Exploring knowledge spillovers: innovation strategies in resource-rich countries

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RESEARCH

Exploring knowledge spillovers: innovation strategies in resource-rich countries

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Abstract
Exploring innovation strategies within the knowledge spillover theory is key to understanding how knowledge generated in one context can unintentionally flow or "spill over" into other contexts, leading to new insights, ideas, and innovations. Resource-rich countries face unique challenges and opportunities when applying this theory, which primarily focuses on the influence of external factors on entrepreneurial behaviour and the innovation process. While abundant natural resources can provide a strong economic base, they also pose the risk of a resource curse, where overreliance on resource extraction hampers diversification and innovation in other sectors. This study aims to unravel how and why the knowledge spillover theory can facilitate regional economic development and growth in resource-rich countries. We do so by performing a systematic literature review of relevant peer-reviewed articles published between 1996 and 2024 and discussing the mechanisms and conduits of knowledge spillover in countries rich in natural resources.

Keywords Innovation spillovers · Resource-rich countries · Knowledge spillover mechanisms · Natural resources · Knowledge spillover entrepreneurship and innovation theory

1 Introduction

The Knowledge Spillover Theory of Entrepreneurship and Innovation (KSTEI) posits that knowledge created within a firm or institution spills over to the surrounding environment, fostering entrepreneurial activities and innovation. The theory suggests that knowledge created within one organisation can spill over to new ventures, fostering innovation and economic growth. This theory is grounded in the key idea that knowledge is a public good, characterised as non-rival and partially non-excludable, with the potential to benefit mul-

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tiple entities beyond its origin (Audretsch & Keilbach, 2007; Audretsch et al., 2023a, 2023b; Shu et al., 2014). Entrepreneurship scholars argue that regions with abundant knowledge generate more entrepreneurial opportunities, leading to higher rates of innovation and firm creation (Qian, 2013, 2017, 2018). In recent years, the KSTEI research stream has developed a marked focus on regional economic development and practice as well as policy-oriented research (Acs et al., 2016; Audretsch et al., 2018, 2021; Belitski et al., 2021; Cristo-Andrade & Ferreira, 2020; Iftikhar et al., 2020; Kraus et al., 2021; Lattacher et al., 2021; Morris et al., 2024). This approach is particularly relevant to resource-rich countries, which face increasing pressure to diversify their economies and transition toward sustainability in alignment with the United Nations Sustainable Development Goals (SDGs) (COP 28, 2023; Feng et al., 2023; Kalyuzhnova & Belitski, 2019; Li & Huang, 2023; Wang et al., 2023).

These economies, often reliant on natural resources, encounter unique challenges and opportunities that make knowledge spillover mechanisms essential for fostering innovation that supports both global sustainability standards and economic development (Alper & Oguz, 2016; Feng et al., 2023). The reliance on extractive industries typically limits the diversification of economic activities, resulting in structural dependencies that constrain domestic innovation capacity. Consequently, resource-rich countries face an urgent need to invest in knowledge creation and acquisition, actively sourcing external expertise to enable sustainable growth and economic diversification grounded in innovations and entrepreneurship growth (Li et al., 2022a, 2022b; Zhu et al., 2024). Therefore, it is beneficial to obtain a better understanding of how these economies can transition toward more resilient and sustainable models, leveraging innovation to align with global developmental priorities.

Previous research has primarily validated the KSTEI within developed and knowledge-driven economies (e.g., Acs et al., 2009; Fotopoulos, 2023; Knoben et al., 2011; Nonnis et al., 2023; Tsvetkova et al., 2014). However, its applicability and core concepts still require comprehensive investigation in the context of resource-rich countries (Dzwigol et al., 2023; Heim et al., 2023; Hou et al., 2023). Moreover, existing research on this topic remains fragmented, lacking systematic analysis of how and why the KSTEI is utilised in resource-rich countries to drive innovation, promote knowledge-based entrepreneurial activities, and identify effective mechanisms underlying the knowledge spillover-innovation-collaboration nexus for firms in these regions (Cerver-Romero et al., 2020; Morris et al., 2024; Qian, 2018).

This study aims to bridge this gap by systematically examining how the KSTEI can support regional economic development and foster knowledge-driven entrepreneurship in resource-rich countries, offering insights into its potential as a transformative framework in these unique economic contexts. This study fills this gap by bringing together the two research streams of the Knowledge Spillover Theory of Entrepreneurship and Innovation and its role in the context of resource-rich countries, particularly in enabling growth and fostering more innovative businesses. Applying the systematic literature review method, we analysed 89 articles in peer-reviewed academic journals included in the *Academic Journal Guide* issued by the Chartered Association of Business Schools (CABS) from 1996 to 2024. This study is guided by the following research questions:

How and why can the KSTEI facilitate regional economic development and growth in resource-rich countries?

This theoretical study contributes to the research field of knowledge spillover theory entrepreneurship and innovation in resource-rich countries by addressing the current research

limitations. We systematically examine what resource-rich countries can learn from the theory to move forward with a knowledge-based and sustainability-focused approach to their future outlook. This greater understanding will be instrumental for researchers, practitioners, and policymakers as they rebuild economies and address future trends and challenges (Baker & Phillips, 2019; COP 28, 2023; Feng et al., 2023; Gong et al., 2023; Li & Huang, 2023). One of the important findings and outcomes of the systematic literature review is the conceptualisation of the distinct factors and knowledge spillover mechanisms tailored to the context of resource-rich countries, discerning how the theory can facilitate regional economic development and growth. Our study's theoretical and practical contribution is of particular relevance for managerial practice and provides avenues for future research.

The paper is organised as follows. Section 2 presents the origins of the Knowledge Spillover Theory of Entrepreneurship and Innovation and explains how the theory fits the context of resource-rich countries. Section 3 outlines the methodology of the study and explains the rationale for choosing a systematic literature review method to answer the research questions. Section 4 provides the results of the systematic literature review analysis and sample. Section 5 analyses the results of the study and considers how future research in the field of knowledge spillover theory entrepreneurship and innovation may be developed in relation to resource-rich countries, further outlining the policy implications of the study.

2 Literature review

2.1 Genesis of the knowledge spillover theory entrepreneurship and innovation

The genesis of the Knowledge Spillover Theory of Entrepreneurship and Innovation can be traced back to the 1980s, with ground-breaking cross-disciplinary research by a range of scholars, particularly in economics, economic geography, entrepreneurship, and innovation studies (e.g., Coe & Helpman, 1995; Cohen & Levinthal, 1989; Raut, 1995; Steurs, 1995). The theory was rooted in the postulate of the dual role of research and development (R&D) activities in driving both innovation and organisational learning within firms. The first research stream of scholars provided a nuanced perspective of how R&D investments along with international and intra/inter-industry collaboration not only contribute to the development of new products, processes, and technologies, but also serve as vehicles for learning, knowledge acquisition, and productivity (e.g., Grossman & Helpman, 1991; Suzumura, 1992; Ziss, 1994). The research streams on knowledge spillovers have significantly evolved over time, focusing on SMEs (e.g., Audretsch & Belitski, 2020; Audretsch et al., 2022, 2023a, 2023b, 2024a, 2024b), the spatial aspects of knowledge spillovers and economic growth (e.g., Anokhin et al., 2021; Audretsch & Belitski, 2013, 2022; Audretsch & Lehmann, 2005; Belitski et al., 023), universities (e.g., Guerrero & Urbano, 2014; Radko et al., 2023; Wennberg et al., 2011), start-up and new firm formation (e.g., Audretsch & Belitski, 2024a, 2024b; Audretsch et al., 2006a, 2006b, 2024; Barboza, 2024; Belitski et al., 2021; Colombelli & Quatraro, 2018; Kanellopoulos & Fotopoulos, 2019). Therefore, the knowledge spillover concept is quite dynamic, and researchers approach it as a diffusion or sharing of knowledge, processes, external benefits, or knowledge externalities (Agarwal et al., 2010; Audretsch & Belitski, 2020; Stough & Nijkamp, 2009) (Table 1).

Table 1 Key definitions of knowledge spillovers

References	Definition
Stough and Nijkamp (2009), p. 835	A diffusion or sharing of knowledge from its source to another agent in the society
Audretsch (2014)	Processes whereby knowledge created in one context is transformed into entrepreneurial opportunities by individuals or firms in close proximity
Agarwal et al., (2010) p.271	External benefits from the creation of knowledge that accrue to parties other than the creator and occur at multiple levels of analysis, be it within or across organisations and networks
Audretsch and Belitski (2020), p. 2	Knowledge externalities which both directly and indirectly change innovation and productivity in a firm

The KSTEI was developed in response to the realisation that traditional models of innovation and entrepreneurship often neglected the critical role of knowledge diffusion and spillovers in fostering economic growth and innovation (Audretsch, 1995). Building on the definition by Audretsch and Belitski (2022, p.1330), we conceptualise firm innovation as "a firm's capacity to develop new market products through significant transformations in its products, processes, technologies, organisational structures, and methods." According to the KSTEI, the essence of entrepreneurial and innovation opportunities lies in the new knowledge and ideas generated within a specific context (Audretsch & Lehmann, 2005). This framework emphasises the importance of knowledge as the foundation for economic agents to identify and capitalise on innovative opportunities. The literature posits that innovations are driven by the spillover of knowledge from existing firms and research institutions to new firms. Scholars largely agree that the knowledge spillover theory gives useful and practical insights into the mechanisms and sources of ideas in companies, universities, regions, and other stakeholders (e.g., Acs et al., 2009, 2013; Audretsch & Belitski, 2021; Audretsch & Keilbach, 2004).

In the context of the KSTEI, one of the key determinants of knowledge spillovers is the concept of knowledge recombination, where research emphasises its benefits in promoting innovation and continuous learning in organisations. Yang et al., (2010, p. 371) argued that knowledge spills over from an originating firm and is recombined with complementary knowledge by recipient firms, creating new opportunities such as knowledge spillover pools and learning opportunities for originating firms focused on improving their innovation strategies and ability to explore new knowledge opportunities more effectively. Ultimately, knowledge recombination is particularly relevant for firms operating in uncertain business environments dominated by shocks, institutional changes, and other challenges (Fleming & Sorenson, 2001). By leveraging diverse, existing knowledge components, firms can generate unique insights, functions, or products that might not emerge from single, isolated ideas. Their focus on novelty, adaptability of products, cross-disciplinary innovation, and economic diversification enable knowledge resilience, which is key since it helps businesses enhance their absorptive capacity as well as embrace and apply external knowledge (Carnabuci & Operti, 2013; Colombelli, 2016; Colombelli & Quatraro, 2018; Karim & Kaul, 2015). Therefore, the knowledge recombination concept is central to innovations, as it involves creating new ideas, products or solutions by combining existing knowledge components—each representing a core scientific or technological concept (Xiao et al., 2022).

In addition, the research also identifies knowledge filters as an important element of the knowledge spillover process. Knowledge filters are often viewed as context-specific knowledge, shaped by social norms, organisational behaviour, and policies (e.g., Acs & Plummer, 2005; Guerrero & Urbano, 2014; Mueller, 2006). The knowledge filter concept was pioneered in the KSTEI research stream by Acs et al. (2004), where scholars made a distinction between general knowledge and economically useful knowledge. Knowledge filters function as a barrier, limiting the potential of knowledge to become economically useful (e.g., for processes, products, or organisations) in both industry and academic settings (Audretsch & Link, 2012; Carlsson et al., 2007). In their seminal work, Audretsch and Link (2012) highlighted the critical challenges and barriers that hinder the flow of knowledge potential between industries and its commercialisation. They argued that the knowledge filter is a process whereby new ideas generated by firms and industries can become lost. This is particularly significant for companies pursuing knowledge-based growth, as it highlights the need to explore mechanisms that effectively transform economically useful knowledge into commercial activities within organisations and industries (@@e.g., Audretsch et al., 2006; Qian & Acs, 2015; Audretsch e, Keilbach, & Lehmann, 2006a, 2006b).

2.2 Linking knowledge spillover theory entrepreneurship and innovation to resource-rich countries

The KSTEI offers a robust framework that provides a better understanding of how latent knowledge and technology in resource-rich environments can act as a catalyst for broader economic development towards knowledge-driven economies. Resource-rich countries, also known as resource-dependent countries, are nations that possess large quantities of natural resources which significantly contribute to their economy, often making up a major part of their export income and national wealth (Kalyuzhnova & Nygaard, 2008). Economic performance in these countries can be heavily influenced by global commodity prices and the management of these resources (Kalyuzhnova, 2017; Kalyuzhnova & Belitski, 2019). The International Monetary Fund (IMF) defines a country as ‘resource-rich’ when its exports of non-renewable natural resources, such as oil, minerals, and metals, comprise more than 25% of the total value of the country’s exports. This classification helps identify economies significantly dependent on natural resource exports, impacting their economic strategies and development policies (Baunsgaard et al., 2012).

In countries with abundant natural resources, substantial investments in sectors like mining, oil, and gas can often lead to the accumulation of specialised knowledge and cutting-edge technologies. However, the centralised focus on resource extraction often means that much of this expertise is underutilised. In addition, the characteristics of resource-dependent industries often create significant knowledge filters that limit the potential of knowledge to be transformed into economically valuable outputs and eventually commercialised, ultimately diminishing entrepreneurial activities and initiatives. In addition, this can also hinder knowledge recombination, preventing firms from combining diverse ideas into innovative solutions (Audretsch & Link, 2012; Yang et al., 2010). However, with the implementation of effective knowledge spillover mechanisms tailored to the industry—such as strategic R&D investments and robust knowledge infrastructure to support high-growth firms and foster an entrepreneurial culture—entrepreneurs can unlock these untapped resources. Prior research argues that the management of resources and the wealth thus generated in such economies

present both opportunities and challenges (Gelb, 2010; Kalyuzhnova, 2008; Larsen, 2005). On one hand, these resources give extra financial means for development and economic growth. On the other hand, these countries often face unique developmental challenges such as economic volatility due to fluctuating resource prices, governance issues, and the "resource curse" — a phenomenon where countries with an abundance of natural resources tend to have less economic growth, less democracy, and worse development outcomes than countries with fewer natural resources (Kalyuzhnova, 2006; Kalyuzhnova & Kaser, 2006).

Recent studies and the United Nations Climate Change Conferences showcase that many resource-rich countries are under increasing pressure to transition to sustainable economies and align with the United Nations' Sustainable Development Goals (SDGs) (COP 28, 2023; Feng et al., 2023; Tiba & Frikha, 2019). This shift is driven by a combination of global climate targets, evolving market demands, and the environmental and social challenges associated with extractive industries. Achieving this transition requires reducing dependency on non-renewable resources while investing in renewable energy, sustainable infrastructure, and innovative technologies that minimise ecological footprints. Furthermore, as global demand for low-carbon and sustainably sourced products continues to grow, resource-rich countries must diversify their economies to remain competitive in international markets (Gong et al., 2023; Sahin et al., 2019). Therefore, the KSTEI plays a critical role in this context by enabling resource-rich countries to leverage their existing expertise in resource management and apply it to emerging sustainable sectors.

By fostering innovation and knowledge-driven entrepreneurship, the KSTEI can provide effective support in achieving the SDGs and facilitate a gradual transition toward diversified, sustainable economic structures. This transformation not only enhances the competitiveness of these countries, it also positions them for success in high-value, knowledge-driven manufacturing and other advanced industries. For instance, technologies developed in the energy sector can be adapted to improve energy efficiency or develop renewable energy sources, aligning with global sustainability initiatives. Moreover, through proactive regulatory support and financial incentives, governments can create an enabling business environment and entrepreneurial ecosystem, accelerating the adoption of these technologies across various sectors.

Engaging with the KSTEI's principles can ultimately lead to a more varied economic landscape, mitigating the risks associated with dependence on finite natural resources. More importantly, by transforming underutilised knowledge into commercial opportunities, resource-rich countries can foster a vibrant entrepreneurial ecosystem, driving sustainable economic growth and creating a buffer against the volatile commodity markets that often characterise such economies. Prior studies demonstrated how entrepreneurs can successfully utilise technologies developed in one sector and how this knowledge can flow into other industries. For example, Khan et al., (2021) demonstrated how technologies from the energy sector, such as drones for land surveying or water management systems, could be adapted for agricultural use, enhancing productivity and sustainability. Kusumah et al., (2023) explored how knowledge from environmental management practices in mining can help develop eco-tourism businesses that promote biodiversity conservation while generating income.

Finally, the potential for economic transformation in resource-rich countries through the application of the KSTEI goes far beyond economic diversification. Knowledge and technology spillovers from resource-intensive industries can be harnessed to establish

sustainable businesses that align with environmental and social goals. A central aspect of this transformation is the recombination of knowledge, which is particularly critical for resource-rich economies. This dynamic interplay between knowledge sources and recipients facilitates the transfer and adaptation of existing knowledge into innovative applications. By effectively utilising external ideas, firms in resource-rich economies can enhance their competitiveness and drive growth beyond traditional sectors, fostering a more diversified and sustainable economic landscape (Srivastava & Gnyawali, 2011; Terziovski, 2010).

3 Methodology

Undertaking a systematic literature review serves as a robust mechanism for advancing theoretical, practical, and methodological understanding within a given subject domain (Kunisch et al., 2023). Previous studies indicate that systematic literature reviews provide the most efficient means of identifying and evaluating extensive bodies of literature (Fisch & Block, 2018; Snyder, 2019; Tranfield et al., 2003). This methodology is applied extensively across various fields of business, management, and entrepreneurship research (e.g., Ghio et al., 2015; Karlsson & Hammarfelt, 2019; Khlystova et al., 2022a, 2022b; Morris et al., 2024; Urbano & Aparacio, 2019). This systematic approach helps to identify key trends, gaps, and areas for further investigation within the entrepreneurial landscape. Moreover, it facilitates the integration of diverse methodologies and perspectives (such as the evolution of the Knowledge Spillover Theory of Entrepreneurship and Innovation in the specific context of resource-rich countries) (Farzanegan, 2014; Heim et al., 2023), fostering a more comprehensive understanding of knowledge spillover processes and outcomes. Thus, the systematic literature review method adopted in this study serves as a vital tool for enhancing scholarly discourse and informing evidence-based entrepreneurial practice (Morris et al., 2024).

To conduct such a review, we utilised the Web of Science and Scopus research databases as our main sources of publications. In the literature review process, we identified four main stages of the systematic literature review process: defining the research question of the study and understanding the gaps in existing research; selecting the search strings and prompts; stablishing main and additional inclusion criteria; and data cleaning (Denyer et al., 2008; Fisch & Block, 2018; Palmatier et al., 2018).

In order to complete the first step, we built this literature review around the main keywords related to the Knowledge Spillover Theory of Entrepreneurship and Innovation, entrepreneurial activity, and resource-rich countries following prior theoretical and empirical studies in this research field (e.g., Audretsch & Belitski, 2022; Audretsch & Keilbach, 2007, 2008; Kalyuzhnova, 2017; Morris et al., 2024). The research query included "*Knowledge spillover theory entrepreneurship innovation OR knowledge spillover OR knowledge filter OR R&D spillover* OR spin-off* OR spin-out* OR knowledge transfer OR KSTEI OR innovation OR Knowledge spillover theory innovation*" AND "*Resource-rich countries; Natural-resource-rich countries; Natural resources; Oil and gas; Commodity funds; Abundant-resource countries; Mineral-rich countries; Natural bounty nations; Resource-abundant nations; Resource-endowed nations; Resource-laden countries; Resource dependent*". The initial search yielded 4427 articles in Web of Science and 5467 in Scopus. In this study, we targeted peer-reviewed articles published between 1996 and 2024 in English only.

After applying the first-level inclusion criteria, the search narrowed down to 3766 articles in Web of Science and Scopus. The next step was to identify articles published in relevant research fields, such as business and management, economics, environmental studies and sciences, as well as multidisciplinary research. This search resulted in 860 articles in Web of Science and 1430 articles in Scopus. Finally, after all the available criteria had been applied, we started the review process, additionally controlling for the reputation and ranking of journals, targeting publications from the *Academic Journal Guide 2021* published by the Chartered Association of Business Schools (CABS). This is a reliable and trusted benchmark of journals that meet international academic standards, as well as a good proxy for a quality check of the literature review sample (Paul & Benito, 2018).

Based on Linnenluecke et al. (2020), the research team analysed how keywords were employed within the articles to prevent "false positives." After selecting papers for the sample, we rigorously reviewed them to ensure adherence to inclusion criteria, encountering no disagreements. The last phase of data cleaning entailed scrutinising the reference lists of included papers to avoid overlooking significant contributions as well as ensuring a focus on resource-rich countries only, to fulfil the aim of this systematic literature review (Denyer et al., 2008).

We analysed both conceptual and empirical studies on the KSTEI and resource-rich countries as the main focus of the investigation. Therefore, grounded in prior empirical comparative studies on resource-rich countries (e.g., Amiri et al., 2019; Kalyuzhnova et al., 2016; Lashitew et al., 2021; Mlachila & Ouedraogo, 2020; Ouoba, 2016), our systematic literature review included those resource-rich countries that have abundant natural resources which often form a significant part of their economy through exports (Lashitew et al., 2021). Countries such as Saudi Arabia, Russia, Australia, Canada, the United States, Brazil, China, Venezuela, Norway, Nigeria, the United Arab Emirates, Kazakhstan, Qatar, Indonesia, and Iraq are known for leveraging their natural resources to drive economic growth, although the degree to which they can manage these resources sustainably and equitably varies greatly. Upon completion of the data cleaning process, the final literature review comprised 89 articles, which went through an additional screening process to ensure that the publications were of a suitably high quality. Therefore, we only considered articles published in the Chartered Association of Business Schools (CABS) *Academic Journal Guide 2021*. The research design for both databases is illustrated in Fig. 1.

4 Results

4.1 Descriptive results

As a result of the literature review analysis, we selected a unique sample of 89 peer-reviewed publications, published between 1996 and 2024, from 47 distinct journals included in the CABS *Academic Journal Guide 2021*. The top five academic journals to have published articles on the resource-rich countries-knowledge spillovers entrepreneurship and innovation research stream include the *International Journal of Industrial Organization*, *Research Policy*, *Resources Policy*, *Small Business Economics*, and *Technology Analysis and Strategic Management.* The full list of journals included in the review and their distribution around the articles in the sample is presented in Table 2.

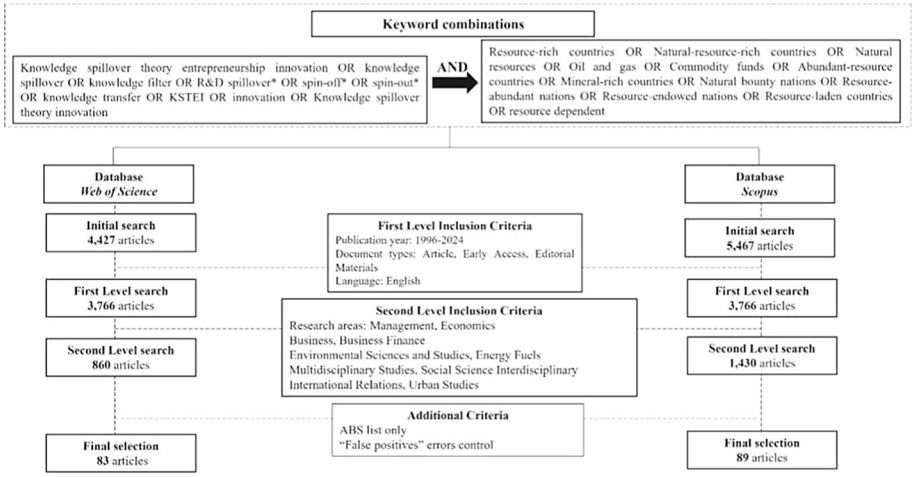

Fig. 1 Web of science and scopus research design.
Source: Authors

The systematic literature review sample covers different contexts, varying from country-specific studies covering, for example, China, Canada, the US, and Norway (e.g., Anokhin et al., 2021; Boadu et al., 2023; Flammer & Kacperczyk, 2019; Iftikhar et al., 2022; Moshiri, 2016; Steen & Hansen, 2014; You et al., 2024), cross-national studies (e.g.,Chatzistamoulou et al., 2022; Cojoianu et al., 2020; Hao et al., 2021), and conceptual articles (e.g., Audretsch & Keilbach, 2008; Audretsch et al., 2020; Coe & Helpman, 1995).

Our literature review sample results show that in resource-rich countries, where economies often depend on natural resources, the KSTEI theory is fused with other business and management theories to reveal specific pathways for fostering innovation and economic diversification. Essentially, the application of KSTEI and other theories highlights the potential of resource-rich countries to harness knowledge spillovers to mitigate reliance on natural resources, foster innovation in related industries, and encourage economic diversification through strategic partnerships, regional clustering, and open innovation practices. Our analysis demonstrates that the most common theories used in the sample are Strategic management, Value co-creation, Endogenous growth, Institutional voids, the Triple helix model, Interorganizational learning, Related variety, Open innovation, Proximity concept, Knowledge production, the Resource-dependence theory, and the Rivalry-based theory (Table 3) (this list is not exhaustive).

The literature review results show that existing research looked into various knowledge spillover mechanisms, such as absorptive capacity, R&D investments, institutional intermediaries, innovation systems, knowledge filters, organisational capital and operational experience, Corporate Social Responsibility (CSR) policies, digitalisation, and Public–Private Partnerships (PPTs), etc. For example, several studies underpin the benefits of absorptive capacity within endogenous growth theories, highlighting the importance of R&D investments as a conduit to absorb and integrate external knowledge into their operations. Studies suggest that in resource-rich economies, investment in R&D within resource industries (e.g., energy or mining) enables local companies to adopt cutting-edge technologies, enhance

Table 2 List of academic journals included in the literature review.
Source: Authors

Journal Title	No of articles
International Journal of Industrial Organization	9
Research Policy	6
Resources Policy	6
Small Business Economics	5
Technology Analysis and Strategic Management	4
European Economic Review	3
Technological Forecasting and Social Change	3
Journal of Industrial Economics	3
Growth and Change	2
Applied Economics	2
Economics Letters	2
International Entrepreneurship and Management Journal	2
Journal of Regional Science	2
Scandinavian Journal of Economics	2
American Economic Review	2
Strategic Management Journal	2
International Review of Financial Analysis	2
R & D Management	2
Energy Economics	2
Economic Geography	1
Regional Studies	1
Environment And Planning A-Economy and Space	1
Thunderbird International Business Review	1
European Planning Studies	1
Management and Organization Review	1
Economic Inquiry	1
Economic Modelling	1
Quarterly Journal of Economics	1
Open Economies Review	1
Journal Of Economics and Management Strategy	1
Journal of Political Economy	1
Entrepreneurship Theory and Practice	1
Entrepreneurship and Regional Development	1
Economics of Innovation and New Technology	1
Management International Review	1
Management Decision	1
Environmental Science and Policy	1
Journal of Management Studies	1
Studies in Economics And Finance	1
Finance Research Letters	1
Industrial and Corporate Change	1
Harvard Business Review	1
Journal of Environmental Economics and Management	1
Journal of the Knowledge Economy	1
Journal of Economic Perspectives	1
Economic Journal	1
Energy Policy	1
Total journals: 47	Total articles: 89

Table 3 Descriptive summary of the literature review sample results.
Source: Authors

Examples of theories used in combination with the KSTEI	Methodological approaches	Spillover mechanisms examples	Research gaps
Strategic Management	Quantitative	Corporate Social Responsibility (CSR) policy	Firm strategic engagement in relationship-based practices as a defence mechanism against knowledge spillovers
Value Co-creation	Case studies and interviews	Digitalisation and Public–Private Partnerships	Network value co-creation model for knowledge spillovers
Endogenous Growth	Quantitative	Absorptive capacity; R&D investments	Micro-level of knowledge spillovers; cultural and institutional contexts for knowledge spillovers
Institutional Voids	Qualitative	Institutional intermediaries	Institutional intermediaries as spillover conduits between businesses and public resources in emerging economies
Triple Helix Model	Conceptual	Innovation systems	Distinct patterns of knowledge transfer and integration
Interorganisational Learning	Quantitative	Knowledge filters	Optimal knowledge spillover mechanisms between knowledge recipients and innovators; knowledge filters in different cultural contexts
Related Variety	Qualitative and Quantitative	Organisational capital and operational experience	Knowledge spillover feedback effect; cross-sectional knowledge spillovers and their regional dynamics
Open Innovations	Quantitative	R&D investments	Social effects of open innovations and knowledge spillovers
Proximity Concept	Quantitative	Institutional, social, cognitive, cultural and geographical proximities	Institutional proximity studies for knowledge spillovers; Geographic components of knowledge spillovers
Knowledge Production	Quantitative	Incubation programmes; employee skills	Informal social networks for knowledge spillovers
Resource-Dependence Theory	Quantitative	R&D expenditure; new product alliances	Other forms of alliances for knowledge spillovers and R&D
Rivalry-Based Theory	Quantitative	Innovation awards	Labour mobility; firm-to-firm linkages

productivity, and transfer these advancements to other sectors, fostering economic diversity (e.g., Chatzistamoulou et al., 2022; Heim et al., 2023; Liu & Fan, 2020).

One of the most beneficial and context-important theories used to explore the knowledge spillover process and mechanisms is the institutional voids theory. Many resource-rich countries experience institutional gaps, particularly in regions where local governance may not fully support economic diversification. Institutional intermediaries, such as development agencies or NGOs, could act as conduits for knowledge spillovers, fostering collaboration between resource industries and emerging sectors like technology or clean energy (e.g., Armanios et al., 2017; Rakas & Hain, 2019). In addition, the Interorganizational learning theory was particularly useful to shed light on knowledge filters and how companies manage them (e.g., Shu et al., 2014; Zhou et al., 2024). The combination of these two concepts arose from the exploration of the various mechanisms whereby companies learn from each

other, distinguishing intentional and unintentional knowledge sharing and identifying how this process is moderated by knowledge filters.

To analyse the sample, we utilised bibliometric analysis, a tool that measures and processes data using various algorithms to manage large data sets. This tool is valuable as it helps uncover "hidden patterns" in the literature, which is particularly useful during the literature review process (Donthu et al., 2021; Kraus et al., 2022). Additionally, this technique enables an understanding of the main trends in the literature, enriching the discussion and providing deeper insights into the themes that emerged from the analysis (Khlystova et al., 2022a, 2022b; Van Eck & Waltman, 2010). We conducted a co-occurrence analysis of the keywords used in the articles to identify thematic clusters within the literature review sample. The network visualisation of keywords (co-word analysis) clarifies the content and focus of the publications (Donthu et al., 2021; Verma & Gustafsson, 2020). Using this technique, we employed the software VOSviewer to analyse keywords with a minimum occurrence of ten, focusing on those found in the authors' keywords, titles, abstracts, and full texts (Fig. 2).

4.1.1 Outbound knowledge spillovers in resource-rich industries

From our systematic literature review, we identified several mechanisms and rationales that enabled us to shed light on the concept of *outbound knowledge spillovers* as it applies to resource-rich countries. *Outbound knowledge spillovers* refer to the transfer of expertise, technologies, and practices developed within a specific industry to other sectors or regions, fostering open innovations (Rahko, 2017; Triguero & Fernández, 2018). Resource-rich countries often have established industries, particularly in sectors like oil, gas, mining, and

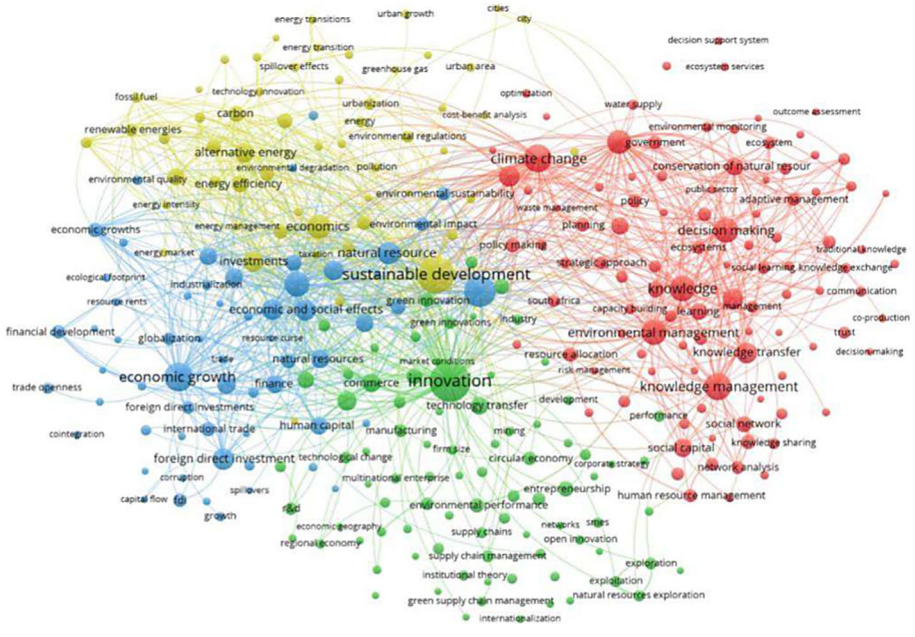

Fig. 2 The network visualisation of keywords used in the literature review sample.
Source: Authors

related services. These industries create a substantial knowledge base that can spill over to other sectors. However, they often require substantial investments in cutting-edge technologies and operational systems. The literature review analysis demonstrates that these sectors act as pools of specialised knowledge, providing a conducive environment for the generation of outbound knowledge spillovers—an essential mechanism that enhances the capabilities of other sectors and entrepreneurial activities. For example, the oil and gas industry is renowned for its advanced technologies in drilling, refining and logistics, as well as its management practices tailored to complex supply chains. When these technologies and practices spill over into other industries, they foster innovation and new business opportunities.

Knowledge spillovers are particularly evident when employees trained in resource sectors transition to other industries or start their own ventures. These individuals carry technical and managerial expertise, which can be applied to emerging fields (Ghebrihiwet, 2019). Resource-rich countries often experience the growth of urban centres around resource extraction sites. These hubs attract a highly skilled workforce, educational institutions, and research facilities, creating an ecosystem that facilitates frequent knowledge exchange. In such environments, startups and small businesses often thrive by leveraging knowledge from resource-intensive industries. For example, the establishment of innovation clusters around mining operations in South Africa has led to the development of new environmental technologies and services tailored to local needs (Ghebrihiwet, 2019).

From the literature review analysis, it is evident that outbound knowledge spillovers also occur through labour mobility, where professionals transitioning into resource-rich industries from other sectors bring valuable insights and innovative approaches. The literature review sample shows that skilled labour mobility facilitates knowledge transfer to new industries, entrepreneurial activities, and innovation performance (Castillo et al., 2020; Farole & Winkler, 2014; Liu et al., 2010). In addition, skilled labour mobility could be potentially beneficial to overcome technological gaps between knowledge creators and recipients with more limited innovative capacity (Battke et al., 2016; Corredoira & Rosenkopf, 2010). For example, environmental scientists have contributed to the development of eco-friendly extraction processes, reducing the environmental impact of mining operations. In South Africa, foreign direct investment (FDI) in mining has facilitated technological spillovers, enabling local firms to acquire and adapt knowledge for process innovations (Ghebrihiwet, 2019).

Similarly, skilled professionals bring organisational and technical expertise from other industries, which enhances the capacity for innovation within resource sectors (Castillo et al., 2020). When multinational companies train local workers, it enables knowledge transfer to other local firms or new local ventures, thus disseminating the knowledge throughout the local economy. Secondly, multinational companies often source inputs from local suppliers, which can lead to knowledge transfer and technological improvements among these suppliers. This is especially relevant in the mining industry, where local suppliers might adopt and adapt technologies from multinational firms to enhance their competitiveness (Newman et al., 2020).

Several studies in the literature review sample demonstrated that urbanisation plays a critical role in amplifying outbound spillovers. Recent studies have extensively investigated the positive effect of urbanisation, facilitating knowledge spillovers by concentrating skilled workforce, educational institutions, and R&D facilities, and through the creation of hubs for innovation beyond the resource sector. The development of high-quality infrastructure in

urban areas enables efficient knowledge diffusion and collaboration, which in turn fosters frequent interactions and partnerships, enhancing the exchange and application of knowledge across various industries (e.g., Chen et al., 2020; Iftikhar et al., 2020, 2022; Sun et al., 2021).

Additionally, partnerships between multinational corporations and local firms in resource-rich industries enable technological transfer and capacity building. Multinationals often require local suppliers to meet specific standards, prompting these suppliers to adopt advanced technologies and improve their processes. Over time, this dynamic raises the overall technological capability of the region, allowing knowledge to spill over into other industries and enhancing competitiveness and innovation (Newman et al., 2020). Moreover, resource-rich industries can drive the development of complementary sectors. For instance, the renewable energy sector has benefited significantly from knowledge and technologies originally developed for oil and gas (Chen et al., 2023; Choi et al., 2017; Kang et al., 2020). Offshore wind turbine installations, for example, leverage expertise in offshore drilling and subsea operations. This cross-pollination demonstrates how knowledge generated in one context can catalyse advancements in others, driving diversification and economic resilience.

4.1.2 Inbound knowledge spillovers into resource-rich industries

From our systematic literature review, we identified the critical role of *inbound knowledge spillovers* in shaping innovation and diversification within resource-rich industries. *Inbound knowledge spillovers* refer to the transfer of expertise, technologies, and practices from external sectors into resource-rich industries, enabling these industries to modernise, adopt new technologies, and align with sustainability goals (El Maalouf & Bahemia, 2023; Jha & Basu, 2024; Van de Ven et al., 2018). A number of empirical studies have provided mixed evidence on the applicability of the KSTEI in resource-rich countries. The results of the literature analysis have shown that in some resource-rich countries, knowledge spillovers have positively impacted firm creation and innovation. For instance, in the context of Asian economies, urbanisation combined with high levels of professional employment has been found to significantly enhance the diffusion of knowledge and the creation of new firms (Iftikhar et al., 2020). However, there are also significant challenges. For example, in some African countries, the enforcement of property rights is weak and the number of patents is low, which can hinder the effective utilisation of created knowledge for entrepreneurial activities. Additionally, the presence of non-compete clauses and other legal barriers can limit the mobility of knowledge workers and restrict the spillover of knowledge (Tsvetkova & Partridge, 2021). The literature review analysis provides valuable insights into how resource-rich industries can serve as knowledge spillover sources, benefitting significantly from inbound knowledge originating in other fields such as artificial intelligence (AI), information technology (IT), environmental sciences, and education (Fang & Xie, 2023; Heim et al., 2019, 2023; Moshiri, 2016). These inbound spillovers are increasingly critical as resource-rich countries seek to innovate, diversify, and align with global sustainability goals. The adoption of advanced technologies such as AI and machine learning is transforming traditional resource industries. For example, predictive maintenance systems powered by AI are now employed in oil and gas operations, significantly reducing downtime and operational costs (Chen et al., 2021). Similarly, digital twin technologies, which create vir-

tual replicas of physical assets, are revolutionizing how companies monitor and manage large-scale operations, enhancing efficiency and safety (Heim et al., 2023).

Collaborations with academic institutions and research organisations represent key channels for inbound spillovers (Segarra-Blasco & Arauzo-Carod, 2008; Triguero & Fernández, 2018). Universities and technical institutes often partner with resource companies to translate cutting-edge research into practical applications. For instance, advancements in carbon capture and storage technologies have been integrated into oil and gas operations, reducing their carbon footprint and supporting climate targets (Fang & Xie, 2023). This underscores the importance of fostering cross-sector partnerships to harness external knowledge effectively (Farzanegan, 2014).

The effectiveness of knowledge spillovers in fostering entrepreneurship and innovation in resource-rich countries depends on several factors, of which absorptive capacity—the ability of local firms to absorb and utilise external knowledge—is critical. This capacity is influenced by the firm's own R&D activities, the skill level of its workforce, and its overall technological capabilities (Cohen & Levinthal, 1989). Absorptive capacity is crucial for resource-rich countries as it determines the extent to which firms can effectively harness external knowledge for innovation and diversification. In these contexts, firms in the dominant resource sectors often have access to advanced technologies and practices, but their ability to apply and extend this knowledge to other sectors depends on their absorptive capacity. Studies show that firms with higher absorptive capacities are better positioned to identify, assimilate, and utilise external knowledge, leading to increased innovative efforts and economic diversification (Aldieri et al., 2018; Kirschning & Mrożewski, 2023; Nieto & Quevedo, 2005). For resource-rich developing economies, enhancing absorptive capacity—through investments in education, R&D, and organisational practices—enables firms to capitalise on technological opportunities and knowledge spillovers, transforming them into competitive advantages beyond the resource sector.

Inbound spillovers are not limited to technology transfer and also include organisational and managerial innovations. Concepts such as agile project management, originally developed in the IT sector, have been adopted by resource companies to streamline operations and respond more flexibly to market changes. Likewise, sustainability practices from other industries, including circular economy models, are increasingly applied to resource extraction processes to minimise waste and improve resource efficiency (Karim & Kaul, 2015).

Government initiatives and institutional frameworks further facilitate inbound spillovers. Policies encouraging collaboration between resource sectors and other industries, such as joint R&D funding or tax incentives for technology adoption, create an environment conducive to knowledge exchange. For example, institutional intermediaries have proven effective in bridging resource sectors with academia and other industries, enabling the integration of innovative solutions (Armanios et al., 2017; Rakas & Hain, 2019). In Norway, government-supported initiatives in renewable energy have successfully leveraged knowledge from the oil and gas sector, fostering technological advancements in offshore wind energy (Van der Loos et al., 2021). Similarly, Qatar's investments in education and research have enhanced the technological capabilities of its gas sector while supporting diversification into biotechnology and sustainable urban development (Weber, 2014).

These examples illustrate how inbound knowledge spillovers contribute to the modernisation and sustainability of resource industries. By integrating knowledge from diverse fields, resource-rich countries can enhance their competitiveness and accelerate their transi-

tion towards more diversified, innovation-driven economies. Understanding and fostering both outbound and inbound spillovers is essential for resource-rich countries to unlock their full economic potential. By investing in education, R&D and cross-sectoral collaborations, these countries can create resilient economies that thrive on innovation and sustainability.

5 Discussion, future research, and implications

The KSTEI brings useful lessons for resource-rich countries in terms of understanding how they can leverage their natural endowments to foster innovation and economic growth. Therefore, we argue that, in order to harness the knowledge and innovation-driven trajectories of economic growth, it is important to enhance the absorptive capacity of local firms, implement supportive policies, and promote economic diversification. This study contributes to the extant literature on KSTEI research and resource-rich countries, in particular with regards to the sustainability component, by systematically reviewing how the theory can facilitate regional economic and entrepreneurship development in the context of resource-rich countries, thus extending prior studies (e.g., Belitski et al., 2023; Dzwigol et al., 2023; Newman et al., 2020; Robins, 2006; Sheng et al., 2019; Zhou et al., 2024). This study also identifies specific factors that enable the innovation process in resource-rich countries (Fitjar & Timmermans, 2019).

The facilitation of knowledge spillovers, entrepreneurship, and innovation is a complex process influenced by a number of interrelated factors. Researchers in entrepreneurship and regional economics have argued that the spatial aspects of knowledge spillovers, university–industry collaborations (Triple-Helix model), effective government policies, R&D, strong IPR protection, and economic incentives all contribute to creating an ecosystem that supports and sustains innovation and entrepreneurial spillovers (e.g., Audretsch, 2003; Plummer & Acs, 2014; Döring & Schnellenbach, 2006; Ji et al., 2018; Iftikhar et al., 2022; Morris et al., 2024; Audretsch & Fiedler, 2024). A strategic approach that leverages these factors can enhance a country's innovative capabilities and foster a more dynamic and innovative business environment. We extend prior research by demonstrating which distinct factors could be effective in facilitating knowledge spillover innovations in the context of resource-rich countries. From the literature reviewed and prior research on inbound/outbound knowledge spillovers for open innovations and entrepreneurship, we distinguish several factors of inbound/outbound knowledge spillovers, such as training and new knowledge, labour mobility, academic and research collaboration, new partnerships, and absorptive capacity, in addition to government initiatives (e.g., Corredoira & Rosenkopf, 2010; Heim et al., 2023; Jha & Basu, 2024; Segarra-Blasco & Arauzo-Carod, 2008; Van der Loos et al., 2021) (Fig. 3).

Our analysis supports the idea that in order to strengthen the role of innovation, firms in resource-rich countries need to reinforce their absorptive capacity, being the ability of firms to recognise, assimilate, and apply external knowledge. This capability is influenced by factors such as prior related knowledge, the diversity of the firm's knowledge base, and the quality of its human capital (Hao et al., 2021; Xia et al., 2023). Firms with high absorptive capacity are better equipped to leverage external R&D and knowledge spillovers, leading to more significant innovation outcomes. The interplay between collaborative networks and absorptive capacity has also been considered core to levelling up innovation knowledge

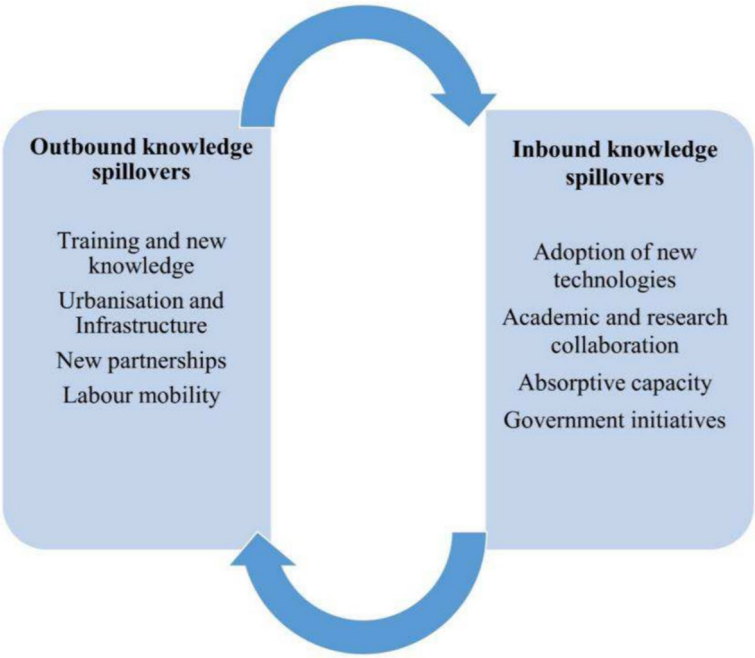

Fig. 3 Distinct factors affecting the knowledge spillover of entrepreneurship and innovation in resource-rich countries.
Source: Authors

spillovers. Prior research has extensively analysed the exchange of complementary knowledge and resources enabling firms to undertake more complex and risky R&D projects (Operti & Carnabuci, 2014; Yang et al., 2010).

Simultaneously, government interventions, such as establishing cooperative R&D funds and improving technology intermediary services, are essential for promoting innovation. These policies support the creation of innovation cooperation networks which enhance the transfer and application of scientific and technological achievements. By providing financial support and creating favourable regulatory environments, governments can stimulate innovation and economic growth (Blackburn & Ravn, 1993; Davis & Botkin, 1994; Ghebrihiwet, 2019; He et al., 2023; Park, 1995). A number of future research opportunities derive from the KSTEI research stream. One of these is related to the geographic proximity and regional clustering of firms in resource extraction areas and how governments can create supportive knowledge spillover ecosystems to foster innovation collaboration between related industries. While prior studies have extensively focused on how R&D spillovers facilitate entrepreneurial opportunities and collaboration (e.g., Acs et al., 2009; Audretsch & Belitski, 2020; Liu & Fan, 2020), future research would benefit from more in-depth analysis of how resource-rich countries could strategically utilise R&D spillovers to achieve a balance between resource dependence and sustainable innovations.

We argue that a more balanced approach to fostering sustainable and open innovation is required, specifically supporting emerging technologies. Economic incentives, such as grants, loans, and startup support systems, have always proved instrumental for companies

in reducing the financial risks associated with innovation because of the need for capital investment for startups to develop and scale such innovation (Ali & Frick, 2016; Armanios et al., 2017; Kraal, 2019; Osmundsen et al., 2008). Additionally, our systematic literature review analysis shows that innovation awards and competitions serve as catalysts for technological advancements by providing recognition and financial incentives for breakthrough innovations. Prior studies examined how award-winning firms often set benchmarks for industry standards, prompting other firms to innovate to keep up with or surpass these benchmarks (Byun et al., 2021; Chatzistamoulou et al., 2022; Li et al., 2022a, 2022b; Machokoto et al., 2021; Tseng, 2022; You et al., 2024). Ultimately, a supportive innovation ecosystem that includes academic–industry partnerships creates a conducive environment for knowledge spillover of entrepreneurship and innovation (Segarra-Blasco & Arauzo-Carod, 2008). Prior research extensively demonstrated how such ecosystems reduce barriers to entry and provide startups with access to the resources and networks necessary for growth (Audretsch & Belitski, 2017; Audretsch et al., 2022, 2023a, 2023b; Belitski et al., 2024; Liu et al., 2024; Masucci et al., 2020).

Our literature review analysis also demonstrates the importance of the institutional context for firms in resource-rich countries. Government policies play an important role in terms of developing a supportive innovation landscape and promoting institutional trust. Prior research found that some resource-rich economies are characterised by weak formal institutions dominated by institutional voids, insufficient quality of regulations, lack of control, and corruption (Kalyuzhnova & Belitski, 2019; Khlystova et al., 2022a; Pourjavan, 2014). Some scholars have argued that effective government policies, such as R&D subsidies and tax incentives, can significantly lower the financial barriers for firms engaging in innovative activities (Elmawazini et al., 2022; Hao et al., 2021; Xia et al., 2023). However, it is important to recognise that the effectiveness of these policies is contingent on their design and implementation. For example, over-subsidisation can lead to inefficiencies and the 'crowding out' of private investment, with government funds displacing rather than complementing private sector R&D spending. This creates fruitful avenues for future research, where future studies could examine how institutional intermediaries could address institutional voids in order to facilitate knowledge spillover mechanisms between industries. In particular, it would be useful to explore how the interplay between various entrepreneurship ecosystem (EE) stakeholders and domains (e.g., culture, formal institutions, infrastructure, networks) enhances the knowledge transfer and spillover process (Audretsch & Belitski, 2017; Audretsch et al., 2024a, 2024b). As argued earlier, developed countries are heavily involved in knowledge-oriented activities and sustainable economic growth; this is not always the case in the resource-rich countries confronting their current challenges. By applying the ecosystem perspective, it would be beneficial to explore how EEs, in combination with knowledge spillover mechanisms, could foster economic diversification in these countries, with the perspective of progression towards knowledge and sustainability-driven economies (Audretsch et al., 2015; Eichler & Schwarz, 2019; Volkmann et al., 2021).

The literature review analysis indicates that these partnerships facilitate the flow of knowledge and resources, fostering an environment where theoretical research can be translated into commercial innovations (Fang & Xie, 2023; Landry et al., 2006). However, strong intellectual property rights protection (IPR) is fundamental to enable such cooperation. The context of resource-rich countries demonstrates that IPR encourages more firms to engage in innovative activities, safe in the knowledge that their intellectual property will

be protected from unauthorised use or imitation (Burnett & Williams, 2014; Chen et al., 2021; Dos Santos Silvestre & Dalcol, 2009; Gui et al., 2018; Rakas & Hain, 2019; Robins, 2006). Beyond internal investments, the reviewed literature demonstrates that resource-rich economies benefit significantly from sourcing knowledge through direct collaboration and knowledge spillovers. Direct collaboration, often through partnerships with universities, multinational corporations, and other innovation-intensive organisations, provides a channel for acquiring advanced technological knowledge and management practices that can be adapted to local needs. Such partnerships are pivotal for introducing new technologies and methods to traditionally resource-dependent industries, fostering industry diversification. However, there is a need for future research to investigate the dynamics and sustainability of university–industry–government collaboration and determine how this mutual collaboration could be integrated into EEs and local innovation systems in resource-rich countries. More importantly, it is essential to consider the role of knowledge filters, and therefore focus on optimal knowledge transfer models with distinct cultural and institutional settings of resource-rich countries (Audretsch & Link, 2012).

Understanding the KSTEI is instrumental for policymakers in resource-rich countries, particularly those seeking to mitigate reliance on natural resources and transition toward sustainable, innovation-driven economies. Countries such as Norway, Saudi Arabia, Qatar, and Azerbaijan offer insightful examples of how knowledge spillovers can be harnessed to foster entrepreneurship, industrial diversification, and economic resilience. Resource-rich countries possess unique opportunities for leveraging outbound and inbound knowledge spillovers to drive economic transformation. The significant investments and technological advancements within sectors such as oil, gas, and mining serve as the foundation for broader innovation and diversification efforts.

Policymakers in resource-rich economies must prioritise the creation of an environment that enables knowledge spillovers to develop further. Effective policies should focus on technology transfer, intellectual property protection, startup support, and absorptive capacity. The establishment of technology parks and university-industry partnerships can facilitate the diffusion of advanced technologies. For instance, Brazil has implemented initiatives that integrate cutting-edge technologies into its oil and gas operations while supporting R&D in renewable energy sectors. Robust intellectual property rights frameworks are essential to protect innovative ideas and encourage entrepreneurial risk-taking. Such protections foster trust, allowing firms and individuals to leverage local knowledge for innovation without fear of misappropriation (Kalyuzhnova et al., 2016). In Norway, knowledge and expertise derived from offshore oil and gas drilling technologies have been adapted to offshore wind energy, enabling the country to establish itself as a leader in renewable energy innovation. Similarly, Qatar has utilised technological and managerial expertise from its natural gas sector to develop adjacent industries. Resource industries also benefit from adopting innovations from other sectors. For example, Saudi Arabia has incorporated AI and digital twin technologies into its oil production processes to enhance operational efficiency and sustainability, underscoring the reciprocal nature of knowledge spillovers.

Policies aimed at supporting startups through grants, tax incentives, and innovation awards can incentivise entrepreneurial activities. Saudi Arabia's Vision 2030 programme exemplifies this by fostering startup ecosystems that utilise knowledge from the oil sector to diversify into areas such as technology and clean energy (Amran et al., 2020; Saudi Arabia Vision, 2030, 2020). Building absorptive capacity is crucial for local firms and entrepre-

neurs to effectively utilise external knowledge. Investments in education, workforce development, and R&D enable resource-rich countries to enhance their capability to adopt and apply knowledge from diverse sources. Norway's emphasis on education and research has equipped its workforce to lead in sectors like renewable energy (Karlstrøm & Ryghaug, 2014; Van der Loos et al., 2021). The knowledge spillovers facilitated by resource-rich sectors can also drive sustainability. By promoting knowledge-based entrepreneurship and innovation, countries can transition from reliance on finite resources to sustainable economic models. For example, in Kazakhstan, spillovers from the oil and gas sector have supported the integration of environmental technologies, aligning traditional industries with sustainability goals (Belitski, 2017; Kaiser & Pulsipher, 2007; Kalyuzhnova & Pomfret, 2017; Webber, 2017).

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