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OPEN INNOVATION IN COMPLEX ECOSYSTEMS: KNOWLEDGE NETWORKS AND BEYOND

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Abstract

The contemporary world is characterized by accelerating innovations in a dense knowledge pool which is a byproduct of networked relationships in a complex ecosystem. In this manner, open innovation has become a revolutionary paradigm in the quickly changing innovation landscape. When used in complex ecosystems, this strategy enhances the intangible capital by amplifying the collective intelligence of many players. Today it is evident that open environments for knowledge, provide higher rates of innovation and hence more productivity and comparative advantage. Following the critical importance of the concept, this study tries to highlight the mutual beneficial interaction between open innovation principles in knowledge networks and complex ecosystems. In this context, this study underlines the increasing importance and attention of open innovation practices within intricate ecosystems. It emphasizes the need to manage intellectual property, facilitate cooperation and continue skill development as crucial policy elements to build an effective open innovation environment across complex ecosystems. Hence, the study contributes to the related literature by underlying the interplay between open innovation in complex ecosystems and the role of knowledge networks.

Keywords: open innovation, knowledge networks, complex ecosystems, systematic literature review

KARMAŞIK EKOSİSTEMLERDE AÇIK İNOVASYON: BİLGİ AĞLARI ve ÖTESİ

Özet

Günümüz dünyası, karmaşık bir ekosistemdeki ağ bağlantılı ilişkilerin bir yan ürünü olan yoğun bir bilgi havuzundaki yeniliklerin hızlanmasıyla karakterize edilir. Bu şekilde açık inovasyon, hızla değişen yenilikçi ortamda devrim niteliğinde bir paradigma haline gelmiştir. Karmaşık ekosistemlerde kullanıldığında bu strateji, birçok aktörün kolektif zekasını güçlendirerek soyut sermayeyi artırmaktadır. Bugün bilgi için açık ortamların daha yüksek oranda yenilik sağladığı ve dolayısıyla daha fazla üretkenlik ve karşılaştırmalı avantaj sağladığı açıktır. Kavramın kritik önemini takiben bu çalışma, bilgi ağlarındaki açık inovasyon ilkeleri ile karmaşık ekosistemler arasındaki karşılıklı yararlı etkileşimi vurgulamaya çalışmaktadır. Bu bağlamda bu çalışma, karmaşık ekosistemler içerisinde açık inovasyon uygulamalarının artan öneminin ve ilgisinin altını çizmektedir. Ayrıca karmaşık ekosistemlerde etkili açık inovasyona ortamı oluşturmak için işbirliğini kolaylaştırma ve beceri geliştirmeyi sürdürme ihtiyacını önemli politika unsurları olarak vurgulamaktadır. Dolayısıyla çalışma, karmaşık ekosistemlerdeki açık inovasyon ile bilgi ağlarının rolü arasındaki etkileşimin altını çizerek ilgili literatüre katkıda bulunmaktadır.

Anahtar Kelimeler: açık inovasyon, bilgi ağları, karmaşık ekosistemler, sistematik literatür analizi

Introduction

Innovation has changed from being a secretive, inward-looking process to a dynamic and collaborative action that crosses corporate boundaries in the modern day. "Open Innovation (OI)" is a notion that best captures this transition. The concept of "open innovation" encourages businesses to use the richness of outside information, resources, and experiences accessible to them in their quest for new ideas (Chesbrough, 2017; Chesbrough, 2006).

OI is an effective tool in and of itself, but it becomes much more effective when it is used to function inside the complex and varied context of complex ecosystems. Complex ecosystems are made up of linked networks of businesses, people and markets, and the health of these ecosystems depends heavily on the interactions and relationships between several stakeholders.

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OI assumes a distinctive character in these ecosystems and develops as a critical catalyst for advancing knowledge, promoting teamwork, and tackling the complex problems of the contemporary world.

Today's world is characterized with accelerating innovations in a dense knowledge pool which is a byproduct of networked relationships in a complex ecosystem. However, there is still a traditional perspective about inventing on innovation and developing productive processes. Some organizations and economies still assume that limited sharing of innovative knowledge can provide them a persistent comparative advantage. However, today it is evident that open environments for knowledge, provide higher rates of innovation and hence more productivity and comparative advantage. This fact has also taken increasing attention in the related literature.

This study aims to explain the idea of OI within the framework of complex ecosystems by underlining its guiding principles, advantages, and strategic implications. In the light of the related literature, we seek to clarify the relationship between OI and complex ecosystems. It's supposed that this clarification will provide insights for both organizations and policymakers in today's complex economic environments. In this manner, the first section of the study is devoted to conceptual background. In this section, OI, complex ecosystem and knowledge network concepts are explained in detail. Then, the second section is attributed to a systematic literature review. In this section, the development path of studies examining OI in complex systems and in knowledge networks is tried to be given. Lastly, some recommendations are developed for organizations and economies.

1. Conceptual Background

Analyzing complex ecosystems and OI separately can provide useful insights on how to utilize teamwork and creativity for sustainable growth and problem-solving. Complex ecosystems are complex networks of interconnected biological, physical, and environmental components that are resilient and changeable. These ecosystems, whether they are natural or artificial, reveal complicated interactions between many parts and conditions. For successful conservation and management that supports the principles and practices of sustainable development, it is essential to understand these interdependencies (Chesbrough, 2017).

On the other hand, OI is a cutting-edge strategy for problem-solving and invention that cuts across corporate boundaries. It promotes the sharing of information, ideas, and resources amongst internal and external parties, including clients, vendors, and academic institutions. OI promotes teamwork, co-creation, and ongoing learning while acknowledging that great ideas may originate from anyone. Organizations may speed up their innovation processes and maintain a competitive edge in a changing market by utilizing a larger ecosystem of information and experience (Chesbrough, 2006; 2017).

OI in complex ecosystems can produce dramatic results when used together. Complex ecosystems provide a wealth of information, abilities, and experience. Organizations may access a wide variety of viewpoints and knowledge by opening innovation processes to external contributors and stakeholders within these ecosystems (West and Bogers, 2017). Additionally, OI in complex ecosystems may spur sustainability activities by incorporating environmentally friendly procedures and sustainable practices into the invention process, coordinating innovation efforts with overarching sustainability objectives. This partnership does present some difficulties, though. It can be difficult to strike the correct balance between the need for cooperation and information sharing and the requirement to safeguard intellectual property rights (Pilav-Velic and Jahic, 2021).

Therefore, OI offers a strong strategy for tackling current issues and promoting sustainable development by comprehending and using complicated ecosystems. OI may pave the way for

a future in which inventive ideas and cooperative problem-solving are at the forefront of global growth by embracing the diversity and interconnection within these ecosystems. This strategy preserves and respects the fragile balance of the natural and social ecosystems while encouraging the growth of sustainable practices, technological developments, and societal well-being.

1.1.Open Innovation

In the traditional innovation framework, innovation is created by internal corporate R&D efforts. However, Chesbrough (2003) introduced OI as an emerging corporate strategy in which corporates benefit from innovative knowledge created outside the boundaries of the organization. OI is a strategic concept about opening organizational boundaries for free knowledge flows and hence getting sustainable competitive advantage (Wallin and von Krogh, 2010). In this respect, it has a critical importance for corporation survival in the contemporary world.

OI is a multi-level process including strategic, organizational, human and IT components. The complex interplay of them creates some well-managed efficient OI outcomes for corporations (Schneckenberg, 2015: 23). The fundamental tenet of OI is that no one company has exclusive access to valuable resources or ideas. Businesses may increase their creativity and competitiveness by utilizing outside information, skills, and views. Organizations can access a sizable pool of intellectual capital and technical breakthroughs through partnerships, mergers, acquisitions, joint ventures, licensing agreements, and other similar arrangements. Through these cooperative efforts, products are developed more quickly, the market is more responsive, and customer demands are better understood. Being open to outside ideas and inputs, utilizing them efficiently, and incorporating them into profitable business strategies, goods, or services are all aspects of OI.

Additionally, OI spans a variety of approaches, from outbound OI (using internal ideas to enter new industries) to inbound OI (absorbing information from the outside world). It requires building systems for efficient information transmission and absorption as well as strategically controlling knowledge flows, determining which ideas should be explored internally and which should be pursued outside. Companies using an OI strategy are aware of how crucial it is to foster an environment that values teamwork, taking risks and lifelong learning.

1.2.Complex Ecosystems

Complex ecosystems are sophisticated networks of many parts, including biological, physical, and environmental aspects, as well as the species that live there. These ecosystems are distinguished by their complex web of interrelationships, where each component is vital to preserving the overall harmony and efficiency of the system. Complex ecosystems may be found in a variety of habitats, including terrestrial ecosystems like rainforests, aquatic ecosystems like coral reefs, and even socioeconomic ecosystems like cities or the world's financial markets. Making educated decisions regarding resource management, conservation, and sustainable development requires an understanding of these ecosystems (Chesbrough, 2003b; Chesbrough et al., 2006). Therefore, this approach has recently been used for organizational, social, and economic systems by inspiring an ecological approach.

Ecosystems of socio-economic environments refer to self-organizing, evolutionary, organic and complex systems. This ecosystem view tries to explain the interdependent web of relationships between socio-economic agents (Wikhamn and Wikhamn, 2013: 178). Lichtenstein (2000) defined complex systems with four basic properties: (i) change is constant (ii) interactions of elements of the system create more value than their simple sum (iii) causality displays interdependency (iv) behaviours are not proportional. In this respect, organizations should be

aware of the importance of basic elements for the efficient OI process. These elements can be listed as permeable boundaries, interconnectedness, self-organization of system actors, and adaptiveness (Poutanen et al., 2016: 22).

Resilience and flexibility are important characteristics of complex ecosystems. These systems have developed over millennia to survive shocks and changes, displaying a remarkable capacity to recover from disruptions and adapt to new situations. The diversity of species, interactions between them, and redundancy of functions within an ecosystem all contribute to resilience. Complex ecosystems may continue to work and offer critical services in the face of external pressures like climate change but with some adjustments (Obradović et al., 2021).

The idea of interconnectedness is also highlighted by complex ecosystems. These systems' species and parts depend on one another for food, energy, and a variety of ecological functions. Because of this interconnectedness, the ecosystem is in a delicate equilibrium where modifications to one component can have ripple effects on the entire system. It emphasizes the significance of understanding how all living and non-living components of an ecosystem are interrelated and the possible repercussions of upsetting these complex interactions (Enkel et al., 2009; Annosi et al., 2022).

1.3.Knowledge Networks

A network is simply defined as a structure where several nodes are linked to each other with several threads (Hakansson and Ford, 2002: 133). This structure is especially important in the contemporary global economy. Globalization has accelerated technological development and reduced transaction costs owing to networked economies (Möller and Svahn, 2004: 2020). Today, networks characterize international, sectoral, and individual relationships, and also determine their cumulative socio-economic impacts. These results come to the fore due to the fundamental properties of networks. These properties can be listed shortly as follows; (i) they create social capital (ii) they are the engines of innovative regions (iii) they shape the diffusion of technologies and practices (iv) they create tastes and preferences (v) they alternate markets and create new ones (Oven-Smith, 2009: 6).

Knowledge networks have critical importance in networked economies. Knowledge as both public good and quasi-private good properties, is perceived because of a collective process. In this context, knowledge is created by interconnected agents and serves the community. Indivisibility and complementarity features of knowledge characterize the creation and dissemination of knowledge across economic units. In this approach, technological proximity has a key role in the absorption of knowledge by learning agents (Allen, 1983; Von Hippel, 1988).

The economics of knowledge governance define the knowledge-sharing dynamics in ecosystems. Especially, open knowledge disclosure and closed knowledge disclosure contexts have shed more light on the transaction cost bases of knowledge sharing. Knowledge is a key factor in economic growth and innovation, and its efficient administration and control are crucial for sustainable development. This field explores the economic incentives and procedures affecting how information is produced, shared, and used in public and private spheres (Fan and Lee, 2009; Marin and Kaminski, 2020).

Intellectual property rights are very important when discussing knowledge governance. These legal protections and inducements to invest in knowledge production, such as patents, copyrights, trademarks, and trade secrets, are provided by these rights, which also include copyrights. The Economics of Knowledge Governance examines the impact of different legal systems on the production, sharing, and commercialization of knowledge. One of the biggest

problems in this field is finding a balance between encouraging innovation and guaranteeing that knowledge is accessible to everybody (Lichtenthaler, 2011; Chen et al., 2015).

The Economics of Knowledge Governance goes more into how institutions and laws influence knowledge ecosystems. The creation and dissemination of knowledge are substantially influenced by public policies, rules, funding sources, and educational institutions. It is essential to comprehend how these aspects affect the dynamics of knowledge generation and usage when developing effective policies to encourage innovation and social growth (Gassmann et al., 2010, Arias-Perez et al., 2022).

2. Systematic Literature Review

Due to its potential to address current difficulties and promote sustainable development, the combination of complex ecosystems and OI has received considerable attention in academic literature. Complex ecosystems have been the focus of research because of their deep linkages and nonlinear interactions between different constituents. To understand complex ecosystems' resilience, variety, and contributions to the health of the world, researchers have looked at their ecological, social, and economic elements (Franzò et al., 2022). In this context, the literature highlights the necessity of protecting and managing complex ecosystems sustainably to ensure their ongoing benefits to both the environment and human civilization.

In parallel, OI has arisen as a paradigm shifter, moving the conventional closed innovation paradigms in the direction of collaboration, openness, and information sharing. The concepts, processes, and effects of OI on competitiveness and organizational performance are the subject of much research (Ngo, 2023). OI promotes the exchange of concepts, information, and assets across organizational boundaries, fostering alliances, partnerships, and collaborations. To leverage outside knowledge, speed up the innovation process, and maintain agility in a quickly changing global market, organizations must implement OI methods, according to the literature (Gentile Lüdecke et al., 2020).

The literature also discusses the difficulties that might develop when OI is used in the setting of intricate ecosystems. The establishment of trust between many players, intellectual property issues, and efficient governance processes are all cited as major obstacles. Additionally, it stresses the importance of creative techniques to encourage cooperation and knowledge exchange within complex ecosystems. Scholars argue that further in-depth investigation of these issues and the formulation of workable solutions might help OI be successfully integrated into complex ecosystems in the future. Therefore, the literature on OI and complex ecosystems stresses the potential for synergies when the two ideas are joined while also offering a thorough knowledge of each one alone. Researchers and practitioners may strive towards creative solutions for sustainability, ecosystem preservation, and general societal well-being by investigating and implementing OI within complex ecosystems. For this integration to reach its full potential and to successfully navigate the difficulties that can occur in this complex and dynamic environment, more study in this area is very necessary.

In this context, this study conducts a systematic literature analysis indicating the roots and development path of OI understanding in terms of network approach in complex ecosystems. The roots of the OI concept go back to the knowledge disclosure frameworks and the first introduction of OI as a concept was by the study of Chesbrough (2003a). Following this seminal study, academics, managers and policymakers have paid increasing attention to this concept (Bigliardi et al., 2021: 1130). Table 1 gives a summary of a comprehensive literature survey on OI. It includes 109 studies between the years of 2003 – 2023. This time interval has been determined in parallel with the emergence of the concept and the studies have been chosen across the most cited and downloaded articles, conference papers and book chapters. Google

Scholar and WoS Databases have been used to reach the studies. ‘Open Innovation’, ‘knowledge networks’ and ‘complex ecosystems’ have been selected as keywords.

Table 1 classifies the studies according to their structures. Hence, there are 3 classes as conceptual and theoretical studies, empirical studies and literature surveys. This classification is as to the contexts of the studies. In this manner, the studies handling the topic just with a theoretical frame or conceptual definitions, are classified as conceptual and theoretical studies. Here, the basic reason to merge conceptual and theoretical studies in one heading is the fact that conceptual studies use the existing theoretical background. Moreover, the studies examining the issues with empirical applications and deriving some empirical facts, are classified as empirical studies. And lastly, the studies examining the topics by literature surveys and meta analysis on the related literature, are classified as literature surveys. Such a classification shed light on the basic roots and the development path of the studies about open innovation. The basic evidence from this survey is; (i) the most of the studies are empirical studies, (ii) literature surveys have evolved to meta-analyses in recent years, (iii) the most of the studies have been published in specific journals (most of them are in Journal of Open Innovation: Technology, Market, and Complexity).

Table 1: Structural Classification of OI Studies

Conceptual and Theoretical Studies	Empirical Studies			Literature Reviews
Chesbrough (2003a)	Hughes and Wareham (2010)	Del Vecchio et al. (2019)	Singh et al. (2021)	Wikhamn and Wikhamn (2013)
Chesbrough (2003b)	Malecki (2011)	Gershman et al. (2019)	Solarte – Montufar et al. (2021)	West and Bagers (2014)
Chesbrough et al. (2006)	Munoz and Lu (2011)	Gomezel and Rangus (2019)	Teran-Bustamente et al. (2021)	Poutanen et al. (2016)
Lubello (2008)	Zou and Yilmaz (2011)	Su et al. (2019)	Aleksic et al. (2022)	Natalicchio et al. (2017)
Rio et al. (2011)	Figaredo and Alvarez (2012)	Capone and Innocenti (2020)	Basic (2022)	Fisher and Qualls (2018)
Wang et al. (2012)	Wang and Chen (2012)	Giusti et al. (2020)	Bigliardi et al. (2022)	Lopes and Garvalho (2018)
Billington and Davidson (2013)	Lefebvre et al. (2013)	Han et al. (2020)	Chabbouh and Boujebene (2022)	Tani et al. (2018)
Sekliuckiene et al. (2016)	Abreu and Urze (2014)	Huggins et al. (2020)	Daradkeh (2022)	Alvarez-Meaza et al. (2020)
Dolfsma and van der Eijk (2017)	Taheri et al. (2014)	Liu and Tang (2020)	Gajdzik and Wolniak (2022)	Chaurasia et al. (2020)
Zobel (2017)	De Beer and Armstrong (2015)	Marin and Kaminski (2020)	Jabeen et al. (2022)	Baierle et al. (2021)
Della Peruta et al. (2018)	Schneckenberg (2015)	Naruetharadhol et al. (2020)	Kashosi et al. (2022)	Iqbal and Suzianti (2021)
Lau (2018)	Hau (2016)	Scuotto et al. (2020)	Kurniawati et al. (2022)	Solarte – Montufar et al. (2021)
Chu et al. (2019)	Parmentola andTutore (2016)	Sun et al. (2020)	Latifah et al. (2022)	Abbate et al. (2022)
Jankovic and Golubovic (2019)	Sekliuckiene et al. (2016)	Velez-Rolon et al. (2020)	Li et al. (2022)	Bigliardi et al. (2022)
Gimenez-Fernandez et al. (2021)	Schurman et al. (2016)	Almeida (2021)	Ober (2022)	Carrasco – Carvajal et al. (2022)
Ritala and Stefan (2021)	Su et al. (2016)	Chen et al. (2021)	Rua et al. (2022)	
Arvaniti et al. (2022a)	Alberti and Pizzurno (2017)	Grimaldi et al. (2021)	Sedita and Grandinetti (2022)	
Arvaniti et al. (2022b)	Ramirez – Portilla et al. (2017)	Jiao et al. (2021)	Turon and Kubik (2022)	
Cheng (2022)	Santoro et al. (2017)	Lam et al. (2021)	Wang et al. (2022a)	
Ji et al. (2022)	Vayrynen et al. (2017)	Papa et al. (2021a)	Wang et al. (2022b)	
Jun and Kim (2022)	Flores et al. (2018)	Papa et al. (2021b)	Zhang and Ji (2022)	
	Peris – Ortiz et al. (2018)	Sanchez – Henriquez and Pavez (2021)	Zhao (2022)	
	Villasalero (2018)	Sanchez – Teba et al. (2021)	Kitsios and Kamariotou (2023)	
	Wilhelm and Dolfsma (2018)	Shi et al. (2021)		
	Bernal et al. (2019)	Shmeleva et al. (2021)		

Notes: (i) Studies are arranged as to dates in ascending order.
(ii) Solarte-Montufar et al. (2021) listed in both empirical studies and literature reviews since it has both dimensions.

Studies combining OI approach with network perspective can be listed as Malecki (2011), Munoz and Lu (2011), Rio et al. (2011), Zou and Yilmaz (2011), Wang and Chen (2012), Wang et al. (2012), Billington and Davidson (2013), Lefebvre et al. (2013), Abreu and Urze (2014), Scheneckenberg (2015), Schuurman et al. (2016), Alberti and Pizzurno (2017), Dolfsma and van der Eijk (2017), Lubello (2017), Vayrynen et al. (2017), Villasalero (2018), Chu et al. (2019), Su et al. (2019), Capone and Innocenti (2020), Han et al. (2020), Huggins et al. (2020), Giusti et al. (2020), Liu and Tang (2020), Pikatza et al. (2020), Chen et al. (2021), Papa et al. (2021a), Shi et al. (2021), Shmeleva et al. (2021), Cheng (2022), Ji et al. (2022), Kashosi et al. (2022), Latifah et al. (2022), Wang et al. (2022b), Zhang and Ji (2022). However, the number of studies directly examining knowledge networks and OI interplay is far low. We face with few studies as Scheneckenberg (2015), Hau (2016), Wang and Chen (2012) and Wang et al. (2012). In this manner, it's important to underline that OI and networks interplay is an emerging study area, especially in recent years. The increasing number of studies indicating this relationship exhibits the rise of this understanding. However, knowledge networking and OI interplay still needs more attention in the literature.

Our structural classification of OI studies exhibits that OI concept in terms of knowledge networks and complex ecosystems are mainly examined with empirical methods. The research area seems to be opened by conceptual and theoretical studies as the beginning of 2000s. Then the development path tilted to empirical examinations. Although literature reviews have also emerged in recent years, they still lack behind the empirical studies. All these facts underline that open innovation issue in terms of knowledge networks and complex ecosystems, has a high and accelerating attention with an empirical probation tendency.

Although knowledge networking as a complex ecosystems understanding still lags behind the OI framework, the critical importance of knowledge flows and sharing in OI systems have a wide acceptance in the literature. There are numerous studies examining knowledge flows in OI environment. Figure 1 shows the map of studies examining this issue in the literature. Artificial Intelligence based literature mapping programme Litmaps has been used to construct this map.

Figure 1: Literature Map of Knowledge in OI

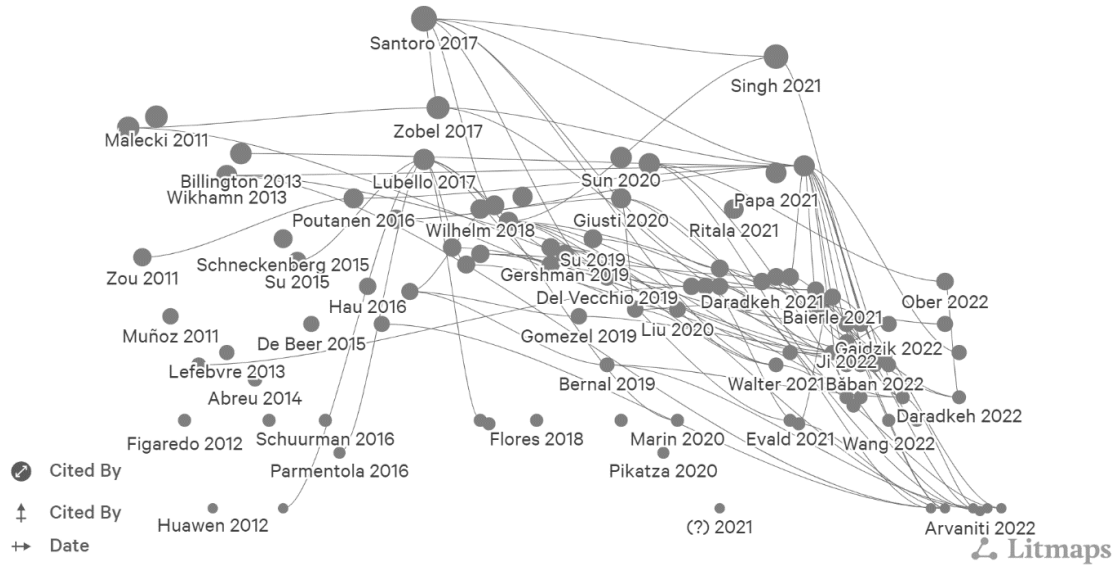

Figure 1 exhibits that knowledge and OI interplay has started to take attention in the literature in 2011 and it's significant that studies examining this issue have accelerated in recent years. They are closely linked to each other and hence the network of this literature is quite dense. This evidence shows that studies about knowledge in OI perform high reciprocal citation performances due to the fact that the research area is still small. And hence this research area has a high potential to develop. What is more is that the most of the studies are empirical studies and their findings are similar indicating the critical importance of OI in knowledge flows and sharing.

Conclusions

OI in complex ecosystems is a paradigm shift that can reshape how innovation is accomplished and sustained in the contemporary world. This study focused on the development of knowledge networks idea in OI to examine the complicated interaction between OI and complex ecosystems. This paper underlines the importance of well-constructed rules and frameworks to steer OI projects within these complex ecosystems through an examination of the current literature.

OI in complex ecosystems goes beyond simple organizational strategy to encompass a comprehensive plan that considers the diversity of information and experience among different players. When used inside complex ecosystems, the collaborative aspect of OI increases the ecosystem's capacity for creativity and collective intelligence. In this setting, intellectual property, one of the core elements of intangible capital, emerges as the cornerstone of innovation. The frameworks and rules described here are essential for managing intellectual property and making sure that openness in invention does not jeopardize its commercialization and protection.

OI is mostly driven by cooperation and knowledge sharing, thus policies that encourage this culture are crucial. To fully use the potential of OI, a supportive atmosphere that promotes knowledge sharing, trust, and respect for intellectual property rights is essential. Furthermore, rules that reward active involvement and acknowledge significant achievements are essential for encouraging stakeholders to remain engaged and committed over time.

Systematic literature review developed in this study exhibits that knowledge and OI interplay has started to take attention in the literature in 2011 and the studies examining this issue have accelerated in recent years. What is more is that studies are closely linked to each other and hence the network of this literature is quite dense. Furthermore, the most of the studies are empirical studies and their findings are similar indicating the critical importance of OI in knowledge flows and sharing.

The studies examined in this study exhibits a consensus about the role and importance of OI in knowledge networks of complex ecosystems. OI within intricate ecosystems is crucial for negotiating the complexities of the contemporary innovation landscape. A significant result of this integrated strategy is the creation of intangible capital, which is fueled by cooperative knowledge networks and directed by clear regulations. To stay at the forefront of innovation, maintain long-term development, and be competitive, enterprises must embrace OI across complex ecosystems as the global innovation environment continues to change.

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