Exploring the green tapestry of sustainable entrepreneurial ecosystems

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Objectives of the paper

The central role of entrepreneurship in fostering economic development has been widely acknowledged (Acs & Szerb, 2007; Audretsch & Belitski, 2021; Dejardin, 2011; Fritsch & Wyrwich, 2017). However, the contemporary landscape is witnessing a transformative shift, with entrepreneurship increasingly championing in promoting sustainability (Acemoglu et al., 2012). Sustainable entrepreneurs, like their counterparts, engage in identifying, creating and exploiting opportunities to produce goods and services. They distinguish themselves by prioritising the protection of the natural and communal environment while promoting development benefits for the general public (Patzelt & Shepherd, 2011). By leveraging eco-innovation and green technologies, these entrepreneurs not only achieve significantly higher revenues and growth compared to their peers (Colombelli et al., 2021), but also nurture a more diverse knowledge ecosystem. This, in turn, becomes fertile ground for the emergence of green start-ups (Colombelli & Quatraro, 2019), creating an ecosystem where ambitious entrepreneurs seize opportunities to bring new sustainable products and services to market (Hermans et al., 2015; Stam et al., 2011). In this way, they contribute, directly or indirectly, to the overall well-being of society (Stam, 2015).

The distinctive ecosystem necessary to support sustainable development tends to concentrate in specific locations, revolving around visionary pioneers of eco-innovation and green technologies. Understanding the spatial dynamics of knowledge diffusion is crucial, given that knowledge tends to be geographically concentrated (Feldman, 1994; Jaffe et al., 1993). This spatial localisation of knowledge is particularly beneficial for innovative start-ups as they draw on the wealth of knowledge that exists in their immediate ecosystems (Braunerhjelm et al., 2010). The theory of knowledge spillovers in entrepreneurship further posits that knowledge-rich environments create fertile ground for the development of entrepreneurial opportunities that new entrepreneurs can exploit (Acs et al., 2009).

In the realm of innovative start-ups, which tend to refrain from conducting extensive in-house R&D (Braunerhjelm et al., 2010), their formation tends to cluster near larger knowledge-generating entities (Acs et al., 2013; Mansfield et al., 1977; Spigel, 2022) and research institutions, including universities—a phenomenon well documented in the literature (Chepurenko et al., 2019; Fritsch & Aamoucke, 2013, 2017). Moreover, the competitive advantage of firms is closely linked to the local fabric including social, political, economic and cultural elements, often limited to specific parts of cities rather than covering entire urban areas or regions (Audretsch & Belitski, 2017). In this context, ecosystems supporting sustainability show a more local presence, resonating with certain neighbourhoods in cities rather than encompassing entire urban landscapes or regions.

To unpack the geographical and structural dimensions of successful ecosystems that support sustainability, key questions arise: Where are these thriving ecosystems located? What scale do they cover? Do they show a preference for specific urban environments? Do they specialise in related or unrelated industries? Moreover, do these ecosystems spread to neighbouring economic areas or do they remain closed and isolated units? This article seeks to answer these questions by identifying ecosystems that systematically drive sustainable development. The emphasis is not on identifying ecosystems where sporadic individual solutions that contribute to sustainability have emerged, but rather on highlighting those where ecological solutions are consistently cultivated. This ongoing process influences various aspects of the business, culminating in an overarching commitment to sustainability. Our aim is to recognise the distinguishing features of these ecosystems compared to their counterparts moving in the opposite direction.

Methods and data

Our study will be conducted within the innovation ecosystems of Poland, focusing on the analysis of patents and utility models (a patent-like intellectual property right to protect inventions) spanning the years 2005 to 2023. We will leverage the database provided by the Polish Patent Office, extracting comprehensive descriptions outlining the purpose, benefits, and drawbacks of each solution. These descriptions will undergo analysis using a pre-trained linguistic classification model designed to identify whether a given solution contributes to sustainable development. Indicators of sustainability may include reduced natural resource usage, diminished greenhouse gas emissions, resource reusability, prolonged solution lifespan, or decreased production costs contributing to enhanced societal accessibility.

This approach offers a significant advantage by not being limited by the limitations of the International Patent Classification (IPC) codes associated with sustainable activities. It is worth noting that not all innovations within these IPC codes will be classified as sustainable activities, adding robustness to our results. We will benchmark our findings against methodologies used in previous studies (by IPC codes) to strengthen the credibility of our conclusions.

Assigning geographical locations to each innovative solution will be achieved by utilizing the exact address of the applicant or assignee. This information will be sourced from the official register of Statistics Poland, providing the business entity's address. Geolocalization will be conducted using OpenStreetMap. Additionally, we will retrieve information on other entities

within the innovation ecosystem, encompassing NACE codes of primary and secondary activities, establishment dates, ownership structures, etc. Industrial designs and trademarks, recognized contributors to higher financial performance, will complement the assessment of entity performance. In addition, their nature will be analysed to determine whether they relate to pro-environmental products and services.

Our initial analysis will involve dynamic spatial panel models, wherein the number of patents and utility models filed in each ecosystem in a given year (t) will serve as the explanatory variables. We will explain these variables using data from the preceding period (t-1) and incorporate data from spatially adjacent ecosystems. Explanatory variables will encompass the number of remaining patents/utility models in period (t-1), the relatedness and complexity of emerging knowledge, ecosystem size, including the number of patenting entities, startup prevalence, average enterprise age (maturity of ecosystem), economic structure, including related and unrelated diversity levels, proximity and quality of scientific entities, and various contextual variables such as population density, residential and educational shares, green areas, and road density.

Subsequently, we will extend this analysis to evaluate the impact of patents and utility models supporting sustainability on specific ecosystem achievements, such as the number of start-ups in sustainability-supporting industries. Additionally, we will examine their influence on the number of industrial designs and trademarks related to sustainability, providing insights into the systemic support for sustainability within ecosystems.

The final phase of our analysis will involve determining the size of the ecosystems. We will adopt various area sizes and approaches for determining spatial weights, starting with 1 km² squares, and expanding to larger areas, assessing up to which point indirect effects remain visible in the models. Adjustments will be made to ecosystem and surrounding area sizes, progressing to 4 km² and potentially 9 km² if needed. This comprehensive approach aims to provide a nuanced understanding of the spatial and systemic dynamics within Polish innovation ecosystems and their impact on sustainable development.

Contribution of the paper

This paper makes a distinctive contribution to the field of innovation and sustainable development by adopting a comprehensive approach to analysing Polish innovation ecosystems from 2005 to 2023. The key contribution of this research is that the paper goes beyond traditional metrics by employing a nuanced linguistic classification model to assess the sustainability impact of patents and utility models. This methodology broadens the scope of analysis, ensuring a more comprehensive understanding of how innovative solutions contribute to sustainable development. Secondly, by geolocating the entities involved in innovation ecosystems, the paper introduces a spatial perspective to the study. This allows for a granular analysis of the geographic concentrations of sustainable innovations, providing insights into the localized nature of sustainable entrepreneurship. Thirdly, the study employs dynamic spatial panel models to investigate the relationship between patents, utility models, and ecosystem performance. This approach accounts for temporal and spatial dimensions, offering a robust framework to understand how innovation, both in terms of volume and type, influences the overall development of

ecosystems. Fourthly, in addition to patents and utility models, the research incorporates industrial designs and trademarks, providing a more comprehensive evaluation of ecosystem performance. By exploring the relationship between sustainable innovations and the emergence of start-ups, industrial designs, and trademarks, the paper unveils the systemic impact on sustainability within ecosystems. Fifthly, the investigation into the size of ecosystems, coupled with spatial weight analysis, offers a nuanced understanding of the spatial dynamics and indirect effects within these innovation ecosystems. Finally, the paper enhances its credibility by comparing results with existing methodologies, serving as a robustness check. This not only validates the findings but also contributes to the evolving discourse on sustainable entrepreneurship by offering a fresh perspective.

Results and conclusion

To be added later.

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