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ECOSYSTEM SMARTIFICATION

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1. INTRODUCTION

Artificial intelligence (AI) refers to devices that perform cognitive activities that, in general, are associated with human mental capacity, such as learning, interaction and problem solving (Nilsson, 1971). The evolution of AI opens new opportunities for companies to create products, services, and business models (Akter et al., 2023; Favoretto et al., 2022) and consequently impacts how collaboration with partners is structured to create solutions (Sjödin et al., 2021). Companies are reacting to the evolution of AI with the smartification of their ecosystem (Sjödin et al., 2021; Stahl, 2022).

Based on Adner's (2017) definition, where an ecosystem refers to the "alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize", this research posits that ecosystem smartification refers to the structural alignment of the set of partners with the goal of creating AI-based solutions. For example, Google and Tesla have structured ecosystems that exploit AI to increase their revenues with advanced features for autonomous vehicles. This structuring involved empowering actors, attracting new actors, defining new governance structures, defining new activities and links between the actors involved (Kohtamäki et al. 2019). Microsoft in addition to offering AI solutions in cloud computing with Azure, has modified its ecosystem to offer AI-powered solutions for smart manufacturing (Ricci, Battaglia & Neirotti, 2021). Caterpillar explores a rich ecosystem with AI-based solutions to provide reliable products and efficient service to its customers (Subramaniam, 2020). However, many collaborations for the development of systemic-level innovations applying AI fail to meet expectations due to the absence of ecosystem redesign to ensure the creation and capture of value with AI (Akter et al., 2023; Burström et al., 2021; Sjödin et al., 2021).

Previous research highlights the relevance of the redesign of structure (Favoretto et al., 2022; Kamalaldin et al., 2021) and ecosystem governance to provide for the creation of AI-based solutions (Li et al. 2022). Indeed, ecosystems is one of the emerging and increasingly important topics to research (Thomas & Autio, 2019). However, smartifying an ecosystem to create AI-based solutions is a complex task that does not only involve redesigning its structure and governance (Stahl, 2022). For example, the focus on developing AI-based solutions changes the ecosystem's value proposition and the profile of the actors involved (Jocevski, Ghezzi & Arvidsson, 2020). Therefore, a crucial obstacle for ecosystems is to adjust their practices, plans and governance, and the consequences may be incompatible with those of their partners, presenting threats to the implementation of these new guidelines and regulations to manage these complex elements within the ecosystem (Cennamo et al., 2020; Linde et al., 2021). Thus, despite the potential in the smartification of the ecosystem, in reality most focal companies involved in the smartification process face difficulties or even fail to fully take advantage of its benefits (Burström et al., 2021).

Research addresses different perspectives on how ecosystems can be digitized and deliver digital value. For example, digital servitization (Chen et al., 2021; Favoretto et al., 2022; Hsuan, Jovanovic & Clemente, 2021), digital entrepreneurial ecosystem (Endres, Huesig & Pesch, 2021; Sussan & Acs, 2017) and digital ecosystem (Subramaniam, 2020), but the literature on the process of ecosystem redesign due to the impact of AI faces a lack of definition.

Given the above, it is true that, despite the considerable amount of research carried out in the area of ecosystems related to digital technologies, there are still many unknown aspects about the reconfiguration of the ecosystem with the aim of creating AI-based solutions.

First, there is a need for a better understanding of the ecosystem *redesign* process for smartification. Despite previous literature providing much important information on how ecosystem transformation can be facilitated (Burström, et al., 2021; Kolagar, Parida & Sjödin, 2022), we still have no explanation of how the *redesign* process for creating AI-based solutions is carried out. In fact, it is necessary to understand how the value proposition and structure of the ecosystem is modified in order to deliver AI-based solutions. Understanding what the design of data governance and AI looks like becomes imperative to smartify the ecosystem (Buhalis & Leung, 2018; Mosterd et al., 2021).

Second, the literature still lacks a full understanding of how new AI and data governance structures can be experimented, and the AI scalability strategies and the new AI-based value proposition validated, as the experimentation of the proposed redesign of ecosystem can be influenced by many factors that can affect how ecosystem management should prepare for smartification and its further expansion (Chen et al., 2021). In this way, it is necessary to understand how to deal with the emergence of AI learning and the tensions generated in the transition to the new smartified ecosystem. This will provide a solid foundation for making strategic smartification decisions. Understanding how to experiment with the new process can better enable us to remove obstacles and enable the redesign of the ecosystem to deliver AI-based solutions to succeed.

Finally, the literature lacks an explanation of how a smartified ecosystem expands. Because in addition to evaluating the results and impacts of the effective implementation of the smartified ecosystem redesign, it is necessary to understand how its expansion takes place. Although authors (Kolagar, Parida & Sjödin, 2022; Moore, 1993) discuss the expansion of the ecosystem, it is not explained in the literature how the connection between multiple smartified ecosystems occurs and how data and AI algorithms are shared between ecosystems with the purpose of create a large autonomous network for the purpose of scaling usage and revenue. It is also true that it has not yet been explained how the capabilities of ecosystems erode and what are the disruptions caused by the advent of AI.

In an attempt to fill these gaps, this study aims to provide an understanding of the process of redesign, experimentation and expansion of the smartified ecosystem. In this way, the present study seeks to answer the following research question: *"how are the focal companies involved in smartification redesigning their ecosystem to create AI-based solutions?"*. To achieve this goal, we performed a systematic literature review (SLR), combining bibliometric and content analysis. Examining the previous literature involves the relationships between ecosystems, AI, big data, digital innovation and digital transformation.

The main contributions to the literature are: a) Conceptualize and explain the process of redesign, experimentation and expansion of an ecosystem that creates AI-based solutions; b) Proposal of a framework with 3 dimensions (Redesign, experimentation and expansion) that guides the transformation process of an ecosystem with the objective of smartification; c) Explain how data and AI algorithms are shared across ecosystems, creating an autonomous network with the aim of driving its usage and revenues.

This text is organized as follows: Firstly, the justification for the research is presented, secondly, we present the methodological procedures adopted in the research, then we present the synthesis of the literature and its discussion. We end with conclusions and limitations of this study.

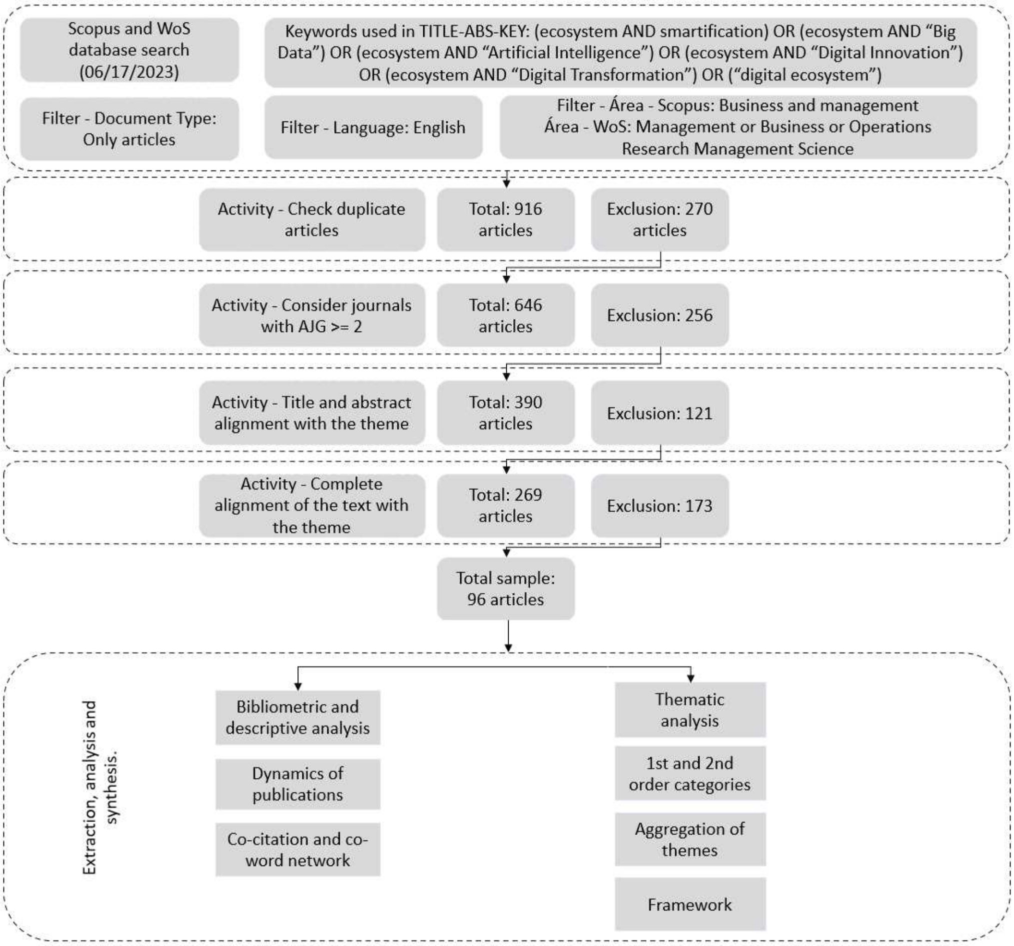
2. METHODOLOGY

Following the approach of previous studies (Gomes et al., 2021; Kolagar, Parida & Sjödin, 2022), we use an SLR to develop a theoretical framework that integrates different research streams and provides insights into possibilities for future research on ecosystem smartification. We also intend with this SLR to ensure the quality, precision, objectivity and transparency of our research, as well as the replicability and validity of the results. Through SLR, researchers can mitigate bias and subjectivity through a structured process (Tranfield, Denyer & Smart, 2003).

As in previous studies that used SLR (Akter et al., 2023; Gomes et al., 2021), we developed a process and steps to conduct our own SLR. Naturally, we made adaptations and incorporated some steps according to the particularities of our research.

We summarize below the main methodological phases suggested by previous studies (Gomes et al., 2021; Kolagar, Parida & Sjödin, 2022) to develop an SLR methodology that is transparent and replicable: a) formulating the research question; b) define criteria for searching, filtering and extracting articles; c) bibliometric analysis; d) analysis and codification of articles; e) discuss the results.

Figure 1: Systematic literature review process



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We conducted a comprehensive and replicable literature search to form our SLR database. All articles were reviewed following the principles of equality, accessibility, transparency, focus and replicability (Thorpe et al., 2005). We chose to use the Web of Science and Scopus, recognized as high quality databases due to the range of journals they offer (Akter et al., 2023). Figure 1 illustrates the search and selection process for articles carried out for the SLR, including the keywords and filters applied in the databases.

Given the considerable number of records in the database, we chose to adopt the exclusion criteria described in recent studies (Akter et al., 2023; Leonidou, et al., 2020). This criterion led us to direct our analysis to more influential journals that publish studies with high theoretical and methodological rigor. Therefore, only records published in journals ranked 4*, 4, 3, and 2 in the 2021 Chartered Association of Business Schools - Academic Journal Guide (AJG) (CABS, 2021) were included in our analysis. This approach allowed us to focus on sources that are recognized by the academic community as being of high quality and that contribute significantly to the advancement of knowledge.

We then employed a bibliometric analysis (Gomes et al., 2018) to identify the most important references, for which we performed a citation and keyword analysis (using the r Bibliometrix package and VOSviewer) in order to identify the different research streams that investigated ecosystem smartification.

Content analysis began with the codification of the collected data, resulting in twenty-three first order categories. By identifying the relationships between these categories, six second-order themes were identified. Finally, these themes were generalized into three aggregated themes at a more abstract level (Gioia et al., 2013). To ensure the reliability and credibility of the results from the coding process, a triangulation process was carried out involving the team of authors (Akter et al., 2023). Team members reviewed the final article samples and the coding framework to ensure the reliability of the entire coding process. Then, the proposed framework was developed based on the themes and dimensions obtained. The general process flow is summarized in Figure 1.

3. DESCRIPTIVE AND BIBLIOMETRIC FINDINGS

In order to present a complete conceptual view, in this section we carry out a descriptive and bibliometric analysis of the 96 selected articles. This analysis provides a complete synthesis of the literature included in our review.

3.1 Distribution of articles by year of publication, journal and AJG rating

The purpose of this section is to categorize the articles selected for the SLR according to the year of publication and to analyze the publications' annual trends. Figure 2 and Figure 3 illustrate the number of articles published over the years, revealing a peak of 28 articles in 2022, with the years 2021, 2022 and 2023 representing 65% of publications. Our analysis indicates that the scientific community's interest in the topic began to awaken in 2015, and since then there has been a steady increase in the number of publications related to ecosystem smartification each year. This trend suggests that in recent years there has been a greater number of studies addressing ecosystem smartification as a way to keep up with technological changes arising from AI. We also understand that the year 2023 will have more publications on the topic, as the search was limited to the month of June. Figure 4 shows the number of articles selected by AJG classification rating, where 68% of publications are in scientific journals with rating 3 and 4, which shows the quality of the sample selected for the SLR and the interest in the topic by the main journals. scientific.

3.2 Bibliometric analysis

We performed a bibliometric analysis of co-citation networks and keywords using the R Bibliometrix package with the 96 selected articles. In authorship co-citation analysis, we identified 280 authors cited in the reference list of articles in our database. Among these, 41 authors were cited more than three times together as the first author. The top ten authors with the most citations are Gawer (26), Sjodin (26), Adner (23), Eisenhardt (21), Kohtamäki (21), Nambisan (21), Teece (20), Jacobides (16), Yin (16), Kowalkowski (15). Figure 5 presents the network diagram resulting from the co-citation analysis of authorship, emphasizing that these authors are not only the most cited, but are also more interconnected based on the co-citation analysis. Given that ecosystem smartification is an emerging topic, we decided to complement the citation analysis with a keyword co-occurrence analysis in order to identify the main topics and trends investigated in this area. Only keywords that occurred at least twice were kept, in order to ensure relevance and frequency in the analysis. As a result, 33 keywords were identified out of a total of 354 to constitute the interconnected terms for analysis. The ten keywords that occurred the most are: ecosystem (19), digital platforms (16), digital transformation (15), artificial intelligence (14), digital servitization (13), digitalization (12), innovation ecosystem (9), business model innovation (8), digital ecosystem (8), business ecosystem (7), digital innovation (7), digital technology (7), iot (7), value creation (7). Figure 6 presents the keyword co-occurrence analysis network diagram.

Figure 2: Annual scientific production

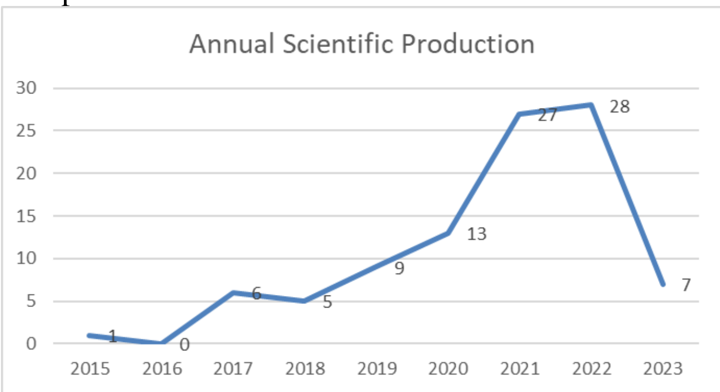

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Figure 3: Annual publication by scientific journal

Source Dynamics - Top 10												
#	Journal	-2015	-2016	-2017	-2018	-2019	-2020	-2021	-2022	-2023	T	%
1	JOURNAL OF BUSINESS RESEARCH	0	0	0	0	2	1	7	1	0	**11**	11,5%
2	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	1	0	0	1	0	2	2	4	0	**10**	10,4%
3	TECHNOVATION	0	0	0	0	0	0	3	1	3	**7**	7,3%
4	INDUSTRIAL MARKETING MANAGEMENT	0	0	0	0	1	0	1	3	0	**5**	5,2%
5	IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT	0	0	0	0	0	0	2	2	0	**4**	4,2%
6	CALIFORNIA MANAGEMENT REVIEW	0	0	0	0	0	1	0	1	1	**3**	3,1%
7	ELECTRONIC MARKETS	0	0	0	0	0	0	2	1	0	**3**	3,1%
8	BUSINESS PROCESS MANAGEMENT JOURNAL	0	0	1	0	0	0	1	0	0	**2**	2,1%
9	CREATIVITY AND INNOVATION MANAGEMENT	0	0	0	1	0	1	0	0	0	**2**	2,1%
10	INFORMATION SYSTEMS RESEARCH	0	0	0	0	0	0	0	1	1	**2**	2,1%
11	INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT	0	0	0	0	0	0	0	1	1	**2**	2,1%
12	INTERNATIONAL JOURNAL OF INNOVATION MANAGEMENT	0	0	0	0	0	0	1	1	0	**2**	2,1%
13	INTERNATIONAL JOURNAL OF OPERATIONS AND PRODUCTION I	0	0	0	0	0	0	2	0	0	**2**	2,1%
14	INTERNATIONAL JOURNAL OF TECHNOLOGY MANAGEMENT	0	0	0	0	0	1	1	0	0	**2**	2,1%
15	JOURNAL OF INFORMATION TECHNOLOGY	0	0	0	0	0	1	0	1	0	**2**	2,1%
16	JOURNAL OF INTERNATIONAL BUSINESS STUDIES	0	0	0	0	1	0	0	1	0	**2**	2,1%
17	JOURNAL OF ORGANIZATION DESIGN	0	0	1	0	0	1	0	0	0	**2**	2,1%
18	JOURNAL OF THE ACADEMY OF MARKETING SCIENCE	0	0	0	0	0	1	0	1	0	**2**	2,1%
17	RESEARCH POLICY	0	0	0	0	1	1	0	0	0	**2**	2,1%
18	SMALL BUSINESS ECONOMICS	0	0	1	0	0	0	1	0	0	**2**	2,1%
17	OTHERS	0	0	3	3	4	3	4	9	1	**27**	28,1%
-	**Total**	**1**	**0**	**6**	**5**	**9**	**13**	**27**	**28**	**7**	**96**	
-	**% Total**	1,0%	0,0%	6,3%	5,2%	9,4%	13,5%	28,1%	29,2%	7,3%	-	-

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Figure 4: Number of articles selected by AJG rating rating

AJG Rating	Qty Articles	%
4	16	16,7%
3	49	51,0%
2	31	32,3%
Total	**96**	**100,0%**

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Figure 5: Author co-citation network

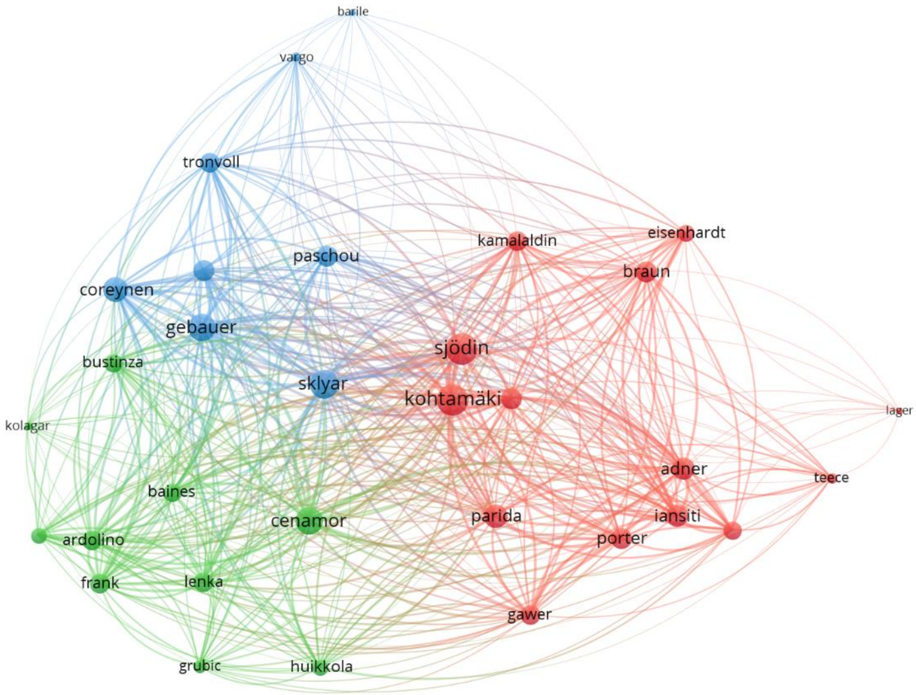

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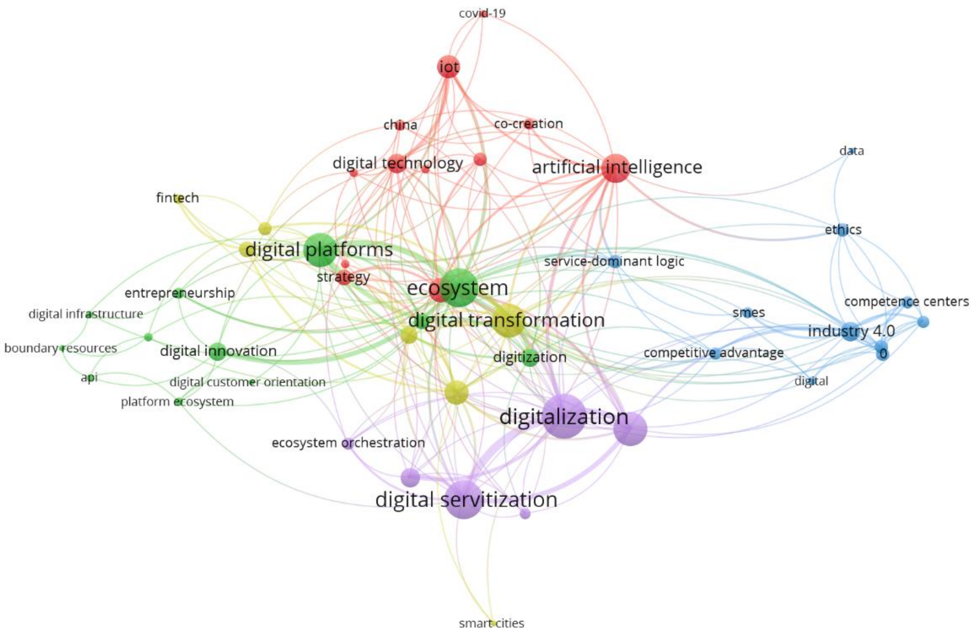
Figure 6: Keyword co-occurrence network.



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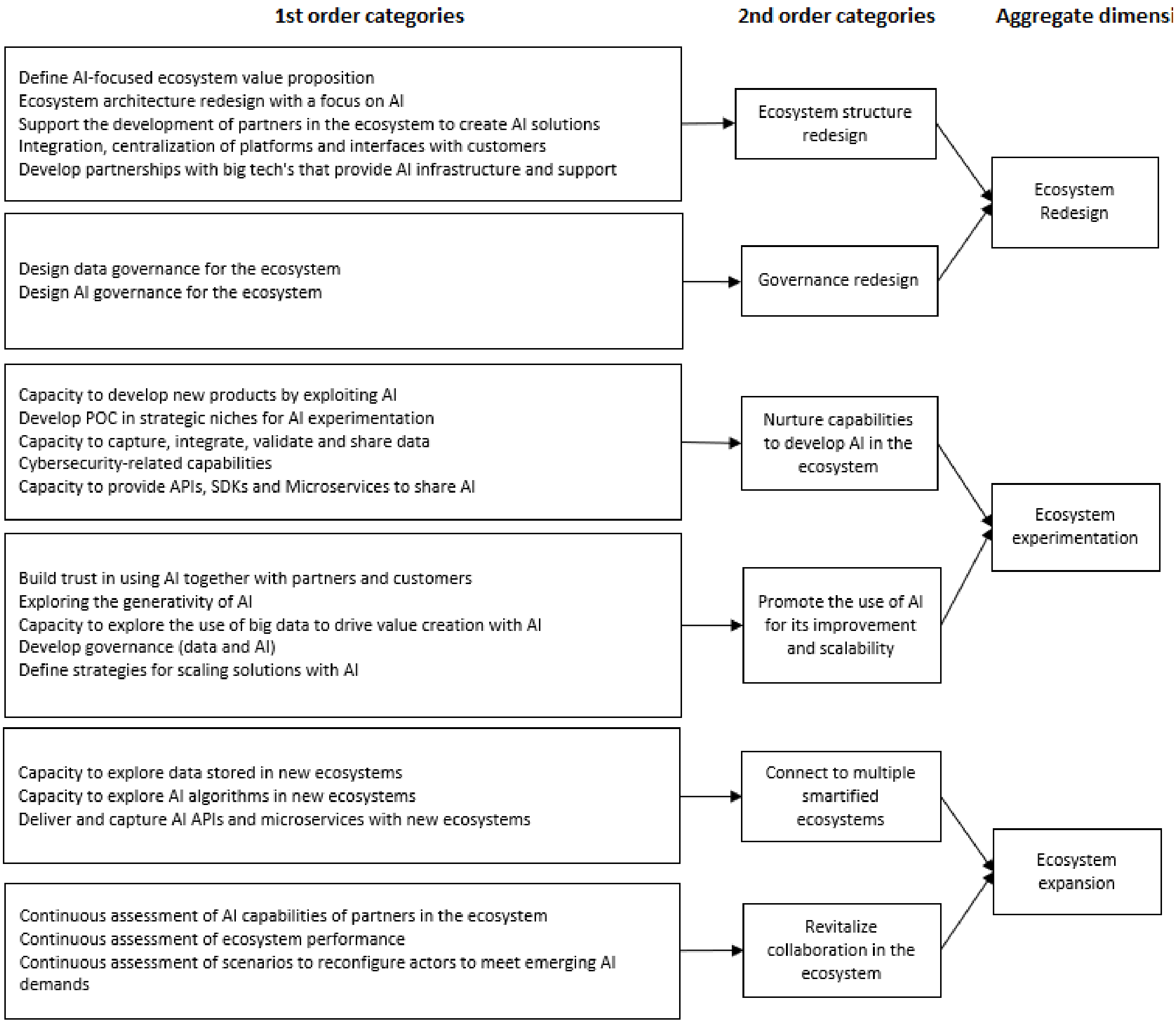
4. RESULTS AND DISCUSSION

The analysis and synthesis of the articles in the final sample, including the process of coding the previous literature, are key elements to effectively answer the research question. The coding process resulted in 23 categories. Based on the identification of the relationships between these codes, 6 second-order themes were identified. Finally, these themes were aggregated into 3 general themes of a higher level of abstraction (Gioia et al., 2013). This approach allowed us a deeper and more comprehensive understanding of the results obtained.

Based on the coding and analysis of the data collected in the SLR, several insights were identified on how ecosystems are reconfigured to create AI-based solutions. Figure 7 presents the data structure with first-order category, second-order category and aggregated dimension. The aggregate dimension presents the ecosystem redesign, ecosystem experimentation and ecosystem expansion phases, which we understand as relevant to smartification. Table 1, Table 2 and Table 3 provide a more detailed overview of the first order categories extracted from the literature. The results for each of the identified dimensions are presented below.

Figure 7: Data structure for ecosystem smartification



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4.1 Ecosystem redesign

Based on the SLR, we found that focal companies offering AI-based solutions have engaged in redesigning the ecosystem structure and developing new forms of governance, especially data and AI. The purpose of this redesign is to establish an adequate structure and architecture that enables the effective development of AI solutions.

The main triggers that lead the focal companies to propose the redesign of the ecosystem are: a) Technological change: AI is a technology that can be incorporated into several products and systems to provide benefits to customers at different stages of the value chain (Burström, et al., 2021); b) New customer demands: Growing customer demands are driving the need for advanced products and services that have capabilities such as learning, interaction, and problem solving (Kohtamäki et al. 2019).

First, to redesign the ecosystem structure, the focal companies redefine the AI-focused ecosystem architecture. This redefinition requires new front-end and back-end interfaces, and new definitions of roles and functions in the smartified ecosystem due to the specificities of AI solutions (Burström, et al., 2021). As change is complex and involves many actors, implementation can be modularized (Hsuan, Jovanovic & Clemente, 2021) and iterative (Hoch & Brad, 2021).

Second, we identified in the literature the need to define the value proposition of the ecosystem focused on AI in collaboration with partners, which is an enabler for smartification (Chen et al., 2021; Kindermann et al., 2022) taking into account the potential contribution of each actor (Brea, 2023).

Third, the focal companies are likely to have to support the development of partners in the ecosystem to create AI-enabled solutions. Knowing partners' AI creation capabilities can help identify development opportunities (Cetindamar, Lammers & Zhang, 2020). The focal company must support technological change with the advent of AI by empowering partners, promoting the dissemination of knowledge and successful experiences (Romanelli, 2018), and inserting them in the development of AI solutions (Handfield, 2019). This may include investing in partnerships with startups, innovative small companies with AI (Sun & Zhang, 2021) and partnerships with universities, which, through their technology transfer offices, can collaborate in knowledge sharing (Ricci, Battaglia & Neirotti, 2021). Prodi et al. (2022) argues that establishing an AI competence center can promote knowledge transfer in the ecosystem.

With the advent of AI, it is necessary to proactively understand and meet future and hidden needs of its customers as part of a continuous value creation process (Sun & Zhang, 2021), therefore, the integration and centralization of platforms, and interfaces with clients is necessary in order to increase knowledge about client groups (Sussan & Acs, 2017). The new configuration requires platforms integrated with other smartified ecosystems to collect, integrate and analyze data, thus boosting innovative activities (Sahut, Iandoli & Teulon, 2021).

Previous literature has revealed that the development of partnerships with big tech's that providers of infrastructure and support for AI is important to obtain complementary resources that will support the development of the smartified ecosystem and its future scalability (Sjödin, Parida & Visnjic, 2022), because initially, focal companies do not have or are expensive the necessary resources to deliver the AI value proposition (Palmié et al., 2022). Companies like Google, Amazon and Microsoft have standard AI and big data modules that facilitate the creation of AI solutions (Beverungen, et al., 2022).

Currently, data, which was previously seen as an asset without borders, is subject to an increasing number of regulatory restrictions (Furr, Ozcan & Eisenhardt, 2022; Kitsios & Kamariotou, 2022) and the SLR results revealed the need for governance of data. The governance and security of data in the ecosystem can lead to a competitive advantage, as it enables the creation of trust in the solutions offered to customers (Quach, 2022). It is essential to ensure that the collected data has clear ownership definitions and is protected against security breaches (Secundo, Shams & Nucci, 2021; Wirtz et al., 2023). While using behavioral data and tracking customer actions can increase the likelihood of profits, it is important to consider the ethical and privacy implications of its use in co-creating mutual value for companies and customers (Neuhofer, Magnus & Celuch, 2021).

We observe the importance of AI governance in SLR, therefore, the focal companies are creating clear rules on how AI algorithms will be accessed, observing the possible economic and social benefits to be obtained from their use (Battisti, Agarwal & Brem, 2022). Ethical and human rights issues must be anticipated due to the fact that AI has no moral understanding of what is right or wrong (Boeing & Wang, 2021). AI governance should provide roles and obligations to encourage research and innovation in responsible AI, encompassing the union of technical and ethical skills (Ietto et al., 2022; Stahl, 2022). Solid AI governance will contribute to increased trust, more agile adoption, greater customer satisfaction and acceptance of the solutions offered (Tawaststjerna & Olander, 2021).

Table 1: Categories extracted from the literature – Aggregate dimension: Ecosystem redesign

1st order category	2nd order category
Ecosystem architecture redesign with a focus on AI (Burström, et al., 2021; Hsuan, Jovanovic & Clemente, 2021; Hoch & Brad, 2021) **Define AI-focused ecosystem value proposition** (Brea, 2023; Chen et al., 2021; Kindermann et al., 2022) **Support the development of partners in the ecosystem to create AI-powered solutions** (Cetindamar, Lammers & Zhang, 2020; Handfield, 2019; Ricci, Battaglia & Neirotti, 2021; Romanelli, 2018; Sun & Zhang, 2021; Prodi et al., 2022) **Integration, centralization of platforms and interfaces with customers** (Sahut, Iandoli & Teulon, 2021; Sun & Zhang, 2021; Sussan & Acs, 2017) **Develop partnerships with big tech's that provide AI infrastructure and support** (Beverungen, et al., 2022; Palmié et al., 2022; Sjödin, Parida & Visnjic, 2022)	**Ecosystem structure redesign**
Design data governance for the ecosystem (Furr, Ozcan & Eisenhardt, 2022; Kitsios & Kamariotou, 2022; Neuhofer, Magnus & Celuch, 2021; Quach, 2022; Wirtz et al., 2023) **Design AI governance for the ecosystem** (Battisti, Agarwal & Brem, 2022; Boeing & Wang, 2021; Ietto et al., 2022; Stahl, 2022; Tawaststjerna & Olander, 2021)	**Governance redesign**

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4.2 Experimentation of the new design

The experimentation of the ecosystem redesign aims to validate and explore the new structure, architecture and governance proposal developed in the previous phase. Based on the SLR we found that it is essential to nurture capabilities to develop AI in the ecosystem and promote the use of AI for its improvement and scalability.

The focal company needs to nurture capabilities to develop AI in the ecosystem, this process requires the ability to develop new products that: a) explore algorithms that enable the creation of cognitive functions with AI; b) enable prediction of future state or actions using automated insights from data analysis; c) seek to develop data-driven approaches and co-creation in interactions with customers (Gupta et al., 2021; Sjödin et al., 2021). The development of products with AI must be aligned and impact the value proposition of the ecosystem (Burström et al., 2021). An enabler for smartification is the ecosystem has services orientated AI (Sjödin et al., 2021).

Table 2: Categories extracted from the literature – Aggregate dimension: Ecosystem experimentation

1st order category	2nd order category
Capacity to develop new products by exploiting AI (Burström et al., 2021; Gupta et al., 2021; Sjödin et al., 2021) **Develop POC in strategic niches for AI experimentation** (Leone et al., 2020; Rocha et al., 2021; Tahi et al., 2021; Valkokari, Hemilä & Kääriäinen, 2022) **Capacity to capture, integrate, validate and share data** (Gupta, Panagiotopoulos & Bowen, 2020; Tatarinov, Ambos & Tschang, 2022; Trabucchi & Buganza, 2020) **Cybersecurity-related capabilities** (Cerchione et al., 2022; Frandsen, Raja & Neufang, 2022; Langley et al., 2021; Quach et al., 2022; Riasanow et al.,2021; Saura, Ribeiro-Soriano & Palacios-Marqués, 2021) **Capacity to provide APIs, SDKs and Microservices to share AI** (Addo, 2022; Jovanovic, Sjödin & Parida, 2022; Sjödin et al., 2021; Um et al., 2022; Zapadka, Hanelt & Firk, 2022)	**Nurture capabilities to develop AI in the ecosystem**
Build trust in using AI together with partners and customers (Akter et al., 2023; Favoretto et al., 2022; Langley et al., 2021; Leone et al., 2020; Sklyar, 2019; Zeng, Tavalaei & Khan, 2021; Zhang, 2021) **Exploring the generativity of AI** (Cennamo et al., 2020; Hsuan, Jovanovic & Clemente; Saadatmand, 2019; Lindgren & Schultze, 2019; Zeng, Tavalaei & Khan, 2021) **Capacity to explore the use of big data to drive value creation with AI** (Casado-Molina et al., 2020; Paredes-Frigolett & Pyka, 2022; Secundo et al., 2017; Shaw; Allen, 2018; Song et al., 2021; Strange, Chen & Fleury, 2022; Tan & Zhan, 2017) **Develop governance (data and AI)** (Denicolai & Previtali, 2020; De Prieëlle, De Reuver & Rezaei, 2020; Gupta et al., 2021; Ietto et al., 2022; Ishfaq, Davis-Sramek & Gibson, 2022; Macha et al., 2023; Stahl, 2022)	**Promote the use of AI for its improvement and scalability**

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Developing POC (proofs of concept) in strategic niches for AI experimentation together with partners in the ecosystem is important to validate knowledge and gain experience to deliver the ecosystem value proposition. Authors (Valkokari, Hemilä & Kääriäinen, 2022) emphasize the importance of involving partners in POC so that they gain experience and understand future opportunities with the proposed solutions. Authors (Leone et al., 2020; Tahi et al., 2021) highlight success stories in the health area, where focal companies managed to gain experience validating AI concepts to improve products operating in specific niches. In turn, authors (Rocha et al., 2021) present successful cases in collaborations exploring the experience of centers of competence in AI and scientific partnerships for the development of solutions for Industry 4.0.

The literature has shown the importance of developing the ability to standardize data capture, integration, validation and sharing (Gupta, Panagiotopoulos & Bowen, 2020), aiming at data quality and veracity (Trabucchi & Buganza, 2020). Other authors (Tatarinov, Ambos & Tschang, 2022) highlight the importance of sizing the infrastructure to support large volumes of data. Authors (Buhalis & Leung, 2018; Denicolai & Previtali, 2020) highlight this ability as an enabler for smartification.

With the advancement of AI it becomes evident that the exchange of data between different smart things presents security risks, such as espionage, hacking, unauthorized access to data and devices, therefore, the need to develop capabilities related to cybersecurity (Cerchione et al., 2022; Quach et al., 2022; Riasanow et al., 2021) are fundamental to enable: a) consistency in the software platform (Sklyar, 2019); b) secure access to partners and customers (Frandsen, Raja & Neufang, 2022; c) protection of intellectual property; d) protection of technical specifications and business models (Saura, Ribeiro-Soriano & Palacios-Marqués, 2021); e) gain the trust of customers and partners (Langley et al., 2021).

A central element in the experimentation process is the development of the ability to provide API (Application Programming Interface), SDK (software development kit) and microservices to share AI in the ecosystem (Addo, 2022; Zapadka, Hanelt & Firk, 2022) with the objective of to reduce transaction costs on its AI platform and allow users and developers to customize application interfaces by improving the offered solution (Sjödin et al., 2021), or recombining and creating new solutions with other resources (Jovanovic, Sjödin & Parida, 2022), increasing the variety of products offered by the smartified ecosystem (Um et al., 2022).

The focal company needs to experience the projected governance structures (data and AI) (Ishfaq, Davis-Sramek & Gibson, 2022). Authors (Gupta et al., 2021) suggest that data culture within the smartified ecosystem be explored through secure data acquisition, visualization, integration and sharing. Legal licensing for accessing and sharing the data model for exploiting complementors must be validated and improved to ensure trust and accessibility (Macha et al., 2023). With regard to AI, it is necessary to validate whether the governance rules are effective for the ethical use of AI algorithms (Denicolai & Previtali, 2020) and whether their value creation is responsible (Ietto et al., 2022; Stahl, 2022). Data and AI governance is critical for customers as it ensures data ownership and ethical use of algorithms (De Prieëlle, De Reuver & Rezaei, 2020).

Focal companies in the experimentation phase promote the use of AI for improvement and scalability. First, this process consists of building trust in the use of AI together with partners and customers (Favoretto et al., 2022; Kopalle, Kumar & Subramaniam, 2020; Langley et al., 2021; Morgan-Thomas, Dessart & Veloutsou, 2020; Rong et al., 2021; Zhang, 2021), as inadequate AI implementation can undermine end-user trust, resulting in delayed adoption (Akter et al., 2023). The idea is to create perceptual mechanisms and knowledge from customers and collaborations with partners for understanding behavior, acceptance and future scalability (Leone et al., 2020; Sklyar, 2019). The usefulness of an AI algorithm is related to the scale of data learning gained from its use. As an AI algorithm is widely adopted, more experience is accumulated and, consequently, it is improved (Zeng, Tavalaei & Khan, 2021).

To promote the use of AI for improvement and scalability, focal companies develop the ability to exploit AI generativity (Hsuan, Jovanovic & Clemente), which is the ability of technologies such as AI to produce unsolicited change driven by large audiences, varied and uncoordinated through recombination (Cennamo et al., 2020). This capability allows smartified ecosystems to identify and experiment with new combinations of resources that were previously disconnected or with limited connections to create completely new or alternative solutions with AI (Zeng, Tavalaei & Khan, 2021). The generativity of AI allows complementors to quickly generate and capture value, while they can also reuse their knowledge and skills in other smartified ecosystems (Geest & Angeren, 2023; Saadatmand, 2019; Lindgren & Schultze, 2019), even facilitating business internationalization (Nambisan, Zahra & Luo, 2019).

We identified that focal companies develop the ability to explore the use of big data to create value with AI (Buhalis & Sinarta, 2019; Casado-Molina et al., 2020; Pesce, Neirotti & Paolucci, 2019; Secundo et al., 2017; Shaw; Allen, 2018; Song et al., 2021; Strange, Chen &

Fleury, 2022; Tan & Zhan, 2017), as data is the new oil that fosters new sources for value creation (Sjödin, Parida & Visnjic, 2022). Big data is recognized as an essential and widespread complementary asset in smartified ecosystems (Paredes-Frigolett & Pyka, 2022), can accelerate innovation (Zhan et al., 2017) and opens up opportunities for value creation through collaboration with external partners (Jovanovic, Sjödin & Parida, 2022). According to authors (Zhan et al., 2017), big data plays a key role in identifying product weaknesses early in the development cycle, allowing the addition of features that customers are willing to pay an additional value for, while eliminating unwanted features. Furthermore, big data assists in identifying and prioritizing customer needs in specific markets, opening up a variety of business opportunities (Kohtamäki et al. 2019).

4.3 Expansion of the smartified ecosystem

The expansion of the smartified ecosystem aims to increase the ecosystem's reach to new audiences and markets and revitalize the innovative capacity. The literature revealed that this expansion involves connecting multiple smartified ecosystems and revitalizing collaboration in the ecosystem.

To connect with multiple smartified ecosystems, first, the ecosystem needs to be able to exploit data stored in other ecosystems (Abella, Ortiz-De-Urbina-Criado & De-Pablos-Heredero, 2017; Kwon, Kwak & Kim, 2015; Fritzsche & Bohnert, 2022) to foster data-driven innovation with solutions refined to the market (Battisti, Agarwal & Brem, 2022). Considering that data plays a crucial role in technological advances such as AI, focal companies can be guided by consuming data from other ecosystems to co-innovate following the principles of recombinant innovation, which involve the addition, association and dissociation of resources to creation of complex AI solutions (Beverungen, et al., 2022). The evolution of ecosystems and their open data services can be understood as a strategy to enhance the interconnection of both the public and private sectors (Kitsios & Kamariotou, 2022).

Second, our SLR showed the importance of developing the ability to exploit AI algorithms in other ecosystems (Langley et al., 2021; Marcon, Le Dain & Frank, 2022; Zhang et al., 2021). The smartified ecosystem must operate broadly, transcending its borders and its smart solutions must be developed to operate and interact with the solutions offered by several other ecosystems (Ciasullo et al., 2021; Kohtamäki et al. 2019). In this way, establishing connections between smartified ecosystems, the integration and sharing of AI algorithms occurs, resulting in increased learning and scalability of solutions. With an extended and open ecosystem, it is possible to connect previously unknown audiences and actors from different sectors to collaboratively create and capture value in multiple markets (Yang et al., 2020).

The third point related to the connection with multiple smartified ecosystems is the ability to deliver and capture AI APIs and microservices with other smartified ecosystems (Mosterd et al., 2021; Pervin, Ramasubbu & Dutta, 2019). Authors (Fink et al., 2020), point out that the APIs provided by the smartified ecosystem have become a fundamental infrastructure. An example is banks with an open digital architecture for API consumption, having a more favorable position to take advantage of the benefits and achieve success in expanding the smartified ecosystem (Anagnostopoulos, 2018).

The SLR revealed that the smartified ecosystem to expand needs to revitalize its collaboration, for this it needs to continuously evaluate the partners' AI capabilities (Radziwon et al., 2022). Authors (Linde et al., 2021) argue that establishing a structured process to assess the ability of partners to develop complementarities with AI is a crucial element in keeping the ecosystem smartified. These insights reveal valuable information, indicating that the objective is not only to attract members, but to attract and retain members who have essential knowledge and skills to promote the diversity necessary for the emergence of innovation with AI (Brea, 2023).

Table 3: Categories extracted from the literature – Aggregate dimension: Ecosystem expansion

1st order category	2nd order category
Capacity to explore data stored in new ecosystems (Abella, Ortiz-De-Urbina-Criado & De-Pablos-Heredero, 2017; Battisti, Agarwal & Brem, 2022; Beverungen, et al., 2022; Kitsios & Kamariotou, 2022; Kwon, Kwak & Kim, 2015; Fritzsche & Bohnert, 2022)	**Connect to multiple smartified ecosystems**
Capacity to explore AI algorithms in new ecosystems (Ciasullo et al., 2021; Langley et al., 2021; Marcon, Le Dain & Frank, 2022; Kohtamäki et al. 2019; Yang et al., 2020; Zhang et al., 2021)	
Deliver and capture AI APIs and microservices with new ecosystems (Anagnostopoulos, 2018; Fink et al., 2020; Mosterd et al., 2021; Pervin, Ramasubbu & Dutta, 2019)	
Continuous assessment of AI capabilities of partners in the ecosystem (Brea, 2023; Linde et al., 2021; Radziwon et al., 2022)	**Revitalize collaboration in the ecosystem**
Continuous assessment of ecosystem performance (Kindermann, et al., 2022; Linde et al., 2021; Wang, 2021)	
Continuous assessment of scenarios to reconfigure actors to meet emerging AI demands (Beltagui, Rosli & Candi, 2020; Ciasullo et al.,2021; Kindermann, et al., 2022; Kolagar, Parida & Sjödin, 2022; Makkonen et al., 2022)	

Font: Authors

We also found that continuous assessment of the performance of the smartified ecosystem (Kindermann, et al., 2022) plays an important role in its expansion. The performance of an ecosystem can be characterized as the level at which the core innovation values are realized by its participants (Wang, 2021). Authors (Linde et al., 2021) show that the monitoring and continuous evaluation of the generation, delivery and capture of value provide focal companies with the ability to constantly improve collaboration in the ecosystem, in addition to identifying and evaluating new opportunities that may arise. Performance across the ecosystem not only reflects the diverse values sought by participants and the different patterns of their activities, but also reveals the common values shared by the ecosystem (Wang, 2021).

The accelerated advance of AI may demand that the focal companies evaluate possible scenarios of changing roles, routines and agreements (Kolagar, Parida & Sjödin, 2022). For this reason, we highlight the importance of continuous evaluation of scenarios to reconfigure actors to meet emerging AI demands (Beltagui, Rosli & Candi, 2020; Makkonen et al., 2022). Authors (Kolagar, Parida & Sjödin, 2022) argue that the expansion of the smartified ecosystem can be facilitated by promoting new partners to implement AI algorithms with value-added to efficiently meet emerging demands. As the focal companies improve their ability to assess technology changes, adjust their complementors and anticipate the potential consequences of these changes in suppliers, the smartified ecosystem will become more efficient and innovative in its delivery of value with AI (Kindermann, et al., 2022). According to the research carried out by Ciasullo et al. (2021), a focal company evaluated new scenarios due to the growing demands for AI solutions and was successful in involving new actors, such as universities, research centers and scientists. This collaboration made it possible to acquire new knowledge to offer innovative solutions with AI.

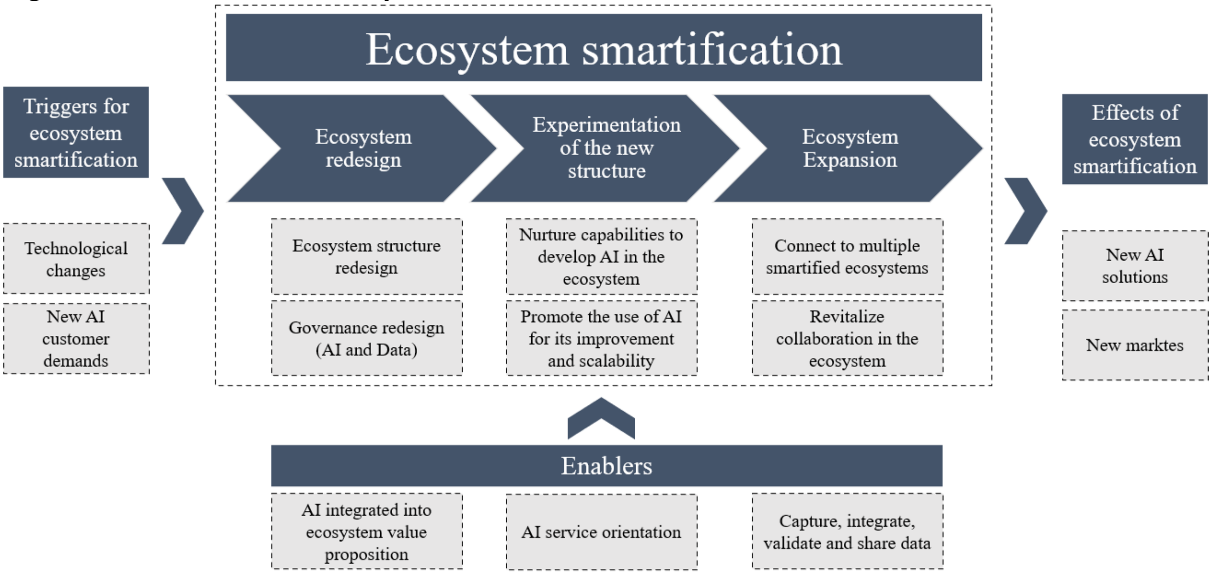
5. FRAMEWORK FOR ECOSYSTEM SMARTIFICATION

We synthesize our findings into a framework that guides the ecosystem smartification process (Figure 8). The proposed framework has 3 phases: Ecosystem Redesign, Ecosystem experimentation and Ecosystem expansion.

First, we explain the need for ecosystem redesign to drive the development of AI solutions. This process involves redesigning the structure (actors, links and roles) and creating new governance to handle data and AI. We explore the relevance of a new AI-focused value proposition, which is an enabler for smartification. We discuss how partners are defined and supported, as well as the impact of AI and data governance rules on developing solutions, engaging stakeholders, and establishing trust with partners and customers. We present that the triggers that lead companies to smartification are technological change with the advent of AI and new customer demands.

Secondly, we highlight the need to experiment with the new structure, architecture and governance proposal developed in the previous phase. Based on the SLR we found that it is essential to nurture capabilities to develop AI in the ecosystem, develop the governance structures and promote the use of AI for its improvement and scalability. Through the co-creation of AI-based solutions with partners and validation with customers, it is sought to improve knowledge and gain experience to deliver a solid value proposition within the smartified ecosystem. This approach makes it possible to refine solutions based on user feedback, ensuring that they meet real needs and offer tangible benefits to ecosystem actors. We reinforce that service orientation is an enabler for smartification. The ecosystem towards smartification experiments with data management, big data, cyber security and algorithm sharing, which put to the test the new governance of data and AI and the proposition of delivering value with AI.

Figure 8: Framework for ecosystem smartification



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Finally, we explain how the focal companies that develop solutions with AI expand the performance of the smartified ecosystem, reaching new audiences and markets. This expansion involves consuming and sharing data and AI algorithms in other smartified ecosystems, aiming to co-innovate and recombine solutions both internally and from other ecosystems. This approach promotes a complete exploration of the potential of available solutions, stimulating creativity and maximizing the benefits offered. We also discovered in our SLR the importance of revitalizing collaboration in the smartified ecosystem. Focal companies continually assess partners' AI capabilities and performance, measuring the degree to which the focal innovation is realized by their ecosystem participants. This process also comprises continuous evaluation of scenarios to reconfigure actors to meet emerging AI demands.

6. CONCLUSIONS

6.1 Theoretical and practical contributions

This study investigated how focal companies involved in smartification are redesigning their ecosystem to create AI-based solutions. More specifically, we relied on an SLR which covers the examination of 96 articles selected from the Scopus and Web of Science databases to explain the steps involved in ecosystem redesign to create and deliver AI-enabled solutions. Thus, this research offers theoretical and practical contributions to enrich current knowledge about ecosystems. With these results, we hope to broaden the understanding of the topic and provide valuable insights for researchers and practitioners.

First, we conceptualize and explain how the redesign process, the experimentation process, and the process of expanding an ecosystem that creates AI-based solutions work. In addition to presenting research (Sjödin et al., 2021; Stahl, 2022) that influenced the creation of AI solutions in an ecosystem, we proposed a framework for successful smartification. The result is a comprehensive analysis of the current state of academic production that opens doors for future investigations aimed at gaining more knowledge about collaboration to create AI-based solutions.

Second, we explain how data and AI algorithms are shared across ecosystems, creating an autonomous network with the goal of driving its usage and revenues. In this way, we show that it is feasible to promote learning, risk mitigation and expansion of AI solutions. By relying on an expanded, open and smartified ecosystem, it is possible to connect previously unknown audiences, enabling actors from different sectors to collaboratively create and capture value in multiple markets.

Finally, as a practical contribution, we propose a framework with 3 dimensions (Redesign, experimentation and expansion) that guides the process of transforming an ecosystem with the objective of smartification. In doing so, the proposed framework can serve as a guide for focal companies to optimize the benefits of AI when transforming their ecosystems. With the help of this framework, managers can facilitate the transformation of their ecosystems, developing the necessary capabilities to deliver advanced solutions with AI.

6.2 Research limitations

It is important to highlight that this research has some limitations, as is common in SLR. First, this study is based on an SLR that included the analysis of 96 articles. We recognize that this approach has its limitations, and the possibility exists that some relevant articles may not have been selected during the screening process. However, as we identified a significant body of literature, we believe that the 96 studies are a robust representation of the research objective. Second, we recognize that the content analysis of the articles selected for our database was subjective in certain aspects, and the interpretation of the articles' content is the responsibility of the authors of this research. However, the researchers' triangulation and the use of explicit coding rules contributed to increase the reliability of the results.

Despite these limitations, we believe our research offers a deeper understanding of ecosystem smartification, providing valuable insights for researchers and managers alike.

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