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Research Article

On the Dynamics of Entrepreneurial Ecosystems: A Comparative Assessment of Green and 'Traditional' Knowledge-Intensive Entrepreneurship

Anne Kathleen Lopes da Rocha[1]
Bruno Brandão Fischer[1]
Gustavo Hermínio Salati Marcondes de Moraes[1]
Adriana Marcela Bayona Alsina[1]

[1] Universidade Estadual de Campinas, Limeira, SP, Brazil

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ABSTRACT

This study aims to analyze the impact of knowledge and socioeconomic dimensions on entrepreneurial ecosystem dynamics when addressing the emergence of green and 'traditional' knowledge-intensive entrepreneurship (KIE). The methodological approach used in the study was quantitative, using structural equation modeling. Our empirical analysis comprises data from 645 municipalities in the state of São Paulo and 1,372 companies participating in the Innovative Research in Small Businesses (PIPE) program administered by the São Paulo Research Foundation (Fapesp). Of these projects, 343 represent green KIE (25% of the total), and 1,029 are traditional KIE, thus allowing a sound comparative analysis. Results confirmed the positive impact of knowledge and socioeconomic dimensions on entrepreneurial ecosystem dynamics. Moreover, findings show a homogeneous pattern in this relationship for cities that do contain green KIE and cities that do not. Hence, it does not seem necessary to promote different ecosystems configurations in order to foster sustainable transitions in entrepreneurial ecosystems. Rather, policies and initiatives targeting technological generation and diffusion in green technologies can likely represent an effective transformational strategy to achieve environment-friendly productive systems.

Keywords: green entrepreneurship; knowledge-intensive entrepreneurship; ecosystem dynamics; knowledge dimension; socioeconomic dimension

JEL Code: L26, O35

INTRODUCTION

Entrepreneurial ecosystems (EE) are crucial meta-organizations in promoting adaptive economies based on entrepreneurial innovation (Autio, Nambisan, Thomas, & Wright, 2018; Roundy, Bradshaw, & Brockman, 2018). EE is comprehensively defined as a "set of interconnected entrepreneurial actors, entrepreneurial organizations, institutions, and entrepreneurial processes which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment" (Mason & Brown, 2014, p. 5). Thus, the core contribution of EE for entrepreneurial events is associated to the dynamic and systemic interaction of actors, institutions, and processes in cities and regions (Brown & Mason, 2017; Stam, 2015).

A specific view of the processes underlying the interactions between innovation, technology institutions, and socioeconomic dynamics relates to the evolutionary approach, where innovation and knowledge exchange act as fundamental processes (Malerba & McKelvey, 2020; Stam, 2015). Knowledge-intensive entrepreneurs are involved in the creation, diffusion, and use of knowledge by introducing new technologies, products, and services, promoting change and dynamism in the economy. Thus, knowledge-intensive entrepreneurship (KIE) are small, innovation-oriented companies that manage to improve the ecosystems in which they operate (Malerba & McKelvey, 2020).

Scholars have extensively investigated the entrepreneurial ecosystem's dynamics over recent years, aiming to develop a more consistent comprehension of configurations and connections that lead to more intense entrepreneurial activity (Alves, Fischer, & Vonortas, 2021; Audretsch & Belitski, 2017). In this realm, ecosystem dynamics appear to depend on the quality of interactions, which have a strong local character, considering elements such as resource availability, market and institutional conditions, and availability of knowledge generation and dissemination (Isaksen & Trippl, 2017). Complementarily, distinct ecosystem profiles have been observed, thus outlining that these productive structures may not be effectively represented by isomorphic models (Alves et al., 2021; Vedula & Fitza, 2019; Spigel, 2017).

In addition, different sectors and areas of activity can result in high levels of heterogeneity in KIE dynamics, which reflects a need for specific assessments (Malerba & McKelvey, 2020). This has raised recent interest in sectoral specificities attached to entrepreneurial activity, such as fintechs (Spigel, 2022). A particular type of KIE that has gained prominence for its capacity to generate sustainable transitions in ecosystems is termed as 'green entrepreneurship,' i.e., new ventures oriented toward ecologically-friendly activities (Hall, Daneke, & Lenox, 2010; O'Neill & Gibbs, 2016; Shepherd & Patzelt, 2011). Green entrepreneurship is connected to the United Nations Sustainable Development Goals (SDGs) and assists in the necessary structural changes to ecosystems (Horne, Recker, Michelfelder, Jay, & Kratzer, 2020; Parrish, 2010), especially so when these firms are involved in knowledge-intensive endeavors (Horbach, 2020).

Although we have come a long way in our understanding of entrepreneurial ecosystems, we still fall short in comprehending how localized phenomena shape transitions to environmentally sustainable economic structures (Demirel, Cher Li, Rentochini, & Pawan, 2019; Theodoraki, Dana, & Caputo, 2021), especially within the scope of developing countries (Hansen & Coenen, 2015; Potluri & Phani, 2020). This becomes increasingly relevant due to the current global context, where all regions find it challenging to foster ecosystems dedicated to addressing green and sustainable practices (Organization for Economic Co-operation and Development [OECD], 2019).

In this context, the research objectives of our assessments are: (1) to analyze the impact of knowledge and socioeconomic dimensions on entrepreneurial ecosystem dynamics; and (2) to verify whether these contextual dynamics differ when addressing green and traditional KIEs. Thus, the research question is: Do typical EE components affect green KIE similarly to traditional KIE? Besides assessing the specificities of a particular cohort of KIE, the novelty of our research includes a view on ecosystem dynamics as an outcome — instead of the usual approach dealing with the number of new ventures created. In this regard, ecosystem dynamics is approached as a constructed based on intensity of technology transfer, strength of university-industry linkages, and technological activity measured through patents per capita at the city level. We believe this is a valid approach to evaluate entrepreneurial ecosystems' health and maturity, a feature that has been scantly examined by prior literature.

Our empirical analysis uses data from 645 municipalities in the state of São Paulo and 1,372 companies participating in the Innovative Research in Small Businesses (PIPE) program administered by the São Paulo Research Foundation (Fapesp). Of these projects, 343 are green KIEs (25% of the total), and 1,029 are traditional KIEs, which allowed a comparative analysis. Main findings point to a high dependence on geographic location for green KIE. This result is significant for developing economies, which find it more challenging to create distributed entrepreneurial hubs. Furthermore, results indicate that ecosystem configurations and contextual dynamics are homogeneous between cities that contain green KIE and cities that do not in developing countries, suggesting that green and traditional ecosystems follow similar patterns in terms of dynamics and configurations. Thus, it does not seem to be necessary to adopt new policy strategies to foster sustainable transitions in Brazilian EE. Rather, a stronger orientation of technological development can likely have positive effects on the generation of green new ventures. In addition, results have implications for developing public policies in emerging economies to help address the challenges in the knowledge and socioeconomic dimensions.

After this introductory section, the article is structured as follows: Section 2 explores key concepts and elements associated with entrepreneurial ecosystem dynamics, knowledge and socioeconomic dimensions, and green entrepreneurial events. Section 3 presents the conceptual model of the research, and Section 4 the methodological aspects. Section 5 presents the results. Section 6 outlines our discussions and Section 7 closes with concluding remarks.

LITERATURE REVIEW

The dynamics of the entrepreneurial ecosystems

The ecosystem perspective is cross-disciplinary since different fields have adopted it to explore financial, economic, sociodemographic, or political issues (Theodoraki et al., 2021). An entrepreneurial view "consists of all the interdependent actors and factors that enable and constrain entrepreneurship within a particular territory" (Stam & van de Ven, 2021, p. 809). Thus, there is an assortment of elements that interacts with entrepreneurship.

An entrepreneurial ecosystem model is assembled by institutional arrangements that legitimate, regulate, and incentivize entrepreneurship (such as universities, incubators, and tech parks), and public resource endowments of basic scientific knowledge, financing mechanisms, and pools of competent labor (as technology transfer, patents per capita, and university-industry interactions) (Stam & van de Ven, 2021). These are sorted to attend market demand and business activities engaging in productive entrepreneurship.

The dynamics of an ecosystem refer to how its components interact and generate outcomes that can influence and shape opportunities (Clayton, Donegan, Feldman, Forbes, Lowe, & Polly, 2019). In an entrepreneurial ecosystem, these conditions can be deemed as even more critical, because such meta-organizations encompass companies based on the intense use of knowledge and innovation, as well as technological and market disruption, which are often embedded in the economic trajectories of these cities and regions (Malerba & McKelvey, 2020; Sousa & Silva, 2019). Accordingly, companies that have a high impact on the ecosystem are essential to generate sustainable competitive advantages and make regions innovative, increasing the importance of the dynamics of this ecosystem (Han, Ruan, Wang, & Zhou, 2021).

Thus, when these ecosystem dynamics generate innovative outcomes, the institutional arrangements that legitimize, regulate, and encourage entrepreneurship are acting positively in this ecosystem. Therefore, market competitiveness, both the knowledge side — such as universities, incubators, and technology parks — and the socioeconomic side — such as financing mechanisms and pools of competent labor — manage to contribute to the dynamics of operation within these ecosystems (Stam & van de Ven, 2021).

Knowledge dimension

Among the factors and connections needed to stimulate a KIE, a key point is the availability of knowledge in the region (Qian, 2018; Baglieri, Baldi, & Tucci, 2018; Nicotra, Romano, Giusice, & Schillaci, 2018; Stam, 2009; Isaksen & Trippl, 2017). Such conditions can have a twofold impact in the health of entrepreneurial ecosystems: on one hand, they set the stage for local entrepreneurs to tap into knowledge sources and use them as platforms for new business models, and, on the other hand, they act as magnets for entrepreneurial individuals located elsewhere.

Following the knowledge spillover theory of entrepreneurship, such phenomenon is attached to the notion that knowledge cannot be fully internalized by economic agents, thus opening up opportunities for entrepreneurs to absorb and exploit these intangible assets (Acs, Braunerhjelm, Audretsch, & Carlsson, 2009). Local presence of universities represents the best example in this case, as prior literature has identified these institutions as pivotal hubs in entrepreneurial ecosystems (Malecki, 2018; Malerba & McKelvey, 2020; Spigel, 2017). This happens because higher education institutions not only increase the population's educational level, but also establish knowledge flows involving a myriad of actors from within and outside the region

(Chatterji, Glaeser, & Kerr, 2013; Glaeser, 2011; Bercovitz & Feldman, 2006). For these reasons, universities have become strategic elements in triggering market competitiveness in firms and regions (Cruz, Ferreira, & Kraus, 2021; Romero, Ferreira, & Fernandes, 2020). Such conditions have been enhanced by the legitimization of the 'entrepreneurial university' concept, facilitating integration with agents from industry, technology transfer, and the emergence of spin-offs managed by students, researchers, and faculty (Guerrero & Urbano, 2019; Moraes, Fischer, Guerrero, Rocha, & Schaeffer, 2021).

Additionally, incubators and technology parks are essential in this context, providing services and infrastructure that can spur ecosystem dynamics and entrepreneurial activity (Alves et al., 2021; Campos, Moraes, & Spatti, 2021; Rice & Habbershon, 2007; Zou & Zhao, 2014). Thus, the university, incubators, technology parks, and the educational level can translate into a skilled workforce that permeates different industries and leverages employment levels in knowledge-intensive activities (Motoyama & Danley, 2012; Florida, 2002; Audretsch & Feldman, 1996; Storper, 1995).

Following this background, it is expected that the knowledge dimension of EE will shape the entrepreneurial dynamics by affecting the aggregate levels of capabilities and knowledge-intensive connections between agents. Thus, our first hypothesis is derived:

> H1: The knowledge ecosystem positively influences the dynamics of entrepreneurial ecosystems.

Socioeconomic dimension

The socioeconomic dimension comprises a myriad of components, encompassing market dynamics and cultural aspects of the entrepreneurial ecosystem (Alves et al., 2021). Such contextual elements matter because the entrepreneurial activity is a social process that depends on the economic system's structural characteristics and social processes and mechanisms that form its foundations (Stam & Van de Ven, 2019). Hence, entrepreneurial events are not to be taken as solely individual-level activities responding to external opportunities (Radosevic & Yoruk, 2013).

First, a typical feature of KIE is related to its embeddedness in large urban areas, as these geographical units provide a high proportion of business opportunities and agglomeration economies (Auerswald & Dani 2017; Balland, Jara-Figueroa, Petralia, Steijn, Rigby, & Hidalgo, 2018; Duranton & Puga 2002; Malecki 1997). For instance, thriving cities can foster entrepreneurial engagement in denser networks, as well as access to suppliers and customers (Qian, 2018; Isenberg, 2010; Isaksen & Trippl, 2017; Storper, 1995). Such inter-firm relationships are more solid when there is a favorable socioeconomic ecosystem (Alves et al., 2021). For this, small businesses must promote competitiveness at the city level, generating a critical mass of business support services (Isaksen & Trippl 2017; Qian 2018), and large companies must prospect growth and encourage the emergence of small businesses (Brown & Mason 2017; Delgado, Porter, & Stern, 2010). In turn, these dynamics generate efficiency gaps across ecosystems located in-or-near central hubs and those that occupy peripheral positions across the territory (Crescenzi & Rodríguez-Pose, 2012; Godley, Morawetz, & Soga, 2019).

For this research, the socioeconomic ecosystem took into account four leading indicators: (1) population density, which is an indicator that provides information on the dynamics of agglomeration economies/diseconomies; (2) the availability of credit, which is fundamental for developing research and innovation associated with KIE events (Pan & Yang, 2019; Lerner, 2002); (3) per capita income levels, which provide a reasonable proxy for demand quality and productivity levels (Radosevic & Yoruk, 2013); and (4) distance to the main economic hub, as physical distance negatively affects knowledge flows, thus highlighting how the immediate context can have widespread impacts on KIE activity (Crescenzi & Rodríguez-Pose, 2012; Strumsky & Thill, 2013). These vectors offer an analogous perception of entrepreneurial ecosystems as those used in Fischer, Queiroz, and Vonortas (2018) and Alves, Fischer, and Vonortas (2021), addressing socioeconomic conditions of ecosystems located within the context of developing countries. Thus, the second research hypothesis is presented:

> H2: The socioeconomic dimension positively influences the dynamics of entrepreneurial ecosystems.

Green KIE

In recent years, eco-innovations and sustainability-oriented innovations have become topics of increasing interest in academia, organizations, and policy (Fischer, Salles-Filho, Zeitoum, & Colugnati, 2021; Klewitz & Hansen, 2014; Kuckertz & Wagner, 2010). In the field of entrepreneurship, interest has also grown in innovative businesses that deal with environmental demands, exploring business opportunities that minimize impacts on the environment (Gast, Gundolf, & Cesinger, 2017; Hockerts & Wüstenhagen, 2010; York & Venkataraman, 2010). Hence, green entrepreneurship, when using new technologies, can contribute to ecosystems' sustainable transitions (Mullins, 2017). For instance, one can highlight the contribution of green entrepreneurship in implementing green tools for smart cities in urban environments, which reduce environmental impacts (Martin, Evans, Karvonen, Paskaleva, Yang, & Linjordet, 2019; Nielsen, 2016).

However, even with the emerging interest in green entrepreneurship, knowledge of the dynamics of its components and ecosystem characteristics remains largely an uncharted topic in the literature (Demirel et al., 2019). Although the spatial dynamics of green entrepreneurship mimics the localized and place-dependent nature of 'generic' entrepreneurial ecosystems (Hansen & Coenen, 2015), some specificities ought to be considered. The main issue in this regard concerns the territorial dependence of some initiatives attached to the concept of green entrepreneurship. In this regard, many new ventures require access to biological resources that are not freely available across geographical space, a feature that can likely shape the location patterns of these firms (Philp & Winickoff, 2017).

In addition, markets for green products and services present high levels of economic uncertainty, thus generating barriers for entrepreneurs to access capital and investments (Potluri & Phani, 2020). As a consequence, dedicated policies and public initiatives are often needed to encourage entrepreneurs to act on this front (Haldar, 2019). Science and technology parks and business incubators can also facilitate this development, offering not only holding space for these firms to mature but also providing managerial capabilities and promoting network exchanges with partners (Zeng, Cheng, Shi, & Luetkenhorst, 2021; Cohen, 2006). Even though this latter argument is valid for new knowledge-intensive ventures in general, the fact that green entrepreneurship involves business activities that often lie at the margin of mainstream economic structures put emphasis on the critical role of such support institutions.

Thus, although there are similarities between the green KIE and the traditional KIE, there are significant gaps to be uncovered (Demirel et al., 2019). *Vis-à-vis* these structural conditions, we propose the following set of hypotheses:

> H3: There are differences in the relationships that compose the dynamics of entrepreneurial ecosystems when comparing cities with and cities without green KIE.
>
> H3a: The relationship between the knowledge dimension and ecosystem dynamics is heterogeneous when assessing cities with and cities without green KIE.
>
> H3b: The relationship between the socioeconomic dimension and ecosystem dynamics is heterogeneous when assessing cities with and cities without green KIE.

CONCEPTUAL RESEARCH MODEL

From the literature review and formulation of the hypotheses, a model was elaborated to meet the research purpose (Figure 1). This model aims to analyze the impact of knowledge and socioeconomic dimensions on the dynamics of entrepreneurial ecosystems, as well as verify whether heterogeneous patterns can be observed when assessing green and traditional KIE. Whetten (1989) emphasizes that the presentation of the theoretical model as a figure facilitates the understanding of the research.

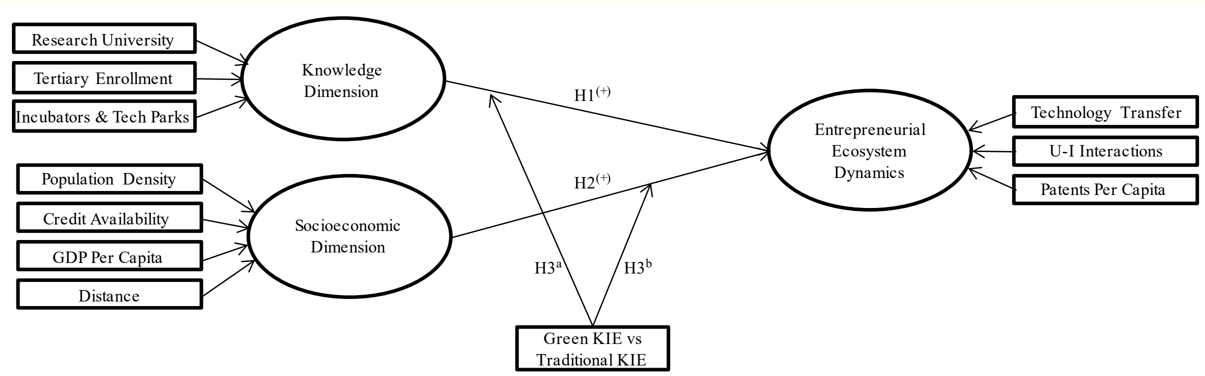

Figure 1. Conceptual model of research.

Our measure of entrepreneurial ecosystem dynamics refrains from including entrepreneurial events as an outcome measure in the model. This is due to the notion that entrepreneurial ecosystems are often treated as tautological entities (Stam, 2015), thus reducing attention on the key aspects that are in fact responsible for creating an entrepreneur-friendly environment. This is of fundamental importance in our discussion, since entrepreneurial events per se (i.e., the emergence of new ventures) are likely defined by temporal lags that can be difficult to capture (Fischer, Queiroz, & Vonortas, 2018). Hence, by including in our assessment a view on the dynamics of technology transfer, university-industry interactions, and patents per capita, we can better scrutinize the 'health' of these entrepreneurial ecosystems.

The research hypotheses were formulated according to the theoretical basis presented. Table 1 shows the consolidated research hypotheses.

Table 1

Research hypotheses

Hypotheses	Description
H1	The knowledge ecosystem positively influences the dynamics of entrepreneurial ecosystems
H2	The socioeconomic dimension positively influences the dynamics of entrepreneurial ecosystems
H3	There are differences in the relationships that compose the dynamics of entrepreneurial ecosystems when comparing cities with and cities without green KIE
H3a	The relationship between the knowledge dimension and ecosystem dynamics is heterogeneous when assessing cities with and cities without green KIE
H3b	The relationship between the socioeconomic dimension and ecosystem dynamics is heterogeneous when assessing cities with and cities without green KIE

METHODOLOGICAL APPROACH

The methodological approach used in the study was quantitative, using multivariate data analysis based on secondary sources of data. The analysis was performed using structural equation modeling (SEM), and tests were conducted with SmartPLS 3.0 software (Ringle, Wende, & Becker, 2015). The technique used was the partial least squares (PLS). The justifications for using partial least square — structural equation modeling (PLS-SEM) are: (1) the research is concerned with testing a theoretical framework from a forecasting perspective; and (2) the model presents formative constructs (Hair, Risher, Sarstedt, & Ringle, 2019; Hair, Hult, Ringle, & Sarstedt, 2022). G*Power software was used to evaluate the minimum sample size (Faul, Erdfelder, Buchner, & Lang., 2009). In terms of sample size, the required minimum calculated was 68 observations. However, the final sample used comprehended 645 observations, thus making the model suitable for estimation by PLS-SEM.

The research sample collected secondary data from all municipalities in the state of São Paulo, Brazil (645 territorial units). Although there is no consensus on the 'ideal' geographical scope to assess entrepreneurial ecosystems (Fischer, Meissner, Vonortas, & Guerrero, 2022), prior research has indicated the strong local character of ecosystems, thus warranting the adequacy of city-level assessments (e.g. Alves et al., 2021; Qian, 2018). The state of São Paulo is a compelling case of analysis to understand the dynamics of green knowledge-intensive entrepreneurship in the context of developing countries. In addition, we assessed information from companies participating in the Innovative Research in Small Businesses (PIPE) program administered by the São Paulo Research Foundation (Fapesp). PIPE Fapesp is an initiative similar to the Small Business Innovation Research Program (SBIR) in the United States to nurture the emergence of knowledge-intensive new ventures. Prior research has identified data from PIPE Fapesp as an effective proxy to address the dynamics of knowledge-intensive entrepreneurship for the Brazilian context (Alves et al., 2021; Fischer, Queiroz, & Vonartas, 2018).

The research indicators comprise secondary data and were collected from different sources: Brazilian Institute of Industrial Property, Brazilian Research Council — Directory of Research Groups, Scimago Institutional Ranking, São Paulo Statistical Foundation, São Paulo Investment Agency, and Google Maps. Table 2 presents the details of the constructs, indicators, and data sources. The analytical period covered three consecutive years for the contextual information of cities (2017-2019).

Indicators included for the ecosystem dynamics construct involve three elements of interest in this respect. First, interactions are assessed through data related to technology transfer practices and university-industry linkages. In this case, formal interactions provide more reliable items to evaluate distinct geographical units (Rondé & Hussler, 2005), although they are limited in capturing the true dimension of all connections taking place among ecosystem agents. Second, patents per capita represent the intensity of technological activity at the local-level, a feature that is expected to positively affect the outcomes of entrepreneurial ecosystems (Kuckertz, 2019; Tran & Santarelli, 2017).

Turning to the knowledge dimension, three representative variables are analyzed. Research universities stand for a core agent in the formation of EE, since they are involved with knowledge generation and deployment (Guerrero, Urbano, Fayolle, Klofsten, & Mian, 2016; Schaeffer, Guerrero, & Fischer, 2021). The inclusion criteria for this variable were based on the selection of leading universities located in the state of São Paulo. Results were confirmed by cross-checking Scimago data with information from the São Paulo Research Foundation Grants and Scholarships database. All selected institutions/cities corresponded to the group of leading cities in terms of research funding, thus warranting robustness to our selection procedures[1]. Second, tertiary enrollment complements this perspective by outlining overall educational attainment, a typical measure of human capital (Fischer, Queiroz, & Vonartas, 2018). Third, incubators and tech parks encompass innovation habitats dedicated to foster innovation-driven activity, thus offering a myriad of opportunities for knowledge-intensive entrepreneurship to emerge (Alves et al., 2021; Giner, Santa-Maria, & Fuster, 2016).

For representative indicators of the socioeconomic dimension, different (and complementary) vectors were included in our model. Population density allows addressing agglomeration economies/diseconomies. In developing economies, large urban areas have been related to negative impacts on KIE activity, a function of poor infrastructure and institutional conditions in these countries (Glaeser & Xiong, 2017). Local-level capital availability offers a proxy for financing conditions for new ventures (Alves et al., 2021). GDP per capita provides elements attached to the characteristics of demand quality and productivity levels (Radosevic & Yoruk, 2013). Last, the distance to the main economic hub (the city of São Paulo) includes a view on the core/periphery structure of entrepreneurial ecosystems, taking into account that propinquity to large metropolitan areas is expected to improve ecosystems' linkages to markets and innovation networks (Crescenzi & Rodríguez-Pose, 2012).

The research used classification information from PIPE projects to classify companies as green or traditional KIE. Traditional KIE is taken as the socioeconomic phenomenon that drives aggregate economic competitiveness and innovative capabilities by intensively using knowledge (Fischer et al., 2021; Sousa & Silva, 2019; Malerba & Mckelvey, 2020), while green KIE is understood as the initiatives that identify, evaluate, and process opportunities with a commitment to sustainability and environmental compatibility (Lotfi, Yousefi, & Jafari, 2018; Ye, Zhou, Anwar, Siddiquei, & Asmi, 2020). Project information is public and available on the Fapesp website (summary, description, location, knowledge area, keywords, direct and indirect impacts). A total of 1,372 companies were analyzed. The researchers independently ranked the projects according to their alignment with green entrepreneurship concepts based on a content analysis of the description of projects. Another researcher evaluated discrepancies. After this classification, cities that contained green KIE were identified.

Table 2

Analytical variables

Indicator	Description	Source
Entrepreneurial ecosystem dynamics		
ED1. Technology transfer	The average number of technology licensing agreements per capita registered at the Brazilian Institute of Industrial Property in the city in the analytical period	Brazilian Institute of Industrial Property
ED2. U-I Interactions	Sum of reported university-industry interactions in the city in the analytical period according to the Census from the Directory of Research Groups (CNPq)	Brazilian Research Council — Directory of Research Groups
ED3. Patents per capita	The average number of patent deposits per capita registered at the Brazilian Institute of Industrial Property in the city in the analytical period	Brazilian Institute of Industrial Property
Knowledge dimension (KD)		
KD1. Research university	Presence of at least one leading research university campus in the city in the analytical period; binary variable	Scimago Institutional Ranking
KD2. Tertiary enrollment	The average share of the city population enrolled in higher education institutions in the analytical period	São Paulo Statistical Foundation
KD3. Incubators & Tech parks	Presence of at least one incubator or tech park in the city in the analytical period; binary variable	São Paulo Investment Agency
Socioeconomic dimension (SD)		
SD1. Population density	The average rate of inhabitants per square kilometer in the city in the analytical period	São Paulo Statistical Foundation
SD2. Credit availability	Average values of credit operations per capita in the city in the analytical period; values in 2019 Brazilian reais	São Paulo Statistical Foundation
SD3. GDP per capita	Average GDP per capita in the city in the analytical period; values in 2019 Brazilian reais	São Paulo Statistical Foundation
SD4. Distance to the main economic hub	The road distance from each municipality to the main economic hub, the city of São Paulo	Google Maps
City classification		
Traditional KIE	Cities that did not contain any green KIE	The São Paulo Research Foundation — Fapesp
Green KIE	Cities that contained at least one green KIE	The São Paulo Research Foundation — Fapesp

Note. The analytical period covers three consecutive years (2017-2019).

EMPIRICAL RESULTS

In the research model, the directions of the variables are from the indicator to the construct, as a correlation between the indicators of each construct is not expected. Considering the guidelines of Hair, Hult, Ringle, and Sarstedt (2022), the three constructs are classified as formative.

Since the research model has three formative constructs (knowledge dimension, socioeconomic dimension, and ecosystem dynamics), the criteria used to assess the constructs were: convergent validity, multicollinearity, and significance and relevance (Hair et al., 2019; 2022). Redundancy analysis correlates the variables with a global measure to evaluate the convergent validity. The criterion used by Hair et al. (2019; 2022) is that the path coefficient value is more significant than 0.80 for convergent validity. For the three constructs presented, the values were above 0.85, supporting convergent validity. To test the collinearity of the indicators, the variance inflation factor (VIF) values for the variables of the formative construct should be less than five (Hair et al., 2019; 2022), and all values were within the established value.

The bootstrapping technique was used to analyze significance and relevance. All variables were significant according to the t statistics of external weights and external loads. Therefore, we have kept all variables in the analysis (Hair et al., 2019). Furthermore, before evaluating the structural model, the collinearity was analyzed for each subpart of the model, and all results were below five (Hair et al., 2019; 2022). The significance of the relationships was analyzed with the bootstrapping technique (Efron & Tibshirani, 1998). The results (Table 3) supported hypotheses 1 and 2, presenting Student' t values above 1.96 (significance level = 5%).

Table 3

Analysis of the significance of relationships

Relationship	Sample mean	Standard deviation	t-statistic	p-values
Knowledge Dimension -> Entrepreneurial Ecosystem Dynamics	0.289	0.125	2.684	0.008
Socioeconomic Dimension -> Entrepreneurial Ecosystem Dynamics	0.436	0.117	3.141	0.002

The coefficient of determination (R^2) was analyzed according to the studies by Cohen (1988) and Faul, Erdfelder, Buchner, and Lang (2009). They determine that values of f^2 equal to 0.02, 0.15, and 0.35 are considered, respectively, as a small, medium, and large effects. For these f^2 values, one can consider R^2 values equal to 2%, 13%, and 25%, respectively. The results indicated that the dynamic ecosystem presented $R^2 = 0.310$, which can be considered high.

The multigroup analysis was used to test our hypothesis related to the differences in the relationships between cities that contained green KIE and cities that did not (Hair, Sarstedt, Ringle, & Gudergan, 2018). We remind the reader that this classification was made through content analysis of the description of all PIPE projects and was cross-validated independently by the authors. Table 4 presents the results from the multigroup analysis.

Table 4

Multigroup analysis

Relationship	Path coefficients difference (Green vs. Traditional)	p-values
Knowledge Dimension -> Entrepreneurial Ecosystem Dynamics	0.675	0.105
Socioeconomic Dimension -> Entrepreneurial Ecosystem Dynamics	-0.300	0.228

According to the results (Table 4), there is no significant difference in the relationships, thus not confirming hypothesis 3 (H3, H3a, and H3b). Table 5 presents the results of the hypotheses tests.

Table 5

Hypothesis test results

Hypotheses	Description	Result
H1	The knowledge ecosystem positively influences the ecosystem dynamics in academic facilities and supporting infrastructure	Confirmed
H2	The socioeconomic ecosystem positively influences the ecosystem dynamics in terms of the availability of human and financial resources	Confirmed
H3	There are differences in the relationships between cities with and cities without green KIE	Not confirmed
H3a	The relationship between knowledge dimension and ecosystem dynamics is heterogeneous when assessing cities with and cities without green KIE	Not confirmed
H3b	The relationship between socioeconomic dimension and ecosystem dynamics is heterogeneous when assessing cities with and cities without green KIE	Not confirmed

The model resulting from the research is shown in Figure 2.

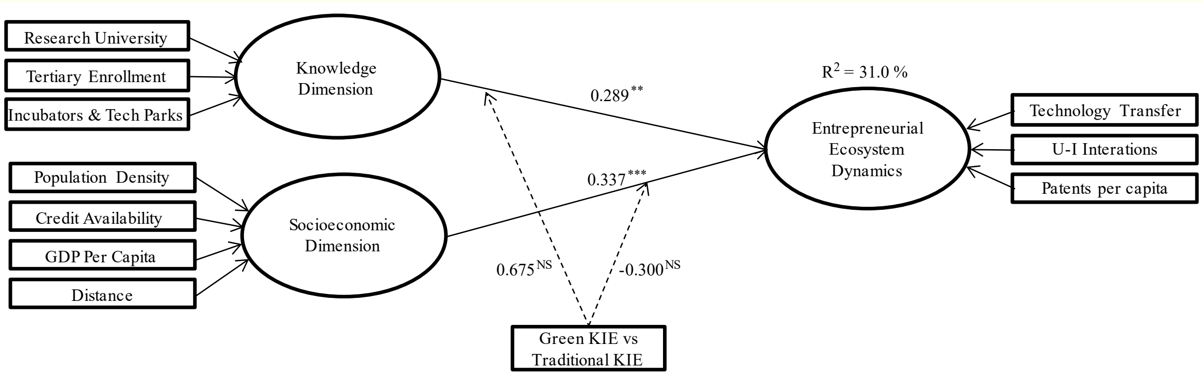

Figure 2. Resulting research model.

Note. *** = significant at 0.1%; ** = significant at 0.5%; * = significant at 1%; NS = not significant.

DISCUSSION

In this research, we approach the case of a developing country with a broad set of secondary data that allow a more consistent view of the configurations and dynamics of knowledge-intensive green entrepreneurship, with statistical associations from a multiscale perspective. Such empirical perspective allows not only investigating the specificities of the 'green' cohort within the KIE phenomenon (a call recently made by Wurth, Stam, & Spigel, 2021) but also offers a perspective on entrepreneurial ecosystem dynamics, i.e., a complement to the most usual take on rates of new firm formation. In this regard, our appraisal provides insights into the underlying mechanisms of ecosystems' processes and the alignment between traditional models and the reality of green entrepreneurship.

The complete empirical model (Figure 2) allows us to confirm that a knowledge ecosystem positively affects ecosystem dynamics in KIE, which is coherent with the literature (Abualbasal & Badran, 2019; Isaksen & Trippl, 2017; Malerba & McKelvey, 2020; Morris, Shirokova, & Tsukanova, 2017; Spigel, 2017; Stam, 2009). In addition, it is confirmed that the socioeconomic dimension impacts the ecosystem dynamics, where the geographic and regional characteristics impact KIE, allowing a local intensification of initiatives as well as considering local and economic issues, as is the case of São Paulo (Fischer, Schaeffer, & Silveira, 2018; Sousa & Silva, 2019). This result also has theoretical and empirical support from previous assessments (Crescenzi & Rodríguez-Pose, 2012; Radosevic & Yoruk, 2013; Strumsky & Thill, 2013).

Ecosystem dynamics scored an R^2 value of 31.0%, which is considered high for social sciences (Cohen, 1988; Faul et al., 2009), indicating that the model captures a sizeable portion of the variance. The impact of the socioeconomic ecosystem on ecosystem dynamics is slightly more significant than the impact of the knowledge ecosystem, but both effects are positive.

It was not possible to confirm the knowledge-intensive ecosystems hypothesis regarding heterogeneity in relationships considering cities with and cities without green KIE (H3). This finding carries relevant implications, as the literature points out similarities between the green and traditional KIE, but reinforces that research on this front is still insufficient (Demirel et al., 2019).

Based on the results, we can draw two main conclusions. First, we demonstrate that KIE is highly dependent on geographic location, with much more expressive results in developed regions. These regions have more abundant resources, better market and institutional conditions, and a high concentration of knowledge sources (Isaksen & Trippl, 2017). This result is significant for developing economies, which have more difficulty developing entrepreneurial hubs. This geographic dependence has implications for developing public policies in peripheral regions, particularly within the context of developing economies (Potluri & Phani, 2020). In this case, it seems challenging to promote spatial diffusion of thriving entrepreneurial ecosystems, a situation that places significant stress in overpopulated areas. Such conditions highlight the different stages of maturity of local economies when it comes to effectively promoting entrepreneurial activity of any kind. Such argument follows contributions from prior literature that identifies entrepreneurial ecosystems as highly heterogeneous phenomena, thus requiring policies aligned with local needs (Fischer et al., 2022; Brown & Mason, 2017). In turn, this means that dedicated policies should take local specificities into account when trying to foster stronger entrepreneurial dynamics — instead of simply emulating initiatives and configurations observed in thriving places (Alves et al., 2021).

Second, ecosystem configurations and contextual dynamics are homogeneous between cities with and cities without green KIE in developing countries. Significant differences between these types of entrepreneurial activity could not be observed, a situation that indicates that green and traditional ecosystems follow similar configurational trajectories. This result implies that to achieve a transition to a more sustainable local economy, entrepreneurial projects with a green perspective do not require structural disruptions with ordinary pillars of entrepreneurial ecosystems. In this case, implications comprehend involving key actors from the knowledge dimension (universities, incubators, and tech parks) in the promotion of knowledge flows and business harnessing that can effectively promote a stronger entrepreneurial activity directed toward green initiatives. Drawing from recent contributions by Mazzucato and colleagues (Kattel & Mazzucato, 2018; Mazzucato, 2018; Mazzucato, 2016; Mazzucato & Perez, 2015), these shifts toward a sustainable transition can be triggered by mission-oriented policies that induce private agents' involvement with particular sets of technologies that can simultaneously spur economic development and mitigation of environmental hazards. Concrete examples of how to tackle these issues involve the promotion of research programs aiming at transferring green technologies from academia to markets. In addition, initiatives that favor ventures with green orientation as tenants in incubators and tech parks can accelerate the speed of an environmental transition in entrepreneurial ecosystems.

CONCLUDING REMARKS

The growing awareness of companies about the impacts of agents on nature has increased interest in the topic of environmentally sustainable entrepreneurship (Labella-Fernández, 2021). Green entrepreneurship is aligned with the United Nations Sustainable Development Goals (SDGs), and these businesses can fill essential gaps in the sustainable development of countries, promoting necessary and desirable structural changes (Horne et al., 2020; Parrish, 2010).

Yet, green entrepreneurship requires systemic support to convert ideas into innovation and natural economic competitiveness (Lazarevic, Kautto, & Antikainen, 2020). Hence, an in-depth understanding of how ecosystem factors combine efforts to promote KIE is strategic for ecosystems to achieve sustainable transitions (O'Neill & Gibbs, 2016). Such aspects and specificities can provide policymakers and companies with relevant insights on how to promote such shifts in regional productive structures. Our main findings underscore the pivotal importance of both knowledge and socioeconomic dimensions on fostering the dynamics of entrepreneurial ecosystems. Our expectations that different patterns would be observed for the reality of green entrepreneurship respective to traditional KIE were not met, suggesting that achieving a sustainable transition in terms of entrepreneurial activity does not require structural shifts in configurational terms.

Our results do not go without limitations. First, we used only two latent variables of the entrepreneurial ecosystem, which offer a limited perspective of the complex interactions between agents. Second, only companies participating in the PIPE program were analyzed, a situation that potentially causes sample bias. Third, our evaluation has a cross-section nature, not allowing to capture how these constructs are related from an evolutionary perspective (Alvedalen & Boschma, 2017). In this context, some suggestions for future research are presented: (1) carry out similar research among other contexts and regions; (2) use complementary methodologies, both quantitative and qualitative, which can deepen the results; and (3) design longitudinal assessments that allow incorporating how the features and dynamics of entrepreneurial ecosystems change over time.

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NOTE

[1] Because of these selection procedures, the research universities variable is not multicollinear respective to U-I interactions (which can take place in academic institutions that are not classified as leaders). In addition, from a theoretical perspective, the local presence of research universities can be taken as a pillar of entrepreneurial ecosystems, but their commitment to establishing interactions with agents from industry comprehends a typical element of the knowledge flows and dynamics that can (or cannot) take place within a given city or region.

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Authors' contributions

1st author: conceptualization (equal), data curation (lead), formal analysis (equal), investigation (lead), project administration (supporting),resources (lead), writing – original draft (lead), writing – review & editing (supporting).

2nd author: conceptualization (equal), data curation (supporting), formal analysis (equal), investigation (equal), project administration (lead), resources (equal), supervision (equal), writing – review & editing (lead).

3rd author: formal analysis (equal), investigation (equal), methodology (lead), project administration (equal), resources (equal), software (lead), writing – original draft (equal), writing – review & editing (equal).

4th author: conceptualization (supporting), data curation (equal), investigation (equal), resources (equal).

Authors

Anne Kathleen Lopes da Rocha *
Universidade Estatual de Campinas
Rua Pedro Zaccaria, n. 1300, 13484-350, Limeira, SP, Brazil
anne.rocha@hotmail.com.br
https://orcid.org/0000-0003-2978-3937

Bruno Brandão Fischer
Universidade Estadual de Campinas
Rua Pedro Zaccaria, n. 1300, 13484-350, Limeira, SP, Brazil
bfischer@unicamp.br
https://orcid.org/0000-0003-3878-9097

Gustavo Hermínio Salati Marcondes de Moraes
Universidade Estadual de Campinas
Rua Pedro Zaccaria, n. 1300, 13484-350, Limeira, SP, Brazil
salati@unicamp.br
https://orcid.org/0000-0001-5238-0314

Adriana Marcela Bayona Alsina
Universidade Estadual de Campinas
Rua Pedro Zaccaria, n. 1300, 13484-350, Limeira, SP, Brazil
a263983@dac.unicamp.br
https://orcid.org/0000-0002-0735-5336

* Corresponding author