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Review Article

Open innovation in Smes: a literature review

Innovación Abierta en las PYMEs: una Revisión de la Literatura

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Abstract

Introduction: small and medium-sized enterprises (SMEs) are essential for economic development in developing countries, as they play a key role in job creation and the dynamization of local economies. Innovation is crucial for enhancing their competitiveness; however, due to limited resources, open innovation presents a viable alternative to boost their innovative capacity. Despite the importance of this approach, research on innovation in the context of SMEs remains limited.
Methodology: this paper conducts a comprehensive literature review to explore how open innovation develops in these organizations. A total of 127 academic articles were analyzed, sourced from databases such as Scopus, Web of Science, and Science Direct. The analysis focused on identifying the main strategies, challenges, facilitators, and indicators associated with open innovation, as well as the role technology plays in this process.
Results: the findings reveal a growing adoption of open innovation strategies in SMEs. The importance of innovation indicators and the use of technologies that facilitate knowledge transfer is emphasized, which is crucial given the resource limitations. Case studies and surveys are the most commonly used methods for studying this phenomenon. Furthermore, there is a growing focus on tools for engaging with customers and collaborating with large companies. Technology plays a vital role in knowledge integration and enhancing market agility.
Conclusions: despite the advantages of open innovation, SMEs face significant challenges, such as lack of funding, resistance to change, and difficulties in protecting intellectual property. However, collaboration with universities and consultants strengthens innovation ecosystems, and digital technologies play a crucial role in optimizing knowledge absorption. The risks associated with intellectual property protection and optimizing knowledge transfer processes are critical areas to address in order to improve open innovation outcomes in SMEs.

Keywords: Open innovation, SMEs, literature review.

Resumen

Introducción: Las pequeñas y medianas empresas (pymes) son esenciales para el desarrollo económico en los países en desarrollo, ya que juegan un papel clave en la generación de empleo y en la dinamización de las economías locales. La innovación es crucial para mejorar su competitividad; sin embargo, debido a los recursos limitados con los que cuentan, la innovación abierta se presenta como una alternativa viable para potenciar su capacidad innovadora. A pesar de la importancia de este enfoque, la investigación sobre innovación en el contexto de las pymes sigue siendo limitada.
Metodología: Este artículo realiza una revisión exhaustiva de la literatura existente sobre innovación abierta en pymes, con el objetivo de explorar cómo se desarrolla este proceso en dichas organizaciones. Se analizaron 127 artículos académicos obtenidos de bases de datos como Scopus, Web of Science y Science Direct. El análisis se centró en identificar las principales estrategias, desafíos, facilitadores e indicadores asociados con la innovación abierta, así como el papel que desempeñan las tecnologías en este proceso.
Resultados: Los resultados muestran una adopción creciente de estrategias de innovación abierta en las pymes. Se destaca la importancia de los indicadores de innovación y el uso de tecnologías que faciliten la transferencia de conocimiento, lo cual es clave dada la limitación de recursos. Los métodos más utilizados para estudiar este fenómeno son los casos de estudio y las encuestas. Además, se observa un enfoque creciente en herramientas para interactuar con los clientes y colaborar con grandes empresas. La tecnología juega un papel esencial en la integración del conocimiento y en la mejora de la agilidad en el mercado.
Conclusiones: A pesar de las ventajas de la innovación abierta, las pymes enfrentan desafíos significativos, como la falta de financiación, la resistencia al cambio y las dificultades en la protección de la propiedad intelectual. Sin embargo, la colaboración con universidades y consultores fortalece los ecosistemas de innovación, y las tecnologías digitales juegan un rol crucial en optimizar la absorción de conocimiento. Los riesgos asociados a la protección de la propiedad intelectual y la optimización de los procesos de transferencia de conocimiento son áreas críticas a abordar para mejorar los resultados de la innovación abierta en las pymes.

Palabras clave: Innovación abierta, pymes, revisión de la literatura.

How to cite?

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Contribution to the literature

Why was it done?

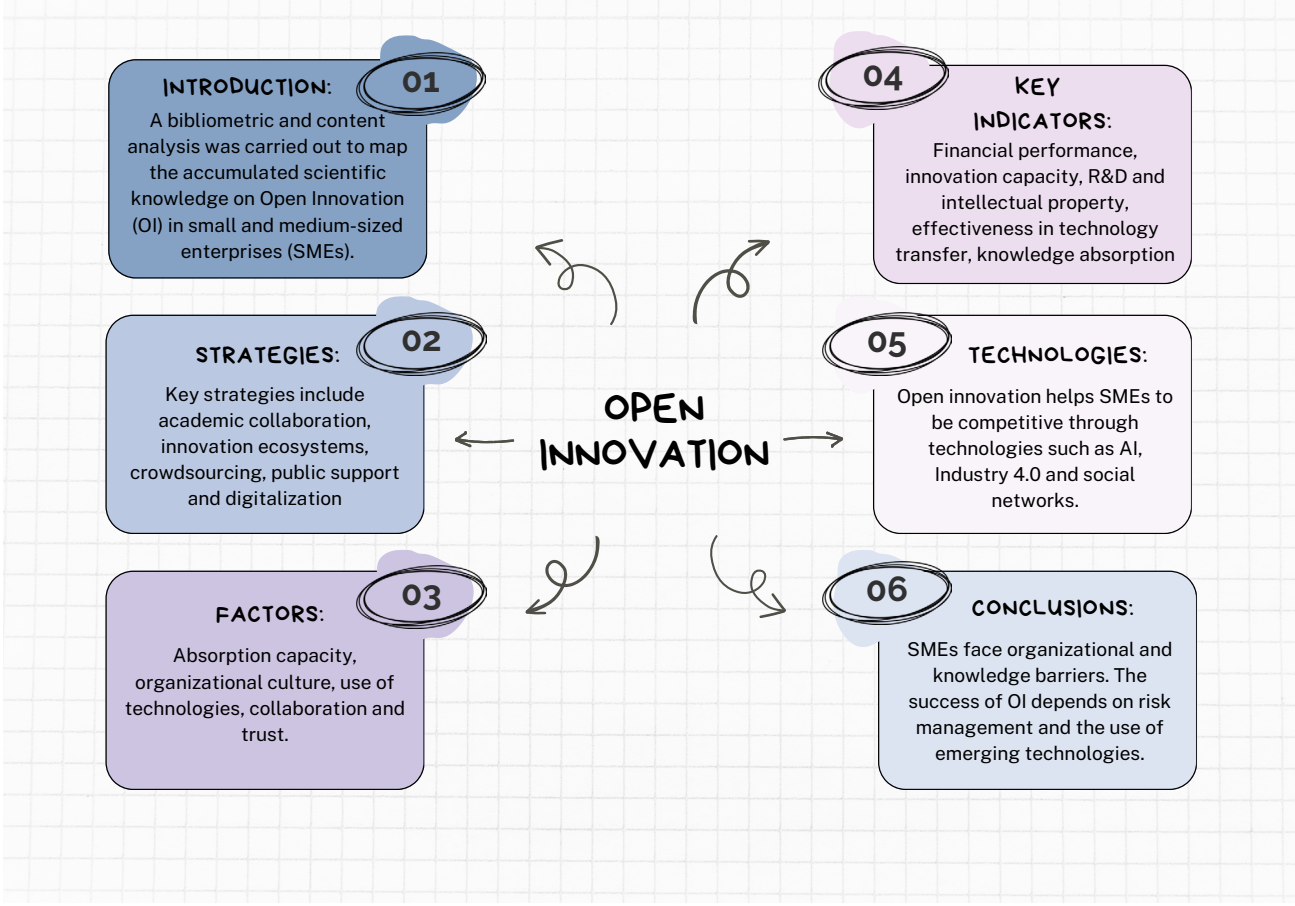
This research was conducted to analyze the discussion in the literature regarding Open Innovation in the context of SMEs, considering that these enterprises constitute nearly 100% of the business sector in Peru. Identifying previous studies in this field is essential for building a knowledge base that can serve as a reference for future research, such as case studies or action research, focusing on the Peruvian context and subsequently enabling comparisons at the Latin American level. Moreover, strengthening collaborative networks among SMEs, government agencies, and academic institutions—especially in resource constrained environments like Peru—is crucial for overcoming financial barriers and enhancing knowledge-sharing. These integrated efforts not only facilitate the effective adoption of open innovation strategies but also foster long-term growth, bridging gaps in expertise and laying the foundation for sustainable competitiveness. In this way, the findings of this study contribute not only to scientific advancement but also to the development and competitiveness of these enterprises in the Peruvian context.

What were the most relevant results?

Technology plays a crucial role in Open Innovation (OI) by facilitating knowledge transfer, agility, and market adaptation, ultimately enhancing competitiveness. Industry 4.0 technologies and social media contribute to improving operational efficiency, decision-making, and customer relationships. While R&D collaboration is beneficial, SMEs often face organizational and knowledge barriers; therefore, public policies must assess their maturity in knowledge transfer and financing. In resource-constrained countries, collaboration with academia can be highly advantageous, as joint efforts between industry and academia can accelerate the adoption of Industry 4.0 technologies, social media tools, and knowledge-transfer practices.

What do these provide results?

These initiatives not only lead to cost reductions, product enhancements, and improved operational efficiency but also position SMEs to compete more effectively in global markets. In developing regions such as ours, where access to cutting-edge technology and funding is limited, fostering OI through academic partnerships can be transformative, catalyzing innovation and solidifying the long-term viability of SMEs.



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Introduction

The open innovation (OI) term coined by Chesbrough (17). Since its introduction, it has been studied from different area of knowledge, within the main ones being management, business, and industrial engineering. OI is a paradigm where companies could and should use both internal and external ideas to create value, accelerate internal innovation, and expand markets, allowing companies to complement and enhance their internal innovative capacity without relying exclusively on sources within the company, Chesbrough & Bogers (15) define OI as a distributed innovation process based on knowledge flows (from outside to inside and from inside to outside) intentionally managed to accelerate innovation in their own market. In a more recent work from Chesbrough (18), talks about the future of open innovation, commenting that the most studied knowledge flows are from outside to inside, however, there is also the knowledge flow from inside to outside, which also occurs but is little studied and used by companies.

OI has been more applied in the context of large companies, for example, Procter & Gamble increased the efficiency of its R&D area by 60% and increased the success of its products by 50% by introducing OI in its company (24). A survey conducted by Chesbrough & Brunswicker (16) shows the main challenges that large companies face when working with OI and are related to organizational change, the management of external relationships with innovation partners, and problems with processing new ideas at the internal level, also facing the “not invented here” syndrome, the research highlights the importance of senior management’s participation in the whole process.

The study by Van de Vrande et al. (67) shows that small and medium-sized enterprises (SMEs) are increasingly adopting open innovation as a strategy to improve their innovative capacity and competitiveness. In this context, OI becomes a valuable strategy to access external knowledge and resources that are not available internally. This helps SMEs overcome challenges such as limited resources, restricted access to information, and lack of experience, by collaborating with other actors in the ecosystem, including large companies, startups, universities, among others (49).

Recently, the work of Micheli et al. (50) shows that, thanks to government support and funding, the interest of SMEs in Europe in adopting OI has increased; significant benefits are observed such as cost reduction and a greater ability to quickly adapt to environmental changes. Despite OI being encouraged in this environment and these SMEs benefit from external collaborations to innovate, they face challenges that the literature mentions and that limit the success of these collaborations such as: (a) lack of resources, (b) absence of an innovation culture, (c) resistance to change, (d) limited absorption capacity (63; 66).

In order to understand the progress in the discussions that OI in SMEs environments has had, this article depicts a literature review, which includes a bibliometric analysis and content analysis, whose considered categories are: open innovation strategies, factors that affect OI (whether these are facilitators or challenges to overcome), indicators, and technologies.

The results show that there is a certain trend towards the growth of publications related to OI in SMEs, indicating an increasing interest in this field. the majority of the literature focuses on the

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benefits and challenges of implementing open innovation strategies, with a particular emphasis on the role of technologies as facilitators used to measure the success of OI in SMEs. Furthermore, the factors that affect OI are often discussed in a general context, without taking into account the unique characteristics and constraints of SMEs. therefore, future research should aim to develop specific frameworks and models for OI in SMEs, taking into consideration their specific needs and limitations.

Overview, it is observed that OI can be a highly effective strategy for SMEs. Most of the studies reviewed found a positive relationship between the use of OI and business performance. Mainly, it was found that SMEs that adopt OI practices tend to be more innovative and competitive in the market. This can be especially important for SMEs, which often have limited resources to invest in research and development. However, it is crucial to maintain the public funding and support policies that are used to attend SMEs in their innovation activities, thus contributing to economic growth. Given their size, these companies are more likely to face financial limitations and access to specific knowledge order to innovation (43). Therefore, it is essential to foster R&D collaboration with external knowledge providers. Open innovation networks can be a useful tool for the exchange of multiple types of knowledge by a variety of actors who play heterogeneous roles in relation to different types of knowledge (27) (37).

Despite SMEs being globally recognized as key drivers of economic growth and job creation, their innovation capacity remains constrained by limited resources, restricted access to advanced technologies, and lower participation in knowledge networks, while existing studies have extensively explored OI in large corporations, its impact on SMEs, mainly in emerging economies, has received limited attention. This work addresses this gap by providing a systematic analysis of how SMEs can effectively adopt OI strategies, considering their unique constraints and the transformative potential of emerging technologies of Industry 4.0 and digital collaboration networks.

Methodology

The method employed is a literature review, using bibliometric analysis and content analysis, given the benefits that each of these methods offers. Bibliometric analysis is useful for mapping accumulated scientific knowledge and its evolution in fields of knowledge, and thus making sense of large volumes of unstructured data in a rigorous way, this allows researchers to obtain a complete overview, identifying knowledge gaps and novel ideas for research (22).

In order to ensure a comprehensive review of the existing literature, we employed a systematic search equation that combined multiple keywords linked by Boolean operators. Specifically, we used:

(“open innovation” AND “sme”) OR (“open innovation” AND “pyme”) OR (“open innovation” AND (“technology” OR “Industry 4.0”)) OR (“open innovation” AND (“smart” OR “factory” OR “manufactory”))

These keywords and truncations were strategically selected to capture a broad range of studies focusing on open innovation in small and medium-sized enterprises. We included documents

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that addressed open innovation in the context of sme, with additional terms related to emerging technologies and Industry 4.0 to capture any research that might otherwise be overlooked. As our analysis progressed, we applied inclusion and exclusion criteria based on the document's title, abstract, and scope alignment with open innovation in SMEs, thereby narrowing the final corpus to studies that directly contributed to answering our research questions.

For the literature review, the databases Scopus, Science Direct, and Web of Science were used, limiting the search to only full research articles published between the years 2018 to 2023, within the areas of knowledge of: management, engineering, business, management & accounting, decision science, this research no considers book chapter, books, conference paper and reviews. The keywords used for the search were: open innovation and SMEs. With this initial search, 250 articles were selected, whose distribution within the databases is detailed in the table 1, that provides an overview of the publication distribution across databases, this reflects the most common sources referenced in open innovation literature for SMEs.

Table 1. Distribution of Publications in databases

Databases & Number of Publications	
Scopus	34
Science of Direct	148
Web of Science	68
Total number of publications	250

Note: The table shows the number of publications considered for this study.

A database cross-referencing process was conducted to eliminate 18 duplicate articles, resulting in a total of 232 articles. Subsequently, 24 articles were excluded due to the journal's thematic orientation, and the abstracts of the remaining 208 articles were reviewed. A further 81 articles were removed from the analysis as they were not related to the research focus; specifically, they did not address open innovation in the context of small and medium-sized enterprises. This left 127 articles for content review and analysis.

The analysis employed the following categories: open innovation strategies, open innovation facilitators, challenges encountered, indicators, and associated technologies.

The bibliometric analysis was conducted using VOSviewer software to map the most frequent terms and collaborative networks in publications on open innovation in SMEs. The selection criteria for the articles included peer-reviewed status, relevance to the topic, and a publication range. The analysis excluded studies that did not directly address open innovation in the SME context. Following the initial search, data cleaning was conducted to remove duplicates and irrelevant studies.

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Results

In this section, the findings of the review are presented, which reflect the behavior of publications over the past few years, methodologies used. Within the content results, the strategies used within the OI, the factors that affect it, the indicators for its measurement, and finally the role of technologies within the OI in the SMEs environment were observed. The bibliometric analysis of the 127 selected articles reveals an upward trend in the number of publications in recent years, suggesting a growing interest and emphasis on IoT in the SME environment. This increase can be attributed to both rapid technological advances and their increased accessibility, as well as an increased awareness on the part of SMEs of the potential benefits of integrating IoT into their operations. Although not all categories identified in the literature have uniform relevance to all SMEs, they are aligned with the parameters of IoT recognized in the studies. Therefore, they serve as a basis for generating new knowledge on the effective application of IoT in SMEs.

The Figure 1 shows the percentage distribution of the different methodologies applied in the research analyzed. This graph provides a clear view on the frequency of use of each methodology in the case studies, highlighting the methodological preferences and trends in the field of IoT for SMEs. "Case Study" approach, as it allows for a more in-depth exploration of real cases in various contexts. However, its findings cannot be generalized. Additionally, it is observed that quantitative methodologies, such as modeling and simulation, represent an opportunity for future studies on open innovation in SMEs.

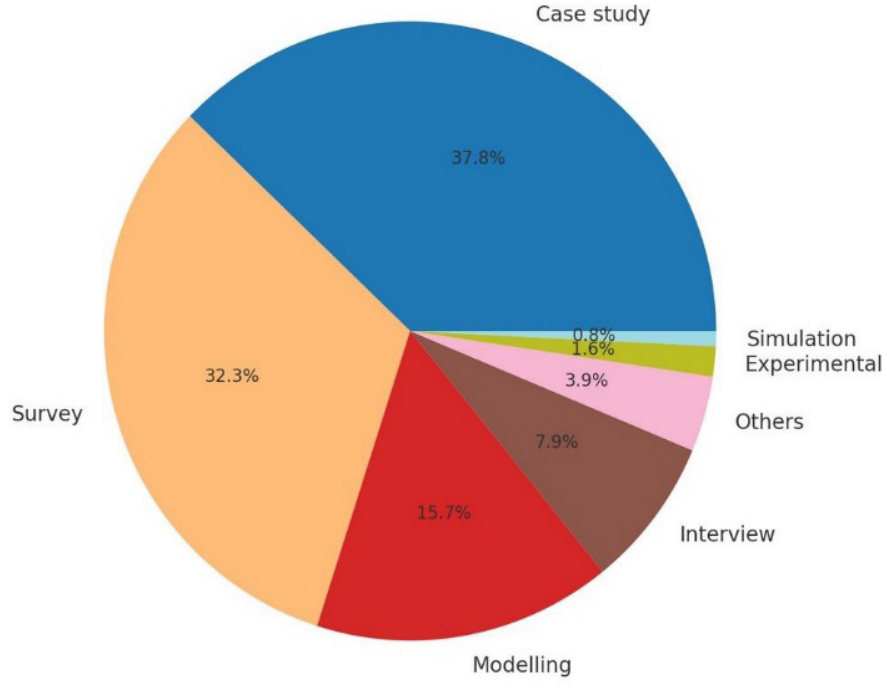

Figure. 1. Methodology percentage

The figure 2 illustrates the evolution of publications over the years, showing that interest in innovation topics within SME environments remains consistent. This trend is driven by the fact that SMEs constitute a significant portion of the global business landscape and play a crucial role in

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economies. Innovation enables them to enhance their competitiveness and sustain their market presence.

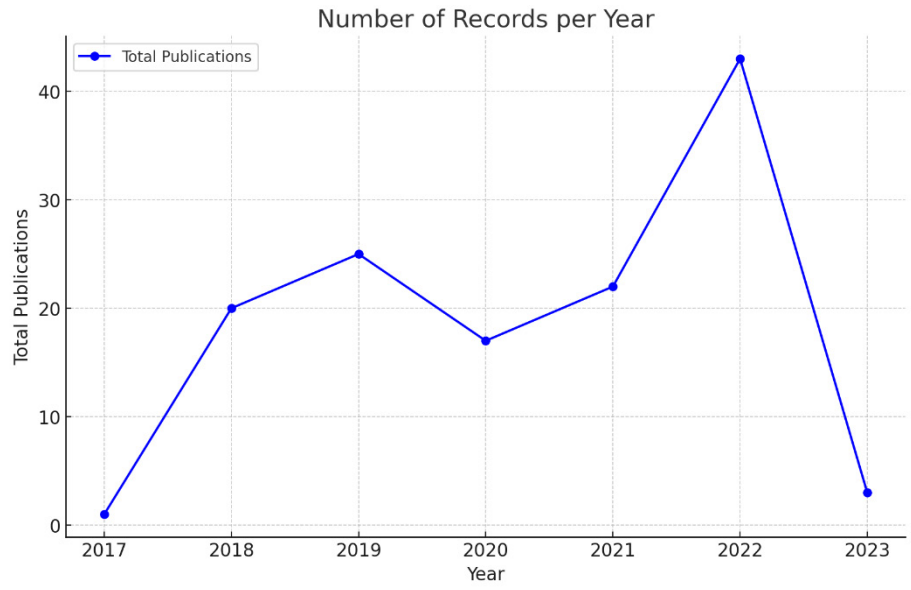

Figure. 2. Evolution of Publications

Figure 3 shows the number of publications in the 10 most common journals, classified according to the research methodology used. This graph shows how some journals, such as Sustainability and Journal of Business Research, cover a variety of methodologies, while others tend to prefer specific approaches. This distribution reflects the predominant methodological preferences and approaches in the publications of each journal.

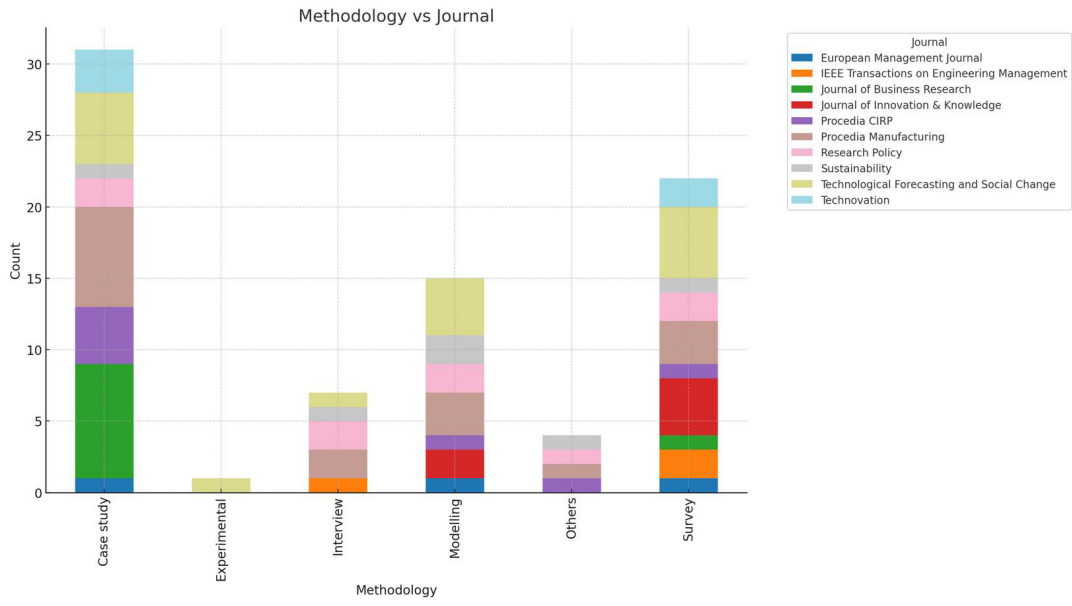

Figure. 3. Number of publications by journal

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This graph 3 illustrates the number of publications for each of the top 10 most common journals, categorized by the publication methodology. Some journals such as 'Sustainability' and 'Journal of business Research', incorporate a variety of methodologies whiles others appear to favor certain methodologies over others.

The data reveal a marked increase in the adoption of open innovation among SMEs, driven in part by digitalization and improved networking capabilities. This trend highlights the role of digital technologies and online platforms in facilitating knowledge exchange and collaborative projects. For instance, SMEs that incorporate cloud-based tools or customer relationship management (CRM) systems are better positioned to integrate external knowledge and enhance their competitive edge. Furthermore, these findings underscore the importance of government support and policy initiatives that enable resource-limited SMEs to overcome barriers to innovation and growth.

Figure 4 presents a graph of the 20 most searched keywords in the field of OI in SMEs. This chart facilitates a visualization of the key concepts and shows the themes that are recurrent in the literature on the subject, providing a comprehensive overview of the most relevant terms in this field.

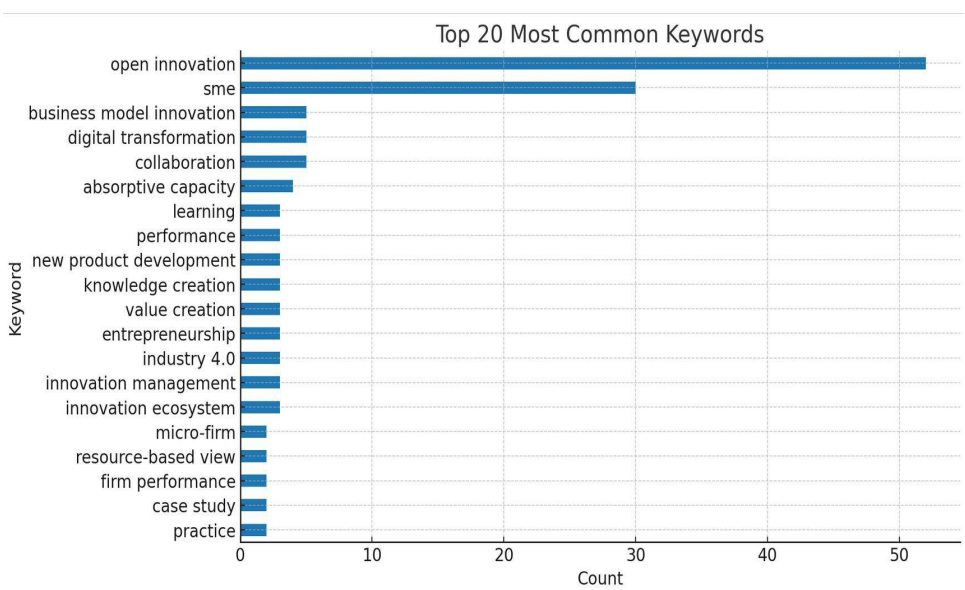

Figure. 4. Top 20 keywords

Content Analysis

The results of the content analysis are presented according to the established categories: 4.1 the strategies used to work the OI in the SME environments, 4.2 factors that affect the OI in SME environments, refers to those aspects or elements that collaborate or hinder the development of the OI, in the investigations both positive and negative experiences are observed, 4.3 the indicators are also an interesting category to be considered, in the literature various articles have given it

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importance, since it is necessary to measure what positive results or not, are being produced with the use of OI in the SME environment, and 4.4 technologies, which increasingly have gained space in all business environments and innovation is part of the advancement and use of technologies in itself.

Strategies

OI is a distributed innovation process based on knowledge flows Chesbrough & Bogers (15) that benefits companies, as it allows SMEs to access a greater diversity of ideas and resources to drive the development of new products and services, which in turn increases their competitiveness and growth in the market (60), but it is more common to observe how external knowledge is brought to companies, however they present some resistance in sharing the knowledge generated internally, that is, from inside to outside (6), aspect also mentioned by Chesbrough (18).

SMEs can use different OI strategies (67), Aschehoug et al. (6) mention that the ways in which companies collaborate with suppliers, customers, and competitors, the use of online platforms to share knowledge, the size of the company and the sector can influence the OI strategy they use. Also, the literature highlights that internationalization can be of great benefit to SMEs (39) and to national innovation systems (54).

The following are key open innovation strategies utilized by SMEs

Academic Support: This serves as an open innovation strategy for SMEs that lack funds for research and development (R&D), as outlined by Aschehoug et al. (6). However, research shows that cooperation with research institutions and universities doesn't seem to significantly contribute to innovation output (65), even though it could reduce R&D costs for SMEs (44). Another way to collaborate with academia is through Teaching Factory; this refers to a methodology where businesses collaborate with educational institutions to develop practical projects and solutions to real business problems. Thus, students gain experience in real industrial use cases, while the industry tests a variety of novel technologies that would be expensive to integrate into current production if not worked with academia (4; 52).

Participation in Clusters and/or Innovation Ecosystems: This is complex and dynamic, determined by different actors such as regional governments and their public policies, research centers, universities, and institutes (31; 67). Within these ecosystems, promoting collaboration and knowledge ex- change to create value for each participant is crucial. Additionally, the importance of access to financing and resources by leveraging other members of the innovation network is highlighted (31). An open environment for promoting innovation among three or four actors: organizations/companies, end users, academics, and optionally, public organizations, involving demonstrations, training, and learning processes is suggested (24; 35). Different forms of orchestration are propose within innovation ecosystems, (47) identifies three distinct patterns of orchestration ecosystems: single, double, and multiple orchestration. It highlights that the degree of innovation within an ecosystem tends to be higher in settings involving diverse orchestrators. Because, the varied expertise and perspectives contributed by multiple actors, fostering a richer and more dynamic environment for innovation.

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Crowdsourcing**:** This is an open innovation strategy, which involves obtaining services, ideas, or creative content by requesting contributions from a large group of people, especially online or through social networks and other digital platforms (34). Intermediaries can help applicants bridge the knowledge gap and obtain effective solutions to problems, providing suggestions to maximize the benefit of open innovation (55).

Collaboration among Companies: Collaboration between suppliers and customers is the most common (6), where reciprocity in knowledge exchange with supply chain partners is important for overall innovation progress (65). Collaborations like "Crowd Engineering" involve customers, suppliers, partners, subject matter experts, and other collaborators in the network, contributing their ideas to create a final product that meets the needs and desires of end users (1).

Support from Public Entities (Government): SMEs can benefit from public institution support, but effective utilization depends on the characteristics that the company possesses, such as its absorption capacity (68). The government plays a crucial role in supporting the development of local businesses and creating a business ecosystem (58).

Technological Development and Digital Transformation Strategies: These improve collaboration and transparency among the different actors involved in open innovation (7; 28; 36; 59). Social networks: the use of social networks as a tool for the open innovation process is perceived as a strategy that emphasizes personalization, being a closeness environment where they interact with customers or with the community, business partners, and suppliers (13; 34).

In the strategies identified in the review, the presence of some stakeholders stands out: the government is one of them, and its role in financing more SMEs to adopt OI is mentioned. Other companies, as customers and suppliers, are one of the main allies when deciding to work with OI. Academic institutions as key entities for the transfer of knowledge and technologies, as well as other intermediaries and financiers, play an interesting role in articulating and making possible some of the strategies mentioned above. Table 2 shows some of the articles that highlight the role of these actors in the context of open innovation. This table provides a clear reference on the specific contributions of each actor in the strategies analyzed.

Table 2. Stakeholders vs articles

Stakeholders	**Papers**
Government	Brock et al. (11), Kleine et al. (43), Petraite et al. (54), Šebestová et al. (58), Jemala (38)
Companies (customers and suppliers)	Stanislawski (60), Weidner et al. (70), Larsen & Lassen (45), Török et al. (65), Lalic et al. (44), Belitski and Rejeb (8)
Academic Institution	Aschehoug et al. (6), Weidner et al. (70), Vega-Jurado et al. (68), Alhusen et al. (5), Teixeira & Ferreira (60), Mourtzis et al. (53), Moon (52), Albats et al (4).
Financiers	Albats et al. (4), Tsakalerou & Akhmadi (64), Teixeira and Ferreira (63)
Intermediaries (crowd-sourcing management)	Xu et al. (72), Pollok et al. (55)

Note: The table shows the different stakeholders considered in each article reviewed

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Factors that affect OI

The absorptive capacity stands out as one of the main factors affecting OI due to its significance in the acquisition and assimilation of new external knowledge as a potential source of competitive advantage (46). Given its reliance on individuals primarily, this capacity becomes even more relevant in the context of SMEs, where there is typically no R&D department and dependence on individuals in innovation activities, which are less institutionalized at the organizational level (70). Companies with higher absorptive capacity are more likely to leverage external knowledge and effectively utilize it to enhance their innovative performance (2; 31; 45). It is also relevant for collaborations between companies and universities, where the involved parties must possess an adequate level of knowledge to foster synergies (4). Conversely, if a company fails to develop absorptive capacities, it will hardly be able to implement open innovation. In other words, without the ability to efficiently acquire, assimilate, and apply new knowledge and technologies, organizations cannot implement innovations or innovation policies (18; 20; 45).

Additionally, Weidner et al. (70) suggest that developing tolerance for failure is crucial for the assimilation of new knowledge and the application of innovative technologies.

A flexible organizational culture is favorable for the adoption of OI policies (27; 31; 58). (21) Likewise, the organization's ability to integrate different cultures and perspectives, seeking cultural balance, is necessary to avoid internal resistance and cultural conflicts within the company (3; 45). In a research study conducted by Limaj & Bernroider (46) that analyzed whether balanced organizational cultures moderate the effects of absorptive capacities in a sample of 138 SMEs, it was found that the positive effects of absorptive capacity on innovation depend on the cultural equilibrium that the organization develops. Another study conducted by Erol & Klug (25) established that the culture of companies in the Austrian region was characterized by cooperation and showed a positive impact on the development of an open innovation laboratory.

The results of the absorptive capacity analysis show that it is key for SMEs to adopt and integrate open innovation (OI) into their processes, enabling them to acquire, assimilate and apply external knowledge in their operational strategy. Beyond adopting new technologies, this capability involves continuous learning and adaptation, which is crucial in companies that, lacking formal R&D departments, rely on the skills of their employees to innovate. Likewise, collaboration in OI with external actors, such as universities and innovation intermediaries, is essential for knowledge sharing and value creation, but it is only effective if the company has a solid absorptive base that facilitates synergy between internal and external knowledge (29).

Another cultural aspect that can affect innovation processes is when a company often underestimates the customer's opinion. In many cases, managers or executives of SMEs do not consider the relevance and value of customer opinions in developing innovations, which results in missed opportunities to develop innovative products. This limitation hinders customer participation and undermines their contributions (1; 10).

The use of technological tools such as cloud computing, artificial intelligence, virtual reality, online platforms, and social networks can help connect relevant actors and facilitate collaboration in

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innovation projects, even overcoming geographical barriers. These tools are crucial for SMEs as their lack of resources and expertise can make managing complex collaboration processes more challenging (1; 10; 19; 28; 36). According to the findings of Gaglio et al. (26), SMEs in South Africa that utilize social networks and mobile phones experience positive effects on innovation as it facilitates knowledge exchange among ecosystem members.

Trust is crucial for coordination and collaboration in innovation ecosystems, given their complexity and dynamism involving various actors such as government and its public policies, research centers, universities, and institutes (31; 67). Trust relationships are essential for information ex- change and successful implementation of open innovation in companies (1; 10; 28; 52).

The significance of proper ecosystem network management and a robust innovation policy, with clear procedures for information exchange, will strengthen trust and enhance communication among the involved actors (1; 8; 18; 59; 68). A relevant aspect is the perception that the shared information is relevant and useful, as these fosters trust in continuing to share information (6).(56)

Having resources is mentioned as one of the factors influencing the adoption of inbound open innovation practices by SMEs (3) (23). However, when it comes to SMEs, they face resource limitations in engaging with open innovation due to their company size and organizational structure (18; 45), making it primarily a constraining factor in this case.

The analysis shows that the use of technological tools such as cloud computing and social networks is fundamental for small and medium-sized enterprises (SMEs) to connect and collaborate in innovation projects, overcoming geographic barriers and compensating for their limited resources and experience (62). Trust emerges as a key element in these innovation ecosystems, as it facilitates the flow of information and effective collaboration among diverse actors, including governments, universities and research organizations. However, SMEs face several challenges, such as underestimation of user opinions and difficulty in establishing trusting relationships, which can limit their ability to innovate and take advantage of valuable opportunities (61). In addition, limitations in the absorption of new knowledge and cultural imbalance within organizations complicate the implementation of innovation policies. These constraints, together with the lack of financial resources and trained personnel, make it even more difficult for SMEs to participate in open innovation processes, highlighting the need for appropriate strategies to foster collaboration and improve communication in these environments.

Key Indicators

Financial Performance: open innovation can enhance the financial performance of SMEs by enabling them to adopt new technologies and reduce costs. A case study in organizational innovation and cost reduction analysis in manufacturing processes shows how the implementation of Industry 4.0 technologies and collaboration with external partners can increase operational efficiency and generate significant savings in production costs (15).

Innovation Capacity: innovation capacity is crucial to improving sustainability in SMEs, especially in emerging economies. A study on the role of innovation capacity in enhancing sustainability in SMEs

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in an emerging economy context points out that companies with a higher innovation capacity are more likely to survive and thrive in the long term (30).

Research and Development (R&D) and Intellectual Property: R&D activities and intellectual property protection are essential for driving open innovation in SMEs. A study on the impact of the type of innovation on R&D capability and intellectual property in SMEs shows that companies that invest in R&D and protect their intellectual property through patents and other legal mechanisms are more likely to develop new and innovative products and services (42).

Effectiveness in Technology Transfer: technology transfer to SMEs can be facilitated through the adoption of project- based approaches. A study on how to foster innovation in SMEs provides evidence of the effectiveness of a project-based technology transfer approach, which enables companies to access new knowledge and technological resources and apply them in their operations (33).

Knowledge Absorption: the ability to absorb knowledge is crucial for SMEs participating in collaborative in- novation networks. A study on SMEs in collaborative innovation networks discusses how to measure their knowledge absorption capacity and highlights the importance of having adequate mechanisms to identify, evaluate, and apply knowledge acquired from external sources (9; 66).

A recurrent theme discussed in several reviewed articles is the role of technology. Previous studies by Sabando et al. (57), Usman et al. (66), Hossain (33), Carrasco et al. (12), and Sikandar & Abdul Kohar (59) underscore the significance of technological tools as enablers of open innovation. The following section presents the key findings related to this topic.

Technologies

Open innovation has become a key approach for small and medium-sized enterprises (SMEs) seeking to stay competitive in a globalized and constantly evolving business environment. Emerging technologies, such as Industry 4.0, Artificial Intelligence (AI), Information Technology (IT), social networks, and CRM, play an increasingly important role in promoting open innovation in SMEs. Reviewed articles explore how these technologies can assist SMEs in boosting open innovation and enhancing their innovation capacity (31; 40; 47; 50; 65).

Improving Operational Efficiency: the adoption of Industry 4.0 technologies, such as automation, the Internet of Things (IoT), and additive manufacturing, can significantly enhance efficiency in production and resource management in SMEs. By optimizing production processes and reducing operational costs, SMEs can improve their financial performance and allocate additional resources to research and development (R&D) activities that drive open innovation (12; 41) (32).

Facilitating Data-based Decision Making: the implementation of artificial intelligence and machine learning enables SMEs to analyze large amounts of data to identify trends, patterns, and opportunities (48). By utilizing advanced data analytic and machine learning techniques, SMEs can make more informed decisions, which improves the innovation capacity and allows for the development of more relevant and competitive products and services in the market (40) (69).

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Improving Collaboration and Communication: information technology and social networks can facilitate collaboration and communication between SMEs and their partners in the value chain, including suppliers, customers, universities, and research institutions. By enhancing communication and knowledge exchange, SMEs can benefit from the experience and resources of their partners to drive open innovation and cocreation of value (40; 57;71).

Increasing Customer Engagement: social networks and social CRM tools can help SMEs interact with their customers more effectively, which in turn can increase customer engagement and provide valuable insights for the development of new products and services. By better understanding the needs and preferences of their customers, SMEs can develop innovative solutions that meet market expectations and generate a competitive advantage (41; 55) (14).

Promoting the Adoption of Data-based Open Innovation Approaches: the adoption of data-based open innovation approaches, such as data mining and big data analysis, can provide SMEs with valuable insights into their markets and customers. By utilizing this information, SMEs can identify market opportunities, anticipate trends, and develop more effective open innovation strategies (41; 57).

Limitations

One of the most significant limitations we encountered was the high paywall cost associated with several key journal articles that fell within our search equation parameters. Even though our keywords yielded a robust set of results, many potentially relevant sources remained inaccessible due to prohibitive subscription fees. This financial barrier might have inadvertently narrowed the scope of our dataset.

Furthermore, while our methodology helped capture a wide range of academic works, we recognize that the rapidly evolving nature of open innovation—particularly in technology-driven contexts—means that new findings may emerge faster than they can be catalogued in traditional academic databases. Finally, the diversity of SMEs contexts across different regions (with varying economic, cultural, and political environments) makes direct comparisons challenging. Future research could benefit from complementary qualitative methods or in-depth case studies in underrepresented regions to generate a more holistic, globally relevant perspective on open innovation in SMEs.

Key Contributions

The table N° 3 summarizes the most relevant findings and authors contributions on open innovations in SMEs, organized by thematic focus (strategies, challenges, indicators and technologies). This structured overview highlights the collective insights from leading studies, offering a snapshot of how different aspects of open innovation intersect and where new research might deepen existing knowledge.

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Table 3. Consolidate Overview of major contributions and their focus areas in open innovation research

Focus Area	Key Authors	Main Contributions
Strategies	Chesbrough & Bogers, Aschehoug et al.	Defined inbound/outbound open innovation flows; documented collaboration models with universities, suppliers, and customers
Challenges	Van de Vrande et al., Limaj & Bernroider	Identified resource constraints, cultural resistance, and absorptive capacity as major hurdles for SMEs.
Indicators	Heenkenda et al., Benhayoun et al.	Proposed measures of innovation performance, financial returns, and R&D outputs specific to SMEs.
Technologies	Gaglio et al., Michna & Kmieciak (51)	Demonstrated how Industry 4.0, AI, and digital tools facilitate collaborative networks and accelerate open innovation.

Note: The table shows the different stakeholders overview of major contributions

Conclusions

From the literature review, it was observed that the most used methodologies in order to discover OI practices in SMEs are the case study and the use of surveys. The research trend in this topic is to investigate technologies that emphasize the interaction with customers and working in conjunction with big firms by knowledge transferring technologies.

Promoting collaboration in R&D with external knowledge providers can be beneficial; however, SMEs may encounter organizational and knowledge barriers to seize these opportunities. Therefore, it is suggested that innovation-oriented public policies should conduct a prior diagnosis to determine the maturity of SMEs in terms of knowledge transfer and financing. It is important to consider that not all companies possess the necessary knowledge to properly take advantage of these opportunities and may face difficulties in incorporating acquired knowledge into their business model, which could limit their sustainable development and long-term problem-solving capabilities.

A company's ability to benefit from open innovation can depend on a variety of internal and external factors. Internally, a company's innovation capacity may depend on its ability to develop new competencies in marketing and commercialization, as well as its capacity to integrate external knowledge with existing internal knowledge. Externally, innovation capacity may depend on its ability to develop effective relationships with its open innovation partners.

The findings of this review emphasize the central role of technology in successfully implementing open innovation strategies within SMEs. Specifically, digital tools not only enable more effective

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knowledge transfer but also foster agility and responsiveness to market changes. The data indicate that SMEs engaging in open innovation, especially through digital means, show improved competitive positioning and innovation capacity. Future studies should explore frameworks for enhancing SME readiness for digital integration, while policy recommendations should aim to provide targeted support for technology adoption in resource-constrained environments.

There are several indicators that can be used to measure the performance of open innovation in a company. Some of the most common ones include the number of registered patents, the number of new products launched in the market, and revenue growth. However, these performance indicators can vary depending on the industry and the type of innovation. Therefore, it is crucial for companies to select the appropriate performance indicators to assess the success of their open innovation strategy.

Managing the risks associated with open innovation can be a key factor in the strategy's success. Effective risk management can help companies identify and address potential obstacles that may arise during the implementation of the strategy. Some of the risks associated with open innovation include lack of intellectual property protection and potential loss of control over innovation.

Open innovation in SMEs is driven by a variety of indicators and emerging technologies. These technologies, including Industry 4.0, Artificial Intelligence, Information Technology, social networks, and CRM, offer significant opportunities for SMEs to improve their performance, increase operational efficiency, facilitate data-based decision-making, enhance collaboration and communication, and increase customer engagement. Additionally, the adoption of data-based open innovation approaches can provide valuable information for driving innovation and business growth in SMEs.

The increasing adoption of OI strategies by SMEs, especially through digital technologies such as IoT, artificial intelligence, and collaborative platforms, underscores the potential for growth and competitiveness in this sector. However, significant challenges persist, including limited knowledge absorption capacity, cultural resistance to change, and financial constraints, which hinder the full implementation of these practices. Successful cases form the literature highlight the critical role of collaborative networks and government support in overcoming these barriers. For example, public policies that fund innovation projects of facilitate technology transfer between universities and companies have proven effective in fostering inclusive innovation ecosystems.

Collaborations between universities, industries, consultants and companies have proven to be very useful in improving connections in innovation ecosystems. These collaborations create new networks and strengthen existing ones. The results show that, after implementing inclusion strategies, universities become more important within these networks, helping to connect key actors and fostering innovation. However, although these initiatives are valuable, more work is still needed to consolidate these connections and improve the innovation capacity of small and medium-sized enterprises (SMEs).

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Based on some identified gaps, future research should explore how SMEs can strengthen their collaboration with larger firms and optimize knowledge transfer within the framework of open innovation, leveraging Industry 4.0 technologies. Additionally, it would be highly valuable to develop diagnostic tools to assess SMEs maturity in areas such as knowledge transfer and access to financing. These findings could contribute to designing innovation-oriented public policies.

Furthermore, research should focus on how SMEs can enhance their absorptive capacity to leverage new knowledge from open innovation and improve their competitiveness. Another key area of study is how SMEs can manage risks associated with open innovation, such as intellectual property protection and potential loss of control over innovation, to foster greater participation in innovation networks. Case studies could also provide insights into how emerging technologies—such as artificial intelligence, cloud computing, and social media—impact SMEs open innovation capacity. Moreover, future studies should aim to develop performance indicators tailored to open innovation strategies, considering industry-specific variations. Finally, deeper research is needed on risk management in open innovation, particularly regarding intellectual property protection, which has been identified as a critical research area.

CRediT authorship contribution statement

Conceptualization - Ideas: Ana Villanueva-Llapa. Data Curation: Nilton Anchayhua, Ana Villanueva-Llapa, María F. Zúñiga-Núñez. Formal analysis: Nilton Anchayhua, Ana Villanueva-Llapa, María F. Zúñiga-Núñez. Investigation: Nilton Anchayhua, Ana Villanueva-Llapa, María F. Zúñiga-Núñez. Methodology: Nilton Anchayhua, Ana Villanueva-Llapa. Project Management: Ana Villanueva-Llapa. Software: Nilton Anchayhua. Supervision: Nilton Anchayhua, Ana Villanueva-Llapa. Validation: Nilton Anchayhua . Visualization - Preparation: María F. Zúñiga-Núñez. Writing - original draft - Preparation: Nilton Anchayhua, Ana Villanueva-Llapa, María F. Zúñiga-Núñez. Writing - revision and editing - Preparation: Nilton Anchayhua, Ana Villanueva-Llapa, María F. Zúñiga-Núñez.

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