

Enhancing the relationship between firm's green innovation and external knowledge flows: A review and research agenda

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ABSTRACT

Objective: The objective of the article is to review the current literature on enhancing the relationship between the firm's green innovation and external knowledge flows.

Research Design & Methods: This study adopts a systematic literature review approach. The articles reviewed were abstracted from Scopus and Web of Science as the main significant scientific indexing platforms. The scope of the review was not limited in time.

Findings: The review suggests that despite the novelty of the topic, the research on enhancing external knowledge flows for the firm's green innovation raises a variety of issues. Among these, established cooperation, network cohesion, and resource flexibility are the most frequently studied areas in the field.

Implications & Recommendations: Despite previous studies on external knowledge flows for green innovation, the review indicates that there is still a need to further explore the issues related to enhancing the firm's interactions with external partners for green innovation. This article provides further guidance to scholars by identifying potential future research avenues. In this context, to explore potential interdependencies, relevant future research could consider more cross-country and cross-regional aspects. More in-depth research on a single sector and a single type of external knowledge provider would also be valuable. The study also proposes to further improve the conditions for firms to strengthen external knowledge flows for green innovation.

Contribution & Value Added: This article adds to the existing knowledge on the drivers of firm innovation by reviewing the relevant literature on the links between the firm's green innovation performance and external knowledge flows. Specifically, this review contributes to the field by providing insights into the enhancement of the relationship between external knowledge flows and the firm's green innovation.

Article type: research article

Keywords: the firm's green innovation; external knowledge flows; systematic literature review; Scopus; Web of Science

JEL codes: O10, O30

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INTRODUCTION

Innovation and its determinants have attracted the attention of many scholars over the years (Lawson & Samson, 2001; Zygmunt, 2018; Lehnert *et al.*, 2020; Audretsch & Belitski, 2020; Fitsch *et al.*, 2020; Gritsch, 2021). In this context, the notion of external knowledge flows has gained increasing interest over the last decade as an essential driver of firms' innovation activities (Rudawska & Kowalik, 2019; Kocot & Kocot, 2020; Uchańska-Bieniusiewicz & Obłój, 2023; Audretsch & Belitski, 2024). This is because external knowledge providers are seen as crucial for the innovativeness of firms and, consequently, for the innovativeness of regions and countries (Urbaniec, 2020; Zygmunt, 2022). Regarding innovation, the concept of green innovation has recently gained attention as an ongoing concern for the firm's innovation performance and the sustainable development of regions and countries (Cooke,

2013; Wang *et al.*, 2023). This is because green innovation stimulates the competitive advantage of firms by incorporating the need to reduce energy consumption and pollutant emissions (Díaz-García *et al.*, 2015; He *et al.*, 2021). Following the premise that green innovation contributes significantly to the economic development of firms, regions, and countries, external knowledge flows in the firm's green innovation performance have gained more and more interest (Marzucchi & Montresor, 2017; Tu & Wu, 2021) becoming prominent research field. The rising call for studies in this area has stimulated systematic literature reviews, which have improved the understanding of this phenomenon. Such systematic literature reviews are provided, for example, by Díaz-García *et al.* (2015) or Melander and Arvidsson (2022), who identified external knowledge flows as a crucial driver of green innovation and suggested the need for further research that expands insights on external knowledge flows and the firms' green innovation. However, despite the number of systematic literature reviews in this area, there seems to be a lack of integrated understanding of how to enhance the firm's interactions with external partners for green innovation. This study aims to address this gap and develop the existing systematic literature reviews in this area. Therefore, the study aimed to review the current literature on enhancing the relationship between the firm's green innovation and external knowledge flows. In this regard, a systematic literature review was conducted to summarise the existing studies in this field. The articles for the study were extracted from Scopus and Web of Science as the main research databases. For the systematic literature review, the protocols for systematic literature review proposed by Tranfield *et al.* (2003) and Snyder (2019) were adopted.

A key contribution of this article is to systematically analyse the current state of the art in the area of enhancing of the relationship between the firm's green innovation performance and external knowledge flows and to suggest future research in this area. The study also provides an original contribution to the ongoing debate on external knowledge flows and the firms' green innovation.

This article is arranged as follows. The next section will provide a brief literature review in the field. The third section will outline the data sources and methodology adopted for the systematic review with emphasis on planning and sample selection stages. The fourth section will illustrate the descriptive analysis of the review in terms of time evolution, geography of the articles, journals, authors and the studies' profile. This section will also report the results of an in-depth review of articles on the links between the firm's green innovation and external partners with particular attention on enhancing the relationship between the firm's green innovation performance and external knowledge flows. This section will also present future lines of research. The last section will discuss the main implications and limitations.

LITERATURE REVIEW

Literature discussing innovation and its determinants has recently paid special interest to issues related to green innovation as crucial for the competitiveness of firms and the sustainable development of regions and countries (Wang *et al.*, 2023). Studies in this area have paid particular attention to the firm's links with external knowledge providers as essential for the firm's green processes (Tu & Wu, 2021). In this respect, the existing literature considers particularly the triple helix agents that provide knowledge for green innovation (Arfi *et al.*, 2018; Bai *et al.*, 2021): the research system, government and local authorities, and other firms. In this context, universities and research institutions are regarded as key actors in supporting green innovation (Arfi *et al.*, 2018) through access to expert knowledge related to green information and technology (Bai *et al.*, 2021) and highly skilled human capital, which is essential for accelerating green innovation (He *et al.*, 2021). The literature in the area has also highlighted the role of government and local authorities in providing relevant regulations related to the reduction of energy consumption and pollutant emissions, subsidies and other support instruments as pivotal to promoting and stimulating the firm's green innovation (Klewitz *et al.*, 2012; Ma *et al.*, 2019). Relevant literature has also highlighted the importance of networks between firms for green innovation (Janahi *et al.*, 2022). In this context, the studies devote special attention to suppliers, customers, and competitors (Arfi *et al.*, 2018). Here, suppliers are seen as providers of knowledge related to, among others, the value chain focused on the development of green innovation (Marzucchi & Montresor, 2017), while customers are regarded as providers of knowledge about

current changes in market trends and customers attitudes towards environmental issues (Ma *et al.*, 2022). On the other hand, competitors are seen as a source of knowledge about new green technologies or products (Arranz *et al.*, 2022).

The considerable research interest in the firm's green innovation and external knowledge flows is reflected in numerous systematic literature reviews on green innovation. In this regard, for example, Díaz-García *et al.* (2015), who analysed 384 articles on green innovation, have identified external knowledge flows as an important macro- and meso-level driver of green innovation, while Klewitz and Hansen's (2014) systematic literature review of 45 articles highlights knowledge diffusion as a key barrier for the sustainable development of small and medium-sized enterprises (SMEs). Regarding the importance of external knowledge flows for the firms' green innovation, Melander (2017) focuses specifically on this area in a systematic literature review. Reviewing 67 articles, Melander (2017) pays particular attention to the drivers of collaboration in relation to green product innovation. External knowledge flows in the context of green processes were also the subject of a systematic literature review of 35 articles provided by Pereira *et al.* (2020). Here, the importance of inter-organisational cooperation was of particular interest. Meanwhile, Sanni and Verdolini (2022) reviewed 288 articles and placed particular emphasis on the knowledge structure for green innovation, pointing to the role of external knowledge providers for open innovation in relation to green processes. Another systematic review, which also motivated this research comes from Melander and Arvidsson (2022). This review of 63 articles further deepens the consideration of the relevance of external knowledge providers for the firm's green innovation.

Thus, the ongoing importance of the links between green innovation performance and external knowledge flows has led to further exploration of this area and the extension of existing systematic reviews in this respect. In particular, this research is motivated by the need to further expand the understanding of external knowledge flows for the firm's green innovation. In this regard, this study extends the previous ones by including articles that are not confined to selected subject areas and journals. It also expands the previous systematic literature reviews by providing insights about enhancing the relationship between the firm's green innovation and external knowledge flows as the existing literature exploring this area lacks a comprehensive review of this emerging phenomenon. Therefore, through a systematic literature review of previous research studies, this study aims to explore the enhancement of the firm's interactions with external partners for green innovation. In doing so, it addresses the following research questions:

- RQ1:** What existing research covers the enhancement of the relationship between the firm's green innovation and external knowledge flows?
- RQ2:** What are the main research areas that address the enhancement of the firm's interactions with external partners for green innovation?

To answer these questions, a systematic literature review was conducted to summarise the existing studies in this field. The articles for the study were extracted from Scopus and Web of Science as the main research databases.

RESEARCH METHODOLOGY

Study Design

The systematic literature review was chosen as the appropriate research approach to address the research questions. The use of this research approach lies in providing a transparent and explicit in-depth study that contributes to a more comprehensive understanding of research trends and paths (Tranfield *et al.*, 2003; Snyder, 2019). This research follows the commonly used protocols for systematic literature reviews proposed by Tranfield *et al.* (2003) and Snyder (2019). Based on this, the following stages were applied (Silva *et al.*, 2020): planning, sample selection, descriptive analysis, and thematic analysis. The first stage involves locating studies, identifying keywords, and constructing a string based on keywords (Tranfield *et al.*, 2003). The second stage concerns the identification of inclusion/exclusion criteria, the selection of studies for review and the establishment of a protocol for coding and structuring the arti-

cles analysed (Snyder, 2019). The next stage refers to the literature categorisation (Silva *et al.*, 2020), while the final stage involves an in-depth review of the articles.

Planning

For the selection of articles, Scopus and Web of Science were used as the main significant scientific indexing platforms (Ding *et al.*, 2016). The keywords for the database search were determined on the basis on relevant works in the field of the firms' green innovation performance and external knowledge flows (Marzucchi & Montresor, 2017; Tu & Wu, 2021) to find articles dealing with the research topic. Thus, the search included the keywords: 'green innovat*', 'eco-innovat*', 'ecologic* innovat*', 'environment* innovat*', 'sustainab* innovat*', 'firm* green innovat*' as related to the firm's green innovation performance. The search also contained the keywords: 'knowledge shar*', 'knowledge diffusion', 'knowledge flow*', 'external knowledge* shar*', 'external knowledge diffusion', 'external knowledge flow*', 'cooperat*', 'collaborat*', 'network*', 'external linkage*', 'external relation*', 'research system', 'science', 'universit*', 'research institut*', 'research organi*', 'research centre*', 'local authorit*', 'government*', 'other firm*', 'expert*', 'supplier*', 'customer*', 'competitor*', 'external partner*' as associated with external knowledge flow. The asterisk (*) was used to include as many studies as possible. The identification of keywords allows to construct the following search string:

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(('green innovat*' OR 'eco-innovat*' OR 'ecologic* innovat*' OR 'environment* innovat*' OR 'sustainab* innovat*' OR 'firm* green innovat*') AND ('knowledge shar*' OR 'knowledge diffusion' OR 'knowledge flow*' OR 'external knowledge* shar*' OR 'external knowledge diffusion' OR 'external knowledge flow OR 'network*' OR 'external linkage*' OR 'cooperat*' OR 'external relation*' OR 'collaborat*' OR 'research system' OR 'science' OR 'universit*' OR 'research institut*' OR 'research organi*' OR 'research centre*' OR 'local authorit*' OR 'government*' OR 'other firm*' OR 'expert*' OR 'supplier*' OR 'customer*' OR 'competitor*' OR 'external partner*'))
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To identify relevant articles, the search string was applied within the titles, abstracts, and keywords. The scope of the research was not limited in time. The search was done between 13 May to 1 July 2024.

Sample Selection

The initial search allowed for retrieving 2726 articles including, in particular, 2293 articles from Scopus and 433 articles from Web of Science, which were exported to Excel. Articles for further review were selected to meet the following inclusion criteria: English language, peer-reviewed academic articles, full-text availability. The following exclusion criteria were also used to identify relevant articles: conference proceedings, book chapters, research notes, editorials, commentaries. Next, duplicates were excluded (337 articles). The titles, abstracts, and keywords of the articles were then reviewed to determine the relevance of the articles to the review questions. This was done by assigning values from 1 (least relevant) to 5 (most relevant). For further review, articles with a score of 4 and 5 were selected as potentially relevant. Consequently, 358 articles remained in the study (of which 253 articles could be fully accessed). The full-text articles were then screened to confirm that the main body of the article was relevant to the scope of the study (using a scoring system of 1 to 5). Thus, 212 articles were excluded from further analysis, because their main body appeared to focus on the relationship of green innovation performance and external knowledge flows rather than on enhancing this relationship. Finally, 41 articles were selected as the most relevant to this study. Such a number of articles in the final sample (in comparison to the initial search) is consistent with other systematic literature reviews on green innovation, provided, for example, by Sanni and Verdolini (2022). Figure 1 illustrates the sample selection process.

The articles from the final sample were then analysed to obtain information on a number of publications per year, geographical distribution, sector of analysis and methodology used. The remaining articles were also examined to indicate emerging main themes. On the basis of this information, descriptive and thematic analyses were conducted.

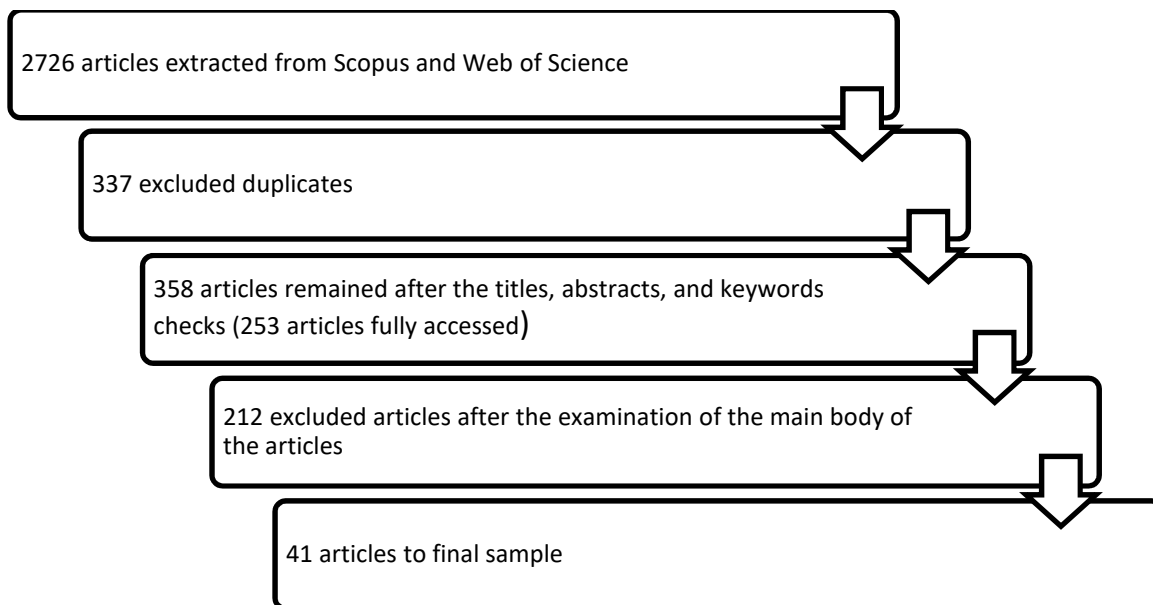


Figure 1. The sample selection process

Source: own elaboration.

RESULTS AND DISCUSSION

Descriptive Analysis

This section explores the reviewed articles by a number of publications per year and by geographical distribution. The reviewed articles have also been examined by sector of analysis and methodology used.

An analysis of the final sample indicates that enhancing the relationship between the firm’s green innovation performance and external knowledge flows is a relatively new research area. The research interest in this area has been growing slowly but continuously, as shown in Figure 2.

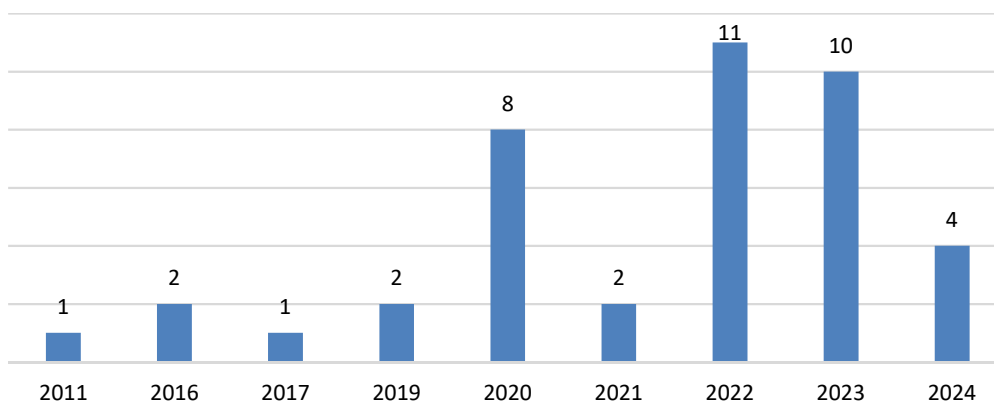


Figure 2. The number of publications per year

Note: *The analysis was conducted in the first half of 2024 and does not include articles that have been published since then.

Source: own elaboration.

As has been noted, the interest in exploring the topic began to emerge in 2011. In that year, Urbaniec and Gerstlberger (2011) published a highly cited article emphasising the role of external coordinators in enhancing external flows for the firm’s green innovation. From 2016 to 2019, there were one or two articles per year, indicating that the interest in enhancing the relationship between firms’ green innovation performance and external knowledge flows was growing slowly. The review indicated that the number of publications on the topic rose in the last five years (2020-2024), with 85% of the reviewed articles from the final sample. This shows a positive trend in research in this area over time

despite the relative scarcity of publications. The analysis of the final sample revealed that although the number of articles on enhancing the relationship between firms' green innovation performance and external knowledge flows is relatively scarce, research on the topic has attracted scholarly interest internationally. Research on this topic has been provided by scholars from 22 countries (Table 1).

Table 1. Countries of Authors

Country of Author	Number of Authors
Bahrain	3
Belgium	1
China	40
Colombia	1
Denmark	2
Finland	1
Germany	3
Greece	4
India	1
Ireland	1
Italy	4
Jordan	1
Katar	1
The Netherlands	1
New Zealand	1
Norway	1
Oman	2
Pakistan	4
Poland	5
Qatar	2
South Korea	5
Spain	15
Sweden	3
Taiwan	3
Tanzania	1
Thailand	3
Turkey	1
United Kingdom	17

Source: own study.

The review indicated that empirical studies on the topic were mainly provided by authors from China (31%) and the United Kingdom (13%). A significant number of authors were also from Spain (12%), Poland (4%), South Korea (4%), Italy (3%), Pakistan (3%), Greece (3%), Italy (3%), Bahrain (2%), Germany (2%), Denmark (2%), Bahrain (250), Oman (2%), Qatar (2%), Thailand (2%), Sweden (2%), and Taiwan (2%). Authors from Belgium, Colombia, Denmark, Finland, India, Ireland, the Netherlands, New Zealand, Norway, Pakistan, Qatar, and Turkey also contributed to this field. This demonstrates that the topic is of global interest.

Considering the country focus of the research, there was a considerable geographical spread (Table 2).

Table 2. Country of analysis

Country of analysis	Authors
China	Hofman <i>et al.</i> (2020), Zhou <i>et al.</i> (2020), Gao <i>et al.</i> (2021), Sun & Sun (2021), Chen (2022), Ma <i>et al.</i> (2022), Zhang and Chen (2022), Zhang & Wang (2022), Chen <i>et al.</i> (2023), Sun <i>et al.</i> (2023), Wang <i>et al.</i> (2023), Cheng <i>et al.</i> (2024)
Germany	Urbaniec & Gerstlberger (2011), Kobarg <i>et al.</i> (2020)
Ghana	Adomako (2020)
Greece	Dimakopoulou <i>et al.</i> (2022)
Iran	Ahmadi <i>et al.</i> (2020)
Italy	Corazza <i>et al.</i> (2022)
Jordan	Awwad <i>et al.</i> (2022)
Kingdom of Bahrain	Janahi <i>et al.</i> (2022)
Oman	Abdelfattah <i>et al.</i> (2024)
Pakistan	Ullah <i>et al.</i> (2023)
Poland	Ryszko (2016), Ocicka <i>et al.</i> (2022)
South Korea	Yang & Park (2016)
Spain	Marzucchi & Montresor (2017), Arroyave <i>et al.</i> (2020), Arranz <i>et al.</i> (2022), Bolívar-Ramos (2023), Chistov <i>et al.</i> (2023), Diez-Martinez <i>et al.</i> (2023), Murillo-Luna <i>et al.</i> (2023), Ozdemir <i>et al.</i> (2023), Carchano <i>et al.</i> (2024)
Sweden	Abadzhiev <i>et al.</i> (2022)
Tanzania	Buzohera (2024)
Thailand	Srisathan <i>et al.</i> (2023)
Turkey and unspecified European continental countries	Burki <i>et al.</i> (2019)

Source: own study.

The analysis indicated that most studies focus on countries in Asia (51%) and Europe (37%), while countries in Africa represent a geographical area of 5% of the studies. The analysis also showed that 7% of the reviewed studies did not specify the country of analysis. This concerns studies by Chen *et al.* (2019), He *et al.* (2020), and Li *et al.* (2020), which refer to research based on the development of scenarios and game models. The descriptive analysis also revealed that the majority of the reviewed articles had a single country focus: China (N=12), Germany (N=2), Ghana (N=1), Greece (N=1), Iran (N=1), Italy (N=1), Jordan (N=1), the Kingdom of Bahrain (N=1), Oman (N=1), Pakistan (N=1), Poland (N=2), South Korea (N=1), Spain (N=9), Sweden (N=1), Tanzania (N=1), Thailand (N=1). Interestingly, only one of the studies analysed covers several countries (Turkey and unspecified continental European countries).

In terms of the sector of analysis, the analysis provides evidence that the majority of the studies reviewed report on specific sectors under investigation (Table 3).

Table 3. Sectors of analysis

Sector of analysis	Authors
manufacturing, service, agriculture	Corazza <i>et al.</i> (2022)
manufacturing, service	Urbaniec & Gerstlberger (2011), Yang & Park (2016), Diez-Martinez <i>et al.</i> (2023), Srisathan <i>et al.</i> (2023), Ullah <i>et al.</i> (2023)
manufacturing	Ryszko A. (2016), Burki <i>et al.</i> (2019), Ahmadi <i>et al.</i> (2020), Arroyave <i>et al.</i> (2020), He <i>et al.</i> (2020), Hofman <i>et al.</i> (2020), Kobarg <i>et al.</i> (2020), Zhou <i>et al.</i> (2020), Gao <i>et al.</i> (2021), Sun & Sun (2021), Abadzhiev <i>et al.</i> (2022), Awwad <i>et al.</i> (2022), Janahi <i>et al.</i> (2022), Ma <i>et al.</i> (2022), Zhang & Chen (2022), Zhang & Wang (2022), Murillo-Luna <i>et al.</i> (2023), Chen <i>et al.</i> (2023), Sun <i>et al.</i> (2023), Abdelfattah <i>et al.</i> (2024), Buzohera (2024), Cheng <i>et al.</i> (2024)
service	Arranz <i>et al.</i> (2022)

Source: own study.

A number of the articles reviewed report research in a single sector (56%), with a preponderance of research interest in manufacturing (54%). Two or more sectors were of interest of 14% of research in the fields: manufacturing, service (12%) and manufacturing, service, agriculture (2%). The review also indicates that 22% of the articles from the final sample lack a clearly stated sector of research. These are studies provided by Marzucchi and Montresor (2017), Chen *et al.* (2019), Li *et al.* (2020), Dimakopoulou *et al.* (2022), Chistov *et al.* (2023), Ozdemir *et al.* (2023), Wang *et al.* (2023) and Carchano *et al.* (2024). Single studies were also considered for: high-tech firms (Ocicka *et al.*, 2022), innovative firms (Bolívar–Ramos, 2023) and new ventures (Chen, 2022).

The analysis of the articles reviewed indicates that the most prominent method used to explore the enhancing of the relationship between the firm’s green innovation performance and external knowledge flows was a quantitative study, corresponding to 97% of the articles (Table 4). In terms of qualitative studies, the review shows that only two articles applied such a method: Janahi *et al.* (2022) – a case study, and Abadzhiev *et al.* (2022) – interviews (only one study uses a combination of qualitative and quantitative methods – Urbaniec and Gerstlberger (2011)). This suggests that scholars use quantitative rather than qualitative methods to explore the topic.

Although enhancing the relationship between the firm’s green innovation performance and external knowledge flows is a relatively new area of research, authors use a variety of research methods to explore this topic from different angles. The most frequently used research methods in this area were various regression methods, corresponding to 49% of the articles in the final sample (Table 5).

In particular, especially regression (*e.g.* Adomako, 2020; Ma *et al.*, 2022) and logistic regression (*e.g.* Chen, 2022; Chistov *et al.*, 2023) were applied for the studies. Similarly, scholars also frequently used structural equation modelling and partial least squares structural equation modelling for research on enhancing the relationship between the firm’s green innovation performance and external knowledge flows (32% of the reviewed articles). Among the different methods used in this field, less frequently used methods can also be distinguished, such as the game method (He *et al.*, 2020; Li *et al.*, 2020), the best-worst method (Ahmadi *et al.*, 2020), and the bootstrap method (Cheng *et al.*, 2024).

Table 4. Applied methods

Applied method	Authors
Quantitative	Urbaniec & Gerstlberger (2011), Ryszko (2016), Yang & Park (2016), Marzucchi & Montresor (2017), Burki <i>et al.</i> (2019), Chen <i>et al.</i> (2019), Adomako (2020), Ahmadi <i>et al.</i> (2020), Arroyave <i>et al.</i> (2020), He <i>et al.</i> (2020), Hofman <i>et al.</i> (2020), Kobarg <i>et al.</i> (2020), Li <i>et al.</i> (2020), Zhou <i>et al.</i> (2020), Gao <i>et al.</i> (2021), Sun & Sun (2021), Abadzhiev <i>et al.</i> (2022), Arranz <i>et al.</i> (2022), Awwad <i>et al.</i> (2022), Chen (2022), Corazza <i>et al.</i> (2022), Dimakopoulou <i>et al.</i> (2022), Ma <i>et al.</i> (2022), Ocicka <i>et al.</i> (2022), Zhang & Chen (2022), Zhang & Wang (2022), Bolívar–Ramos (2023), Chen <i>et al.</i> (2023), Chistov <i>et al.</i> (2023), Diez-Martinez <i>et al.</i> (2023), Murillo-Luna <i>et al.</i> (2023), Ozdemir <i>et al.</i> (2023), Srisathan <i>et al.</i> (2023), Sun <i>et al.</i> (2023), Ullah <i>et al.</i> (2023), Wang <i>et al.</i> (2023), Abdelfattah <i>et al.</i> (2024), Buzohera (2024), Carchano <i>et al.</i> (2024), Cheng <i>et al.</i> (2024)
Qualitative	Urbaniec & Gerstlberger (2011), Abadzhiev <i>et al.</i> (2022), Janahi <i>et al.</i> (2022)

Source: own study.

Table 5. Main statistical methods used

Main statistical methods used in the study	Authors
Structural equation modeling	Burki <i>et al.</i> (2019), Chen <i>et al.</i> (2019), Hofman <i>et al.</i> (2020), Sun & Sun (2021), Awwad <i>et al.</i> (2022), Sun <i>et al.</i> (2023)
Partial least squares structural equation modelling	Ryszko (2016), Arroyave <i>et al.</i> (2020), Diez-Martinez <i>et al.</i> (2023), Ullah <i>et al.</i> (2023), Abdelfattah <i>et al.</i> (2024), Buzohera (2024), Carchano <i>et al.</i> (2024)
Regression	Adomako (2020), Zhou <i>et al.</i> (2020), Ma <i>et al.</i> (2022), Zhang & Chen (2022), Zhang & Wang (2022), Ozdemir <i>et al.</i> (2023), Wang <i>et al.</i> (2023)
Logistic regression	Yang & Park (2016), Marzucchi & Montresor (2017), Arranz <i>et al.</i> (2022), Chen (2022), Corazza <i>et al.</i> (2022), Murillo-Luna <i>et al.</i> (2023), Chistov <i>et al.</i> (2023)
Probit regression	Bolívar–Ramos (2023), Srisathan <i>et al.</i> (2023)
Zero-inflated Poisson regression	Kobarg <i>et al.</i> (2020), Gao <i>et al.</i> (2021)
Mixed process regression	Dimakopoulou <i>et al.</i> (2022)
Regression using a fixed-effect model	Chen <i>et al.</i> (2023)
Fuzzy ANOVA	Ocicka <i>et al.</i> (2022)
Fuzzy set qualitative comparative analysis	Abadzhiev <i>et al.</i> (2022)
Game method	He <i>et al.</i> (2020), Li <i>et al.</i> (2020)
Best worst method	Ahmadi <i>et al.</i> (2020)
Bootstrap method	Cheng <i>et al.</i> (2024)
Thematic analysis	Janahi <i>et al.</i> (2022)

Source: own study.

Regarding the study type, the review highlights that the majority of studies on the topic are cross-sectional (Table 6).

In the final sample, 78% of the articles consider a single point in time (*e.g.* Hofman *et al.*, 2020; Zhou *et al.*, 2020; Bolívar–Ramos, 2023), while 22% of the articles cover a period (*e.g.* He *et al.*, 2020; Dimakopoulou *et al.*, 2022). This indicates that longitudinal studies are still relatively limited and may suggest that research on enhancing the relationship between the firm's green innovation performance and external knowledge flows is still developing. This also points to the need for more longitudinal studies in this research area.

Table 6. Types of study

Type of studies	Authors
Longintual studies	Yang & Park (2016), Marzucchi & Montresor (2017), He <i>et al.</i> (2020), Gao <i>et al.</i> (2021), Arranz <i>et al.</i> (2022), Corazza <i>et al.</i> (2022), Dimakopoulou <i>et al.</i> (2022), Murillo-Luna <i>et al.</i> (2023), Wang <i>et al.</i> (2023)
Cross-sectional studies	Urbaniec & Gerstlberger (2011), Ryszko (2016), Burki <i>et al.</i> (2019), Chen <i>et al.</i> (2019), Adomako (2020), Ahmadi <i>et al.</i> (2020), Arroyave <i>et al.</i> (2020), Hofman <i>et al.</i> (2020), Kobarg <i>et al.</i> (2020), Li <i>et al.</i> (2020), Zhou <i>et al.</i> (2020), Sun & Sun (2021), Abadzhiev <i>et al.</i> (2022), Awwad <i>et al.</i> (2022), Chen (2022), Janahi <i>et al.</i> (2022), Ma <i>et al.</i> (2022), Ocicka <i>et al.</i> (2022), Zhang & Chen (2022), Zhang & Wang (2022), Chen <i>et al.</i> (2023), Diez-Martinez <i>et al.</i> (2023), Srisathan <i>et al.</i> (2023), Ullah <i>et al.</i> (2023), Abdelfattah <i>et al.</i> (2024), Buzohera (2024), Carchano <i>et al.</i> (2024), Cheng <i>et al.</i> (2024)

Source: own study.

Thematic Analysis

With regard to the research questions, three main themes emerged: external knowledge providers, the scope of external knowledge flows for the firm's green innovation, and the enhancement of external knowledge flows for the firm's green innovation performance. The first two themes develop the previous considerations on external partners for the firm's green innovation and the object of external knowledge flows, noting how these issues are presented in articles that address the theme of enhancing the relationship between the firm's green innovation and external knowledge providers. The third theme arose from the need to understand the enhancement of the firm's interactions with external partners for green innovation. As research focusing on enhancing the link between the firm's green innovation performance and external knowledge flows is a relatively new area of research in the literature, the in-depth analysis of the final sample followed Kraus *et al.*'s (2005) approach to reviewing the literature with insufficient diversity of studies to identify interesting sub-results.

The reviewed studies show a high interest in various external knowledge providers for green innovation performance (Table 7). This suggests that the debate in this area is still ongoing and is also considered in the studies on enhancing the relationship between the firm's green innovation and external knowledge providers. That is because external knowledge flows remain critical for green innovation (Wang *et al.*, 2023).

Table 7. External knowledge providers

External knowledge providers	Number of articles
supply chain members	8
government	6
partners	5
suppliers	3
suppliers, customers, universities, research organisations	3
government, other external partners	2
suppliers, customers, government, universities, competitors	2
suppliers, customers, government	2
suppliers, customers, government, universities, research organisations	2
universities, research organisations	2
customers	1
government, universities	1
other firms	1
suppliers, customers	1
suppliers, customers, universities, research organisations, competitors	1
value chain members	1

Source: own study.

The review indicates that many studies from the final sample pay special attention to network structures. Here, especially supply chain members have gained particular consideration as creating inter-organisational connections that support green processes (Ocicka *et al.*, 2022). An interest in supply chain members can be found in Chen *et al.* (2019), He *et al.* (2020), Zhou *et al.* (2020), Sun and Sun (2021), Ocicka *et al.* (2022), and Wang *et al.* (2023). This reveals that, unlike the traditional linear structure between suppliers and customers, the supply chain (consisting of firms, customers, suppliers and other partners) creates ‘a network-based structure,’ as Wang *et al.* (2023) emphasise. Similarly, He *et al.* (2020) note that such a structure can enable the optimisation of internal and external sources of green innovation and is becoming increasingly strategic for high-tech firms, as Ocicka *et al.* (2022) suggest. Among the studies that consider supply chain members as knowledge providers for green innovation, should be highlighted studies that focus specifically on green supply chain members (Chen *et al.*, 2019; Zhou *et al.*, 2020; Sun & Sun, 2021) as providing more knowledge on environmental issues (Zhou *et al.*, 2020). In this regard, Chen *et al.* (2019) suggest that the benefits of the relationship between the firm and green supply chain partners are associated with, among others, the exploratory and tactical knowledge needed for the success of green innovation. In this context, Sun and Sun (2021) also highlight that such collaboration can lead to the firm’s competitive advantage. Moreover, value chain members are seen as critical knowledge providers for green innovation performance. This is observed in the study by Abadzhiev *et al.* (2022), who highlight the role of joint collaboration along the value chain for green processes and value creation.

In the reviewed articles, considerable interest in considering the research system can be noted as an important element of network structures for green innovation. This is especially seen in the studies by Ryszko (2016), Kobarg *et al.* (2020), Arranz *et al.* (2022) and Ozdemir *et al.* (2023). In this context, Kobarg *et al.* (2020) suggest that intensive cooperation between the firm and customers, suppliers, universities, and research organisations is desirable for the development of the firm’s green innovation. Ryszko (2016) emphasises here the influence of these knowledge providers, especially on the development of the firm’s technological green innovation. On the other hand, Arranz *et al.* (2022) highlight that network structures, including the research system, support the firm’s green innovation through the use of prior knowledge. The involvement of the government in network structures for the firm’s green innovation is also noticeable in the articles in the field. The origin of such incorporation lies in the view of the government as a knowledge provider of the legal framework for green innovation of firms (Janahi *et al.*, 2022; Chen *et al.*, 2023; Buzohera, 2024). Following this, Urbaniec and Gerstlberger (2011) and Yang and Park (2016) consider the government together with such external agents as suppliers, customers, universities, and competitors indicating the role of government in the creation conditions for external knowledge flows. On the other hand, Janahi *et al.* (2022) pay special attention to the network structure of external providers consisting of government, suppliers, customers, and universities as supportive of the firm’s green innovation, while Hofman *et al.* (2020) and Chen (2022) emphasise the network structure combining the firm, government, suppliers, and customers.

The analysis of the final sample also allowed for indicating the studies focusing on a specific one or two external knowledge providers for the firm’s green innovation. This is due to the need to understand in detail the relationship between the firm’s green innovation and a specific external knowledge agent. The focus on a single knowledge provider for the firm’s green innovation can be seen in the studies of Burki *et al.* (2019), Adomako (2020), Ahmadi *et al.* (2020), Li *et al.* (2020), Gao *et al.* (2021), Ma *et al.* (2022), and Zhang and Wang (2022). Among them, Adomako (2020), Ahmadi *et al.* (2020), and Li *et al.* (2020) focus on the role of firms’ suppliers in green processes, while Gao *et al.* (2021), Zhang and Wang (2022), Srisathan *et al.* (2023), Ullah *et al.* (2023), Abdelfattah *et al.* (2024) and Carchano *et al.* (2024) pay special attention to the government indicating the involvement of government in creating conditions for external knowledge flows. On the other hand, Burki *et al.* (2019) and Ma *et al.* (2022) focus especially on customers as knowledge providers for firms’ green innovation. Arroyave *et al.* (2020), Awwad *et al.* (2022), Bolívar-Ramos (2023), and Murillo-Luna *et al.* (2023) also pay attention to selected external knowledge providers for the firm’s green innovation. In this context, Murillo-Luna *et al.* (2023) emphasise the firm’s network with universities and government as ‘key triple helix agents’ that provide knowledge for green innovation. Arroyave

et al. (2020) and Bolívar-Ramos (2023) concentrate on the role of universities and research organisations in green innovation of the firm, pointing to their 'still underestimated role' in green processes (Arroyave *et al.*, 2020). On the other hand, Awwad *et al.* (2022) pay special attention to the integration of green suppliers and green customers for a green product of the firm and its flexibility. In addition, references to unspecified knowledge providers for the firms' green innovation performance can also be found in the final sample. Such references can be observed in the studies by Marzucchi and Montresor (2017), Corazza *et al.* (2022), Dimakopoulou *et al.* (2022), Zhang and Chen (2022), Chistov *et al.* (2023), Diez-Martinez *et al.* (2023), and Sun *et al.* (2023).

Regarding the scope of the scope of external knowledge flows for the firm's green innovation, the review shows that the vast majority of studies in the final sample refer to knowledge sharing in general terms, without specifying the extent of external knowledge flows for the firm's green innovation activities. This is observed in the articles by Yang and Park (2016), Marzucchi and Montresor (2017), Adomako (2020), Ahmadi *et al.* (2020), He *et al.* (2020), Kobarg *et al.* (2020), Li *et al.* (2020), Gao *et al.* (2021), Dimakopoulou *et al.* (2022), Zhang and Chen (2022), Zhang and Wang (2022), Chistov *et al.* (2023), Chen *et al.* (2023), Murillo-Luna *et al.* (2023), Wang *et al.* (2023), Srisathan *et al.* (2023), Sun *et al.* (2023), Ullah *et al.* (2023), Abdelfattah *et al.* (2024), Buzohera (2024), Carchano *et al.* (2024), and Cheng *et al.* (2024).

Among the studies that describe in more detail the scope of knowledge provided by external agents for the firm's green innovation, many refer to knowledge related to green product development as important for green innovation activities. In this regard, Ryszko (2016), Janahi *et al.* (2022), and Ocicka *et al.* (2022) highlight the external knowledge that serves the joint development of green products, while Sun and Sun (2021) pay particular attention to shared knowledge for planning and decision-making in green product innovation. On the other hand, the focus on external knowledge about technology, products, and markets as crucial for 'innovation creation and implementation' (Urbaniec & Gerstlberger, 2011) is placed in the studies of Urbaniec and Gerstlberger (2011), Burki *et al.* (2019), Hofman *et al.* (2020), Zhou *et al.* (2020), Awwad *et al.* (2022), Corazza *et al.* (2022), and Ma *et al.* (2022). In this area, Chen *et al.* (2019) also focus on research and development (R&D) collaboration as the scope of external knowledge flows for the firm's green innovation, while Bolívar-Ramos (2023) pays particular attention to basic knowledge, scientific research and research programmes. Furthermore, Arroyave *et al.* (2020) concentrate on external knowledge related to value creation, while Abadzhiev *et al.* (2022) also indicate external knowledge related to conflict resolution. The focus on green product and process innovation can be seen in the articles by Diez-Martinez *et al.* (2023) and Ozdemir *et al.* (2023). Overall, this varying interest in the scope of external knowledge flows for green innovation shows that the topic remains relevant and its complexity calls for further research.

The review shows that although studies on enhancing the relationship between external knowledge flows and the firm's green innovation performance are relatively new areas of research, the results obtained so far are very promising. A detailed analysis of the final sample reveals widely varied scopes of the articles, reflecting the growing interest in this area of research and different approaches to the issues in question. However, despite the novelty of the topic, most can be grouped into similar focus areas: established cooperation, network cohesion, and resource flexibility (Table 8).

Established cooperation, the first of the area mentioned, as crucial for the enhancement of the firm's interactions with external partners for green innovation, falls within the scope of the research by Adomako (2020), He *et al.* (2020), Kobarg *et al.* (2020), Zhou *et al.* (2020), Arranz *et al.* (2022), Corazza *et al.* (2022), Bolívar-Ramos (2023), Diez-Martinez *et al.* (2023), Sun *et al.* (2023), Carchano *et al.* (2024). In this area, Corazza *et al.* (2022) highlight the role of formalised network contracts, whereas Arranz *et al.* (2022), Diez-Martinez *et al.* (2023) Carchano *et al.* (2024), stress the role of prior cooperation that by generating synergies, increases firms' green orientation. Established cooperation with universities and research organisations to strengthen the firm's interactions with external partners for green innovation is considered by Kobarg *et al.* (2020) and Bolívar-Ramos (2023). Here, Bolívar-Ramos (2023) emphasises that such cooperation with universities improves the firm's research used to influence green processes, while established collaboration with research organisations does not support external knowledge flows for the firm's green innovation. As Bolívar-Ramos (2023) argues, such surprising evidence shows that firms benefit more from the basic research received from universities. In

contrast, Kobarg *et al.* (2020) provide evidence that established cooperation not only with universities but also with research organisations strengthens external knowledge flows for the firm's green process and product innovation. Kobarg *et al.* (2020) also emphasise established collaboration among supply chain members, which is also evident in Adomako's (2020) and Zhou *et al.*'s (2020) studies. In this context, Adomako (2020) provides evidence that established cooperation with suppliers strengthens the firm's green innovation through the development of routines that overcome the firm's environmental weaknesses, while Kobarg *et al.* (2020) suggest that the depth of the firm's knowledge collaboration with suppliers is beneficial for green process innovation but not for green product innovation. Surprisingly, Kobarg *et al.* (2020) find the opposite results for customers. Meanwhile, a research study by Zhou *et al.* (2020) reports that embeddedness in the green supply chain positively affects external knowledge flows for the firm's green innovation. In this regard, Zhou *et al.* (2020) also provide evidence that procedural fairness in the chain strengthens the aforementioned embeddedness. On the other hand, Zhou *et al.* (2020) find that distributive fairness in the green supply chain does not support external knowledge flows for green processes. In this vein, studies by Li *et al.* (2020) and Gao *et al.* (2021) also highlight fairness as an important driver for enhancing external knowledge provision for the firm's green innovation. In this context, Gao *et al.* (2021) provide evidence that fairness is essential for the firm's relationship with government to provide a basis for green innovation, while Li *et al.* (2020) highlight the role of trust as a necessary foundation for the firm's successful knowledge interactions with external partners for green innovation. A collaborative innovation atmosphere as well as a risk perception chain are also seen as crucial to strengthening the relationship between external knowledge providers and the firm's green innovation (Sun *et al.*, 2023). This is because they are seen as supportive of increasing the willingness to share knowledge for green processes (Sun *et al.*, 2023).

Table 8. Focus areas

Focus area	Authors
Established cooperation	Adomako (2020), He <i>et al.</i> (2020), Kobarg <i>et al.</i> (2020), Zhou <i>et al.</i> (2020), Arranz <i>et al.</i> (2022), Corazza <i>et al.</i> (2022), Bolívar-Ramos (2023), Diez-Martinez <i>et al.</i> (2023), Sun <i>et al.</i> (2023), Carchano <i>et al.</i> (2024)
Network cohesion	Awwad <i>et al.</i> (2022), Ocicka <i>et al.</i> (2022), Murillo-Luna <i>et al.</i> (2023), Wang <i>et al.</i> (2023)
Resource flexibility	Ryszko (2016), Marzucchi & Montresor (2017), Burki <i>et al.</i> (2019), Sun & Sun (2021), Chen (2022), Janahi <i>et al.</i> (2022), Ma <i>et al.</i> (2022), Ozdemir <i>et al.</i> (2023), Cheng <i>et al.</i> (2024)
Research and development (R&D) cooperation	Chen <i>et al.</i> (2019), Ahmadi <i>et al.</i> (2020), Dimakopoulou <i>et al.</i> (2022)
Community pressure	Hofman <i>et al.</i> (2020)
Regulatory pressure	Zhang & Wang (2022), Chen <i>et al.</i> (2023), Srisathan <i>et al.</i> (2023), Ullah <i>et al.</i> (2023), Abdelfattah <i>et al.</i> (2024), Buzohera (2024)
External coordinators	Urbaniec & Gerstlberger (2011)
Reduction of conflicts	Abadzhiev <i>et al.</i> (2022)
Level of the radicalness of green innovation	Chistov <i>et al.</i> (2023)

Source: own study.

Another focus area was network cohesion. It is essential for enhancing external knowledge flows for the firm's green processes, which is particularly evident in the research of Awwad *et al.* (2022), Ocicka *et al.* (2022), Murillo-Luna *et al.* (2023), and Wang *et al.* (2023). Network cohesion is crucial because it provides a 'joint effect' that stimulates the firm's green innovation (Ocicka *et al.*, 2022). According to Murillo-Luna *et al.* (2023), the positive impact of external knowledge flows on the firm's green innovation is directly proportional to the number of agents involved. In this respect, network cohesion within the supply chain is particularly important for the firm's green processes, as Wang *et al.* (2023) point out. Similarly, Awwad *et al.* (2022) report that the integration of customers and suppliers in the development of new green products strengthens the green innovation potential of firms

through the provision of external knowledge. On the other hand, Ocicka *et al.* (2022) provide evidence that firms that collaborate with both suppliers and customers are more likely to green their innovations than those that collaborate with only one set of partners because they benefit more from external knowledge. Furthermore, Ocicka *et al.* (2022) suggest that early-stage knowledge collaboration with suppliers has a greater impact on greening processes than cooperation with customers. This is because suppliers are seen as the most important actors in the supply chain working with the firm to achieve green innovation (Ocicka *et al.*, 2022).

The analysis of the final sample allowed to isolate another focus area – resource flexibility – as crucial for enhancing the relationship between external knowledge flows and the firm's green innovation. This area is considered in the studies of Ryszko (2016), Marzucchi and Montresor (2017), Burki *et al.* (2019), Sun and Sun (2021), Chen (2022), Janahi *et al.* (2022), Ma *et al.* (2022), Ozdemir *et al.* (2023) and Cheng *et al.* (2024). In this context, resource flexibility is seen as pivotal because it indicates the firm's ability to absorb and use external knowledge (Sun & Sun, 2021). In this regard, Ma *et al.* (2022) highlight the firm's ability to extend knowledge and relationships as essential for successful external knowledge flows from customers, while Chen (2022) provides evidence that high resource flexibility of a new venture allows for stronger green innovation relationships with the government than with other firms, as opposed to coordination flexibility. Another study, by Janahi *et al.* (2022), emphasises the firm's green development plans, strategic alignment and access to platforms and forums as 'critical factors' in enhancing the firm's interactions with external partners for green innovation. Attention to planning is also seen in the research of Zhang and Chen (2022), who identify strategic intellectual property planning as a 'moderator' of the relationship between external knowledge flows and green processes. Similarly, Sun and Sun (2021) report that a green innovation strategy and internal communication support external knowledge in the firm. The role of a proactive green strategy as a mediator between external knowledge flows and technological green innovation is also pointed out by Ryszko (2016). On the other hand, the commitment of the firm's management as an element of resource flexibility is raised by Marzucchi and Montresor (2017) and Burki *et al.* (2019). In this sense, Burki *et al.* (2019) suggest that the commitment of top management is key to enhancing knowledge collaboration with customers for green innovation, while Marzucchi and Montresor (2017) indicate the need for separate management of internal and external knowledge sources for green processes. According to Marzucchi and Montresor (2017), such separate management can strengthen green innovation processes. Meanwhile, the study by Cheng *et al.* (2024) shows the importance of the firm's digital capability as a support for the firm's knowledge collaboration in the green supply chain. Access to information is also seen as crucial for enhancing the relationship between external knowledge flows and the firm's green innovation. In this vein, Ozdemir *et al.* (2023) suggest that access to information related to green innovation and highly skilled human resources strengthens collaboration with suppliers and customers rather than with universities and research organisations.

The review of the research also points to a group of studies that focus on areas other than those mentioned above but are related to enhancing the firm's interactions with external partners for green innovation. In this respect, research and development R&D cooperation between members of the supply chain is of particular interest. This is evident in the studies by Chen *et al.* (2019), Ahmadi *et al.* (2020), and Dimakopoulou *et al.* (2022). In this context, Ahmadi *et al.* (2020) provide evidence that the firm's cooperation with suppliers with sufficient capital for R&D and human resource development strengthens external knowledge flows for green innovation.

Similarly, Chen *et al.* (2019) find a positive relationship of R&D cooperation between supply chain members in enhancing the firm's green processes. In contrast, Dimakopoulou *et al.* (2022) provide evidence that R&D cooperation does not affect enhancing external knowledge for the firm's green innovation. The reviewed studies also consider community and regulatory pressures. Here, Hofman *et al.* (2020) suggest a positive association of community pressure on enhancing knowledge cooperation with suppliers with firms' green process innovation. Hofman *et al.* (2020) also show that regulatory pressure has no effect on enhancing knowledge flows from both suppliers and customers. On the other hand, Abdelfattah *et al.* (2024), suggest that government involvement, through regulatory incentives for green processes, enhances public-private cooperation for the firm's green innovation. In this vein

also Chen *et al.* (2023), Srisathan *et al.* (2023), Ullah *et al.* (2023) and Buzohera (2024) emphasise the role of government in enhancing external knowledge flows. The emphasis on regulatory pressure is also notable in the work of Zhang and Wang (2022), who find that external knowledge flows between external agents for firms' green processes are stronger when environmental regulations are stricter. On the other hand, Yang and Park (2016) find a negative association between the firm's green innovation intentions and external knowledge collaboration, indicating a 'negative moderating effect of external partners' (Yang & Park, 2016) due to the difficulty of maintaining all relationships with external knowledge agents. External coordinators are also highlighted in the reviewed studies. As Urbaniec and Gerstlberger (2011) indicate, the expertise of external coordinators (*e.g.* coordinating agencies) and their organisational and facilitation skills can strengthen external flows for the firm's green innovation. Another study draws attention to the level of radicalness of green innovation as essential for the firms' cooperation with external partners (Chistov *et al.*, 2023). The area of interest in the reviewed studies was also the reduction of conflicts, which is present in Abadzhiev *et al.* (2022). In this respect, Abadzhiev *et al.* (2022) provide evidence that reducing conflicts between supply chain members is crucial for enhancing external knowledge of the firm's green innovation activities.

The above review provides insight into the understanding of external knowledge flows for the firm's green innovation. In this context, the results show a greater research interest in the field. The growing concern on how to strengthen the relationship between external knowledge flows for the firm's green innovation is particularly noticeable. The review indicates that although the number of studies relevant to this area of research is still relatively limited, many themes and research directions have emerged. Nevertheless, many of them remain fragmented and largely underexplored. This offers an opportunity to identify areas for future research. First of all, as there is a noticeable lack of cross-country and cross-regional research, future studies could address this field to explore potential interdependencies. Furthermore, it would be valuable to conduct more in-depth research on a single sector and a single type of external knowledge provider. Future studies could also focus more on a specific scope of external knowledge flows to deepen the understanding of their role in green processes.

Therefore, in light of the results of the review, the following potential future research questions were raised:

- How do countries/regions affect knowledge flows between external agents and, in particular, the firm's green processes?
- How does the enhancement of the relationship between external knowledge flows and the firm's green innovation differ between countries/regions? Are there any similarities/differences? Does the innovation of countries/regions matter?
- What is specific to a particular sector as regards facilitating the relationship between knowledge flows from external sources for the firm's green innovation? Is there a difference in this respect between different sectors? Do dependencies exist only for a particular sector?
- How can a particular external knowledge agent influence green innovation? Is there a difference between agents in their ability to collaborate on firms' green processes? Which factors determine this? Are any characteristics related to the type of agent? How can external agents/firms support knowledge flows?
- What is the role of specific external knowledge providers in enhancing external knowledge flows for the firm's green innovation? Which processes should the firm improve to make better use of external knowledge? How do firms encourage external agents to share knowledge?
- How can a particular scope of external knowledge flow influence the firm's green innovation? Is there a difference between particular scopes in terms of their impact on green processes? Is there a scope of external knowledge flows that can be considered the most important for the firm's green innovation performance?
- How does a particular agent/scope of knowledge flows affect the strength of the relationship between external knowledge flows and the firm's green innovation? What in particular hinders/enhances this relationship? Is this related to a particular sector or type of green innovation?

- What are the critical drivers that provoke enhancing external knowledge flows for the firm's green innovation? How does the type of green innovation affect these drivers? What are the appropriate measures for these drivers?

Future research could also focus more on qualitative research in this area. To better understand the enhancement of the relationship between external knowledge flows and the firm's green innovation, more longitudinal research may equally be needed. Future research could also include more studies on the drivers that support the provision of external knowledge for green processes.

CONCLUSIONS

This article has examined the relevant literature on the links between green innovation performance and external knowledge flows to further explore this area and extend the existing systematic reviews. Specifically, this research broadens previous studies by providing insights into the enhancement of the relationship between external knowledge flows and firms' green innovation as there is a severe lack of comprehensive reviews of hitherto published articles in this area. In this respect, this review contributes by integrating previous findings. The study contains an analysis of 41 articles extracted from Scopus and Web of Science. Geographical distribution, time evolution, methodology used and key findings of the research reviewed are provided. The review shows that the literature on the enhancement of the firm's interactions with external partners for green innovation is relatively scarce. The review also shows that there has been a noticeable increase in publications in this area. This indicates that the topic is of global interest. The review also suggests that research in this field raises a variety of issues.

This review offers contributions and implications for scholars and practitioners. In the theoretical sense, the review shows the ongoing concern about the issues related to external knowledge providers and the firm's green innovation.

The importance of enhancing the relationship between external knowledge providers and the firm's green processes is especially revealed indicating that despite the previous studies on external knowledge flows for green innovation, there is still a need to shed more light on issues related to enhancing firm's interactions with external partners for green innovation. The review finds that research in this area is based on a variety of methods, which may result from the complexity of the issues of external knowledge collaboration and the firm's green innovation. The review also reveals that the interest in the various external knowledge providers is still valid as external knowledge flows remain critical for green innovation. In this respect, the review shows that the results in this area are not heterogeneous. Furthermore, the results highlight a variety of research areas on enhancing the relationship between external knowledge providers and the green innovation of the firm. Specifically, established collaboration, network cohesion and resource flexibility were found to be of particular research interest. These open a space for future research in the field. The review poses some questions which can serve as proposals in this field. Relevant future research could consider more cross-country and cross-regional aspects to explore potential interdependencies. It would also be valuable to conduct more in-depth research on a single sector and a single type of external knowledge provider. In a practical sense, the review can be used by practitioners interested in the relationship between external knowledge flows for the firms' green innovation. Knowing the areas that can lead to the strengthening of such a relationship can enable the improvement of the firm's green processes. The study proposes to further improve the conditions for firms to strengthen external knowledge flows for green innovation.

Despite the implications that can be drawn from this study, there are some limitations. Firstly, the review criteria did not include conference articles or book chapters. Secondly, access to many full-text articles in English was limited. Next, the review used the main scientific indexing platforms. Studies not included in these platforms may also provide relevant evidence in the field. These limitations may pose a challenge for a future systematic review on understanding external knowledge flows for firms' green innovation. Nevertheless, this review provides some useful insights that can guide future empirical research.

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Conflict of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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