DOI: 10.20472/BMC.2021.012.001

LORENA D'AGOSTINO
University of Milano-Bicocca, Italy

A PROJECT-LEVEL APPROACH TO GREEN OPEN INNOVATION

Abstract:

Innovation is a crucial dimension for the transition to a greener Europe, a process that has accelerated notably in the latest years. An open mode has been applied to those innovation that mitigate the impact of economic activities on the natural environment, which is green open innovation (GOI). This is approach is mainly driven by the importance of stakeholders and the specificity of environmental fields, which call for a greater role of the external collaboration in green innovation. Although the interest of management scholars and practitioners in GOI has increased enormously, the empirical GOI literature has overlooked a project-level approach. Firms may have heterogenous openness across different projects depending on the characteristics of the projects or the strategic objective of the firm. This paper contributes to GOI literature by investigating whether green projects are more open than non-green projects in terms of breadth and depth of knowledge sources. Based on a dataset of projects funded by Seventh European research framework, the results confirm the greater openness of environmental-related research projects. These results corroborate the necessity for managers to apply an open mode to green innovation, especially in highly competitive calls such as the European Union framework program.

Keywords:

green open innovation; eco-innovation; sustainability; EU framework programs; FP7; projects; breadth; depth; openness.

JEL Classification: M20, O32, Q56

1 Introduction

Sustainability has been part of the European Union actions for decades. As the process towards a greener Europe accelerates, it is crucial to deepen our knowledge on how firms embark on those innovations that reduce the impact of economic activities on the environment, the so-called *green innovation* (Bocken et al., 2014; Bogers et al., 2020; Porter & Kramer, 2019)

Green innovation differs from general innovation for the stronger role of regulation and external stakeholders (e.g. consumers, government, NGOs) (Orlando et al., 2020), and the more complex and risky process (Ghisetti et al., 2015; Hojnik & Ruzzier, 2016). As argued by green open innovation (GOI) approach, external collaborations are crucial in environmental fields (Aquilani et al., 2020; Behnam et al., 2018; Bogers et al., 2020; D'Agostino, 2020; González-Moreno et al., 2019; Moreno-Mondéjar et al., 2020; Muscio et al., 2017; Olsen et al., 2017).

Despite the fast-growing interest in GOI, further theoretical and empirical contributions are needed (Chistov et al., 2021). This paper contributes to one of the least studied approaches in GOI, which is at project-level (Olsen et al., 2017). In particular, this paper provides evidence of whether a more open approach in terms of breadth and depth of knowledge sources (Laursen & Salter, 2006) is employed by research consortia in environmental challenges. The advantage of a project-level analysis is that firms may have heterogenous approaches across different projects, depending on attributes such as complexity or uncertainty (Bagherzadeh et al., 2019).

The paper is organized as follows. Section 2 presents the literature and develops the hypotheses. Section 3 describes the data. The analysis is developed in Section 4. Finally, Section 4 draws some conclusions.

2 Green open innovation

2.1 Cooperation in green innovation

The open innovation paradigm (Bogers et al., 2018; Huizingh, 2011) has recently involved environmental issues under the label of open eco-innovation, sustainable open innovation, environmental innovation or GOI (Bogers et al., 2020; D'Agostino, 2020; Ghisetti et al., 2015; Russo Spena & Di Paola, 2020). These studies have highlighted the role of cooperation, which is particularly important in environmental technologies for two main reasons (De Marchi, 2012; Ghisetti et al., 2015; Horbach et al., 2013). Firstly, there is greater institutional pressure from multiple stakeholders (Berrone et al., 2013), included governments and NGOs, and consumers (Ketata et al., 2015). This implies that firms have a strong incentive to communicate effectively with these agents (Laperche & Picard, 2013).

Secondly, green innovation manifests additional knowledge complexity and uncertainty (Ghisetti et al., 2015; Ketata et al., 2015), which may come from higher distance between old ways of doing things and new "green" products, from the heterogenous knowledge basis of green innovation (e.g. electric vehicles), and from the need to make radical organizational changes (skills, culture, business model) (Cainelli et al., 2012; Horbach et al., 2013; Laperche & Picard, 2013).

One of the most studied themes in GOI is the degree of openness measured through the 'breadth' and the 'depth' of external collaboration (Chistov et al., 2021; D'Agostino, 2020). Firms differ in their external search strategy. The most innovative firms tend to search widely and deeply, even though this 'openness' is subjected to decreasing returns (Laursen & Salter, 2006).

2.2 The level of openness: 'breadth' and 'depth' of knowledge sources

Recent studies on green innovation have investigated the external search strategy of green innovative firms in terms of 'breadth' and 'depth' (Cainelli et al., 2015; Ghisetti et al., 2015; González-Moreno et al., 2019; Kobarg et al., 2020; Liao & Tsai, 2019; Li-Ying et al., 2018; Martínez-Ros & Kunapatarawong, 2019; Moreno-Mondéjar et al., 2020; Muscio et al., 2017; Olsen et al., 2017; Saez-Martinez et al., 2016; Triguero et al., 2018).

Firms using multiple types of external partners are more innovative, as the variety of knowledge stimulates novel associations, and provide distinct expertise (Chesbrough, 2003; Laursen & Salter, 2006). Empirical studies find confirmation of the positive effect of 'breadth' on green innovation (Cainelli et al., 2015; Ghisetti et al., 2015; Martínez-Ros & Kunapatarawong, 2019; Saez-Martinez et al., 2016; Triguero et al., 2018), on firm growth (Moreno-Mondéjar et al., 2020), and on the capacity to solve environmental problems within a research consortium (Olsen et al., 2017).

Hence, I posit that:

H1. Green projects have higher external search 'breadth' than non-green projects.

Firms are required to have repeated interactions with their partners, building up trust and mutual understanding for a smooth flow of knowledge. This is particular crucial in environmental fields, where partners may be of different types (e.g. firms and NGOs), and knowledge may be more complex. The relation between the 'depth' of knowledge sources and green innovation is generally found positive, although under specific conditions (Ghisetti et al., 2015; Muscio et al., 2017; Saez-Martinez et al., 2016; Triguero et al., 2018).

Hence, I posit that:

H2. Green projects have higher external search 'depth' than non-green projects.

3 Dataset

The hypotheses discussed above are tested on a dataset on the research projects from the Seventh Framework Programme (FP7), which was the main European research funding programme in the period 2007-2013. It had a specific programme on *Cooperation*, from which I select the environmental themes: "Environment" (included climate change), "Energy", "Food, Agriculture and Biotechnology," and "Transport". *FP7-Collaboration* projects[1] have been used to investigate sustainability and open innovation (Olsen et al., 2017).

Traditionally, open innovation studies use innovation surveys (Ghisetti et al., 2015; Laursen & Salter, 2006). These data are indicators of successful knowledge-searching strategy, which lead to the solution of specific problems (Olsen et al., 2017). Instead, the advantage of EU-funded projects is that they tackle a relevant problem which has not a solution yet. These projects signal the commitment of organizations that are willing to bear the cost of setting up a consortium, participating to a competitive call, and investing part of its own money in the funded project (Olsen et al., 2017). Since the proposal needs to be innovative and engage competent partners, these data present open innovation strategies in cutting-edge technologies with high strategic relevance.

4 Variables

The measures of 'breadth' and 'depth' are built on the types of organizations, which are:

[1] Open data are drawn from https://cordis.europa.eu/en

- Higher or Secondary Education Establishments (HES)
- Research Organisations (REC)
- Private for-profit entities (excluding Higher or Secondary Education Establishments) (PRC)
- Public bodies (excluding Research Organisations and Secondary or Higher Education Establishments) (PUB).

The 'breadth' of knowledge sources has been operationalized in several ways in empirical literature (see e.g. D'Agostino, 2020 for a review).

For the breadth, I consider $BREADTH\_LS_i$ which is the number of types of organizations present in the project (Laursen and Salter, 2006)[2] and $BREADTH\_GTS_i$ as the number of participants (González-Moreno et al., 2019).

For 'depth', I use two indicators. H_DEPTH_i is a concentration index, given by the sum of the squared of shares of each type of organization. Lower values of H_DEPTH_i indicate that each type of organizations has similar shares within the project. Higher values indicate a greater share of one or few types of organization (i.e. a concentrated consortium). In its normalized form (ranking between 0 and 1), H_DEPTH_i is computed as:

$$HHI_i = \sum_{j=1}^{N} s_{ij}^2 \quad (1)$$

and then

$$H\_DEPTH_i = \frac{HHI_i - 1/N}{1 - 1/N} \quad (2)$$

where s_{ij} is the share of participants of j type of organization (i.e. HES, REC, PRC, PUB, OTH) on the total number of participants in project i, and N is 5.

As second measure of 'depth', $DEPTH_j$ assesses the importance of each type of organization separately (Kobarg et al., 2020). $DEPTH_j$ is the share of participants in j type of organization.

Table 1 shows the descriptive statistics of the measures of 'breadth' and 'depth' presented above.

Table 1: Descriptive statistics: breadth and depth (n = 7026)

Variables	Mean	Std. Dev.	Min	Max
BREADTH_LS	3.21	0.92	1	5
BREADTH_GTS	12.01	7.84	1	155
H_DEPTH	0.31	0.19	0.0089	1
$DEPTH_{HES}$	34.03	23.29	0	100
$DEPTH_{REC}$	23.90	16.79	0	100
$DEPTH_{PRC}$	32.97	24.20	0	100
$DEPTH_{PUB}$	4.14	11.40	0	100

[2] I excluded 59 projects for which the classification of the type of organizations is not present.

$DEPTH_{OTH}$	4.96	9.87	0	100

Source: Cordis data

5 Analysis

In this section, I investigate whether the measures of 'breadth' and 'depth' of knowledge sources systematically differ between green and non-projects.

As shown in Table 2, green projects are fewer, yet with higher average values than non-green projects, both in terms of types of organizations involved, and in terms of number of participants; these differences are statistically significant. These results confirm *hypothesis 1*.

Table 2: Breadth: green vs. non-green projects

	Green n = 2079		Non-green n = 4947		Independent sample Welch's t-test
	Mean	SD	Mean	SD	p-value
BREADTH_LS	3.38	0.93	3.13	0.9	0.00
BREADTH_GTS	13.76	8.07	11.26	7.61	0.00

Source: Cordis data

As shown in Table 3, green and non-green projects differ also in 'depth'; all the differences are statistically significant.

Table 3: Depth: green vs. non-green projects

	Green n = 2079		Non-green n = 4947		Independent sample Welch's t-test
	Mean	SD	Mean	SD	p-value
H_DEPTH	0.29	0.17	0.32	0.19	0.00
$DEPTH_{HES}$	27.9	19.53	36.59	24.24	0.01
$DEPTH_{REC}$	26.8	17.62	22.64	16.27	0.00
$DEPTH_{PRC}$	34.06	24.75	32.51	23.95	0.01
$DEPTH_{PUB}$	5.16	13.32	3.7	0.14	0.00
$DEPTH_{OTH}$	5.96	10.87	4.54	9.39	0.00

Source: Cordis data

Concentrated consortia (values of 1 in *H_DEPTH*) are frequent in the data, while few projects have balanced shares (20% for each type of organization), also because public bodies (PUB) and other organizations (OTH) are less present in general. *H_DEPTH* suggests that non-green consortia use

more intensively one or few types of organizations, and green projects tend to have more equally distributed weight of different types of organizations.

The variables $DEPTH_j$ provide an overview of which types of organization are more involved in these consortia. Universities ($DEPTH_{HES}$) are more intensively used in non-green projects (36.5%) rather than green projects (27.9%). This could be connected to the higher number of research projects with universities only (D'Agostino, 2020). The remaining three variables show higher values for green projects than for non-green projects.

Hence, *hypothesis 2* is not confirmed. Instead, green consortia have a more equally distributed load of the different organizations.

6 Discussion and conclusion

This paper shows that environmental innovation is pursued by a more open approach than in other fields. I advance a well-established stream of research on GOI about the role of the 'breadth' and the 'depth' of knowledge sources by taking the point of view of the research consortium (Bagherzadeh et al., 2019; Olsen et al., 2017), rather than the more traditional firm-centric view.

These findings provide evidence that green research projects have a higher number of participants and a greater variety of organization types. In terms of intensity of use of types of organizations, green innovation is related to a more equally distributed contribution of different types of organizations. By looking at each type of organization, all but universities have greater importance in green projects than in non-green projects.

Even though the European research program is a natural context where cooperation is encouraged and fostered, this paper highlights that - within the objectives common to all Cooperation themes (e.g. transnational cooperation, involvement of SMEs) - green topics attract a wider and more open consortia. This approach is backed up by the peculiarities of green innovation that require knowledge coming from different fields and industrial competences that may be transversal to many actors.

This paper suggests that managers willing to embark in green projects must consider a wider and diversified network of partners. This could be particularly important in European research programs, such as the new-born Horizon Europe.

These are preliminary and exploratory results that must be taken with cautions. One limitation is that the results could be driven by the specific calls of the FP7, namely green calls are designed to have more partners than other calls. Future research could investigate this aspect. In addition, further empirical analysis could look at how the level of openness of green consortia is connected to measures of output or performance, as well as possible decreasing returns of openness.

7 References

AQUILANI, B., PICCAROZZI, M., ABBATE, T., & CODINI, A., *The Role of Open Innovation and Value Co-Creation in the Challenging Transition from Industry 4.0 to Society 5.0: Toward a Theoretical Framework*, in «Sustainability», vol. 12, n. 21 (2020), pp. 8943.

BAGHERZADEH, M., MARKOVIC, S., & BOGERS, M., *Managing Open Innovation: A Project-Level Perspective*, in «IEEE Transactions on Engineering Management», (2019), pp. 1–16.

BEHNAM, S., CAGLIANO, R., & GRIJALVO, M., *How Should Firms Reconcile Their Open Innovation Capabilities for Incorporating External Actors in Innovations Aimed at Sustainable Development?*, in «Journal of Cleaner Production», vol. 170 (2018), pp. 950–65.

BERRONE, P., FOSFURI, A., GELABERT, L., & GOMEZ-MEJIA, L. R., *Necessity as the Mother of 'Green' Inventions: Institutional Pressures and Environmental Innovations*, in «Strategic Management Journal», vol. 34, n. 8 (2013), pp. 891–909.

BOCKEN, N. M. P., SHORT, S. W., RANA, P., & EVANS, S., *A Literature and Practice Review to Develop Sustainable Business Model Archetypes*, in «Journal of Cleaner Production», vol. 65 (2014), pp. 42–56.

BOGERS, M., CHESBROUGH, H. W., & STRAND, R., *Sustainable Open Innovation to Address a Grand Challenge: Lessons from Carlsberg and the Green Fiber Bottle*, in «British Food Journal», vol. 122, n. 5 (2020), pp. 1505–17.

CAINELLI, G., DE MARCHI, V., & GRANDINETTI, R., *Does the Development of Environmental Innovation Require Different Resources? Evidence from Spanish Manufacturing Firms*, in «Journal of Cleaner Production», vol. 94 (2015), pp. 211–20.

CAINELLI, G., MAZZANTI, M., & MONTRESOR, S., *Environmental Innovations, Local Networks and Internationalization*, in «Industry & Innovation», vol. 19, n. 8 (2012), pp. 697–734.

CHESBROUGH, H. W., *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business School Press, Boston, Mass. 2003.

CHISTOV, V., ARAMBURU, N., & CARRILLO-HERMOSILLA, J., *Open eco-innovation: A bibliometric review of emerging research*, in «Journal of Cleaner Production», vol. 311 (2021).

D'AGOSTINO, L. M., *Green open innovation*, Aracne, Canterano (RM) 2020.

DE MARCHI, V., *Environmental Innovation and R&D Cooperation: Empirical Evidence from Spanish Manufacturing Firms*, in «Research Policy», vol. 41, n. 3 (2012), pp. 614–23.

GHISETTI, C., MARZUCCHI, A., & MONTRESOR, S., *The Open Eco-Innovation Mode. An Empirical Investigation of Eleven European Countries*, in «Research Policy», vol. 44, n. 5 (2015), pp. 1080–93.

GONZÁLEZ-MORENO, Á., TRIGUERO, Á., & SÁEZ-MARTÍNEZ, F. J., *Many or Trusted Partners for Eco-Innovation? The Influence of Breadth and Depth of Firms' Knowledge Network in the Food Sector*, in «Technological Forecasting and Social Change», vol. 147 (2019), pp. 51–62.

HOJNIK, J., & RUZZIER, M., *What Drives Eco-Innovation? A Review of an Emerging Literature*, in «Environmental Innovation and Societal Transitions», vol. 19 (2016), pp. 31–41.

HORBACH, J., OLTRA, V., & BELIN, J., *Determinants and specificities of eco-innovations compared to other innovations—an econometric analysis for the French and German industry based on the community innovation survey*, in «Industry and Innovation», vol. 20, n. 6 (2013), pp. 523–43.

KETATA, I., SOFKA, W., & GRIMPE, C., *The Role of Internal Capabilities and Firms' Environment for Sustainable Innovation: Evidence for Germany*, in «R&D Management», vol. 45, n. 1 (2015), pp. 60–75.

KOBARG, S., STUMPF-WOLLERSHEIM, J., SCHLÄGEL, C., & WELPE, I. M., *Green Together? The Effects of Companies' Innovation Collaboration with Different Partner Types on Ecological Process and Product Innovation*, in «Industry and Innovation», (2020), pp. 1–38.

LAPERCHE, B., & PICARD, F., *Environmental Constraints, Product-Service Systems Development and Impacts on Innovation Management: Learning from Manufacturing Firms in the French Context*, in «Journal of Cleaner Production», vol. 53 (2013), pp. 118–28.

LAURSEN, K., & SALTER, A., *Open for Innovation: The Role of Openness in Explaining Innovation Performance among U.K. Manufacturing Firms*, in «Strategic Management Journal», vol. 27, n. 2 (2006), pp. 131–50.

LIAO, Y.-C., & TSAI, K.-H., *Bridging Market Demand, Proactivity, and Technology Competence with Eco-Innovations: The Moderating Role of Innovation Openness*, in «Corporate Social Responsibility and Environmental Management», vol. 26, n. 3 (2019), pp. 653–63.

LI-YING, J., MOTHE, C., & NGUYEN, T. T. U., *Linking Forms of Inbound Open Innovation to a Driver-Based Typology of Environmental Innovation: Evidence from French Manufacturing Firms*, in «Technological Forecasting and Social Change», vol. 135 (2018), pp. 51–63.

MARTÍNEZ-ROS, E., & KUNAPATARAWONG, R., *Green Innovation and Knowledge: The Role of Size*, in «Business Strategy and the Environment», vol. 28, n. 6 (2019), pp. 1045–59.

MORENO-MONDÉJAR, L., TRIGUERO, Á., & SÁEZ-MARTÍNEZ, F. J., *Successful Eco-innovators: Exploring the Association between Open Inbound Knowledge Strategies and the Performance of Eco-innovative Firms*, in «Business Strategy and the Environment», vol. 29, n. 3 (2020), pp. 939–53.

MUSCIO, A., NARDONE, G., & STASI, A., *How does the search for knowledge drive firms' eco-innovation? Evidence from the wine industry*, in «Industry and Innovation», vol. 24, n. 3 (2017), pp. 298–320.

OLSEN, A. Ø., SOFKA, W., & GRIMPE, C., *Solving Environmental Problems: Knowledge and Coordination in Collaborative Search*, in «Long Range Planning», vol. 50, n. 6 (2017), pp. 726–40.

ORLANDO, B., BALLESTRA, L. V., SCUOTTO, V., PIRONTI, M., & GIUDICE, M. D., *The Impact of R amp;D Investments on Eco-Innovation: A Cross-Cultural Perspective of Green Technology Management*, in «IEEE Transactions on Engineering Management», (2020), pp. 1–10.

PORTER, M. E., & KRAMER, M. R., *Creating Shared Value*, in G. G. LENSSEN & N. C. SMITH (A C. DI), *Managing Sustainable Business: An Executive Education Case and Textbook*, Springer Netherlands, Dordrecht 2019pagg. 323–46.

RUSSO SPENA, T., & DI PAOLA, N., *Moving beyond the Tensions in Open Environmental Innovation towards a Holistic Perspective*, in «Business Strategy and the Environment», vol. 29, n. 5 (2020), pp. 1961–74.

SAEZ-MARTINEZ, F. J., AVELLANEDA-RIVERA, L., & GONZALEZ-MORENO, A., *Open and Green Innovation in the Hospitality Industry*, in «Environmental Engineering and Management Journal», vol. 15, n. 7 (2016), pp. 1481–87.

TRIGUERO, A., FERNÁNDEZ, S., & SÁEZ-MARTINEZ, F. J., *Inbound Open Innovative Strategies and Eco-Innovation in the Spanish Food and Beverage Industry*, in «Sustainable Production and Consumption», vol. 15 (2018), pp. 49–64.