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Five research themes of knowledge spillover theory of entrepreneurship: An analysis of 30 years of research

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Abstract

In the past 30 years, the Knowledge Spillover Theory of Entrepreneurship (KSTE) has emerged as a prominent explanation of how knowledge created by incumbent firms leads to knowledge commercialization and new firm formation. This study systematically reviews 130 key contributions and offers an understanding of the KSTE's role in shaping other fields of science. Our analysis identifies five distinct research themes influenced by KSTE, namely, open innovation, economic geography, knowledge transfer, academia, and international business. Moreover, these themes are interrelated and feature a range of prominent research fields, such as family business, knowledge transfer, innovation, knowledge management, and entrepreneurial ecosystems. Based on these literature themes, we develop a multi-level approach for a more nuanced understanding of the KSTE. We then explain the interrelated nature of these themes and discuss future research directions.

INTRODUCTION

The Knowledge Spillover Theory of Entrepreneurship (KSTE) provides a theoretical framework for understanding how knowledge translates into entrepreneurial activity and economic growth. The idea that knowledge is not fully appropriable and generates spillovers has deep roots in economic thought, particularly in theories of agglomeration and clusters, as well as in seminal works by Griliches (1979) and Jaffe (1986, 1989). These studies underscore the importance of research and development (R&D) investment and proximity to innovation hubs in fostering unintended knowledge flows that drive entrepreneurship. Audretsch (1995) built on this foundation by adding the role of entrepreneurial cognition and developing the 'Knowledge Spillover Theory of Entrepreneurship'. Recent research on the KSTE has provided further insights into the knowledge spillover mechanisms through which economic agents become key contributors to the economic performance of firms and regions (Acs et al., 2009, 2013; Audretsch & Belitski, 2020; Audretsch & Lehmann, 2005; Ghio et al., 2015; M. Guerrero & Urbano, 2014). However, there are three issues that still beset research in this domain.

Firstly, the literature on the KSTE remains fragmented. This fragmentation can be seen in the division between studies that focus narrowly on specific types of spillover, such as those occurring within particular industries, regions, or clusters, versus those that take a more holistic view, incorporating broader cultural, economic, and societal influences on entrepreneurship (Tavassoli et al., 2021).

Secondly, the link between KSTE and other theories, such as institutional theory, open innovation, strategic management, and organizational learning, remains limited (Thurik et al., 2024). For example, strategic management literature has applied KSTE to micro-level entrepreneurial behaviour and microfoundations (Davis & Aggarwal, 2020), examining how social and geographic spillovers shape the transition from invention to entrepreneurship among independent inventors. Studies in open innovation have also used KSTE to explain how within- and between-industry investment in knowledge and collaboration with multiple knowledge partners enable incremental and radical improvements in products and services (Audretsch & Belitski, 2023; Ferreira et al., 2023). Despite these advancements in linking KSTE to other fields, the potential of KSTE to inform broader discussions on firm strategy, digital transformation, entrepreneurial ecosystems (EEs), and the role of formal and informal institutions enabling knowledge spillovers is yet to be realised.

Thirdly, recent research highlights the methodological and contextual complexities that hinder theoretical integration. Significant differences in economic, cultural, and regulatory environments across firms, regions, and countries complicate efforts to generalize the KSTE's role beyond entrepreneurship, limiting its application in fields such as international business, political economy, and public policy (Audretsch & Fiedler, 2024). Moreover, these challenges point to the need for more nuanced empirical approaches and theoretical reviews that can adapt KSTE to diverse disciplinary frameworks and contextual realities (Thurik et al., 2024). Empirical evidence from various geographical and industrial contexts supporting the KSTE is mixed (Ghio et al., 2015), leaving important questions open. For example, are the observed effects of the KSTE consistent and significant across different studies? Do knowledge spillovers captured by new business creations have genuine links to knowledge transfer? Although the KSTE has been empirically tested, especially in developed countries (Audretsch & Belitski, 2021; Braunerhjelm et al., 2010; M. Guerrero et al., 2021), the extent to which knowledge spillover shapes entrepreneurial activity and regional economic development varies greatly across regions (Audretsch et al., 2015), sectors, and countries (Audretsch, 2007; Ejermo et al., 2011; Stuetzer et al., 2018).

We address these issues by conducting a systematic literature review. Our review is motivated by two research questions: (1) To what extent has KSTE extended our knowledge of entrepreneurial activity and its relationship with the economic performance of firms and regions? (2) What has the KSTE contributed over time to other research fields? Whereas prior reviews mainly focused on co-author network analysis (e.g., Karlsson & Hammarfelt, 2019; Morris et al., 2023), our review involves a systematic analysis of studies in business, economics, and management disciplines published over the last 30 years.

GENESIS OF THE KNOWLEDGE SPILLOVER ENTREPRENEURSHIP THEORY

Brief chronological evolution of the KSTE

The KSTE explains why entrepreneurs create new firms and why it matters for innovation and regional economic growth. Marshall (1890) was the first to describe how locating in close proximity to other firms can help a firm recruit employees and develop ideas. Birch (1981) then shifted the focus to the economic contributions of small and new firms, arguing that they are dominant job creators. Birch's 'paradox of the small firm' became foundational, paving the way for theories like KSTE and enhancing our understanding of how embryonic and entrepreneurial ventures thrive in diverse economies. Romer (1986) further developed the research stream by proposing an endogenous growth model in which knowledge is a non-rival input that drives long-run economic growth through increasing returns. Porter (1980, 1998) highlighted the importance of clusters for generating knowledge externalities fostered by geographic concentrations of R&D investment and interconnected companies, specialized suppliers and service providers, firms in related industries, and associated institutions that compete and cooperate.

Audretsch's (1995) book was important in laying the foundations of the KSTE and also builds on Romer's (1986) study, which draws on the fact that privately produced knowledge is organically disseminated to other economic participants. Later works focused on the role of *agglomeration economies* and how actors harness knowledge spillovers through co-location and proximity to transform ideas into marketable goods (Acs & Audretsch, 1988; Acs et al., 1994; Glaeser et al., 1992). We follow the definition of *agglomeration economies* by Glaeser (2010, p. 1) as "the benefits that come when firms and people locate near one another together in cities and industrial clusters". Further research by Acs et al. (2004, 2009) argued that knowledge spillovers are not inherently automatic and introduced the concept of the 'knowledge filter', distinguishing between raw knowledge and its commercialized counterpart. A considerable knowledge filter indicates a larger gap between new stocks of knowledge and commercialized economic knowledge (Acs et al., 2004; Audretsch et al., 2005).

A current trend in the KSTE literature is its integration with firm and regional innovation, reinforcing the

theory's presence within innovation studies (Qian, 2018). The recent studies by Audretsch et al. (2021, 2025) and A. J. Guerrero et al. (2023) found that increased knowledge spillover aids the innovation performance of startup firms more than that of incumbent firms. This study also categorizes various external knowledge sources for knowledge spillovers, including publications, industry affiliations, trade exhibitions, patents, and academic symposia. In summary, the dynamic evolution of the KSTE, along with its synergies with other theoretical frameworks, is forging new academic pathways, both within the entrepreneurship realm and beyond.

Intellectual background of the KSTE

The KSTE also draws on prior economic growth research (Grossman & Helpman, 1994; Romer, 1990) and argues that knowledge is embodied in entrepreneurs who absorb existing knowledge and modify it in a way which eventually contributes to the development of new ideas, products, and services, leading to economic growth (Romer, 1986, 1990).

A significant shift in the KSTE was made by Audretsch and Keilbach (2007), who highlighted the importance of knowledge rooted in established organizations. They argued, in line with KSTE principles, that enriched knowledge environments inherently generate numerous entrepreneurial opportunities, whereas less enriched environments reduce prospects. Since knowledge spillover is widely recognized as an antecedent of entrepreneurship (Acs et al., 2009) and innovation (Acs et al., 2013; Audretsch & Belitski, 2022, 2023; Carlsson et al., 2009), a poor understanding of the mechanisms of knowledge spillover might result in an incomplete conceptualization of the links between knowledge, innovation, and entrepreneurship.

Criticisms of the KSTE

Critics argue that KSTE, although conceptually appealing, suffers from a lack of precise theory formulation (Tsvetkova & Partridge, 2021). Does the existing model of the KSTE need a more explicit formulation? Should the theory be recalibrated, making it more theoretically stringent, or should it expand its relevance by encompassing broader, more varied theoretical contexts and disciplines? Further insights and clarity are needed to bridge the gap in understanding how knowledge spillovers facilitate, directly and indirectly, various types of entrepreneurial activity.

The criticisms of the KSTE rest in the mechanisms that enable entrepreneurs to learn from the business environment and develop new skills that benefit their business (Acs et al., 2013; Audretsch & Belitski, 2013). Whereas earlier research focused on knowledge spillovers which were only made possible within a certain spatial proximity to the actual source of the knowledge (business, university) (Audretsch & Lehmann, 2005), entrepreneurship literature calls for further unpacking the link between knowledge creation and transfer by entrepreneurs and the type of entrepreneurial activity which enables knowledge creation, transfer, and appropriation (Acs et al., 2004; M. Guerrero & Urbano, 2012; M. Guerrero et al., 2014; Link & Siegel, 2007; Siegel & Phan, 2005).

METHODOLOGY

Systematic literature reviews help to advance our theoretical, practical, and methodological knowledge of a subject (Kunisch et al., 2023). In order to conduct the systematic literature review analysis, we used the Web of Science research database to collect relevant literature. Prior research suggests that a systematic literature review offers the most effective tools to identify and evaluate large volumes of literature (Cassell et al., 2006; Grant & Booth, 2009; Snyder, 2019; Tranfield et al., 2003). Such reviews are also widely used in different business and management studies (e.g., Witell et al., 2016; Khlystova et al., 2022; Linnenluecke, 2017; Macpherson & Jones, 2010; Verma & Gustafsson, 2020). Grounding our review in prior theoretical literature review studies (Denyer et al., 2008; Palmatier et al., 2018; Rousseau et al., 2008), we followed a five-stage review protocol to perform a systematic literature review.

The first stage of the protocol involves identification of the relevant research question, rationale, and the scope of the literature review. Therefore, the search prompts were grounded in the concepts/theories underpinning KSTE. The Web of Science database was used as a main source for the systematic literature review. In the second stage, we aimed to design search strings relevant to the KSTE. We utilized keyword combinations such as "Knowledge spillover OR Knowledge spillover theory OR Knowledge filter OR KSTE OR R&D spillovers" AND "entrepreneur* OR entrepreneurial activity, startup, new venture, new business, small business, SMEs, self-employ* OR Intrapreneur*" Our selection of keywords was informed by prior theoretical and empirical studies on the KSTE by Audretsch and Keilbach (2007, 2008), Acs et al. (2009), and more recently Ghio et al. (2015) and Audretsch, Belitski, Guerrero, Siegel (2022); Audretsch, Belitski, Guerrero (2022). This initial search yielded 2419 publications.

In the third stage, we established main inclusion criteria to shortlist articles for the final sample. Our inclusion cri-

teria for the literature review considered articles, including early-access and editorial materials published from 1996 to 2023, in the English language only. After applying these criteria, we narrowed it down to 2030 articles. The next set of main inclusion criteria focused on research areas such as business and management, economics, geography, operational research, management science, and multidisciplinary studies. At this stage, we also excluded several citation indexes as they pertained to life sciences and food-related disciplines (e.g., BIOSIS Citation Index, BIOSIS Previews, Medline, Zoological Record, FSTA (Food Science and Technology Abstracts), which reduced the number of relevant publications to 1667. In the fourth stage of the protocol, we applied additional inclusion criteria to further eliminate irrelevant publications as well as ensure that the sample consists of high-quality publications. Therefore, we chose the following additional inclusion criteria: (a) the relevance of the article's keywords and (b) the reputation of the journal. To do so, we considered only articles published in journals featured on the approved list of the Association of Business Schools (ABS) in the UK, which is widely recognized as a benchmark database of journals of international standard (Paul & Benito, 2018). This resulted in narrowing down the sample to 987 articles.

When screening the publications, the lead reviewer looked at the consistency of the keywords used for this study against the keywords in the potential paper. Should more than three keywords not match within the prospective paper and our chosen keywords, we would read the abstract and then eliminate the article if not relevant for the final literature sample. In applying these two criteria, we draw on Linnenluecke et al. (2020) and consider how the keywords are used in the article in order to avoid "false positive" errors. This resulted in excluding another 164 articles and narrowing down the sample to 823 documents.

We also excluded the papers that only briefly considered the KSTE and did not include it within the main framework of their analysis or specifically focus on its various elements or dimensions, reducing the sample further to 597 articles. For example, we included an article that examined the survival of entrepreneurship using the KSTE as a dependent variable, rather than using entrepreneurial activity as an outcome variable or performance of startups. Departing from 567 articles, we identified key studies that have become a springboard for inward- and outward-looking theorizing of the KSTE, shaping other fields (e.g., Urbano & Aparacio, 2019; Acs & Audretsch, 2010; Audretsch & Belitski, 2024a, 2024b; Audretsch & Hinger, 2014; Audretsch & Lehmann, 2005, 2017; Audretsch et al., 2005; Belitski et al., 2024; Bikard & Marx, 2020; Callejón, 2019; Estrin & Shapiro, 2019; Fritsch & Wyrwich, 2019; Karlsson & Hammarfelt, 2019; Lambrechts et al., 2023; Wright, 2019).

To ensure that inclusion/exclusion criteria were applied correctly and consistently while also eliminating potential selection biases, two authors cross-checked a small sample of articles. We used the snowball technique and read keywords and references of the potentially relevant articles for the final sample. For example, while some articles referred to the KSTE and knowledge spillover mechanisms, their keywords and abstracts were not related to the KSTE (Cao & Shi, 2021; Cao et al., 2024). Drawing on the final stage of the protocol and selection process described in Pinto (2019), we reviewed the final outputs to check whether the knowledge spillover constructs and mechanisms were significantly covered in their content, and if they were not, the article was excluded. Thus, we omitted another 64 articles. After all these steps, the final literature review sample yielded 130 articles for full-text analysis. Figure 1 graphically illustrates the step-by-step review process of the search (Figure 1).

ANALYSIS

Descriptive analysis

Our methodology resulted in a sample of 130 articles published between 1996 and 2023 from 31 ABS-listed journals. The top five journals that published manuscripts on the selected literature review topic are *Small Business Economics*, *International Entrepreneurship and Management Journal*, *Strategic Entrepreneurship Journal*, *Research Policy*, and *Entrepreneurship and Regional Development* (see Table A1 in the Supporting Information Appendix).

The yearly output of research on the KSTE is presented in Figure 2. There has been an increase in publications testing and exploring the theory: from two publications in 2000 and 25 in 2007 to 190 in 2020, followed by a decrease in 2023 to 135 publications. The surge since 2007 can be attributed to several factors. Firstly, there is a growing academic interest in entrepreneurship as a field (Thurik et al., 2024). Since the late 2000s, there has been a surge in academic interest in entrepreneurship as a critical driver of economic growth, innovation, and employment. This increased focus has naturally led to more research exploring various aspects of entrepreneurship, including KSTE. Since the year 2020, Figure 2 illustrates the slight decline in papers dedicated specifically to the KSTE as the theory becomes an embedded assumption within broader entrepreneurship and innovation research. As recognition of the importance of knowledge spillovers in agglomeration economies has grown, the core premises of the KSTE have become more accepted and internalized across the field. In this sense, KSTE has shifted from being a novel theoretical proposition to becoming a background

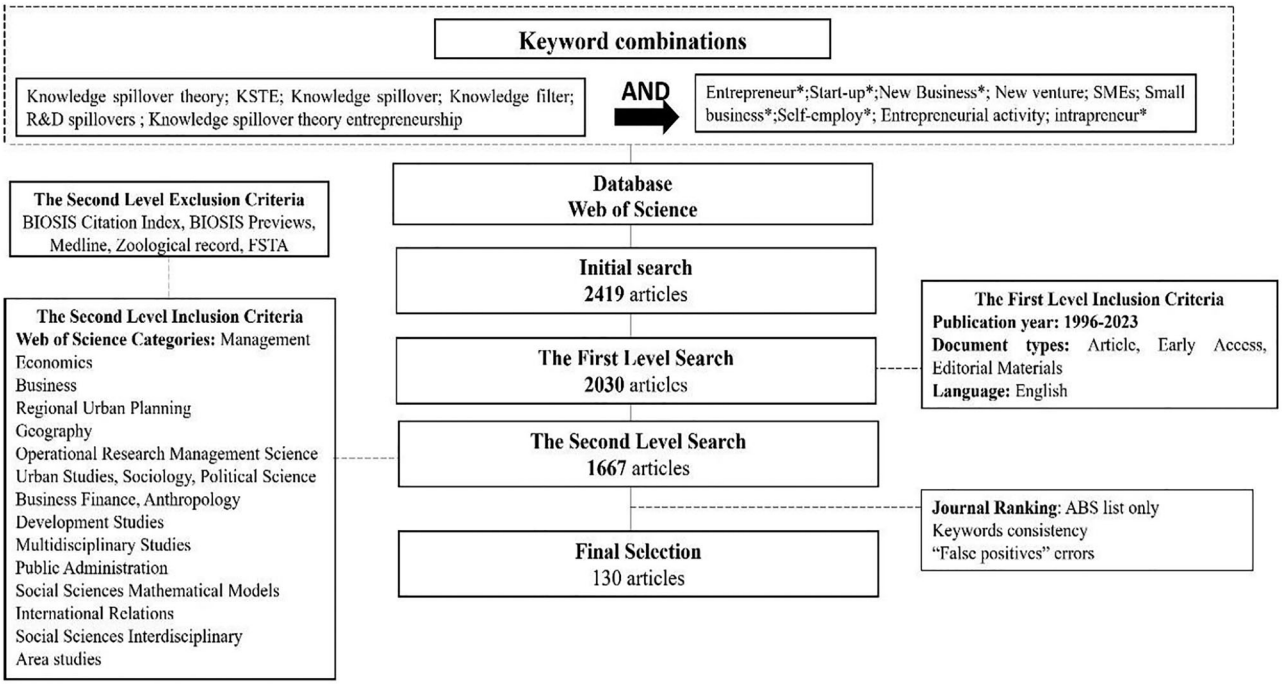

FIGURE 1 Web of science search design.

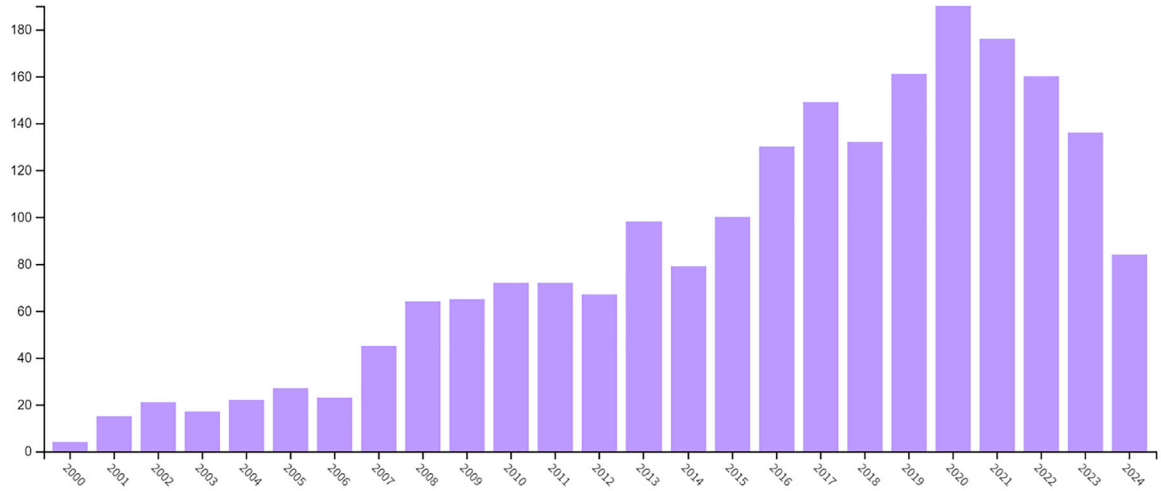

FIGURE 2 Publications on the Knowledge Spillover Theory of Entrepreneurship (KSTE) field (per year). Data for the year 2024 is incomplete, covering only the period between January 2024 and June 2024, and is provided here for illustration. *Source*: Web of Science.

condition that underpins many studies in entrepreneurship, regional development, and innovation. Rather than continuing to test or refine the theory itself, researchers are now more likely to focus on applied questions that assume knowledge spillovers and collaboration as inputs with performance and fundraising as outcomes. Moreover, advances in panel data availability have enabled researchers to explore more nuanced and interdisciplinary questions that extend beyond the original scope of the KSTE in entrepreneurial psychology, sociology, and international business, diluting the visibility of any single theory such as KSTE.

Our literature review covers various contexts, ranging from country-specific studies, such as in Italy, the UK, the United States, China, Sweden, and Australia (accounting for 64% of the articles), to conceptual articles (20%) as well as cross-national studies (16%) involving regions such as the OECD Organisation for Economic Co-operation and Development and EU (European Union) countries.

Keyword analysis

We start our analysis section by following the literature review protocol and performing the keyword analysis (10 keywords co-occurrence) to identify key themes in the existing literature concerning the evolution of the KSTE and its effect on other research fields and visualize the literature themes of the KSTE. Employing network visualization through co-word analysis (10 keywords co-occurrence), as suggested by Donthu et al. (2021) and Verma and Gustafsson (2020), proved valuable for our comprehension of publication content and focus. By importing the data collected from the Web of Science into the VOSviewer software, we were able to analyse frequently used words in authors' keywords, titles, abstracts, and full texts. This approach facilitates our understanding of predominant trends in the literature sample, as highlighted by Van Eck and Waltman (2010) and Donthu et al. (2020). The analysis enabled us to identify five major literature themes: open innovation (red), economic geography (green), knowledge transfer (purple), academia (light blue), and international business (dark blue) (Figure 3).

RESULTS

Open innovation

We derived themes from the visualization of keywords in Figure 3. The first theme (red in Figure 3) represents the literature on the effects of knowledge spillovers, networks, internal capabilities, cooperation and knowledge co-creation as well as knowledge flows facilitating firm innovation (Audretsch & Belitski, 2020; Audretsch et al., 2022b; Chesbrough, 2003). Other literature includes R&D collaboration with key stakeholders in the industry and communities (Audretsch et al., 2021), and innovation-driven economic growth (Audretsch, 2007). This theme is also linked to the literature on the competitive advantage of a firm and on strategic entrepreneurship (Agarwal et al., 2010), firm capabilities (Sarkar, 2017), decision-making for exploration and exploitation (March, 1991), and university spinoffs (Klofsten et al., 2021). In addition to the core red cluster on innovation, our keyword analysis also identified a smaller yellow cluster "product innovation", that is thematically aligned with this domain. This cluster includes keywords, such as product innovation, protection, costs, competition, and research joint ventures. These terms complement the open innovation literature (Chesbrough, 2003) by highlighting the role of innovation inputs and context, enabling firms to face competition and use internal and external knowledge for product innovation (Audretsch et al., 2025). Overall, this theme demonstrates effects on innovation and performance and identifies salient factors at the system level (Audretsch, 2007), firm level (Minola et al., 2021), and individual level (Acs et al., 2009) that influence this link.

For example, a study by Audretsch et al. (2021) claimed that increased knowledge spillovers (KS) generate more innovation in startup firms than incumbent firms. Additionally, the authors recognized and differentiated between various sources of external knowledge, such as publications, industry associations, trade fairs, patents, and conferences. Knowledge spillovers to entrepreneurship are also related to the absorptive capacity of a firm, which enables a firm to create knowledge internally and to understand external sources of knowledge (Cohen & Levinthal, 1989, 1990). Audretsch and Keilbach (2007) emphasized the importance of knowledge generated in incumbent organizations as a source of entrepreneurial opportunities. They articulated the argument that, according to KSTE, an environment with more knowledge will create more entrepreneurial opportunities, whereas an environment with less knowledge will create fewer opportunities (Audretsch & Keilbach, 2007).

Strong knowledge management capabilities directly assist entrepreneurs to capture knowledge spillovers (Audretsch et al., 2020, 2023; Caiazza et al., 2020; Ferreira et al., 2017). For example, Ferreira et al. (2017) describe a firm's knowledge management capability as a process involving the creation, transfer, integration, and application of knowledge to support the purposeful acquiring of specific knowledge through unstructured knowledge sharing among individuals. These authors argue that firms must constantly develop their knowledge management capabilities to integrate internal knowledge with spillover knowledge, particularly to maximize benefits during the innovation process, because the movement of skilled individuals between organizations and investment in R&D and human capital is a key mechanism for knowledge spillover of innovation (Audretsch & Belitski, 2022; Audretsch et al., 2024). Entrepreneurs often act as agents who transform knowledge spillovers into practical, marketable innovations.

Economic geography

The second theme (highlighted in green in Figure 3) relates to the role of knowledge spillovers and entrepreneurship as a conduit, as well as regional economic development and the role of proximity in this relationship (Audretsch & Belitski, 2013; Audretsch et al., 2015). This theme also includes a smaller orange cluster, "physical proximity" (Figure 3), representing keywords such as clusters, eco-

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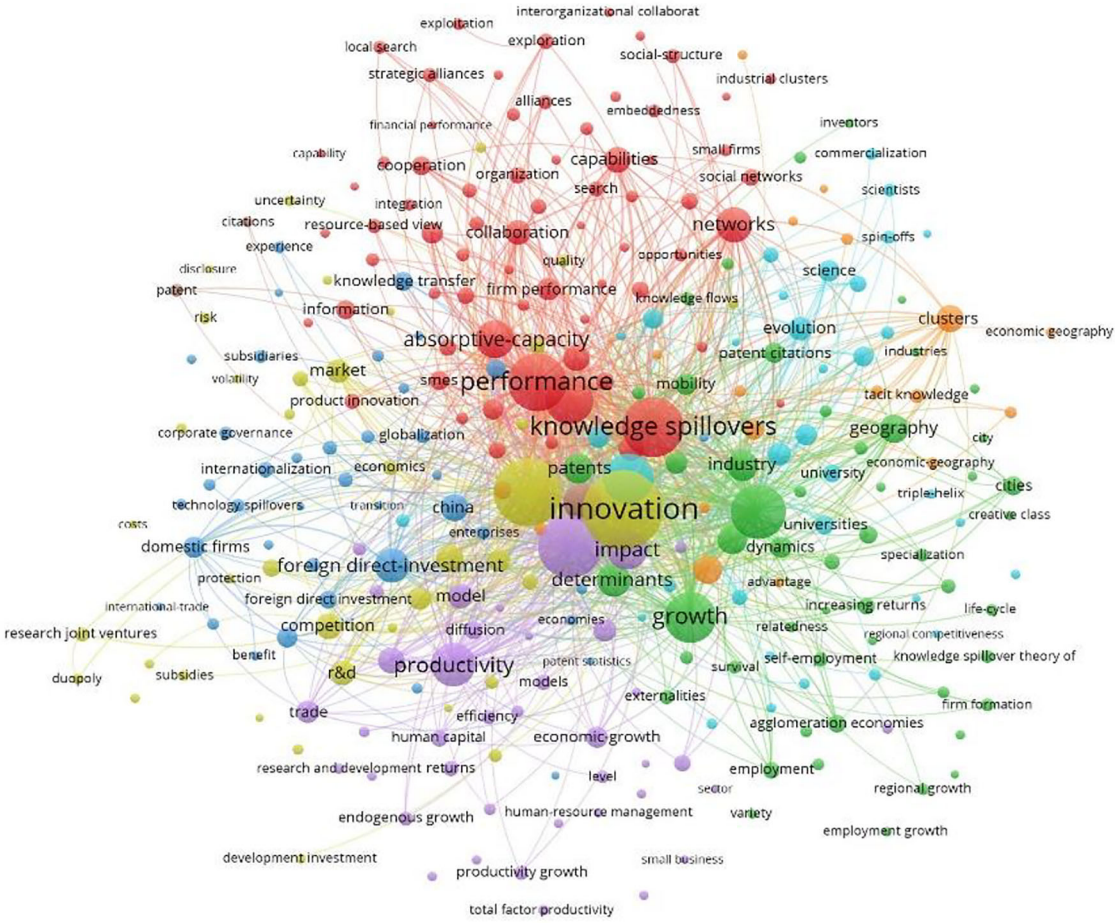

FIGURE 3 Keyword visualization of the literature review results (1996–2023). Smaller clusters, such as the yellow called "product innovation", are associated with the "open innovation" theme, and the orange cluster "physical proximity", associated to the economic geography theme, capture supporting concepts that reinforce and extend the understanding of both thematic areas.

nomic geography and tacit knowledge. These terms are related to the physical proximity, which refers to the closeness or nearness of firms and individuals in terms of physical space, and it is important in clusters and communities for exchange of tacit knowledge enabled by face-to-face interactions (Audretsch & Feldman, 1996). Audretsch and Feldman (1996) and Jaffe, 1986 subsequently discovered that the knowledge generated from R&D and human capital not only leads to innovative activities for other third-party firms but is also spatially localized within close geographic proximity to the knowledge source, whether that be a firm or a university. The spatial localization of knowledge spillovers has been attributed to the significance of clusters and agglomeration economies. Significant progress has been made recently in understanding the boundary conditions of knowledge spillovers and the role of proximity in facilitating knowledge creation for innovation and new firm establishment (Audretsch et al., 2024; Balland et al., 2015). Papers that are related to this theme examine the effect of localized R&D on new firm creation (Link et al., 2019). It has been found that knowledge spillovers from universities are particularly highly localized. Regional economic development is inherently linked to KSTE in learning from internationalization and foreign direct investment (Belitski et al., 2023) as well as in facilitating trade in domestic firms and multinationals (Driffield et al., 2014).

The extant literature reveals a significant role of universities in regional knowledge creation and economic development (M. Guerrero & Urbano, 2014; M. Guerrero et al., 2015), which can be leveraged through technology transfer (Qian, 2018; Qian et al., 2013). The role that spatial localization plays in KSTE is well-documented in the literature (Audretsch & Belitski, 2021; Audretsch & Feldman, 1996; Audretsch et al., 2015). This literature is also linked to EEs theory (Feld, 2020; O'Connor & Audretsch, 2023) and the role of proximity to key resources and stakeholders for EE outcomes (Audretsch & Belitski, 2017). Studies exploring the effect of EEs on entrepreneurship argue that

the nature of EEs leads to the promotion of entrepreneurial activity and the commercialization of research (Qian, 2018; Spigel & Harrison, 2018).

Other key arguments include the contention that EEs lead to beneficial outcomes for entrepreneurial firms, such as innovation and growth (Ferreira et al., 2023; Spigel, 2017). For example, this literature acknowledges that firms' growth and competitiveness result from the idiosyncratic contexts of EEs and the structures and interactions created by entrepreneurs (Brown & Mason, 2014, 2017), which facilitate EE growth. Digital transformational activities and strategies for success are often constrained by specificities originating in an entrepreneurial context, with increasing knowledge spillovers coming from the adoption of digital tools and platforms (Cuvero et al., 2023).

Prior research (Audretsch & Lehmann, 2005; Jaffe, 1986, 1989) demonstrated that distance plays a key role in transmitting tacit knowledge, while such knowledge could still be transferred across regional boundaries (Bikard & Marx, 2020). However, the validity of localized knowledge creation assumptions may change with the digitalization of knowledge transfer, since digitalization can transfer both tacit and codified knowledge internationally via platforms such as Zoom and Google. While the benefits of tacit knowledge spillovers are often locally bounded (Jaffe, 1986), the development of novel digital tools and digital transformation means that the implicit assumption that tacit knowledge is geographically bounded (Acs et al., 1994) no longer holds.

The development of fibre optics and other technologies, which can manage more data traffic and more customers, as well as provide access to real-time platforms such as Zoom, means that greater openness of innovation, ideas, and live knowledge exchange on such platforms reduces the cost of knowledge transfer and the co-creation of knowledge. The assumptions used in prior research on the localized tacitness of knowledge (Acs et al., 1994; Jaffe, 1989) and general human capital (Audretsch & Lehmann, 2005) may not hold now as they did decades ago (Jaffe et al., 1993): both tacit and codified knowledge may be transferred across regions, particularly if connection and trust between people have been previously created, enabling further tacit knowledge transfer on the platforms.

Knowledge transfer

The third theme (purple in Figure 3) visualized includes the literature on the role of R&D returns, human resource management and knowledge transfer in achieving firm as well as regional growth and productivity (Audretsch & Belitski, 2024a, 2024b; Belitski et al., 2021; Bresman, 2010). Literature represented in this theme describes the following types of organizations included in knowledge creation and dissemination: family businesses (Amato et al., 2022; Hahn et al., 2021), multinational corporations (MNCs) (Hallin & Lind, 2012), entrepreneurial ventures (Audretsch & Belitski, 2013), and public and private universities (Belitski & Heron, 2017).

Belitski et al. (2021) argue that entrepreneurial firms can develop a stronger absorptive capacity and facilitate spillovers by ensuring a strong base of relevant internal knowledge. This assists them to assimilate knowledge spillovers and facilitates organizational learning, which in turn strengthens absorptive capacity (Lattacher et al., 2021). The authors argue that the existing pool of knowledge is necessary for firms to engage with, but also that firms need to invest in their R&D and digital technologies internally to enable knowledge recognition, transfer, and appropriation. KSTE highlights the pivotal role of knowledge transfer, which is a subset of knowledge management, as a key mechanism for knowledge spillovers.

Knowledge can exist both outside and within individuals in a firm. Entrepreneurs use and combine their own and external knowledge to facilitate technological and market insights in the commercialization of new products and services and to establish new firms (Antonelli & Colombelli, 2015). Technological knowledge, often codified in patents, licences, and publications, is typically acquired through economic transactions and may not be readily accessible to all firms. The ability of firms to utilize external knowledge depends further on firm-level capabilities, including their absorptive capacity (Qian et al., 2013), digitization-related knowledge (Proeger & Runst, 2020), investment in human capital (Ganotakis et al., 2021), such as individual skills and creativity (Audretsch & Belitski, 2013), and geographical proximity to the source of knowledge (Cantù, 2017).

Globalization and interconnected economies have further facilitated knowledge transfer nationally and internationally based on the competitive advantages of regions (Porter, 1980). This global openness of knowledge has sparked interest in understanding how knowledge flows take place and what mechanisms enable them.

Academia

The fourth theme (light blue in Figure 3) deals with knowledge transfer from universities, which act as conduits for entrepreneurial activity and spill over new ideas and knowledge (Audretsch et al., 2015). The literature examines the Triple Helix hybrid models (M. Guerrero & Urbano, 2017) and the role that university–industry collaborations play in knowledge spillover (Siegel et al., 2001, 2003). Knowledge created by universities contributes to

economic performance via starting new businesses and spinoffs (Civera et al., 2019; Hayter, 2016; Meoli et al., 2019; Schillo, 2018) as well as creating university EEs that are able to transfer teaching and research into ideas and commercialized products (Belitski & Heron, 2017; Belitski & Sikorski, 2024; Belitski et al., 2019).

The literature considers university managers as entrepreneurs who effectively facilitate research by allocating resources to researchers, thereby achieving the university's objectives and meeting the requirements of higher education agencies (Etzkowitz, 2003). University–industry collaboration as an outcome includes university spinouts, where technology transfer takes place within a university, or indirect knowledge transfer to industry via a technology transfer office (Radko et al., 2023).

Research activities, as a key source of knowledge at universities, constitute a prerequisite for knowledge transfer and technology commercialization (Compagnucci & Spigarelli, 2020; Cunningham & Menter, 2021; Graf & Menter, 2022). More disruptive research outcomes are strongly related to knowledge spillover effects from publications and the commercialization of knowledge. In this view, research citations are a proxy for an advanced representation of dynamic research capabilities that facilitate the emergence of new collaborative projects among multiple scientists from local/international research centres, labs, and worldwide universities (Cerver Romero et al., 2021).

At the industry and individual levels, studies within this theme explore the dynamics of university–industry interactions and collaboration in research teams, university incubators, and science parks (Amoroso et al., 2018; Audretsch & Belitski, 2019) where entrepreneurs may create knowledge which spills over from university research. This stream of literature demonstrates the importance of tailored support to university startups and spinouts across universities of different types (Radko et al., 2023). Numerous studies within this theme argue that the R&D conducted by universities can lead to the creation of university spinoffs, and this is a main mechanism of knowledge transfer from universities (Audretsch et al., 2023; Hayter, 2016; Wagner et al., 2021). These studies indicate that university spinoffs are a form of university knowledge transfer that, along with university science parks and business incubators, facilitate the entrepreneurship growth continuum (Sohail et al., 2023; Vardhan & Mahato, 2022).

International business

The fifth theme (dark blue in Figure 3) examines the role of MNCs in the market entry of both global and local startups (Driffield et al., 2014). Within this theme, we distinguished studies that demonstrate the role of multinationals along with universities and domestic corporations in creating collaborative networks and EEs that induce knowledge spillover of entrepreneurship (Bhawe & Zahra, 2019; Buratti et al., 2023; Spigel & Vinodrai, 2021). Spigel and Vinodrai (2021) suggest that large firms, both public and private, should be considered anchor firms in EEs, partly because these firms are a source of knowledge spillover of entrepreneurship, whether through observation, direct partnerships between firms, or the movement of workers. Bhawe and Zahra (2019) suggested that knowledge spillover from multinationals into entrepreneurial activities may be intentional or unintentional. For example, unintentional spillover may occur through employee mobility or during business transactions with stakeholders. Recent research suggests that entrepreneurs can better position themselves to receive knowledge spillover—whether intentionally or unintentionally (Cassiman & Veugelers, 2002, 2006)—not by simply capturing new knowledge by situating themselves in close geographical proximity to MNCs (Cuvero et al., 2023), but also by forming connections to sources of spillovers and embedding themselves in digital ecosystems.

Studies in our review show that the relationship between entrepreneurship as a conduit for knowledge spillovers is influenced by the country context. Studies investigating the boundary condition of the KSTE, in both developing economies (González-Pernía et al., 2015; Mahn & Poblete, 2023) and developed countries (Knoben et al., 2011), reveal a complex relationship between institutions, a country's development stage, types of firms, and knowledge spillovers, which is important for the field of international business. For instance, González-Pernía et al. (2015) show that the nexus between knowledge spillovers, innovation, and entrepreneurship is weaker in developing countries. While supporting the fundamental premise of the KSTE, which asserts that entrepreneurship acts as a catalyst for economic growth via knowledge spillovers, the study suggests that the relationship between innovation-driven entrepreneurship and knowledge is more complex in developing economies, depending on country-level institutions and policies, such as R&D investment and inward FDI (Foreign Direct Investment), and their interactions. Other studies suggest that cross-country connectivity, often facilitated by individual entrepreneurs, is an important factor impacting the KSTE (Veréb & Ferreira, 2018).

Knowledge spillovers that originate from the human capital within local subsidiaries of foreign multinationals serve as valuable external knowledge sources (Driffield et al., 2014; Yang et al., 2022). Recent work by Castellani and Lavoratori (2020) demonstrates that offshore R&D and co-location with production activities facilitate firm performance as a result of R&D spillovers, extending Makino and

Delios's (1996) study on three potential channels for firms to be exposed to knowledge spillovers from human capital mobility between MNCs domestically or internationally. A firm with access to foreign employees, both locally and internationally, can generate knowledge spillovers from other subsidiaries co-located with the firm in other countries, thus becoming an important conduit of external knowledge. Firstly, a firm may form a joint venture with an MNE (Multinational Enterprise), where employees exchange ideas and experiences. Secondly, there is the transfer of knowledge from the parent company's existing stock in the country of origin, including international market experience and skills (Audretsch et al., 2021; Faems et al., 2005). Thirdly, firms can accumulate skills and knowledge from employees through the poaching of workers or through joint R&D projects involving workers with knowledge in the origin country or abroad.

DISCUSSION

Key insights of the KSTE

Our paper maps the evolution of the KSTE within the last 30 years. This approach enables us to identify emerging trends and theoretical sub-streams, while also highlighting how KSTE has influenced adjacent research themes and pointing to future research opportunities across disciplines.

Since the works of Griliches (1979), Jaffe (1986, 1989), Romer (1986), and more recently Audretsch (1995), the concept of the KSTE has shaped and expanded, leading to its greater application across a broad spectrum of diverse streams of literature. While originally limited to economics and business studies, it has expanded our understanding of how knowledge is created and then "spills over" into the broader economic environment and third-party firms, which enables the creation and commercialization of knowledge. These literature themes provide insight into how KSTE research has influenced other academic fields, expanding prior research on the interdisciplinary nature of entrepreneurship (Thurik et al., 2024) and leading to new insights about the antecedents, mechanisms, consequences, and multi-level nature of knowledge spillover.

Sources of the KSTE span various levels, including the individual, firm, industry, and system levels (region, city, and county), which shape different outcomes of entrepreneurship activity, including growth, sustainability, innovation, and well-being. KSTE is enabled by various mechanisms, which are present on multiple levels, such as policy to stimulate R&D (macro-level), absorptive capacity (firm-level), and individual entrepreneurial capital, such as entrepreneurship orientation and capabilities. We summarize the multi-level nature of the KSTE, its enablers, and the outcomes identified in Table A2 of the Supporting Information Appendix.

Based on the results of our analysis and Table A2, we developed a conceptual model (see Figure 4), which offers a dynamic multi-level perspective of the KSTE. Various sources of knowledge—at the system, industry, firm, and individual levels—have been investigated in the KSTE literature. The knowledge available from various sources, including EE, industry clusters, and various groups of actors, builds the foundation of the stock of knowledge available—a key contextual condition—for knowledge to spill over. However, for knowledge to spill over, contextual factors, such as geography and competitive dynamics, as well as entrepreneurship policy, business regulations, and culture, are important (Anokhin et al., 2021).

Additional factors include knowledge collaboration between actors and their co-location, cultural conditions such as the level of corruption, the degree of competition, the proximity of actors to knowledge sources, and creativity, among others. These contextual enabling factors affect various levels, facilitating KSTE. The outcome from knowledge spillover is an increase in the quality of entrepreneurship (Chowdhury et al., 2019) and regional economic growth and sustainability (Colombelli et al., 2021). Importantly, our conceptual model indicates that by the prosperous line, the outcomes of the KSTE also change as the contextual conditions change, namely, the stock of knowledge. The context where the knowledge spillover takes place may add to the dynamism of the model that originates from the interplay between the process (sources, enablers, and outcomes), with future research needed to guide scholars on the conditions of such processes. Whereas researchers over the past 30 years have mainly focused on the technological KSTE, the shift towards sustainable values and more inclusive participation of entrepreneurship in the ecosystem raises concerns about economic and social value creation by entrepreneurs—concerns which the KSTE can help to explain.

Theoretical contributions

This study's findings further explain how integrating the literature has yielded further theoretical insights. Firstly, integrating knowledge inputs, knowledge mechanisms, and outcomes together in this systematic literature review has helped us to better understand the KSTE's explanation of how knowledge mechanisms can transform knowledge inputs into outputs, and the role of digital technology as well as human capital, which moderates the relation-

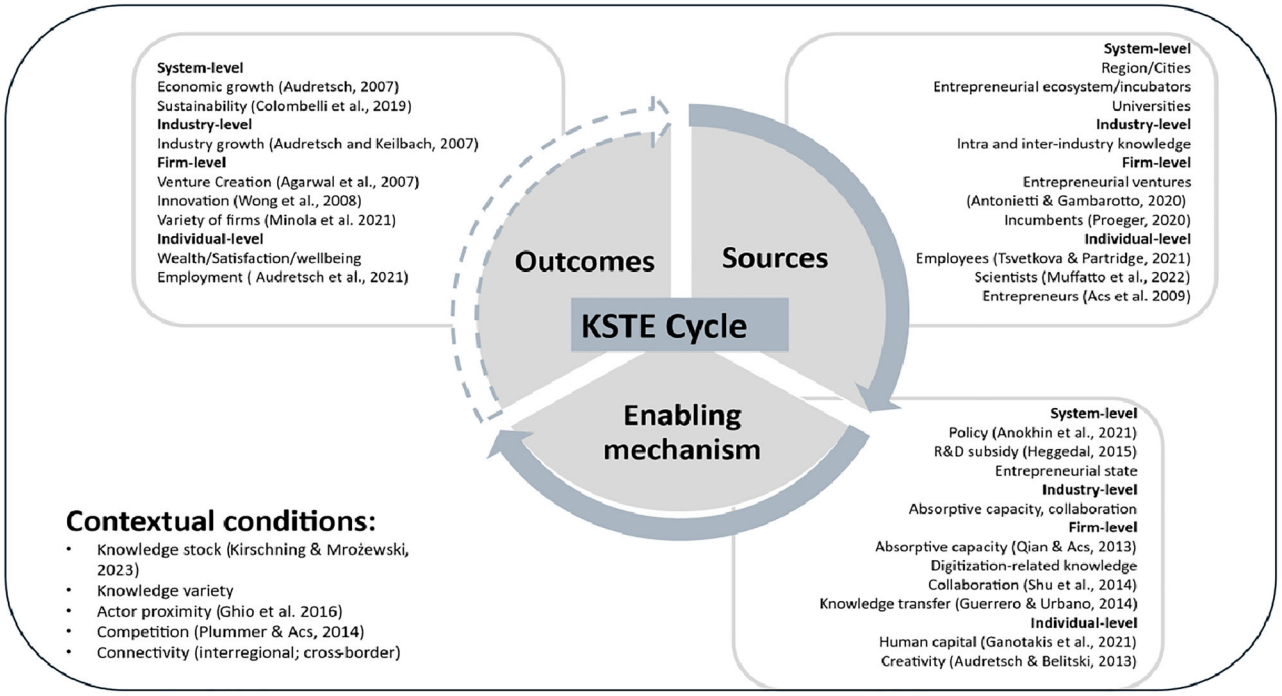

FIGURE 4 Multi-level conceptual framework for the Knowledge Spillover Theory of Entrepreneurship (KSTE).

ship between knowledge spillovers and entrepreneurship activity. Audretsch and Lehmann (2005) have demonstrated that it is not only tacit knowledge that matters but also the availability of general human capital, that is, the skills needed to run a business and operate in a risky environment for entrepreneurship.

Meanwhile, the latest research by Belitski et al. (2024) with more recent data has found that knowledge from external collaborators—regionally, inter-regionally, and internationally—contributes to innovation activity, with investment in digital tools facilitating both regional and international knowledge collaboration and spillovers. Thus, this study responds to an important question regarding whether KSTE is still significant in explaining growth and entrepreneurship in the realms of digitalization, open innovation, or artificial intelligence (AI). Based on our analysis, the answer for knowledge spillovers that originate regionally, inter-regionally, and internationally is positive. It can be expected that digital tools and technologies accelerate knowledge spillovers by increasing the velocity with which knowledge circulates across systems, firms, and actors. This also creates the potential for knowledge to reach a wider range of actors for more inclusive growth towards an entrepreneurial society.

Secondly, this study clarifies how knowledge spillover can inform various types of entrepreneurship and innovation activities, thereby demonstrating the wider applicability of the KSTE for understanding radical and incremental innovation of firms (Audretsch & Belitski, 2022). The KSTE complements firms' skills and capabilities, affects regional openness and culture (Tavassoli et al., 2021), and influences the decisions of multinationals to relocate between regions and countries or compete for talent. Furthermore, it explains the mechanisms and speed of knowledge transfer, eventually contributing to economic and sustainable performance and productivity at the firm level as well as to regional performance and growth at the meso- and macro-levels.

Thirdly, by highlighting the knowledge mechanisms that are intended to scan and explore new knowledge and that suggest that the three groups of knowledge transfer mechanisms—exploration, transfer, and integration of knowledge—must be closely intertwined, this study emphasizes their mediating role in KSTE. We also advance the works of Jaffe (1986), who assumes a geographic coincidence index to cover locational proximity, while our review demonstrates that research activities and knowledge created in one location may be transferred across regions and internationally.

Much has changed since Jaffe (1986, 1989) found that knowledge may spill over only within the confines of spatially restricted boundaries. The analysis of knowledge spillovers by Jaffe (1989), Acs et al. (1994), and finally Audretsch (1995) predated the World Wide Web and the subsequent pervasive proliferation of smartphones and personal computers, enabling distance working and working from home. Despite a fundamental revolution in technology, along with its ancillary reduction in the

cost of transmitting not just explicit but also tacit knowledge through face-to-face communications via platforms such as Zoom, with few exceptions, the literature on the KSTE continues to hold on to the spatial localization of knowledge as a truism (Audretsch et al., 2024; Balland et al., 2015; Jaffe et al., 1993).

Fourthly, this study shows how prior research on knowledge externalities has shifted the conversation into knowledge spillover mechanisms and knowledge enablers (Morris et al., 2023). These mechanisms and enablers are needed for entrepreneurs to access tacit and explicit knowledge within and across industries and regions for innovation. Our review has thus provided complementary insights into how creative works and the accumulation of human capital for new knowledge creation could be achieved, extending prior research on the innovation-enhancing effect of knowledge externalities (Chesbrough, 2003; Kirschning & Mrożewski, 2023; Lambrechts et al., 2023) and the productivity-enhancing effect of the knowledge spillover of innovation (Audretsch & Belitski, 2024a, 2024b).

Fifthly, mapping the networks of keywords across five different research themes revealed the most interconnected themes. The effects of the KSTE can be clustered in a certain geographical location or be international (Belitski et al., 2024). Heterogeneous resources within an industry may trigger different types of spillover, and firms' access to knowledge will often require stakeholder and niche market-specific mechanisms that allow them to recombine resources and knowledge. This, in turn, contributes to the co-creation and commercialization of knowledge. Furthermore, our review has validated that firms access spillovers across technologies, industries, and countries.

Future research

This section explains how two contributions to the field of management and entrepreneurship can shape future research. Our first contribution is in explaining the mechanisms and multi-level nature of knowledge spillover entrepreneurship and calls for future research on a multi-level and nuanced relationship between knowledge inputs (spillovers) on the one hand and knowledge outputs (innovation, imitation, first market entry, productivity, sustainability) on the other.

This research may involve the following: (a) Matching innovation surveys, such as the Community Innovation Survey and Business Enterprise Research and Development (BERD) data, which include innovation inputs and outputs and detailed information on knowledge transfer—such as intensity and breadth of knowledge collaboration—with multiple organizational units and external stakeholders (e.g. customers, suppliers, universities, consultants, national and local government, R&D labs, and competitors); (b) identifying market and technology constraints on innovation activity; (c) analysing investment in internal and external R&D, training, and purchasing of hardware and software for innovation, as well as marketing expenditure for innovation, employment in Science, Technology, Engineering, and Math (STEM) workers, and the share of employees with Master of Arts/Science degrees and above; (d) examining the share of new-to-market and new-to-firm products (services) sales, share of products and services for which firms seek formal intellectual property rights protection, number of patents, trademarks, and copyrights, as well as various forms of informal protection.

Within this contribution, we propose future research to focus on a nuanced understanding of knowledge spillovers and highlight the importance of the KSTE's mechanisms in achieving differentiated outcomes across various institutional, cultural, socioeconomic, and political contexts (Balland et al., 2015). Future research will use longitudinal panel data for at least 10 years, which should enable the tracking of the short- and long-term effects of knowledge spillovers on innovation outcomes. In addition, it will allow investigation into the timing of managerial responses to changes in knowledge spillovers related to hiring STEM workers, investment in internal and external R&D, the pursuit of intellectual property right protections, and the role of the external business context, such as changes in regulation or market and industry dynamics. These data for the UK and European countries are available through the Community Innovation Surveys and special Eurostat surveys. For the United States, the Federal Statistical System is composed of 13 designated statistical agencies, including the US Census Bureau (DOC), the Bureau of Economic Analysis (DOC), the Bureau of Labor Statistics (DOL), the Bureau of Justice Statistics (DOJ), the Economic Research Service (USDA), the National Center for Science and Engineering Statistics (NSF), and others.

Our second contribution is by emphasizing the importance of mechanisms enabling knowledge spillover, as well as other reverse mechanisms of knowledge transfer (Cassiman & Veugelers, 2006), which look at knowledge and creativity not only as an antecedent of entrepreneurial ideas but also as an outcome of innovation activity (Acs et al., 2004, 2009). This requires moving away from the spatially localized view of knowledge spillover that emphasizes the implications of knowledge to the region and industry directly (Romer, 1986). Given the development of digital technologies, platforms, and tools, we should expand the spatial, industry, and other boundaries of knowledge spillovers.

Within this contribution, we propose that future research should aim to investigate different types of knowledge and their ability to 'spill over' regionally and internationally using international comparisons and data. International databases such as Orbis and Amadeus could be used to link firm-level data across countries and connect subsidiaries' data to that of their headquarters. Orbis and Amadeus are global databases provided by Bureau van Dijk, a Moody's Analytics company. Orbis contains comprehensive information on companies worldwide, allowing users to find, analyse, and compare specific details of companies regarding financials, ownership, industry, and mergers and acquisitions. Amadeus specializes in companies in Europe, has comprehensive data, and is particularly useful for comparative financial analysis within the European markets.

To analyse the role of digitization in knowledge spillovers, national statistical agencies have taken steps to measure automation, technology, and the associated workforce. For example, the US Census Bureau is teaming up with the National Center for Science and Engineering Statistics (NCSES) to add questions on the use of digital technologies and AI to the Annual Business Survey. The Annual Business Survey collects information from over 300 000 firms on the use of AI, robotics, dedicated equipment, specialized software, and cloud computing, enabling users to analyse the role of digital technologies in knowledge transfer and innovation. Census Bureau and NCSES data may also be combined with the BERD survey data and may bring information on R&D expenditures and R&D employees of not-for-profit, publicly, and privately held businesses. Some experimental data collected during the COVID pandemic, such as the Business Trends and Outlook Survey, could be matched with innovation surveys to evaluate the changes in knowledge spillovers during the exogenous shocks.

Future research will also explore the role of different proximities (institutional, technological, digital, and spatial) in influencing an entrepreneur's ability to transform knowledge into economic value by starting a new firm and innovating (Acs et al., 2013; Autio et al., 2018). However, as our literature review suggests, the concept of knowledge spillovers, while remaining at the intersection of geography and entrepreneurship, reveals that knowledge is a complex multi-level construct embedded in individual entrepreneurs, industries, and regions. Business Dynamics Statistics (BDS), which aims to embrace all firms with at least one employee, can measure the net change in employment, sales, and productivity at the establishment level. BSD data could be further linked to data on how firm innovation characteristics relate to knowledge flows. The BDS-Innovative Firms data describe subpopulations of firms engaged in activities related to knowledge transfer and innovation with data on zip (post) codes, industry classification, the legal status of firms, their internationalization level, and technology intensity (e.g., low-tech vs. high-tech firms). Such data are available at regional, industry, and region–industry levels (Goldschlag & Miranda, 2016) and could be used in future research to unpack the complex multi-level nature of knowledge spillover of entrepreneurship and innovation.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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