The collection of information took place over approximately three months, from May to July 2015. The two mailing efforts yielded 112 usable returned surveys (a 28.9% response rate). This sample size is sufficient to run PLS according to Chin (1998) and Hair et al. (2013) guidelines. Given that our research model lacks from formative-measured constructs, the minimum sample size requirement responds to the following rule of thumb: 10 times the largest number of structural paths directed to the

endogenous construct with the largest number of latent variables impacting on it (Chin, 1988), which in our model would sum 10 times 2 paths, which makes 20 cases.

Several strategies have been implemented to improve the quality of the data collection process. To support the validity of the questionnaire, an early draft of the survey instrument was reviewed by a group of business academics with expertise in the subject area and senior project managers. They provided feedback regarding the clarity, comprehensiveness, appropriateness, face validity, and readability of the scales and survey instructions. Additionally, to improve the reliability of the data collected, we ensured that these respondents were professionally interested, conscientious, and committed to providing accurate data by assuring them of the confidentiality of their responses and offering them a summary of the results. Furthermore, we assessed the potential nonresponse bias through a series of t-tests that compared early (responses to the initial mailing) with late (responses to the follow-up mailing) respondents in terms of all the key constructs (Armstrong and Overton, 1977). Responding companies were compared with those that did not respond in terms of size and performance. No significant differences were found between these two groups, thus suggesting there was no response bias.

3.3. Measures

This study applies a seven-point Likert type scale ranging from 1 (high disagreement) to 7 (high agreement) to measure the questionnaire items, which are fully listed in the Appendix section. The items used for evaluating Absorptive Capacity (AC) are the same that have been validated and used by Jansen *et al.,* (2005) and Cepeda-Carrion *et al.*, (2012). In particular, the intensity and direction of the efforts expended in acquiring and assimilating new external knowledge (PACAP) has been assessed by nine items, whereas the construct of RACAP was built on the twelve-items construct developed by Cepeda Carrión *et al.* (2012), assessing the extent to which firms are able to transform and exploit the newly acquired knowledge. To measure Relationship learning (RL), this study adapts the scale proposed by Selnes and Sallis (2003), following their conceptualization for the three dimensions of RL: information sharing, joint sensemaking and knowledge integration. The final scale includes 17 items. Finally, we refer to Chen *et al.* (2006) to measure green innovation performance, a measurement including eight items. The design of the measurement model presents three constructs

designed as composites. We selected Mode A for AC, RL, and GIP at both first and second order construct levels. Mode A uses correlation weights. That is recommended when estimating standardized regression coefficients in small to medium-sized samples and when dealing with indicators that are correlated (Becker *et al*., 2013).

Considering that measurements obtained by single-source and self-report methods are subject to common method bias (CMB) (Podsakoff, 2003), we performed both a priori and post hoc strategies to minimize this potential problem. A priori, we minimized the effect of biased relationships by conducting a meticulous study design and data collection accordingly with what suggested by Podsakoff *et al.* (2012). First, we selected a suitable sample for the context and the topic of the study (i.e., CEO or high level corporate managers), which possess the ability to understand the survey queries. Second, in order to elude respondent exhaustion and to boost their motivation, we chose questions of personal relevance, created a fairly brief survey instrument (10-12 minutes), used clear and unequivocal items, and abstained from using a complex and abstract language. Third, to minimize the difficulty of satisficing, we relied on the use of distinct scale properties as well as some negatively formulated items. Accordingly with Podsakoff *et al.* (2012), survey respondents are satisficing when they answer stylistically instead of providing exhaustive and accurate responses. Fourth, to avoid respondents answering on the basis of preconceived or implicit theories concerning the constructs of the study and the relationships between them, we reversed the causal order of dependent and independent variables items within the survey. Fifth, to minimize social desirability in the respondents' answers, we assured the total confidentiality of the responses and stressed the relevance of accurate study results. Finally, to decrease evaluation apprehension, we assured the respondents that there were no correct or incorrect answers and that their responses should be based on their own personal evaluations (Podsakoff *et al.,* 2012).

Post hoc, we employed statistical remedies to partial out CMB in our analyses. To address potential common method variance (bias) in the survey, we relied on the post-hoc Harman's one-factor test. If a common method bias was a serious concern, either a single factor would arise or a general factor would account for most of the variance in the data. Our results reveal that three distinct factors account for the majority of the variance in the variables, providing evidence that this type of bias is not a problem.

3.4. *Data analysis*

In order to test the research model and hypotheses (Fig. 1), we use partial least squares (PLS), path modeling, a variance-based structural equation modeling (SEM) method technique (Roldán and Sánchez-Franco, 2012). This technique enables the assessment of the reliability and validity of the measures of theoretical constructs –outer model– and the estimation of the relationships among these constructs –inner model (Barroso *et al*., 2010; Hair *et al*., 2011).

We selected PLS principally because the constructs that shape our research model correspond to a composite measurement model. Both theoretical contributions (Rigdon, 2012; Henseler, Dijkstra, Sarstedt, Ringle, Diamantopoulos, Straub, Ketchen, Hair, Hult, & Calantone, 2014) and empirical simulation studies (Becker, Rai, & Rigdon, 2013; Sarstedt, Hair, Ringle, Thiele, & Gudergan, 2016) endorse the usage of PLS for composite models. Secondly, following Chin (2010), we use PLS because we employ component scores in a subsequent analysis for modeling a multidimensional construct applying the two-stage approach. A third reason that endorses the use of PLS is that our aim was to maximize the predictability of the dependent construct, GIP (Hair et al., 2013) We have used the SmartPLS 3.0 software (Ringle *et al*., 2015) for the assessment of both the measurement model and the structural model.

4. Results

4.1. Assessment of global model fit

Henseler et al. (2016) recommend the evaluation of global model fit as the first stage of PLS models assessment. If the model does not fit the data, it implies that the data contains more information than the model conveys. For this purpose, we use ADANCO 2.0.1 (Henseler and Dijkstra, 2015) to perform three bootstrap-based tests of model fit: (i) the standardized root mean squared residual (SRMR), (ii) the unweighted least squares discrepancy (dULS), and (iii) the geodesic discrepancy (dG). If any of these tests exceeds bootstrap-based 95% (HI95) and 99% (HI99) percentiles, it is doubtful that the research model is accurate (Henseler, 2017). Our results reveal that the three tests of model fit are below HI95 and HI99. Additionally, we use the SRMR (Hu and Bentler, 1998) as an approximate model fit criteria that depicts how significant the discrepancy between the model and the empirical correlation matrix is. Henseler et al.

(2016) suggest a threshold of 0.08 for acceptable fit in PLS-SEM. Our research model reveals an acceptable value of 0.032 (Table I).

Table I. Model fit

	Value	HI95	HI99
SRMR	0.032	0.033	0.037
dULS	0.093	0.098	0.129
dG	0.121	0.116	0.139

Notes: SRMR: standardized root mean squared residual; dULS: unweighted least squares discrepancy; dG: geodesic discrepancy; HI95: bootstrap-based 95% percentile; HI99: bootstrap-based 99% percentile.

4.2. Measurement model - building the key constructs

The analysis of a PLS model is interpreted in two phases: measurement model and structural model. This sequence ensures that the measures of constructs are reliable and valid before attempting to draw conclusions with respect to the relationships between constructs (Roldán and Sanchez-Franco, 2012).

The assessment of reflective measurement model evaluates model's reliability and validity. Results, reported in Table II, show that measurement model meets all common requirements. First, reflective individual items are reliable because all standardized loadings are greater than 0.707 (Carmines and Zeller, 1979). Second, all reflective constructs meet the requirement of construct reliability. Since their composite reliabilities (CR) and Dijkstra-Henseler's indicator (Rho_A) are greater than 0.7 (Nunnally and Bernstein, 1994). Third, these latent variables achieve convergent validity because their average variance extracted (AVE) surpasses the 0.5 level (Fornell and Larcker, 1981).

Table II. Measurement model: loadings, construct reliability and convergent validity

Construct/ indicator	Outer Loading	Composite Reliability (CR)	rho_A	Average variance Extracted (AVE)
Absorptive Capacity (AC)		0.971	0.939	0.943
Potential Absorptive Capacity (PACAP)	0.973			
Realized Absorptive Capacity (RACAP)	0.969			
Green Innovation Performance (GIP)		0.933	0.916	0.636
GIP-PD_materials_poll	0.852			
GIP2-PD_materials_en	0.825			
GIP3-PD_materials_effi	0.829			
GIP4-PD_endoflife	0.851			

GIP5-MP_emissions	0.743			
GIP6-MP_recycle	0.882			
GIP7-MP_consumption	0.711			
GIP8-MP_materials	0.752			
Relationship Learning (RL)		0.929	0.887	0.816
Information Sharing	0.922			
Joint Sensemaking	0.892			
Knowledge Integration	0.895			

Notes: Rho_A: Dijkstra-Henseler's indicator.

Table III describes discriminant validity. Confirmation of this validity comes from comparison of the square root of AVE versus the corresponding latent variable correlations. Indeed for satisfactory discriminant validity, diagonal elements (in italics) should be significantly greater than off-diagonal elements in the corresponding rows and columns (Roldán and Sánchez-Franco, 2012). Moreover, all the variables satisfy the Heterotrait-Monotrait Ratio (HTMT) criterion, as their values are under the threshold of 0.85 (Kline, 2015). Therefore, all variables meet discriminant validity requirements (Henseler *et al.,* 2015).

Table III. Measurement model: discriminant validity

Discriminant Validity: *Fornell-Larcker Criterion*			
	AC	GIP	RL
AC	*0.971*		
GIP	0.775	*0.840*	
RL	0.751	0.798	*0.903*
Discriminant Validity: *Heterotrait-Monotrait Ratio (HTMT)*			
	AC	GIP	RL
AC			
GIP	0.833		
RL	0.824	0.827	

Notes: Fornell-Larcker Criterion: Diagonal elements (italics) are the square root of the variance shared between the constructs and their measures (AVE). For discriminant validity, diagonal elements should be larger than off-diagonal elements. Off-diagonal elements are the correlations among constructs. Heterotrait-Monotrait Ratio (HTMT) criterion should be under the threshold of 0.85 (Kline, 2015).

4.3. Structural model - evaluating the AC, RL and GIP relationships

In order to test the hypotheses on the relationship between AC, RL and GPI and the moderating effect of RL on the AC-GPI relationship, we implemented a structural model. Table III shows the explained variance R^2 in the endogenous variables and the path coefficients for the two models under study. Bootstrapping (5000 samples)

provides p-values that enable the evaluation of relationships' statistical significance in the research model (Roldán and Sánchez-Franco, 2012). It includes both a model measuring just direct relationships (Model 1) and a model including also the moderating effect (Model 2). The model comprising solely the AC-GIP and RL-GIP direct links provides results supporting H1, which postulates a positive effect of absorptive capacity on green innovation performance (a = 0.330; p-value = 0.000), and H2, which posits a direct positive impact of relationship learning on green innovation performance (b = 0.592; p-value = 0.000). Subsequently, when relationship learning is introduced as a moderator variable on the AC-GIP link (H3), our results show a weaker but still significant interaction effect (c = 0.151; p-value = 0.071), finding hence support for the moderation hypothesis. As summarized in Figure II, reporting both Model 1 and Model 2, the three hypotheses proposed in model 2 are hence significant, even though it is important to notice the lower significance of the moderating effect.

In table IV, the moderating effect relationship learning on the AC-GIP link is reported, being consistently positive and significant. Bootstrap confidence interval to the 95% for the direct and moderating effects is always greater than zero (Baron and Kenny, 1986). Hence relationship learning moderates the relationship between absorptive capacity and green innovation performance. Following Williams and MacKinnon´s (2008) proposals, we used the bootstrapping technique to test the moderation effect. Chin (2010) suggests using the specific model in question, performing N-bootstrap resampling. This study's 5000 resamples also generate 95% confidence intervals (percentile) for the moderators (Leal-Rodríguez *et al*., 2014).

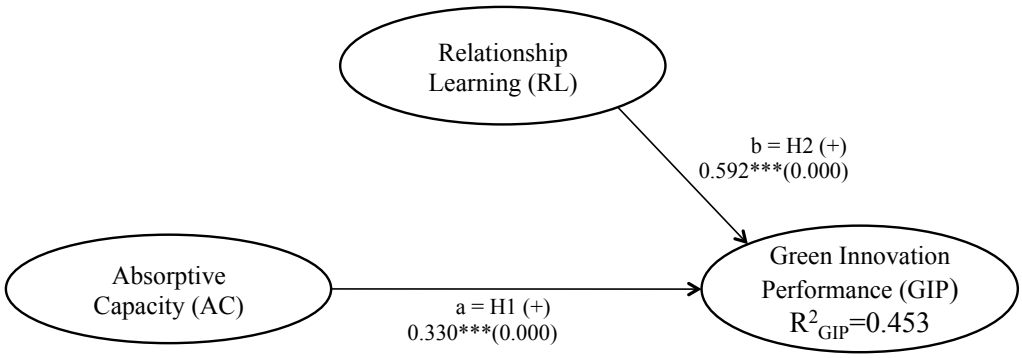
Table IV. Structural model results

Relationships	Model 1 R^2_{GIP}= 0.453	Support	Model 2 R^2_{GIP} = 0.458	Support
H1: AC → GIP	0.330*** (0.000) [0.212; 0447]	Yes	0.343*** (0.000) [0.229; 0.449]	Yes
H2: RL→ GIP	0.592*** (0.000) [0.466; 0.706]	Yes	0.635*** (0.000) [0.511; 0.778]	Yes
H3: AC*RL → GIP			0.151* (0.071) [0.017; 0.123]	Yes

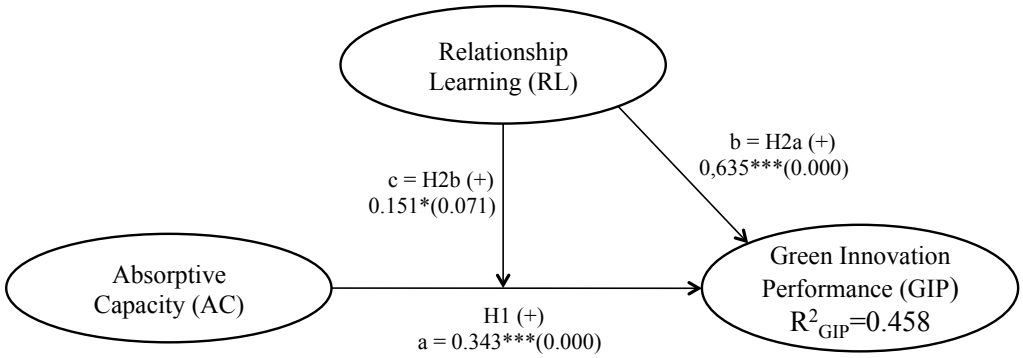
Notes: AC: Absorptive capability; GIP: Green innovation performance; RL: Relationship learning. p-values in parentheses. Bootstrapping bias corrected 95% confidence intervals in square brackets (based on n = 5000 subsamples) ***p b .001; **p b .01; *p b .05 (based on t(4999), one-tailed test). t(0.05, 4999) = 1.645; t(0.01, 4999) = 2.327; t(0.001, 4999) = 3.092; ns = not significant.

Figure II. Summary of structural model results

A) Model with direct effects



B) Model with moderating effect



5. Discussion and conclusions

Green innovation (GI) practices are more and more advocated as a way to sustain competitive advantages, meeting the requirements by external stakeholders, improving corporate image or reputation, or differentiating from competitors. An increasing number of contributions investigating the drivers of the development of GI, pointed to the fact that their peculiarities support the higher importance of building cooperation with external partners and rely on their complementary knowledge (De Marchi 2012, Cainelli *et al.,* 2015, Ghisetti *et al.,* 2015). Against this background this paper investigates the importance of the ability of the firm to effectively assimilate the knowledge developed by such external organizations in order to introduce environmental innovations. In particular, building upon the literature on general innovation, this paper develops a research model that links absorptive capacity (AC), relationship learning (RL) and green innovation performance (GIP).

The analysis is based on an original dataset on Spanish innovating firms specialized in the automotive components manufacturing (ACM) industry, controlling for possible selection bias due to exclusion from the analysis of non-innovative firms. The ACM is a particularly interesting setting for this analysis, both for the increasing pressure from stakeholders to reduce the environmental footprint, and for the importance of knowledge relationships, especially those involving customers – the principal automobile manufacturers (i.e., Peugeot, Citroen, Renault, Ford).

Results support that absorptive capacity exerts a significant positive impact on green innovation performance. The ability of the firms to acquire knowledge from external partners and to combine it in novel ways with its existing knowledge base is a key competence to ensure the effective introduction of new, green products on the market, in line with Gluch *et al.* (2009) and Hashim *et al.* (2015). We also find support for the existence of a significant relationship between relationship learning and green innovation performance, which is even stronger than that involving AC. Performing joint activities with suppliers and/or customers to share information, develop a common sensemaking and integrate the different knowledge bases is particularly relevant in supporting the ability of a firms to introduce a wide array of innovation reducing the firm's environmental footprint.

With regard to the testing of the moderation hypothesis, the results confirm that relationship learning is a moderator variable on the link between absorptive capacity and green innovation performance, even though significance is week. All in all, the emerging evidence is in line with previous studies that sustain that complementing a firm’s knowledge base with knowledge and competencies belonging to external sources may become a key driver for the introduction of green innovations (Mancinelli and Mazzanti, 2009; De Marchi, 2012), complementing them by investigating the relevance of the firms’ ability to take the most out of those relationships.

All in all, results bespeak that the potential of any firm to improve its green innovation performance will depend on its ability to foster and develop knowledge-related assets through the enhancement of organizational capabilities such as absorptive capacity and relationship learning, providing important theoretical and empirical implications. As far as the theoretical implications are concerned, we support that, as external knowledge is

particularly relevant for GIP, other than who the firm is collaborating with, it is essential to understand what are its internal knowledge-based organizational capabilities to leverage on that external knowledge. Furthermore, we suggest that different types of capabilities have to be analyzed, both AC and RL, which have to be jointly considered to fully understand their ability to enhance green innovation performance.

As far as the managerial implications are concerned, results support that devoting resources to reinforce firm's ability to identify, acquire and assimilate external knowledge is an effective practice to improve green innovation performance. Therefore, firms should implement organizational strategies to systematically scan their external environment for valuable knowledge but also to embed it in their existing knowledge endowment. Also, results bespoke of the importance to value buyer-supplier relationships as the preferential domain through which access knowledge and ideas to develop green products and processes; managers should develop specific practices to favor the frequent and effective exchange of knowledge with buyers and suppliers, so even to share the risk associated with the innovation activities. Focusing especially on the Spanish automotive component manufacturing sector, our results should inspire also decision-makers activities, to support cooperation and fuel relationship learning and absorptive capabilities of firms in the willingness to ensure a more effective transition toward a lower-carbon economy.

Our study, which extends and is in line with prior studies that consider knowledge management strategies as drivers of business performance (Palacios-Marqués and Garrigós-Simón, 2006), presents some limitations and opens up for further research opportunities. For instance, it only contemplates firms belonging to a particular sector (i.e., the ACM) and geographical context (Spain). Consequently, researchers must be thoughtful while generalizing these results to distinct scenarios, i.e. to the context of service industries or context characterized by a lower degree of cooperation between customers and suppliers. Second, although we provide evidence of relationships, causality itself has not been proven. In order to better investigate the nature of the relationships, further research adopting a case study approach is advocated, as it may provide additional insights to sustain and validate the research hypotheses presented. Further research should also investigate which are the specific firm's level practices, regarding AC and RL, being the most effective in supporting environmental innovation

performance, also considering for the different type of external partners and the type of knowledge involved.

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Appendix

Appendix A. Measurement Scales.

ABSORPTIVE CAPACITY. Potential absorptive capacity (PACAP), (1 = high disagreement and 7 = high agreement). In my project team:

- PACAP1 We have frequent interactions with top management to acquire new knowledge
- PACAP2 Employees regularly visit other units or departments
- PACAP3 We collect information through informal means (e.g. lunches with colleagues. friends. chats with partners)
- PACAP4 Members do not visit other units or areas
- PACAP5 We periodically organize special meetings with clients, suppliers or third parties to acquire new knowledge

- PACAP6 Members meet regularly with external professionals such as advisers. managers or consultants
- PACAP7 We are slow to recognize shifts in our market (e.g., competitors. laws. demographic changes. etc.)
- PACAP8 New opportunities to serve our clients are quickly understood
- PACAP9 We quickly analyze and interpret changing client demands

ABSORPTIVE CAPACITY. Realized absorptive capacity (RACAP), (1 = high disagreement and 7 = high agreement). In my project team:

- RACAP1 We regularly consider the consequences of changing market demands in terms of new ways to provide products/services
- RACAP2 Employees record and store newly acquired knowledge for future reference
- RACAP3 We quickly recognize the usefulness of new external knowledge for existing knowledge
- RACAP4 Employees rarely share practical experiences
- RACAP5 We laboriously grasp the opportunities for our unit from new external knowledge
- RACAP6 We periodically meet to discuss the consequences of market trends and new services development
- RACAP7 It is clearly known how activities within our company and unit should be performed
- RACAP8 Clients' complaints fall on deaf ears in our unit
- RACAP9 We have a clear division of roles and responsibilities
- RACAP10 We constantly consider how to better exploit knowledge
- RACAP11 We have difficulties implementing new products/services
- RACAP12 Employees have a common language regarding our products/services

RELATIONSHIP LEARNING (RL): Information sharing, (1 = high disagreement and 7 = high agreement). In my project team:

- RL1 We exchange information on successful and unsuccessful experiences with products exchanged in the relationship with partners and suppliers

- RL2 We exchange information related to changes in end-user needs, preferences, and behavior
- RL3 We exchange information related to changes in market structure, such as mergers, acquisitions, or partnering
- RL4 We exchange information related to changes in the Technology of the focal products
- RL5 We exchange information as soon as any unexpected problems arise
- RL6 We exchange information related to changes in the organizations' strategies and policies
- RL7 We exchange information that is sensitive, such as financial performance and know-how

RELATIONSHIP LEARNING (RL): Joint sensemaking, (1 = high disagreement and 7 = high agreement). In my project team:

- RL8 It is common to establish joint teams to solve operational problems in the relationships with partners, suppliers and customers
- RL9 It is common to establish joint teams to analyze and discuss strategic issues in the relationship with partners, suppliers and customers
- RL10 The atmosphere in the relationship with partners, suppliers and customers stimulates productive discussion that encompasses a variety of opinions
- RL11 We have a lot of face-to-face communication in this relationship

RELATIONSHIP LEARNING (RL): Knowledge integration, (1 = high disagreement and 7 = high agreement). In my project team:

- RL12 We frequently adjust our common understanding of end-user needs and behavior
- RL13 We frequently adjust our common understanding of trends in technology related to our business
- RL14 We frequently evaluate and if needed, adjust our routines in order-delivery processes
- RL15 We frequently evaluate and if needed, update the formal contracts in our relationship
- RL16 We frequently meet face-to-face to refresh the personal network in this relationship

- RL17 We frequently evaluate and if needed, update Information about the relationship stored in our electronic databases

GREEN INNOVATION PERFORMANCE (GIP): Knowledge integration, (1 = high disagreement and 7 = high agreement). In my project team:

- GIP1 The company chooses the materials of the product that produce the least amount of pollution for conducting the product development or design.
- GIP2 The company chooses the materials of their products that consume the least amount of energy and resources for conducting the product development or design.
- GIP3 The company uses the fewest amount of materials to comprise their products for conducting the product development or design.
- GIP4 The company would circumspectly evaluate whether their products are easy to recycle, reuse, and decompose for conducting the product development or design.
- GIP5 The manufacturing process of the company effectively reduces the emission of hazardous substances or wastes.
- GIP6 The manufacturing process of the company effectively recycles wastes and emission that can be treated and re-used.
- GIP7 The manufacturing process of the company effectively reduces the consumption of water, electricity, coal, or oil.
- GIP8 The manufacturing process of the company effectively reduces the use of raw materials.