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Research Article

Relational Capability, Technological Eco-innovation and Performance: Evidence from Polish Green Companies

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Abstract

The paper presents a theoretical and empirical analysis of the impact of relational capability on the relationship between technological eco-innovation and financial performance of Polish green companies. The research model contains both radical and incremental eco-innovations. Further, based on the assumption that the determinants of generating both types of changes may be different, it includes the external and internal relational capacity. External relational capability refers to establishing cooperation with various actors in the competitive environment. Internal relational capability concerns effective communication and sharing of knowledge and experience within organizational boundaries. A quantitative study conducted among 54 Polish green companies showed that external relational capability is crucial for developing radical eco-innovation, while internal relational one is sufficient for effectively creating incremental eco-innovation. These conclusions contribute to the emerging literature on eco-innovation by providing a moderation model and integrating green and relational aspects. Implications for future research are also discussed.

Keywords: Eco-Innovation, Relational Capability, Performance, Moderation Model

Introduction

Ecological innovations are nowadays considered increasingly important, especially in the face of progressing degradation of the natural environment. This is confirmed not only by numerous academic studies (del Río et al., 2016; Pacheco et al., 2017; Hazarika & Zhang, 2019) but also by practical activities. Such activities are undertaken in many different countries (on both local and regional levels) and lead to the implementation of the circular economy, for which the generation of ecological innovations is a strategic reference point (Prieto-Sandoval et al., 2018). The fundamental guideline for the actions taken in Poland is the European Green Deal, e.g., the European Union's economic growth and development strategy, the purpose (and

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challenge) of which is transforming the EU into a modern and competitive, but most importantly, clean, low-emission and energy-efficient economy, of the future.

In response to the aforementioned strategic changes, companies often face the need to develop and implement new and environment-friendly solutions. This is also driven by the growing ecological awareness of consumers (Triguero et al., 2013; Horbach, 2016) and the increasingly stricter legal regulations adopted in many countries (Frondel et al., 2008; Horbach, 2016; Zhang et al., 2020). The necessary reorientation of companies towards environment protection measures supports the validity of academic studies in this area. On the one hand, their results may constitute valuable guidelines for management practices and, on the other hand, enrich the literature related to the determinants of ecological innovation as the basis for the implementation of the circular economy.

The paper aims to analyze the impact of relational capabilities on conducting efficient eco-innovation activity in Poland. The assumption was that both external and internal relational capabilities moderate the relation between technological eco-innovation and financial performance. Such an assumption results mainly from the fact that the development of ecological innovation requires access to a more significant number of external sources of knowledge/information than conventional innovation (Horbach, 2008; del Río et al., 2016; Rabadán et al., 2020). For this reason, it requires collaboration with many various stakeholders, including customers, suppliers (Albino et al., 2012; Melander, 2018), competitors (Horbach, 2016), universities, research institutes, and agencies (Triguero et al., 2013). Moreover, since the creation of eco-innovations is a process that, by its very nature, is complex and socially-dependent (it includes social relations between organizational members), the effective development of those innovations also depends on efficient communication and internal cooperation (Dangelico et al., 2017; Qiu et al., 2020).
Despite the empirically confirmed critical impact of collaboration (external and internal) on a product (Dangelico et al., 2017; Melander, 2018; Qiu et al., 2020), process (Rabadán et al., 2020), and organizational (Triguero et al., 2013) eco-innovations, there are no studies that analyze the influence of relational capabilities on technological eco-innovations characterized by different novelty levels. This paper aims to fill this research gap and analyze both external and internal relational capabilities concerning the efficiency of the generation of radical and incremental eco-innovations. The research was conducted among the most innovative Polish companies, which develop new environment-friendly technological solutions. The hierarchical regression analysis results may constitute a basis for a more detailed examination of relational determinants of ecological innovation in the Polish economy.

The study is structured as follows. In the next section, a review of the relevant literature and hypotheses are presented. This is followed by a brief discussion of the research methodology. Finally, the results obtained from the empirical analyses and their implications are dealt with. The concluding section summarizes the paper and outlines avenues for further research.

Literature Review and Hypotheses Development

Ecological innovation. Overview of the concept

The studies related to eco-innovation (environmental innovation, green innovation, sustainable innovation) often compare them with conventional innovations (Frigon et al., 2020), using similar approaches and analytical frameworks. Despite the apparent similarities between both types of changes, the most important attribute that differentiates eco-innovations from other innovations is their effects. Eco-innovations reduce environmental risk, pollution, and other negative impacts of resources use (including energy use) compared to relevant alternatives (Kemp & Pearson, 2007; Horbach, 2008; Carrillo-Hermosilla et al., 2010; Triguero et al., 2013; Díaz-García et al., 2015; del Río et al., 2016; Bossle et al., 2016; Horbach, 2016; Rabadán et al.,

2020). Such an approach indicates that eco-innovations may be of a technological (i.e., they may relate to eco-products and processes) or nontechnological nature (i.e., they may relate to new organizational and/or marketing solutions that significantly reduce adverse environmental effects). This paper focuses on technological eco-innovations developed by Polish companies.

Secondly, the paper abandons the commonly adopted in the literature distinction between product and process eco-innovation (Zhang et al., 2020). It follows the notion that the development of innovative eco-products means that the company also implements eco-innovative production processes and vice versa. If a company uses eco-innovative production processes, the outcome of those processes will inherently have an eco-innovative nature. Therefore, the research is based on an alternative classification of eco-innovation according to technological changes. In such an approach, eco-innovation may have an original nature (radical eco-innovation) or constitute a modification of solutions that have already been developed by a given company (incremental eco-innovation). Following the definition of Chen et al. (2014: 7789), incremental technological eco-innovations relate to 'environmental technology that reinforces, modifies, or extends current environmental knowledge.' While the radical technological eco-innovations are related to 'environmental technology that departs from current environmental knowledge.' Since both types of innovations generally differ from each other (the development of radical eco-innovation is undoubtedly more challenging for Eco-innovators), it can be assumed that their effects are also varied.

Relational Capability as A Determinant of Ecological Innovation

As in the case of conventional innovation, many attempts have been made in the literature to identify factors that determine efficient eco-innovative activity (Horbach, 2008; Triguero et al., 2013; Díaz-García et al., 2015; Bossle et al., 2016; del Río et al., 2016; Horbach, 2016; Pacheco et al., 2017).

According to the Resource-Based View of the Firm (Wernerfelt, 1984; Barney, 1991; Amit & Schoemaker, 1993), the determinants of eco-innovation are embodied mainly in the resources owned by companies. Such resources – as an actual source of competitive advantage – should be valuable, rare, imperfectly imitable, and non-substitutable (VRIN Framework), as well as durable and not easily traded. The Competence-Based Theory of the Firm, an extension of RBV, assumes that the accumulation of resources is insufficient to provide a company with a sustainable competitive advantage in changing environment (Lin et al., 2016). In other words, the researchers (Díaz-García et al., 2015; Dangelico et al., 2017; del Río et al., 2016) argue that not only resources but mainly the capabilities have a significant impact on efficient eco-innovative activities.

Some researchers use the terms 'competencies' and 'capabilities' interchangeably, defining them as the bundles of skills and assets needed to organize resources (Doran & Ryan, 2016), the ability to accomplish something by deploying and coordinating a set of material and immaterial resources (Dangelico et al., 2013), the abilities to deploy resources using organizational processes (Albino et al., 2012) that are performed repetitively in a firm (del Río et al., 2016).

Concerning eco-innovations, researchers emphasize the critical importance of technological (Díaz-García et al., 2015; Dangelico, 2016; del Río et al., 2016) and organizational capabilities (Kammerer, 2009; Albino et al., 2012; Kesidou & Demirel, 2012). Technological capabilities are the basis for eco-designing and developing products of specific physical attributes. Organizational capabilities are fostered by the implementation of environmental management systems. Apart from technological and organizational capabilities, researchers (Lin et al., 2016; Rabadán et al., 2020) also examined relational capabilities, highlighting the validity of conducting analyzes in the area of relationship building, which – in the broadest sense – allow for efficient sharing

of assets necessary to generate eco-innovation.

Relational capability is defined in the literature as the ability to initiate, maintain, and exploit relationships with external partners – relations valuable in the context of shaping interaction outcomes (Li & Ogunmokun, 2001; Lavie, 2006). This capability is critical in the context of how businesses operate in a dynamic and uncertain environment. Its creation enables a faster flow of information and knowledge and, as a result, allows building an appropriate configuration of resources. Since eco-innovation involves not only the use of resources embedded in inter-organizational activities and procedures (Albino et al., 2012) but also the collaborative learning of employees working together (Dangelico et al., 2017; Qiu et al., 2020), therefore, this study considers the relational capability two-dimensionally and distinguishes external and internal relational capability. Following Lin et al. (2016: 867), external relational capability refers to 'a wide array of social and economic relationships with other organizations or individuals'. Internal relational capability addresses 'initiates interaction, communication, knowledge, and value sharing across all relationships with the firm'. Clearly, in such an approach, relational capabilities should be treated as orthogonal, coexisting, and complementary. Figure 1 presents the developed research model according to which building intra- and inter-organizational relations determines an effective eco-innovative activity. On the one hand, it allows access to new or complementary resources. On the other, it opens the possibility of achieving benefits related to the complementarity effect in the context of collaborative learning and knowledge sharing (Pichlak & Bratnicki, 2011).

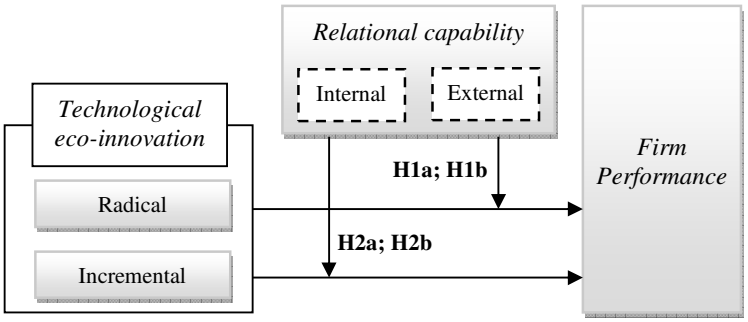

Fig. 1: Theoretical framework

Generally, a high level of external relational capability means that the company has close, formalized, and long-term relationships with many different stakeholders. Concerning the generation of eco-innovation, researchers primarily point out the significance of relations with customers and suppliers (Melander, 2018), competitors (Horbach, 2016), universities, research institutes, and agencies (Triguero et al., 2013). Their development in the context of eco-innovation activities allows recognizing such relations as one of the determinants of competitive advantage (Doran & Ryan, 2016; Rabadán et al., 2020). Moreover, such an approach to relational capabilities relates directly to the concept of Chesbrough's (2004) open innovation that relates such innovations to the processes of intended inflow and outflow of knowledge, i.e., to all innovation activities that go beyond the firm's boundaries. Building on Triguero et al. (2018), who analyzed the impact of open innovation strategy on the adoption of radical and incremental ecological innovations, this paper assumes that:

H1: External relational capability moderates the relationship between the generation of (a) radical and (b) incremental technological eco-innovation and firm performance.

Relational capability can also be understood through the lens of building intra-organizational relationships. These relations play a key role not only in the context of collaborative learning but also in terms of obtaining and use of information and knowledge held by external partners. Such an approach to relational capability relates to the concept of absorptive capacity, defined in the literature as 'a firm's ability to recognize the value of new information, assimilate it, and apply it to commercial ends' (Cohen & Levinthal, 1990: 128). Both the authors of this concept and other researchers (Lin et al., 2016) indicate that absorptive capacity - embedded in organizational learning processes – is primarily determined by building internal relationships. Such relations intensify the sharing of knowledge and experience among the employees and allow for faster and more effective sensing opportunities and threats in the environment. Furthermore, both in the context of incremental and radical eco-innovation, such collaboration seems essential. As Huang & Li (2017) note, the development of such innovations requires (even before starting the design process) intensive cooperation of employees engaged in the entire process of their development. Therefore:

H2: Internal relational capacity moderates the relationship between the generation of (a) radical and (b) incremental technological eco-innovation and firm performance.

Research Methodology

Sample Selection

This research is part of a research project on eco-innovation management in Polish companies, carried out in 2019. The study aimed to conduct it among the most eco-innovative Polish companies; therefore, the research sample was not randomized. However, as a consequence of the targeted selection and relatively small sample size, the sample's representativeness is limited, making statistical inference difficult.

The research was carried out in January–February 2019 using the CATI method (*Computer Assisted Telephone Interview*) and covered all companies (n = 66) awarded in the 2009-2015 Program of the Ministry of Climate and Environment 'GreenEvo Green Technology Accelerator'[1]. As a result, the research sample includes companies actually involved in creating novel technological eco-innovations, which is confirmed by the distinction of these companies in the competition, and not only by the declarative assertions of the respondents. Since only 38 fully completed questionnaires were received after the first round of research, it was decided to conduct a second round among the most eco-innovative enterprises operating in the Silesia Province (this province is one of the most industrialized and polluted regions in Poland and therefore also one of the most eco-innovative). The result of both rounds of research was 54 fully completed questionnaires, then subjected to statistical analysis.

Measurement of Variables

Since the research had a quantitative nature[2], the measurement of variables was based on a questionnaire survey with statements describing the generation of radical and incremental eco-innovations, external and internal relational capacity, and financial performance. Moreover, the metric part of the questionnaire included control variables: the age and size of the company (measured by the number of employees) and the technological domain of the companies' activities.

Incremental and radical eco-innovations were operationalized based on modifying the measurement scales by Subramaniam & Youndt (2005). The questionnaire included six statements (three for each dimension, respectively) regarding the development of ecological innovations that: (1) constitute simple modifications of ecological products, services, or technology; (2) represent minor changes in ecological products, services, or technologies; (3) slightly extend the existing environmental knowledge or applied technology; (4) constitute new radical solutions in ecological products, services or technologies; (5) fundamentally change ecological products, services or technologies, and (6) extend

beyond the existing environmental knowledge or applied technologies. A similar modification of the original measuring scales was used by Chen et al. (2014).

External relational capability was measured using a four-element scale developed by Lee (2009), which relates to cooperation in eco-innovation activities with: (1) customers; (2) suppliers; (3) competitors and (4) universities, research institutes, and agencies. The operationalization of internal relational capability was based on the scale created by Subramaniam & Youndt (2005) and related to developing relations among organizational members to diagnose and solve problems and exchange information and learn from each other.

The measurement of financial performance was based on five statements related to an average net interest rate, return on equity, return on assets, return on sales, and ability to finance growth in profits in 2017-2019. The measurement scale used is an operationalization of the effectiveness concept by Eddleston et al. (2008) and was previously tested in the Polish economy.

The questionnaire used an interval Likert scale. Respondents were asked to indicate their level of agreement from 1 – 'strongly disagree' to 7 – 'strongly agree' with a given statement. Only for efficiency, the respondents evaluated their own company (for each statement) compared to the most important competitors in the sector (from 1 – 'definitely worse' to 7 – 'definitely better').

To assess the reliability of the measurement scales, the Cronbach's Alpha coefficients and the correlation coefficients of particular statements with the whole scale were calculated. It turned out that all research scales are characterized by a satisfactory level of reliability (the values of Cronbach's Alpha exceed the threshold of 0.7, with the highest value recorded for performance: 0.942, and the lowest for incremental eco-innovation: 0.701). Confirmatory factor analysis was conducted to test the dimensional structure of two multidimensional variables (eco-innovation and relational capacity). For both constructs, the chi-squared statistical values do not exceed three times the number of degrees of freedom, which is an acceptable result. Moreover, the calculated value of approximation error (RMSEA) remains below the limit level equal to 0.1, while TLI and CFI indicators exceed or are close to the value of 0.9.

Analysis and Results

This paper, based on a standard procedure proposed by Baron & Kenny (1986), assumes that both external and internal relational capacity determine the conditions under which the independent variables (radical and incremental eco-innovations) impact the dependent variable (financial performance). Table 1 presents the hierarchical regression analysis results, in which relational capabilities were included as moderating variables.

Table 1: The results of the Hierarchical Regression Analysis

		Model 1		Model 2		Model 3	
		β	**p**	**β**	**p**	**β**	**p**
Controls	Organizational Age^	-0.008	0.961	0.031	0.830	0.048	0,735
	Organizational Size^	-0.084	0.607	-0.140	0.348	-0.191	0,193
	Technological Domain 1	-0.283	**0.050**	-0.247	**0.057**	-0.195	0,141
	Technological Domain 2	0.049	0.729	0.114	0.372	0.017	0,898
Incremental Technological Eco-innovation (IE)				0.260	**0.045**	-2.360	**0.035**
Radical Technological Eco-innovation (RE)				0.383	**0.004**	1.564	**0.036**
Moderators	External Relational Capability (ERC)					-0.752	0,240
	Internal Relational Capability (IRC)					0.206	0,703
IE*ERC						1.138	0.176
IE*IRC						1.758	**0.054**
RE*ERC						-1.467	**0.065**
RE*IRC						0.138	0.856
R^2		0.079		0.291		0.434	
ΔR^2		0.004		0.201		0.269	
F		1.050		3.217		2.622	
p (F)		0.391		**0.010**		**0.011**	
p (ΔR^2)				**0.002**		0.163	

^ natural logarithm. Technological domain 1 – Water and sewage management. Technological domain 2 – Biodiversity conservation. The estimation of the parameters for adjusting moderation models to empirical data is based on the use of the least squares' method.

According to the data presented in Table 1 (Model 2), the relationships between radical and incremental eco-innovation and financial performance are statistically significant (β = 0.260 and 0.383, respectively, $p<0.05$). Such results suggest that the eco-innovation activities undertaken by the respondents are efficient. However, an essential part of the analysis is to estimate the interaction effects (Model 3) between radical and incremental eco-innovation (independent variables) and external and internal relational capacity (moderating variables). The analysis indicates that in two cases, the probability level exceeds the marginal level ($p>0.05$) while not exceeding the value of 0.1. The results obtained – taking into account the small size of the research sample – provide a basis for assuming the tendency to the existence of (1) a moderating effect of external relational capacity on the relationship between radical technological eco-innovation and financial performance (β = -1.467; p = 0.065), which confirms hypothesis H1a, and (2) moderating effect of internal relational capacity on the relationship between incremental technological eco-innovations and financial performance (β = 1.758; p = 0.054), that confirms hypothesis H2b.

These results are also worth comparing with the descriptive analysis on strategic and operational forward linkages (to customers), backward linkage (to suppliers), horizontal linkage (to competitors), and public linkage (to universities, research institutes, and agencies). It turns out that 81% of respondents intensively cooperate (in their eco-innovative activities) with their customers. Such a high percentage of respondents declaring strategic and operational cooperation upstream and downstream in the supply chain indicates that the development of eco-innovation involves the engagement of recipients of new

solutions, who become actual partners of technological companies. Intensive cooperation with suppliers is declared by 61% of the respondents, while 72% of them intensively cooperate with universities, research institutes, and agencies. Following the research context (companies with significant eco-innovation potential), such results are not surprising. It is also noteworthy that only 11% of the surveyed companies establish cooperation with competitors. On the other hand, half of the respondents admit that the market activities of the main competitors significantly impact the scope of their eco-innovation activities.

Discussion and Conclusion

Horbach (2008), del Río et al. (2016), and Rabadán et al. (2020) confirm that eco-innovators are more likely than other innovators to collaborate with customers, suppliers, competitors, universities, research institutes, and agencies. Díaz-García et al. (2015) emphasize that eco-innovators establish cooperation to solve primarily technological problems, while other innovators – obtain funding and marketing support. Concerning internal relational capacity, researchers (Lin et al., 2016; Dangelico et al., 2017; Qiu et al., 2020) confirm its importance for building coherent power among all stakeholders to implement innovation (and eco-innovation). The research results presented in this paper complement the literature, indicating that the impact of relational capability is ambiguous and depends on the novelty of the developed technological solutions.

First, external relational capability strengthens the relationship between radical eco-innovation and firm performance (which confirms hypothesis H1a). Such results indicate that developing such innovations may sometimes be too expensive and ineffective. While through cooperation, they may, e.g., gain access to new or complementary resources (Horbach, 2008; Horbach, 2016), new knowledge by conducting R&D activities (De Marchi, 2012) or new organizational capabilities (Lin et al., 2016). The diversification of risks, costs, and uncertainty inherently associated with the innovative activity may also be beneficial (Doran & Ryan, 2016; Rabadán et al., 2020).

Secondly, the internal relational capability strengthens the relationship between incremental eco-innovation and firm performance (which confirms hypothesis H2b). The results indicate that effective internal communication, knowledge, and experience sharing among employees and collaborative learning of people working together are sufficient to develop less original and less complex eco-innovations successfully. In other words, the development of minor modifications of applied technological solutions may be seen as the result of the experience acquired by the company. Furthermore, the obtained results support other studies (Lin et al., 2016; Dangelico et al., 2017; Qiu et al., 2020) according to which internal relational capability (based on commitment and trust) not only leads to an increase of the internal knowledge pool but also enables external knowledge acquisition and exploitation (i.e., two factors of absorptive capacity).

The research results presented in this paper contribute to the still-growing stream of literature on the determinants of eco-innovation (Horbach, 2008; Triguero et al., 2013; Díaz-García et al., 2015; Bossle et al., 2016; del Río et al., 2016; Horbach, 2016; Pacheco et al., 2017). The results obtained can also provide guidelines for improving the efficiency of companies' eco-innovation activities. The identified moderating effect of relational capabilities and their confirmed fundamental importance may encourage managers to establish close relationships with customers, suppliers, competitors, universities, research institutes, agencies, and (and between) subordinates to develop technological eco-innovations. In conclusion, although there is no universal recipe for success, this study indicates that developing relational capabilities deserves further analysis, increases resilience to crises in the environment, and allows for the restoration of so-called frozen relations with various stakeholders who own the necessary resources to solve existing problems.

As with any research, the study described in this paper also has certain limitations. The most crucial reservation is the limited representativeness of the research sample (resulting from its targeted selection) and its relatively small size. Secondly, the collected data are cross-sectional. Such an approach – although common in the literature – raises some concerns regarding the unquestionability of causal inference. A plausible extension of the described research is to conduct longitudinal studies to confirm the identified relationships and their analysis in the long term.

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[1] The objective of the GreenEvo Program is to support the best innovative environmental technologies developed by Polish companies and help promote and transfer these solutions. Solutions designed by GreenEvo winners are used, among others, to utilize hazardous waste in Armenia or to produce ecological fuel in Tanzania.

[2] Due to the companies' significant geographical dispersion in the research sample, the qualitative research was abandoned, and the questionnaire research was used instead.

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