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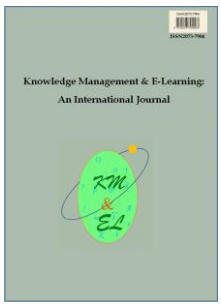

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Knowledge spillovers and entrepreneurial ecosystem: A systematic literature review

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Abstract: The purpose of this study was to synthesize the literature that has been established on the interrelationship of "knowledge spillovers and entrepreneurial ecosystem" through a systematic literature review. The query strings generated 85 articles, of which 51 were selected for final review. The analysis was performed using MySLR software that uses the Latent Dirichlet Allocation (LDA) method, and the effectiveness was measured through the perplexity score and coherence value of the topics. The results reveal that although a plethora of literature is available on these two topics individually, the mutual relationship between these two concepts is understudied. A stronger research interest was observed after 2018 which indicates the infancy of the topic as a whole, which is yet to be explored and empirically tested, specifically in developing economies. Most of the research was focused on the role of universities, innovation, geographic dynamics and policies with respect to entrepreneurial ecosystems. Results reveal the disparity of knowledge spillovers with regard to other contributors; significantly lesser attention was paid to its role in relation to the entrepreneurial ecosystem. Along with critical analysis and synthesis of literature, future directions have also been presented in the paper.

Keywords: Knowledge; Knowledge spillovers; Entrepreneurial activity; Entrepreneurial ecosystem

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1. Introduction

The significance of knowledge in promoting entrepreneurship and economic activity has been widely acknowledged and extensively studied in the influential works of Schumpeter (1934) and Marshal (1920). However, there appears to be a lack of sufficient research and exploration on the connection between knowledge spillover and the entrepreneurial ecosystem in existing literature. Both the Knowledge Production Function (KPF) theory (Griliches, 1979; Jaffe, 1986) and Endogenous Growth Theory (EGT) by Romer (1990) endorsed knowledge spillovers as a fundamental ingredient of entrepreneurial activity; KPF investigates the transfer of knowledge from educational institutes to industry, whereas, in EGT, knowledge spreads from firms to society, raising the overall technological level of the economy and subsequent economic endeavours. Numerous empirical investigations indicate that such spillover effects are regionally bounded and that certain areas have the concentration of certain types of knowledge, for instance, Sialkot city has a stronger and more robust knowledge of sports equipment production, especially football manufacturing, than other cities of Pakistan.

The knowledge spillover theory of entrepreneurship (KSTE) posits that entrepreneurship serves as a vehicle for the transmission of knowledge spillovers. The KSTE economic model, being primarily theoretical in nature, has not been adequately described in existing literature in terms of its theoretical framework, policy implications for economic development, and its potential impact on the development and sustainability of entrepreneurial ecosystems (Qian, 2018). This is particularly true in the context of developing countries, where economic agents often lack sufficient government or institutional support. The comprehension of the connections between locally generated or endowed knowledge and the advancement of regional economies is of paramount importance in the pursuit of regional economic development. Although the entrepreneurial

ecosystem perspective is recognized as a crucial component in existing theories of economic growth, further examination and elucidation are necessary to fully understand its relationship with knowledge spillover.

Given the existing gap in academic literature, the primary aim of this paper is to offer an exhaustive synthesis of the existing body of work pertaining to knowledge spillover and the entrepreneurial ecosystem. This study utilizes a synthesis approach as opposed to a critical approach, which normally seeks to identify deficiencies in an established theory and propose avenues for future research. An attempt was made to consolidate the fragmented research on knowledge spillovers and the entrepreneurial ecosystem, with the aim of highlighting the evolving nature of studies in this field and establishing a foundation for further elaboration and advancement of existing theories.

This synthesis makes three contributions to literature. First, by highlighting research streams in this area, the study would help understand the major contributors to the entrepreneurial ecosystem. Second, assess the equivalence of knowledge spillovers among those contributors and third, single out the vitality of knowledge spillovers and point out its pathways of contribution to the entrepreneurial ecosystem. In the end, we have combined the key findings based on the abovementioned contributions and provided a comprehensive range of future research avenues and theory building.

1.1. Knowledge, knowledge spillovers and knowledge transfers

According to Audretsch (2007), knowledge catalyzes innovation and facilitates the advancement of economic progress. Human capital is widely recognized as a significant means of information diffusion (Ferreira et al., 2017). The flow of knowledge through human capital can occur both intentionally and unintentionally, contingent upon the specific setting (Ghio et al., 2015). The acquisition of knowledge by individuals is facilitated by the process of assessing its practicality for future endeavours (Straus et al., 2013). The transfer of knowledge within a collective can be described as having a free nature, as seen by Tavassoli et al. (2017). The concept of knowledge spillovers pertains to the inadvertent transfer of knowledge from one node to another within a network, as defined by Ko and Liu (2015). Knowledge spillovers facilitate the transmission of knowledge in the absence of an intentional goal. This distinction sets them apart from knowledge transfer, which entails intentional exchanges of knowledge (Cristo-Andrade & Ferreira, 2020).

It is to be noted that knowledge spillovers and knowledge transfers are two distinct forms of knowledge flow that play a critical role in economic development. While both types have their own significance, spillovers appear to have a greater impact at the macro, regional, or societal level. Unlike transfers, spillovers involve no compensation or market-rate compensation to the holder of the knowledge when they occur (Agarwal et al., 2010). The evaluation of knowledge spillovers can be conducted by assessing their quantity, extent, and speed, as highlighted by Ferreira et al. (2017) since the dissemination of knowledge generates advantages for individuals or entities beyond the original source. Due to the close connection the knowledge has with innovation – knowledge spillovers can lead to entrepreneurship (Ghio et al., 2015). When there are variations in knowledge capacity across various areas and sectors, knowledge spillover is said to be the process of knowledge and technology transfer.

Knowledge spillover is a natural by-product of knowledge and technology, and it is one sort of economic externality. Knowledge spillover is time-restricted in a constrained time and space environment. Knowledge spillover, according to Grossman and Helpman (1990), arises from the growth of regional commerce, and as trade grows, so does the degree of knowledge spillover. Knowledge diffusion, decentralization, externality, and efficiency were all investigated by Klibanoff and Morduch (1995). The underlying concepts of knowledge spillover were further addressed to encompass broader and more contextual settings. Among those concepts, skilled human resources and workforce are considered crucial elements of knowledge spillover that play a vital role in the economic development of a certain region through entrepreneurial activities and innovation (Trippl & Maier, 2010). Similarly, spillover is firmly incorporated with technological knowledge. However, most research in this trajectory focused on technological impact yet hardly explained the causality. Hence, causality should be explored since it can define each entity's role in the knowledge exchanges (Perri & Peruffo, 2016).

The concept of knowledge spillover has received considerable attention in academic literature. It has been discussed since its inception by influential scholars such as Arrow (1962), Marshall (1890), and Romer (1986). Fallah and Ibrahim (2004) and Fischer (2001) have provided definitions of knowledge spillover, while Bergman and Schubert (2005) have examined the role of knowledge spillover agents. The role of knowledge spillover has been explored by Montoro-Sánchez et al. (2011) and Stejskal et al. (2016), and its potential outcomes have been investigated by Porter (1990), and Carlino (2001). The propagation of knowledge spillover has been studied by Schmookler (1962) and Hall et al. (2001), and the influence of region and industry on knowledge spillover has been examined by Lucas (1988), Krugman (1991), and Aghion et al. (2005). Furthermore, the relationship between knowledge spillover and innovation and entrepreneurship has been explored by Acs and Audretsch (2003) through the Knowledge Spillover Theory of Entrepreneurship (KSTE). However, there has been a far smaller amount of research conducted on its connection with the entrepreneurial ecosystem.

1.2. Entrepreneurial ecosystem

Entrepreneurial ecosystems have been dubbed as a set of mutually dependent set of actors and elements that interconnect and cooperate in such a manner that promotes and fosters entrepreneurial activity in a certain region (Stam & Spigel, 2016). Another way to look at this concept has been presented by Spigel (2017) as the "*combinations of social, political, economic, and cultural elements within a region that support the development and growth of innovative start-ups and encourage nascent entrepreneurs and other actors to take the risks of starting, funding, and otherwise assisting high-risk ventures*". Consequently, given its elaborate nature, the idea of entrepreneurial ecosystems has attracted the attention of socio-political leaders and policymakers to design and implement strategies for more sustainable growth through the rich amalgamation of final capabilities and social norms to promote long-term entrepreneurial activity and a mindset of innovation (Stam & Spigel, 2016).

There are several major theories of entrepreneurial ecosystems that have been proposed in the literature. These theories highlight the importance of the environment and the interactions between various components in fostering entrepreneurship. For example, Isenberg's model of entrepreneurial ecosystem, proposed by Isenberg (2010) in the Harvard Business Review, suggests that a successful ecosystem for entrepreneurship is

composed of four key components: institutions, individuals, networks, and resources. The Acs and Audretsch model of entrepreneurial ecosystem (1990), suggests that a successful ecosystem for entrepreneurship is composed of three key components: firm, market, and environment. The work of Davidsson (2003), published in the Journal of Business Venturing, suggests that bridging and bonding social capital, consisting of both strong and weak ties, was a robust predictor for nascent entrepreneurs, as well as for advancing through the start-up process. The work of Shane (2003) on entrepreneurial intentions, realization and ecosystem, suggests that successful entrepreneurship is composed of the following components: entrepreneurs, opportunities, resources, networks, and institutions.

A rather neglected domain within the existing body of literature pertains to the comprehensive comprehension of knowledge spillovers within ecosystems, encompassing the attitudes, capabilities, and motivators of entities engaged in entrepreneurial activities. (Jones & Ratten, 2021). In recent years the idea of the entrepreneurial ecosystem through the lens of knowledge spillover has caught the attention of the researchers as is evident by the fact that the knowledge spillover theory of entrepreneurship has found a strong foothold among the literature on the mechanism of modern-day industrial landscape. The ever-growing role of information and communication technologies (ICTs) and rampant acceptance and vitality of knowledge management theories and practices have surely paved the way for a need to comprehend the interrelationship of these two ideas.

The current academic discussion places significant emphasis on the importance of understanding and measuring the interconnections between knowledge spillovers and the entrepreneurial ecosystem. Furthermore, it has been noted that the predominant approach to fulfilling this criterion is through the use of the knowledge spillover theory of entrepreneurship. However, it is worth mentioning that in previous studies, the KSTE received minimal consideration (Ferreira et al., 2019; Ghio et al., 2015). According to Jones and Ratten (2021), there are notable gaps in the existing literature pertaining to the utilization of knowledge spillovers within an ecosystem context. The current body of research lacks comprehensive analysis and explanation regarding the substantial impact of knowledge spillovers on the creation and sustainability of a prosperous entrepreneurial ecosystem. Moreover, in their bibliometric analysis, Calabuig-Moreno et al. (2021) argue that despite the increasing attention and research devoted to the topic, the study of knowledge spillover and EE is still in its infancy, leaving ample room for further exploration and understanding. It is worth noting that there remains a lack of clarity on the determinants of entrepreneurial ecosystems and knowledge spillovers, with no established technique for their investigation. Furthermore, the field of literature has extensively explored the topic of entrepreneurial ecosystems and their assessment while there remains a gap in understanding the nature of knowledge spillover and its significance within the context of entrepreneurial ecosystems.

These gaps surely provide enough grounds to invite an enquiry into the interrelationship of knowledge spillover and EE through SLR. The researcher intends to delve into the fundamental nature of inquiry by asking rudimentary questions to synthesize the literature such as a) the establishment of literature at the intersection of knowledge spillover and EE, b) contributors of EE and finally c) the role of knowledge spillover in EE. Answering these questions would provide profound insights into understanding the complex and contextual nature of EE through a unique and sensitive lens of knowledge spillover. The study would foster theoretical contribution by providing conceptual clarity on the distinguished and singled-out role of knowledge spillover in establishing EE. The

goal is to highlight the key findings and propose a way forward for further theoretical understanding and development.

The structure of this study is as follows. First, the data collection procedure is presented in detail, including the databases or repositories of interest, the query strings and the number of articles. Then, the data analysis procedure is explained to ensure the comprehension of the software MySLR© used for this systematic literature review and the consequent nature of the results. The results are presented through various textual and graphical information produced by the software. The results are then discussed to develop and understand the underlying concepts and their mutual relationship. Based on those findings, the conclusions are drawn and future avenues for researchers in these fields are presented.

2. Method

A systematic literature review is a rigorous and comprehensive evaluation of the available research on a specific topic or research question. It is a type of literature review that follows a structured and systematic approach to identify, critically evaluate, and synthesize all relevant research on a particular topic. The goal of a systematic literature review is to provide a comprehensive and up-to-date understanding of the current state of knowledge on a specific topic (Ammirato et al., 2020; Denyer & Tranfield, 2009). The generic SLR in management research have been laid out by Ammirato et al. (2022) as follows in Fig. 1.

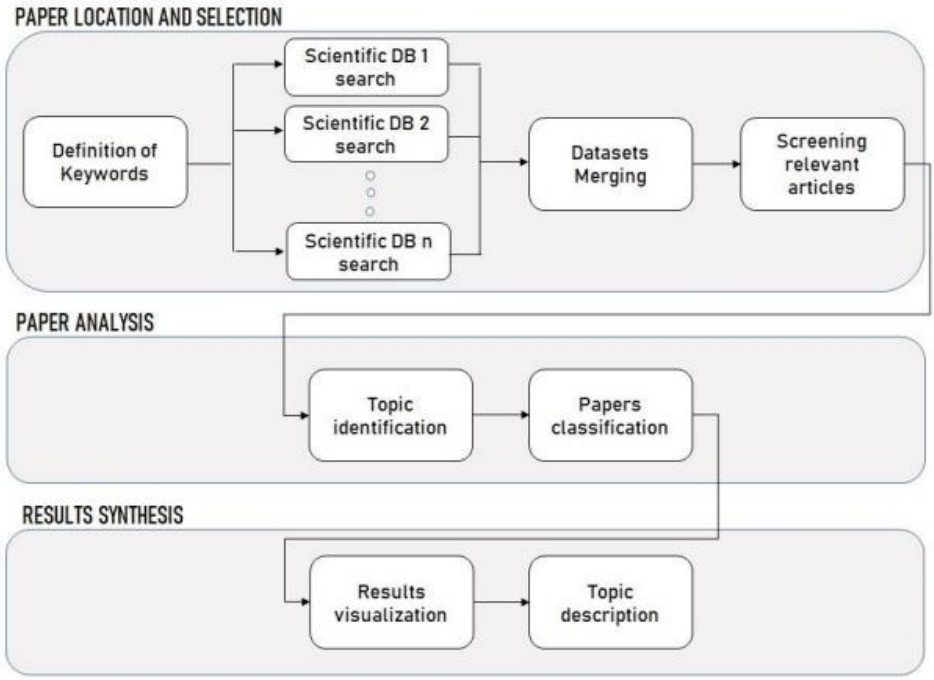

Fig. 1. Systematic literature review process flow in organization and management research, adapted from Ammirato et al. (2022)

2.1. Defining the research question(s)

The first step is to clearly define the research question(s) that the systematic literature review is to address. This study aims to synthesize the scientific literature on the concepts of knowledge spillover and entrepreneurial ecosystem, and to develop an encompassing understanding by asking the following question:

1. What research efforts have been undertaken to comprehend and analyse the interconnectedness between knowledge spillover and the entrepreneurial ecosystem?
2. What major contributors to the entrepreneurial ecosystem have been identified in the literature and where does knowledge spillover stand among them?
3. What role has been attributed to knowledge spillovers in relation to the entrepreneurial ecosystem?

2.2. Identifying relevant studies from scientific database(s)

The next step was to identify relevant studies by searching databases such as Scopus, Web of Science, and other relevant sources. These two repositories remain the most commonly used assessment tool for ranking and evaluating scientific journals (Yang & Zhang, 2013) because they are the world leader in the search for scientific citations and are widely used by global researchers in almost all domains of knowledge.

The following query strings were generated for the retrieval of related documents on knowledge spillover and entrepreneurial ecosystem, and accessed on 12 January 2023:

- Scopus: (knowledge AND spillovers AND entrepreneurial AND ecosystem) AND PUBYEAR > 2013 AND PUBYEAR < 2022 AND (LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ECON") OR LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "COMP")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar"))
- Web of Science (WoS) Core Collection: https://www.webofscience.com/wos/woscc/summary/fcc22504-b618-4ac3-9fca-cd295137241b-6a2ba4d8/relevance/1

It is to be noted that the purpose of this review was to synthesize the research articles that addressed both the concepts; knowledge spillover and entrepreneurial ecosystem, along one and other and not separately.

2.3. Selection of the studies

The following steps were taken for the selection of retrieved studies. The time frame of these publications was set to be between 2013 and 2022; the articles published before 2013 and after 2022, were not considered. Subject areas were also limited to Business, Economics, Social Sciences and Computer Sciences. Engineering and Environmental Sciences articles and articles published in languages other than English were excluded. These queries generated a total of 85 articles collectively from both repositories: 31 articles from Scopus and 54 articles from WoS Core Collection. After careful review of the retrieved data and trimming to ensure topic relevancy and to identify and remove duplication; 51 articles were finalized for subsequent analysis.

2.4. Data analysis and synthesis

The data was analyzed using MySLR; a web-based software that uses metadata from network repositories to draw results for systematic review. MySLR is a web-based tool for conducting SLR with a specific focus on organizational and management sciences research. This platform was initially established and presented by Felicetti et al. (2021), as it assists in carrying out SLRs collaboratively and showing in quasi-real time the new results. Other than that, the tool presents the choice of the algorithm that best classifies the contributions and discovers research topics starting from the initial set of keywords. This tool was preferred over other platforms such as Covidence, Ryyan, Bibliometrix/Biblioshiny, VosViewer and SciMAT because they pay much attention to tools supporting the analysis of bibliometric networks (such as co-authorship, bibliographic coupling, and co-citation networks), and much less attention to the design of software tools that collaboratively support researchers throughout the entire SLR process. MySLR is the first-of-its-kind tool that digitalized the whole SLR process; from paper location and selection, paper analysis to result synthesis.

3. Results

MySLR provides two modeling algorithms for analysis; Latent Dirichlet Allocation (LDA) is a generative statistical model for discovering the underlying topics in a collection of documents. The basic assumption of LDA is that each document is a mixture of a small number of topics and each topic is a distribution over words. LDA uses a three-level hierarchical Bayesian model to discover latent topics from a collection of documents. It represents documents as a mixture of latent topics, where each topic is characterized by a distribution over words. LDA works by iteratively sampling topic assignments for each word in each document and then updating the topic-word and document-topic distributions based on these assignments.

Once the data is added to the software Coherence Score is generated and based on the higher, the type of algorithm is chosen. For this review, LDA was chosen since its values were higher than the LSI; around -5.6 and -5.8 respectively, as shown in Fig. 2.

As the modeling algorithm was selected then analysis is performed. The software allows the user to choose the number of dominant topics upon which to draw the results e.g., Configuration Modeling with 02 Topics, 03 Topics up to K Topics. The configuration with the lowest Perplexity Score and higher Coherence Value would be considered the best.

Perplexity is a measure of how well a probability distribution or model predicts a sample. In the context of Latent Dirichlet Allocation (LDA) models, perplexity is used to evaluate the quality of the model by measuring how well it predicts the likelihood of a given text. A lower perplexity score indicates that the model is better at predicting the text, and thus is considered a more accurate model. A lower perplexity score for the LDA model suggests that the model has effectively captured the underlying topics present in the text and is able to predict the likelihood of observing the text accurately.

Topic coherence is a measure used to evaluate the quality of the topics generated by topic models such as LDA and Latent Semantic Analysis (LSA). It measures how semantically similar and coherent the words in a topic are. A higher topic coherence score indicates that the words in a topic are more semantically similar and coherent, making the topic more interpretable and meaningful. It is important to note that topic coherence is not

an absolute measure, and the score can vary depending on the specific implementation and method used. Additionally, the choice of data to evaluate the models on is crucial for the accuracy of the scores.

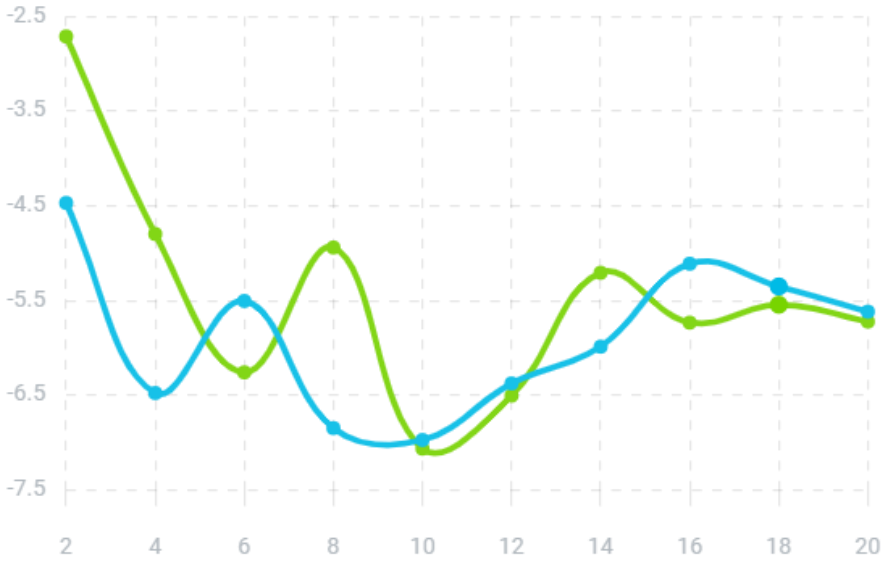

Fig. 2. LDA (blue) and LSI (green) graph for coherence score for modeling algorithm selection

The analysis was run with three model configurations with 02 Topics, 03 Topics, and 04 Topics. Although the model configuration with 02 Topics has a higher perplexity score compared to the other two configurations; -6.73, -6.75 and -6.76 respectively, its topic coherence was the highest among the three configurations; -2.44 to -6.09 and -7.07, as shown in the Table 1. Hence model configuration with 02 Topics is considered the best for result synthesis.

Table 1
Topic modeling configuration sets

Topics	Perplexity	Coherence
02	-6.73	-2.44
03	-6.75	-6.09
04	-6.76	-7.07

Note. The algorithm applied is LDA.

3.1. Modeling configuration with 02 Topics

As shown above, the 02 Topics model configuration has the highest topic coherence of -2.44 and negligibly higher perplexity value among all three configurations, its results yielded the following.

3.1.1. Topics evolution, weight and frequencies

Among 51 articles that have been analyzed, 30 documents were placed in Topic 1 and 21 documents into Topic 2. As per the timeline of the query string of 2013 to 2022, the following histogram shows the evolution of both topics through the decade and the number of articles published in each year. It can be seen that in the last four years, from 2018 to 2021 – research interest in both topics increased exponentially, as shown in Fig. 3.

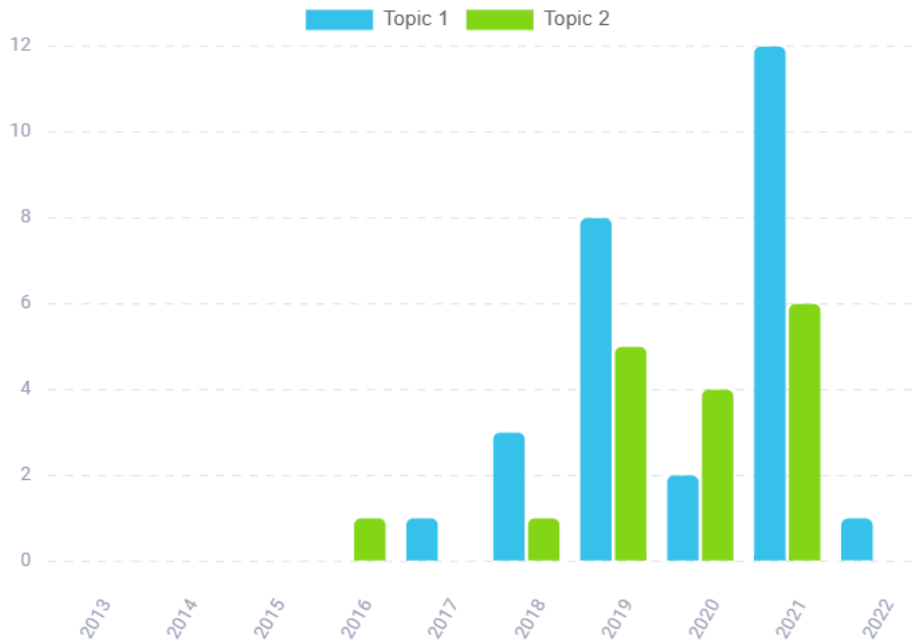

Fig. 3. Number of publications of Topic 1 and 2 over the years

In order to better understand and grasp the idea of knowledge generation in literature and the researcher's interest in these areas, the following word clouds paint a clear picture of the weights of terminologies and keywords that have been the center of attention in research work of the past decade, as shown in Fig. 4. "*Weight*" in a word cloud refers to the importance or frequency of a specific word in a given set of text data. It is usually calculated based on its frequency of occurrence in the text data or the amount of attention it receives from the researchers. In this way, the word cloud provides a visual representation of the most significant words or themes in a given set of text data, it is a measure of the "*Importance*" of a keyword in a topic (Blei 2012; Chang et al. 2009).

It can be seen that in this modeling configuration, the research output of both Topic 1 and Topic 2 mainly revolved around the role of universities, knowledge, entrepreneurial activity and innovation. Other major topics that played complementary roles include knowledge spillover, technology, regional dynamics, policy and ecosystem. Hence, Topic 1 can be labeled as the "*role of universities in knowledge, innovation and entrepreneurial activity*" and Topic 2 can be characterized along the lines of "*entrepreneurial ecosystem, knowledge spillover and policy*". The following tables show the top 20 most frequently used terminologies in Topic 1 and Topic 2.

Fig. 4. Word clouds for Topic 1 (left) and Topic 2 (right)

Table 2
Most frequently used terminologies in 02 Topics model configuration

Term	Frequency	Total	LOGLIFT	LOGPROB
University	47.65	66.03	0.2318	-4.0185
Entrepreneurial ecosystem	40.44	59.57	0.1707	-4.1825
Knowledge	33.23	50.86	0.1324	-4.3788
Ecosystem	49	49	30	30
Entrepreneurial	33.23	48.61	0.1777	-4.3788
Innovation	33.23	44.86	0.258	-4.3788
Policy	18.02	33.4	-0.0591	-4.9909
knowledge spillover	19.62	31.25	0.0926	-4.9058
Regional	21.22	29.85	0.2169	-4.8273
Develop	11.61	23.99	-0.1676	-5.4303
Policy	18.02	33.4	-0.0591	-4.9909
Field	14	14	27	27
Academic	13.21	16.59	0.3305	-5.3011
Model	13.21	15.09	0.4253	-5.3011
Stakeholder	13	13	16	16
Startup	12.41	16.54	0.271	- 5.3636
Cluster	12.41	15.79	0.3174	- 5.3636
Influence	12	12	14	14
Develop	11.61	23.99	-0.1676	- 5.4303
Development	11.61	16.49	0.2074	- 5.4303

Note. Term: the word or phrase being analyzed. Frequency: the number of times the term appeared in the data set being analyzed. Total: the total number of terms in the data set. LOGLIFT: a measure of the term's significance in relation to the other terms in the data set. A higher LOGLIFT value indicates a greater difference in frequency between the term and the average frequency of all terms in the data set. LOGPROB: a measure of the term's statistical significance. A lower LOGPROB value indicates that the term is less likely to appear in the data set by chance.

Based on the data, it appears that the most frequent terms in the data set are "*University*", "*Ecosystem*", and "*Entrepreneurial*". These terms have relatively high frequencies compared to the other terms and also have higher LOGLIFT values, which

indicate that they are more significant in relation to the other terms. On the other hand, terms such as "*Develop*", "*Cluster*", "*Startup*" and "*Influence*" have lower frequencies and LOGLIFT values, which suggest that they are less significant in the data set.

In this Topic modeling configuration, the "*University*" tops the chart with the highest frequency; 47.65 followed by the entrepreneurial ecosystem with a frequency of 40.44. We also see "*Knowledge*", "*Ecosystem*", "*Innovation*" and "*Policy*" at the top position of the table. Then there is knowledge spillover at number eight with a frequency of 19.62; almost half of the frequency of the entrepreneurial ecosystem, clearly stating that the effort of the researcher has been focused on the role and importance of universities as the main source of knowledge and subsequent innovation. These entries are clearly pointing towards the triple helix model. The triple helix model, also known as the triple helix of innovation, is a framework that describes the interactions and relationships between three key actors in the innovation process: government, industry, and academia. It was first proposed by Leydesdorff and Etzkowitz (1998) and has since been widely used to analyze innovation systems and policies in various regions and countries (Guerrero et al., 2017). Knowledge spillover has a role in all this but a meager one. It is to be noted that this model doesn't explicitly address or acknowledge the role and importance of "*knowledge spillover*" in either innovation or entrepreneurial ecosystem. To further supplement the results, an inter-topic map is also presented.

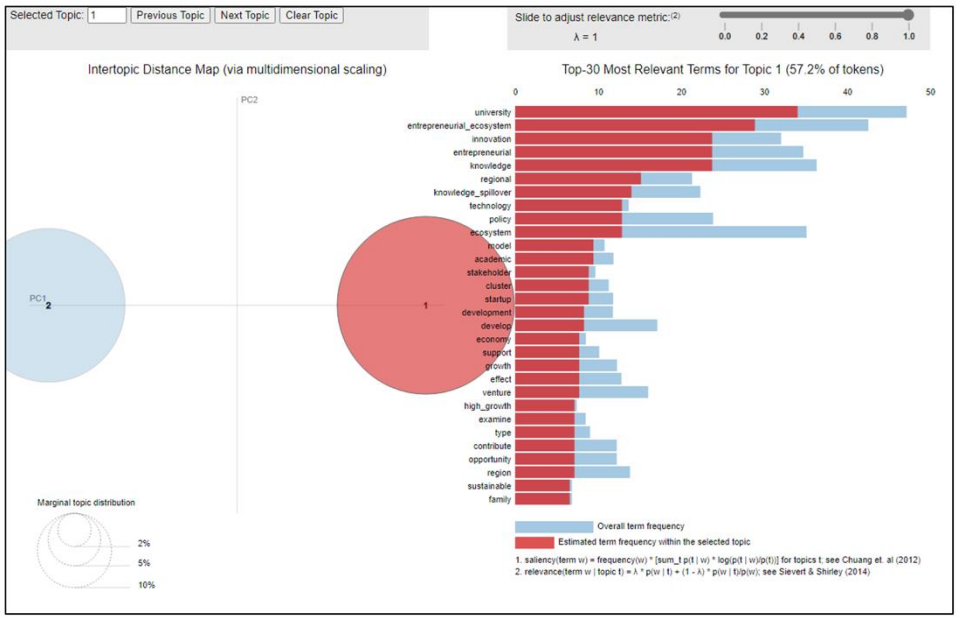

Fig. 5. Inter-topic distance map and term frequencies for topic 1

Fig. 5 and Fig. 6 show Topic 1 and Topic 2 are far apart on the map; as per LDA topic modeling protocol, the more non-overlapping and scattered the bubbles are, the better the topic model is. Upon selecting the bubble of Topic 1, it can be seen that "*University*", "*Entrepreneurial ecosystem*", "*Innovation*", "*Knowledge*" and "*Entrepreneurial*", are the most frequently used terms. Whereas in Topic 2, "*Ecosystem*", "*Entrepreneurial ecosystem*", "*University*", "*Knowledge*" and "*Policy*" are the most frequently used terms. These graphs also evident that research work in the recent decade has focused more on the

interrelationship of universities, knowledge, innovation, and entrepreneurial ecosystem. The role of knowledge spillover or its mutual relationship with other dominant factors is absent from the scene. The entrepreneurial ecosystem approach mainly has been complemented by the role of universities as knowledge creators, innovation, policies and regional factors. It is interesting to see that research and development or R&D as an independent keyword has not been mentioned among the 30 most frequently used terms.

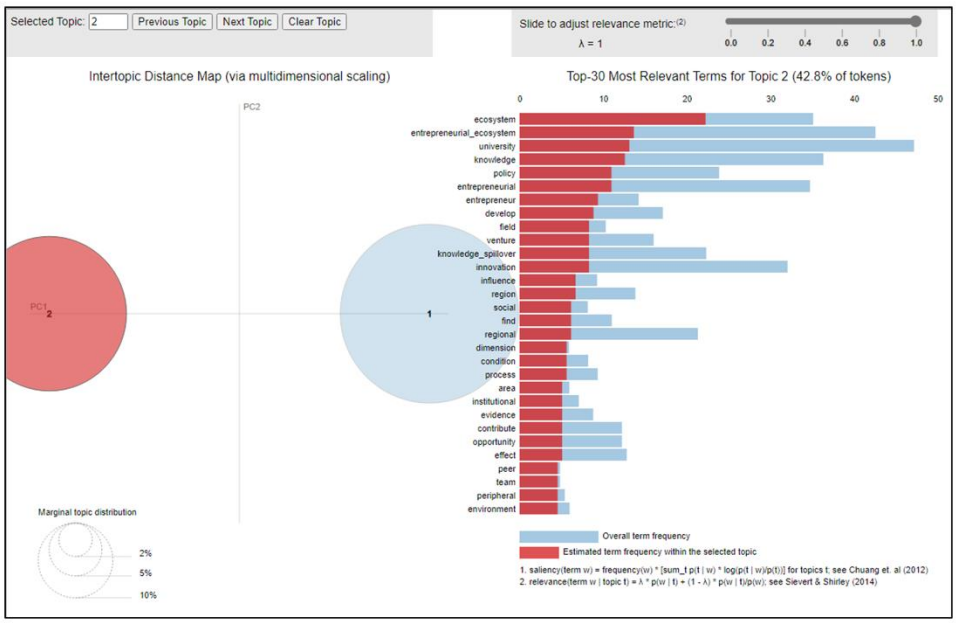

Fig. 6. Inter-topic distance map and term frequencies for topic 2

In order to further understand the convergence of established literature on the interrelationship of knowledge spillover and entrepreneurial ecosystem; a keyword co-occurrence analysis was performed on the same bibliographic data using VOSviewer, as shown in Fig. 7.

Hence, the largest and the most broadly connected cluster is the "*Innovation*" cluster, and this is the only cluster (green) that portrays a stronger interrelationship between innovation, entrepreneurial ecosystem, and knowledge spillover. It is to be noted that the blue cluster also includes the former terms but is not as significant as in green cluster.

4. Discussion

The purpose of this study was to synthesize the literature on knowledge spillover and entrepreneurial ecosystems and to encompass the scattered literature established to comprehend the interrelationship of these two concepts. The study was also aimed at the identification of major contributors to entrepreneurial ecosystems in the literature and the attribution of knowledge spillover among them. Finally, this synthesis sets out to assess and elaborate on the role assignment of knowledge spillover in the overall phenomenon of the entrepreneurial ecosystem. In relation to the first question, the results show that although the concepts of knowledge spillover and entrepreneurial ecosystem are not new,

research on the interrelationship of these two concocts is surely in its earlier stages. It is evident by the fact that a greater emphasis has been placed on knowledge spillover and entrepreneurial ecosystem and their mutual relationship, after 2017. A significant number of studies were published in the years between 2018 and 2022 as shown in Fig. 02. These findings indicate that there is a growing body of literature that explores the contributing factors of the entrepreneurial ecosystem; the second question – the current study found the following major contributors.

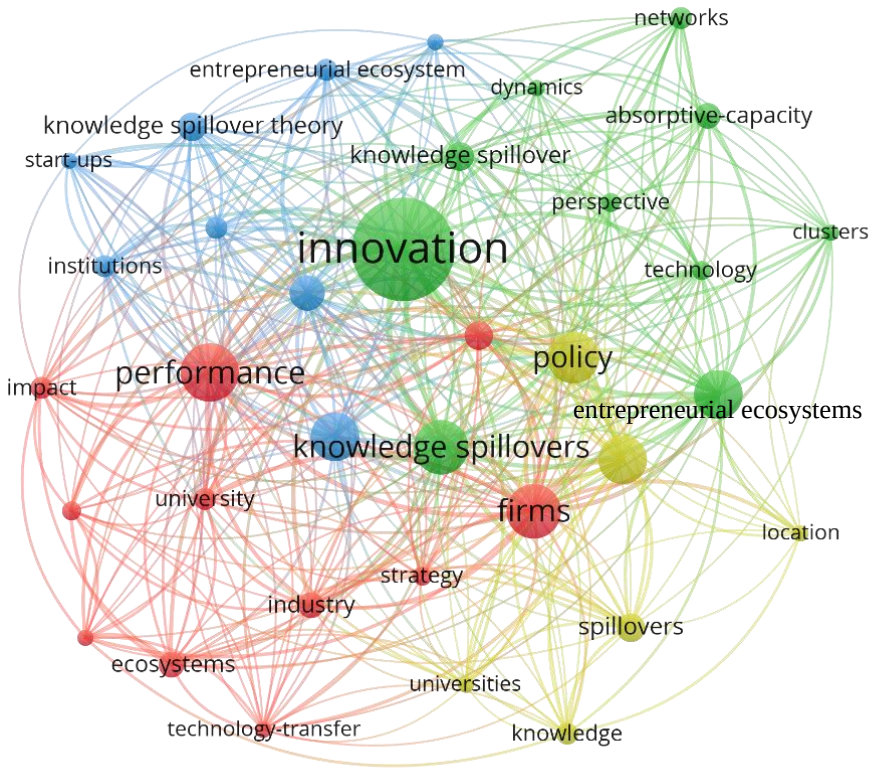

Fig. 7. Bibliographic keyword co-occurrence analysis

4.1. Role of universities, regional dynamics, and policies

The most frequently used terminologies in both Topic 01 and Topic 02 other than entrepreneurial ecosystem are, "*University*", "*Policy*", "*Develop*" and "*Region*". These three concepts were largely found to go hand in hand with each other. Universities often provide a wealth of resources and support to entrepreneurs, including access to funding, mentorship, and networking opportunities (Ierapetritis, 2019). The utilization of knowledge from universities to create start-ups has been recognized as a significant means of promoting knowledge spillover and regional economic growth. Entrepreneurship ecosystems in academia are now regarded as the primary and most effective method of engaging the business community, transferring knowledge, and creating value for society and the regional economy within the university-industry-government framework (Belitski & Heron, 2017; Secundo, et al. 2021). Similarly, Wagner et al. (2021) found that with

respect to regional developments, universities play an important role in knowledge spillovers to improve sustainable entrepreneurial ecosystems that benefit economic revitalization. These findings indicate a transcended role of universities, that is transitioning from mere knowledge producers to active participants in the overall phenomenon of the entrepreneurial ecosystem (Guerrero et al. 2016; Maritz et al. 2015; Maritz, 2017). The same is reported in the study by Padilla-Meléndez, et al. (2021), in which the role played by investment managers from university-focused venture capital firms (UVCs) in knowledge spillovers in entrepreneurial university ecosystems (EUEs) was analyzed, and how a third-party social connector facilitating a two-way knowledge and technology exchange is necessary in the development and sustainment of EUEs.

Another aspect of universities in the context of the entrepreneurial ecosystem that has been recognized is the occurrence of spinoffs. This area has managed to amass a significant focus in academic literature. Universities possess the capacity to exert a direct impact on their entrepreneurial ecosystem by means of establishing spin-offs and engaging in technology transfer operations with industry partners. Prencipe et al. (2020) and Civera et al. (2019), found that university spin-offs (USOs) are a vital element in the process of knowledge spillover and are significantly rooted in the regional entrepreneurial ecosystem.

It is to be noted that although universities are playing a significant role but the direction and robustness of liaison; where universities are proactively offering solutions to the industry or the industry seeking solutions from universities for their problems, has barely been addressed in the literature. The significance of this issue is heightened within the context of developing nations when universities struggle to adequately meet their own needs.

Another aspect that was inadequately addressed in the literature pertains to the factors that drive universities to participate in entrepreneurial initiatives other than the obvious ones. These factors may include a) the level and source of funding from public or private sectors, b) the rate of success of previous projects, and c) the universities' capacity to transform ideas into practical solutions utilizing their academic and research capabilities. Research conducted in these domains can undoubtedly yield valuable insights into the role of universities in the field of entrepreneurial ecosystem.

4.2. Role of institutions

Research has shown appropriate institutional mechanisms in place are necessary to facilitate the interaction of ecosystem components (Alvedalen & Boschma 2017; Autio et al. 2014; Mack & Mayer, 2016). Yet the literature lacks the apprehension as to what mechanism could be adopted if the institutions fall short or outright fail to perform their duty as is usually the case in developing economies and could knowledge spillover be brought in to fill the gap. Only one study by Bendickson et al. (2021) presented the case of institutional void and how it could be compensated by knowledge spillover in EE. This area of research could provide highly critical insight into the multifaceted nature of knowledge spillovers with regard to EE.

4.3. Disparity of knowledge spillover and its role

The result shows that there is a disparity of the term "*Knowledge spillover*" compared to other topics in the table can be seen by comparing its frequency, total, LOGLIFT, and

LOGPROB values with those of other terms. It appears that the term "*Knowledge spillover*" has a lower frequency, total, and LOGLIFT value compared to other terms such as "*University*" and "*Entrepreneurial ecosystem*". Additionally, its LOGPROB value is also lower compared to other terms. This disparity could be due to a number of factors, including the distribution of the term "*Knowledge spillover*" in the text corpus and its relationship with other terms. For example, it could be that the term "knowledge spillover" is used less frequently in the text compared to other terms, or it could be that the term is not as strongly associated with the topic as other terms.

The reason that knowledge spillover found little attention with regard to EE could be that the researchers mainly favoured the empirical measurement of other knowledge-related factors such as knowledge sharing (Azizi et al., 2023), internal knowledge flow and employee productivity (Umer et al., 2023), knowledge management and organization performance (Ullah et al., 2019) or entrepreneurial ecosystem (e.g., Johnson et al., 2022; Liguori et al., 2019; Nicotra et al., 2018; Stam, 2018; Sternberg et al., 2019) and spillovers (Xu et al. 2019). Furthermore, whenever the concept of knowledge spillover was brought up in the discussion of entrepreneurial ecosystem, the majority of the research supplemented and grounded it in the knowledge spillover theory of entrepreneurship. The analysis of the corpus revealed that in a greater number of studies, knowledge spillover has been assigned a lateral role that succeeds entrepreneurial ecosystem, that is to say, that EE must exist first for the consequent existence of knowledge spillover. The idea was initially proposed by Acs and Audretsch (2003) stating that regions with high levels of entrepreneurial activity also tended to have high levels of knowledge spillover. This suggests that a strong entrepreneurial ecosystem can create a positive feedback loop, where the flow of knowledge and ideas leads to the development of more and better entrepreneurial ventures, which in turn leads to even more knowledge spillover. These concepts later developed into the "*knowledge spillover theory of entrepreneurship*" or KSTE by Acs et al. (2004). Audretsch et al. (2005) proposed that new and unused ideas, generated in places such as a corporate research lab or university, serve as the source of inspiration for entrepreneurial opportunities. In other words, it is the flow of knowledge outside of its original context that leads to the creation of new businesses. However, the ecosystem perspective of knowledge spillover is not fully addressed in the theory. This theory highlights the importance of networking through which entrepreneurs tend to seek and exploit new knowledge. Here we can see that by adding a multitude of horizontal and vertical stakeholders with strong interdependence, network structure and sustainability – the idea of the ecosystem can be realized, and a theory of knowledge spillover entrepreneurial ecosystem can be proposed. KSTE is said to be in its infancy and yet to be tested in greater and deeper contextual frameworks, hence future studies can address the interrelationship of knowledge spillover and entrepreneurial ecosystem to reinforce and compound this theory, or perhaps add another dimension of knowledge spillover to the Daniel J. Isenberg's model of entrepreneurial ecosystem (2016).

The work of Qian (2018) points to the fact that existing work on entrepreneurial ecosystems has been generalized and not well-oriented for knowledge spillover entrepreneurship and while developing on the work of Spigel (2017) and Stam (2015), shed light on the regional aspects of knowledge spillover necessary for entrepreneurship, namely, knowledge bases, competition, networks of individual, diversity of industries & people, and culture. The work of Jones and Ratten (2021), Ratten (2021), and Calabuig-Moreno et al. (2021) also have explicitly invited the attention of the researcher towards a deeper understanding of the interrelationship between knowledge spillover and entrepreneurial ecosystem, although they presented their work from sports perspective but the case in point

was to highlight the novelty and infancy of the aforementioned concepts. All in all, there has been greater attention on the role of universities, policies and geographical dynamics of the entrepreneurial ecosystem – the role of knowledge spillover has been shown as secondary and a byproduct of the former. It can be seen that little emphasis is given to the reversed role of knowledge spillover, that is, how knowledge spillover could contribute to the initiation and fostering of the entrepreneurial ecosystem.

Another area that has received limited attention in current scholarly works is the examination of knowledge spillovers in terms of their symmetry, that is to say, the direction and quantity of knowledge transfer across firms, industries, and regions. In instances where the input and outflow of information are of equal magnitude, the spillover is characterized as symmetric. However, it is important to note that such symmetry is infrequently observed in practical contexts. Usually, it's the asymmetry that promotes innovation and economic activity, especially in the case of MNCs in developing economies (Iftikhar et al., 2020; Singh, 2007). Understanding asymmetric knowledge spillovers can greatly enhance our understanding of their impact on the complex nature of entrepreneurial ecosystems.

The recent surge in the development of Artificial Intelligence (AI) such as ChatGPT, Midjourney and others has practically disrupted certain industries, marketing and creative industries in particular. In recent literature only Cetindamar et al. (2020) and Lammers et al. (2021) have addressed the role of AI in knowledge spillover and EE perspective. Focusing research efforts in this area can surely shed light on the speed of knowledge creation, and exploration as well as its adverse effects on knowledge spillover and subsequent EE.

Moreover, this disparity could also be due to the fact that most of these studies have been done in developing countries where govt regulations, industry norms and strong participation of academic institutions promote knowledge transfer rather than knowledge spillovers. It doesn't necessarily mean that knowledge spillovers do not occur in developed countries, it merely points out the fact that where knowledge spillover has a greater effect at the micro level in developed countries, by the same exposition it could have a greater economic effect at the macro level in developing countries since there is little to no R&D infrastructure.

These findings present the double-edged nature of knowledge spillover that can be cut both ways, where on one hand it may facilitate innovation and foster entrepreneurial activity by capitalizing on the knowledge developed by others. On the other hand, it may discourage further research and development by providing incumbent entrepreneurs with a sufficient level of satisfaction and complacency – thereby limiting their exploration of greater potential opportunities. Further research in this area can delineate this ambivalent nature of knowledge spillover and further improve our understanding regarding subsequent pathways into the entrepreneurial ecosystem.

5. Concluding remarks

The synthesis of literature presents that although, in recent years, the research interests have grown in knowledge spillover and entrepreneurial ecosystem, but the major focus was placed on the mechanisms, components and structure of the entrepreneurial ecosystem. This includes, firstly, the greater role of universities as producers of knowledge, as well as a platform for start-ups and baseline human resource providers. Further, the universities are transitioning and playing an ever-greater part in the entrepreneurial ecosystem by

actively participating through spinoffs and incorporating an entrepreneurial educational ecosystem to develop an entrepreneurial mindset among students.

Secondly, innovation, being a large part of published research portrays that the application of new knowledge, research & development by the incumbent firms, and the nexus of industry and universities greatly contributes to innovation and subsequent entrepreneurial activity. Entrepreneurial activity and innovation are closely related to one another. The relationship between entrepreneurial activity and innovation is cyclical and symbiotic. Entrepreneurial activity creates new businesses and drives innovation, while innovation in turn creates new opportunities for entrepreneurial activity. The entrepreneurial ecosystem provides the necessary support and resources to enable both entrepreneurial activity and innovation to thrive.

Thirdly, the policies or the role of governing bodies to assist, promote and regulate regional entrepreneurial activities and innovation. Other factors that dominated the landscape were regional dynamics and knowledge spillover. It is concluded that although the role of knowledge spillover in the entrepreneurial ecosystem is acknowledged but it was given half as much attention as the other contributors such as "*University*" and "*Policy*". These findings confirm the novelty and infancy of this research area that the relationship between knowledge spillover and entrepreneurial ecosystems is complex, multifaceted, and underexplored.

5.1. Theoretical implications and future research agenda

This review presents a gap in the literature regarding the interrelationship of knowledge spillover and entrepreneurial ecosystem by highlighting major contributors of EE and the disparity of knowledge spillover among them. It is an agreed-upon fact that universities, policies, and regional dynamics are key contributors to the entrepreneurial ecosystem, but the role of knowledge spillover and its conduits is still underexplored. Although knowledge spillover has been discussed in relation to EE but in a geographically localized manner which limits its implication and dynamic evolution. Moreover, most of the work done in these areas of research has been undertaken in developed countries, it still remains to be explored how knowledge spillover behaves with regard to EE in developing economies. Subsequently, in relation to developing economies, the future line of inquiry could include how knowledge spillover can play a complementary role in the absence of policies and govt support, weaker educational integrations, meager financial infrastructure and disparity of information and communication technologies since these factors are inherent to struggling economies.

The role of social media is also underexplored, the case in point is that the clients and customers do play a role as knowledge workers and agents that push and propagate knowledge and new ideas, forcing the incumbent firms to acquire and exploit new knowledge to meet demands, these implications could be significant in hospitality, lifestyle, fitness and other similar industries. ICTs have greatly been affected by the recent meteoric rise of Artificial Intelligence (AI), future research should look into the disruptive role of AI and how it has affected knowledge generation/exploitation, spillovers and resulting EEs.

Since industry dynamics are different for manufacturing and services industries; another future venue for research could be highlighting the differentiating configurations of knowledge spillover for the entrepreneurial ecosystem in the manufacturing and services industry. Future research could also be focused on comprehending the role of the industry

leader as a gatekeeper, that regulates the intricate balance of symmetric and asymmetric knowledge spillovers to maintain its position in the market.

Although Jones and Ratten (2021) have tapped into the sports industry with regards to knowledge spillover and entrepreneurial ecosystem, the composite nature of the sports industry was addressed with little to no attention at all – that includes sports manufacturing, leagues and event management, teams and club management, infrastructure and venue management, media and marketing, patents and copyrights, merchandise, coaching, fitness and conditioning and sports tourism and hospitality among others, these are full-fledged industries in their own rights. As to our questions about what has been done to comprehend the interrelation of knowledge spillover in the entrepreneurial ecosystem; it is concluded that we have just scratched the surface. It has been well documented that based on social, cultural and political dynamics, knowledge spillover, as well as EE, vary across regions, cities and countries and each ecosystem might as well be as different as any other; conclusively, there might not be a one size fit for all structure of knowledge spillover and EE.

Therefore, there is a need for a deeper dive into the aforementioned areas to explore the direct, augmented, or auxiliary role of knowledge spillover in the entrepreneurial ecosystem. Another aspect that found little attention in the literature is the survivability or the resilience of the ecosystem - only one study was published by Henn et al. (2022), this presents another important aspect to be explored especially in the case of developing economies where socio-political uncertainty is much greater than the developed ones. The future researcher may explore the fluctuations of knowledge spillover (asymmetries) and subsequent irregularities, reconfigurations and contingencies of the entrepreneurial ecosystem in the face of crisis with implications of global scale such as recent economic sanctions, COVID pandemic, frequent natural disasters and war in Ukraine.

Author Statement

The authors declare that there is no conflict of interest.

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