Received: 22 July 2020 | Revised: 29 October 2021 | Accepted: 10 December 2021

DOI: 10.1111/grow.12618

ORIGINAL ARTICLE

growth and change WILEY

The city of start-ups: Location determinants of start-ups in emergent industries in Barcelona

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Funding information
Departament d'Innovació, Universitats i Empresa, Generalitat de Catalunya, Grant/Award Number: 2017-SGR-159, 2017-SGR-00493 and 2019PFR-URV-B2-80; Ministerio de Economía y Competitividad, Grant/Award Number: ECO2015-68061-R and ECO2017-88888-P

Abstract

In recent years, scholars have highlighted the role of cities as incubators for start-ups. Several studies identify the city of Barcelona as one of the major hubs in Europe for start-up creation, especially in emergent industries. The present paper examines how local attributes, proximity to the elements of an entrepreneurial ecosystem (EE), and to nearby economic activity, influence the location of ambitious start-ups in Barcelona between 2012 and 2015. To do this, we use micro-geographic data of Barcelona start-ups provided by the Catalan Government (ACCIÓ) and open data on the socioeconomic composition of Barcelona neighbourhoods from the Statistics Department of the Council of Barcelona. By dealing with neighbouring effects and endogeneity, our results suggest that localisation economies and proximity to the elements of the EE are the key factors attracting start-ups to Barcelona's neighbourhoods. These results are crucial in helping policymakers understand the locational factors of start-ups within the city.

1 | INTRODUCTION

Several authors suggest that cities promote technology, innovation, and the growth of disruptive technologies (Bosma & Sternberg, 2014; Balland et al., 2020). In recent years, cities have become start-up incubators and high-risk investment has moved from the peripheries to the inner city (Florida & Mellander, 2016). This is a common trend, observed not only in the United States, but in many large cities around the world (Florida, 2013; Florida & Mellander, 2016).[1]

Among these, Barcelona ranks highly internationally, just behind European cities such as London, Paris, Berlin, and Amsterdam. Barcelona is a European paradigm for the creation of technological firms (Arauzo-Carod, Coll-Martínez, Méndez-Ortega, 2018; CITIE, 2015; Start-up Genome, 2017) and ICT innovations (De Prato et al., 2015). Its increasing popularity as start-up hub is at least partially due to efforts made by the Catalan Government over the last years to develop a rich and diverse ecosystem. A measure of their success is that in 2012, it was named the World Mobile Capital; in 2014, the European Capital of Innovation; and one year later, in 2015, it came first in the Worldwide Smart City ranking. Most recently, in 2018, Barcelona was named the third most attractive city for founders (CITIE, 2015; Mobile World Capital Barcelona, 2018; Start-up Genome, 2017). Over these years, around 1,000 technological start-ups, which obtained 871 million euros in investments, have located in Barcelona among these, there have been sixty exits (i.e., acquisitions and IPOs).[2]

Understanding the location of start-ups has emerged as a key issue since knowledge production is spatially bounded (Baptista & Mendonça, 2010; Calcagnini et al., 2016; Florida & King, 2018; Moeller, 2014). Cities are the place where breakthrough innovation can flourish and contribute to the wellbeing of their citizens. Exploring how large urban areas boost innovation ecosystems offers valuable insights for building resilient and sustainable spaces. This seems especially true for Barcelona, since its government aims to put a global start-up ecosystem in place to attract more business, talent, and investment as part of the competition between the world's most dynamic and entrepreneurial regions.

This paper contributes to the literature on the geography of entrepreneurship by examining how the local attributes and proximity to the elements of an entrepreneurial ecosystem (EE) and to nearby economic activity influence the location of ambitious start-ups in Barcelona. We focus on a certain group of start-ups: scalable, ambitious, innovative-based start-ups in emergent industries. We group start-ups into six broad groups: Creative, Ecological, Experiences, Mobility, Health, and Industry 4.0, by applying a multivariate statistical method. The focus on the emergent industries is interesting as new technologies are creating new market opportunities for start-ups and transforming the more traditional sectors. Thus, start-ups operating in different emergent industries present intrinsic characteristics that should feature in the analysis. This is important in determining the local characteristics that influence the location of certain types of start-ups within the city.

When analysing the location decision of start-ups, we can adopt either the point of view of the entrepreneur, or that of the chosen territory (Arauzo-Carod et al., 2010; Devereux et al., 2007). In this paper, rather than examining location decisions from the viewpoint of the agent making the choice, we approach the issue from the viewpoint of the chosen territories (the neighbourhoods of Barcelona). Hence, examining the location of start-ups within the city, it is crucial for policymakers to understand the locational factors and develop necessary measures to deal with an increased attraction to focal points on the city or, conversely, to redistribute them across all the neighbourhoods of the city. At the same time, it is important for both entrepreneurs and investors to identify at an early stage of their project what is the best location for conducting their activities.

This paper builds primarily on research on agglomeration economies and EE. The term EE has emerged in recent years to describe a framework for understanding the environment in which entrepreneurs operate and the effects of entrepreneurship on the economy (Acs et al., 2017; Alvedalen & Boschma, 2017; Stam & Spigel, 2017; Stam & van de Ven, 2021). EE consist of a set of interdependent actors, and factors coordinated for enabling productive entrepreneurship, in a geographical area (Stam & Spigel, 2017; Stam & van de Ven, 2021). Despite considerable research

interest in high tech start-ups (see e.g., Arauzo-Carod, 2021; Bessagnet et al., 2021; Colombo & Piva, 2008; Ghio et al., 2017; Vohora et al., 2004), most scholars have worked to identify EE elements at the national or regional level (Harmaakorpi & Rinkinen, 2020). Empirical evidence testing the impact of EE on the location of start-ups within a city is, however, scarce (Andersson & Hellerstedt, 2009; Audretsch et al., 2010; Bosma & Sternberg, 2014) and, in any case, mostly focused on the US case (Florida & Mellander, 2016; Lee et al., 2004). Analysis on the contribution of EE adapted to the context of European cities are especially necessary (Fritsch & Wyrwich, 2020a, 2020b; Lange & Schmidt, 2020; Stam & van de Ven, 2021).

Many of the contributions on agglomeration economies and entrepreneurship address the location determinants of start-ups at national or regional level, and consider cities as homogeneous areas, while our work focuses on the influence of neighbourhood features within a city. The access to micro-geographic data and the geolocalisation of start-ups allows us to account for the heterogeneous distribution of amenities and elements of the entrepreneurial ecosystem across city neighbourhoods. If start-ups are mainly attracted to well-located city neighbourhoods where 'things happen' (i.e., buzz, social and networking events), they may wish to co-locate in specific locations, and thus a rapid decay of agglomeration economies away from these focal points would be expected. Indeed, Barcelona clearly does not present a homogenous spatial distribution in terms of innovative and creative activities as recent contributions have shown (Arauzo-Carod et al., 2017; Coll-Martínez, 2019; Coll-Martínez et al., 2019).

This paper employs geographically refined data from the Catalan government (ACCIÓ), and open data on Barcelona neighbourhoods' socioeconomic composition provided by the Statistics Department of the Council of Barcelona together with geographic information systems (GIS) software to study the spatial pattern of ambitious start-ups in Barcelona in different emergent industries. The key methodologic contribution in regard to previous studies involves the estimation of the count of incumbent firms and the amount of an EE elements (individually and when defined as an EE index) as well as a set of local attributes that describe neighbourhood environments.

Agglomeration measures, and proximity to urban attributes are computed using GIS techniques. For each creative firm and year, we define distance bands around the centroids of the neighbourhood of the reference start-up (from 0 to 5 km). A series of firm ring variables then counts the number of neighbouring firms or elements of the EE within each band. With this fine level of geographic detail, we can accurately account for agglomeration economies as they are thought to decay with distance rather than being bounded by political borders (Arzaghi & Henderson, 2008; Rosenthal & Strange, 2005). This is a critical point according to recent contributions which find that the spatial extent of agglomeration economies for creative and knowledge intensive firms ranges between 0 and 1 km (Arauzo-Carod et al., 2017; Coll-Martínez, 2019; Coll-Martínez et al., 2019).

Our results suggest that there is an extensive variation within Barcelona in the types of start-ups and elements of the EE. First, our analysis of the sources of entrepreneurship suggests that the number of local activities in a start-up's own industry (localisation economies) can affect its location decision. For certain industries, the effect is non-significant which confirms the differing locational specificities of the six emerging industries considered in our analysis. Third, we show that these localisation economies diminish with distance. Typically, the environment effect beyond one kilometre is an order of magnitude smaller than that of the more immediate environment. An ambitious start-up's location is significantly associated with proximity to the primary elements of a start-up eco-system (e.g., coders, access to financing, talent, coworking spaces). Their influence is always positive even having controlled

for reverse causality. All these results confirm the importance of spatial proximity in terms of networking or information spillover effects during the initial stages of firms, which are supposed to be the most active in terms of innovation, such is the case of ambitious start-ups as previous works suggested (see, for instance, Markusen, 1985, Gallaud & Torre, 2004 or Torre, 2008) and that these results depend on the type of emergent industry in which the start-up operates.

The remainder of the paper is as follows. The next section presents a literature review of the emergence of start-ups and entrepreneurial ecosystems at the urban level. Section 3 describes the research context, the data, and methods. Section 4 describes the main results, while Section 5 discusses the findings and presents our concludes.

2 | START-UPS, ENTREPRENEURIAL ECOSYSTEMS, AND CITIES

The Entrepreneurship Model (Freeman & Engel, 2007) applies to start-ups. They are young (less than 10 years' experience in the market), constantly develop innovation through agile methods and introduce disruptive innovation into the marketplace. Because of their characteristics—youth, riskiness, lower economies of scale and lower networking (liability of newness)—they are, in certain ways, at a disadvantage as compared to incumbent firms in the same sector (see Coad et al., 2013, 2016).

High-tech start-ups naturally make higher investments in R&D and innovation that allow them to increase their knowledge and their innovative capacities (Buddelmeyer et al., 2010; Cefis & Marsili, 2005; Deeds, 2001). In addition, skilled workers and founders are a key resource since they have tacit knowledge for developing projects and commercializing products (Colombo & Grilli, 2010; Hitt et al., 2001; Koch et al., 2013; Rauch et al., 2005). Authors such as Autor et al. (1998), Hitt et al. (2001) and Subramaniam and Youndt (2005) highlight that qualified workers and founders facilitate the absorption and application of new knowledge, the exploitation of technologies and respond more quickly to market and technological changes (Cooper et al., 1994; Gimmon & Levie, 2010). Finally, a key success factor is their access to financial resources (Cassar, 2004; Martin & Justis, 1993). The availability of financial resources is critical because it will affect future decisions regarding the cost and the flexibility of projects (García-Quevedo et al., 2018). The main argument is that ambitious start-ups develop innovative projects. The proximity between investors and start-ups is necessary to monitor the business and diminish agency problems. This is particularly important for venture capital investors and business angels since the evidence shows that they prefer the location in dense areas. Recent contribution from Florida and Mellander (2016) and Florida and King (2018) confirm evidence in this line. Similarly, Pan and Yang's (2019) show that the agglomeration of start-ups in financial centres and neighbouring regions suggest the existence of strong positive externalities of metropolitan cities where the key financial, political, and technology resources are located.

To maximize their technological and economic viability, a balanced resource availability is necessary (see, for instance, studies such as Dierickx & Cool, 1989; Dutta et al., 1999; Belso-Martinez et al., 2013). Colombo and Grilli (2007), Colombo et al. (2010), Bertoni et al. (2013) and Yang et al. (2017) confirm the positive impact of complementary resources on a start-up's survival likelihood; access to these resources is key to their emergence and survival. However, depending on the main economic activity of a start-up, its proximity to external factors (i.e., specialized knowledge, financial resources or even talent) may be even more critical. Such factors are

heterogeneously distributed in large metropolitan areas so, depending on the importance of each factor to its economic activity, a start-up may choose to locate in a particular neighbourhood.

Factors such as proximity, density, and diversity of employees and firms contribute to generating an ecosystem that promotes the emergence of start-ups (Athey et al., 2008; Florida, 2005; Glaeser, 2011; Jacobs, 1969). Indeed, Jacobs (1961) had already highlighted the role of cities as drivers of creativity and innovation facilitating the appearance of new firms and economic growth. Studies have found that entrepreneurs want to live and work in dynamic places where it is easier to interact with human resources including young and skilled employees, other entrepreneurs, and investors (Florida, 2013). Hence, cities facilitate proximity, the networking and interchange of ideas and knowledge since there is frequent social interaction (Athey et al., 2008). Finally, numerous studies highlight the importance of quality of life as a factor in start-up location (CITIE, 2015; Florida, 2005; Florida & Mellander, 2016). Proximity to cultural institutions such as theatres, museums, cinemas, parks, and sport centres may encourage a start-up to locate in a city. This, in turn, facilitates idea creation and knowledge diffusion which attracts entrepreneurs (Florida, 2013).

Although the agglomeration of economic activities in large cities makes them attractive in general, the intra-urban distribution of start-ups is non-uniform for various reasons. On the one hand, since there is a heterogeneous distribution of the elements of the EE and amenities across neighbourhoods within the city, start-ups may agglomerate in the neighbourhoods most conducive to their enterprise (Currid & Williams, 2009). On the other hand, the increasing attraction to these attractive neighbourhoods leads to increasing rents, higher prices for other services, and a lower availability of adequate working space (as Pallares-Barbera et al., 2012 and Paül-i-Agustí, 2014 have found for Barcelona). This may drive the location decisions of some start-ups, who may prefer to locate in less dense, but still well-connected, areas where activity costs are more affordable. Proximity to universities or science and technological parks in the urban periphery may also influence their location decision because of spillovers and diffusion of knowledge arising from these institutions (Andersson & Hellerstedt, 2009). However, recent evidence shows that venture capital investment and start-up activity is moving from the peripheries to the inner city (Florida & Mellander, 2016). Whenever the benefits offset the costs, it seems that start-ups will take on the agglomeration costs (higher rental prices and congestion).

The distribution of start-ups depends on local characteristics (De Prato et al., 2015). Most studies either adopt a regional dimension to analyse the location phenomenon (Ghio et al., 2017) or, because of limited access to data, just focus on large metropolitan areas (Florida & Mellander, 2016; Gries & Naudé, 2010). However, the influence of local variables is crucial in generating an ecosystem which fosters a start-up environment (Andersson & Koster, 2010).

A range of factors (internal and external) have been proposed to explain the location of start-ups (see for instance, Stam, 2015). First, agglomeration economies (Marshall, 1920) respond to the existence of specialized labour markets; proximity to agents such as suppliers, incumbents, and suppliers. Freeman and Engel (2007) point out that agglomeration economies facilitate the transmission of information to counterbalance the uncertainty of innovations, the mobility of resources such as knowledge, financial resources and employees, and the transmission of new technologies and business models. Propensity to locate in such areas is higher in sectors where new knowledge plays a key role, because such knowledge is less likely to be codified and is difficult to transmit over long distances (Audretsch & Stephan, 1996; Baptista & Swann, 1999; Pan & Yang, 2019). So, one might expect start-ups to have a greater propensity to locate in highly dense areas where they can directly benefit from agglomeration economies. And this should be more evident for start-ups in emergent industries, as agglomeration economies are thought to be

essential during the initial stages when they are supposed to be the most active in terms of innovation (Markusen, 1985, Gallaud & Torre, 2004 or Torre, 2008).

Second, an ambitious start-up, understood as project that is led by an ambitious entrepreneur who engages in the entrepreneurial process with the aim to create as much value as possible in growth and innovative terms (Hermans et al., 2015; Stam et al., 2012), is quite different from traditional firm, the previously highlighted characteristics result in it having specific ecosystem requirements. Environments which favour networking may attract more start-ups. For Swedish start-ups, Westlund and Bolton (2003) and Westlund et al. (2014) confirm that social capital positively influences the appearance of start-ups at the regional and local level. Strong ties also increase the likelihood that network partners will share exclusive knowledge (Johnson & Sohi, 2001) and promote the transfer of tacit knowledge (Lane & Lubatkin, 1998). However, high levels of networking frequency introduce higher costs at the transaction interface (O'Donnell et al., 2001; Zhao & Aram, 1995) and may lead to unproductive redundancies in the partnership. Proximity to investors, business angels and financial agencies is crucial during the initial phases and for future development (Mason, 2010). For instance, Harrison et al. (2003) find that investments in technology-based ventures, those involving co-investors and those located in the economic core regions of the United Kingdom are more likely to be proximate to investments. Therefore, the assumption of space neutrality of business angels would not be satisfied under this evidence despite all the organization transformations (Mason et al., 2016, 2019).

In addition, the existence of science and technological parks may give start-ups access to facilities and services which are key to developing their innovations. Technological clusters are characterized by linkages between entrepreneurs, investors, and university research output. Science and technological parks are key sources promoting entrepreneurship and firm innovation and performance (Arauzo-Carod, Segarra-Blasco, Teruel-Carrizosa, 2018; Florida & Mellander, 2016).

Third, in terms of local assets, the presence of a good public transport network is essential for market access (Mariotti et al., 2017). Several case studies suggest that a public transport network facilitates business connections, networks, and knowledge transfer (Athey et al., 2008); however, the contribution of an affordable and fluid transportation network seems to be small compared to that of networking assets (Mulas et al., 2016). Nevertheless, the relativities of these contributions may depend on the inner characteristics of the specific city. For instance, in large European cities the provision of public transport networks is one of the main factors explaining the success of innovative hubs. The integration between different modes of transportation reduces frictional delays and speeds up movement around the city. Moreover, busy entrepreneurs would appreciate a good cycling infrastructure and public bike schemes to move quickly around the city (CITIE, 2015).

Fourth, socioeconomic factors are important in explaining the intra-urban start-up distribution. Local demand can encourage the creation of technological firms in districts where there is a higher income per capita and a higher demand for technological products. In contrast, labour markets exert an ambiguous influence. A high unemployment rate in an area may push the population to create new firms (Parwada, 2008; Wagner & Sternberg, 2004) but, at the same time, high unemployment rates may reduce the attractiveness of the area (Egeln et al., 2004). Other factors more closely related to demography may also influence the concentration of start-ups. Given their major interest in new technologies, areas with a higher share of young and more educated population show a higher propensity to create start-ups (Eliasson & Westlund, 2013; Parwada, 2008). Finally, more culturally diverse environments may drive the creation of new firms—a higher share of immigrants can enrich the local population with innovative ideas. Audretsch et al. (2010) show that cultural diversity positively affects the creation of

technologically oriented start-ups in Germany. Furthermore, formal factors may also play a key role on the quality of EE and the consequent survival of start-ups (Stam & van de Ven, 2021). In this regard, scholars usually make use of data on the quality of governance to capture the quality and efficiency of EE.[3]

The interdependency and interaction of the previously mentioned factors underpin the location of start-ups in large metropolitan areas. This idea comes from organizational ecologists according to which we can identify a community when the population in a territory develops an identifiable cohesion that derives from mutualistic interdependence among symbiotically related actors with complementary differences. This is why the understanding of the factors that enable entrepreneurial process requires the consideration of the interdependent actors and organisations from a complex system framework as argued by Stam and van den Ven (2021).

Another critical issue in the EE literature that lacks empirical evidence is the existence of a potential downward causation when it comes to analyse the impact of EE on the creation of start-ups. In other words, the presence of productive, and successful start-ups may affect the dynamics of the EE. That is, successful entrepreneurs becoming venture capitalists, leaders or network developers in the same EE that helped them to growth (Bosma et al., 2012; Garnsey & Heffernan, 2005; Habersetzer, 2017; Mason & Harrison, 2006).

The relative importance of the aforementioned factors may explain the phenomenon of clustering by industry or technology (Florida & King, 2018). To analyse this, we investigate start-up location for six emergent industries: Creative, Ecological, Experiences, Mobility, Health, and Industry 4.0. Creative industries which include activities such marketing, videogames, fashion or design are more likely to be concentrated in specific highly urbanized districts (Coll-Martínez, 2019; Coll-Martínez et al., 2019; Currid & Williams, 2009). Similarly, industries related to experiences (e.g., sports, travel services) may also be more concentrated in areas where there are agglomeration economies or technological parks. Hence, the influence of agglomeration economies may be higher for both industries. On the other hand, Industry 4.0 which is, inter alia, related to Big Data, Cloud Computing, the Internet of Things, and mobile software, may show a more uniform intra-urban location pattern. Start-ups operating in health sectors (biotech, pharma MedTech, and others) are more likely to be located around universities and laboratories with capabilities in related scientific and technological fields (see for instance, Audretsch and Stephan, 1996; Kenney, 1988, 2000; Owen-Smith & Powell, 2004; Powell et al., 1996; Zucker et al. 1998). Finally, industries related to the environment (Agritech, Foodtech and Greentech) and also those related to mobility may cluster near university-based knowledge and talent sources.

All in all, the emergence of start-ups seems to depend on a mix of knowledge, capabilities, finance, and other resources. And although all these may be relevant, their relative importance for the location of diverse types of start-ups will have implications at neighbourhood level. In this paper we aim to address all these gaps.

3 | DATA AND METHODS

3.1 | Start-ups in emergent industries

We obtained data on start-ups for Barcelona from the public directory *Barcelona & Catalonia Startups Hub* created at the end of 2016 by the Catalan agency for business competitiveness ACCIÓ (Agència per la Competitivitat de l'Empresa), which provides firm-level information including address, year of creation, industry, business model, and target for more than 1,000

start-ups from all of Catalonia. The Government of Catalonia has created this directory to promote start-ups internationally and help them grow. The companies in the directory are start-ups that: (a) are recently established (maximum 10 years); (b) are scalable with high growth potential; (c) are founded by ambitious entrepreneurs, highly committed to growth; (d) are innovative or technological; (e) are focused on the global market; (f) have a company VAT No. (i.e., proposals from the self-employed are not accepted); and (g) should NOT merely be a consultancy/agency or a third-party software/apps developer. Along the same lines, a company stops being considered as a start-up in the directory when any of the following conditions hold—it is acquired by a corporation, its shares are quoted on the stock exchange, its product has been licensed (e.g., for a biotech company), its founders no longer have management functions and become mere shareholders, or it remains inactive for over 1 year.[4]

Although the data in the directory is updated periodically based on new applicants and their validation by ACCIÓ, the data we used refers to all start-ups included into the directory in January 2018. We identified information for a total of 1,245 Catalan start-ups at that point. It is worth saying that more than 60% of the start-ups found were in Barcelona, the Catalonian capital. After a selection process which retained only companies providing address and zip code information in Barcelona, we finally obtained a sample of 460 start-ups created between 2012 and 2015. With this information we were able to define our dependent variable, the count of start-ups by neighbourhood created between 2012 and 2015 (*SUPS*).

To examine the location determinants of start-ups it is necessary to understand the industries and territories where they operate. Consequently, we delve into the role of emerging industries as market niches for Catalan start-ups. Defining an emerging industry is not an easy task - the concept of emerging industry represents the intersection of a unit of analysis, an industry, and an interval of time (Forbes & Kirsch, 2011). Emerging industries are widely understood as new industrial sectors, or existing industrial sectors that evolve or fuse into new industries. The fact that they arise from existing industries makes them encompass sectors traditionally defined otherwise. They are often driven by new needs, applications of new technologies or other radical innovations, new business models, or the new social challenges that industry must tackle to survive. Thus, start-ups operating in different emergent industries present intrinsic characteristics that should be considered in the analysis. Nevertheless, given the dynamic and inter-sectorial aspects of emerging industries (Forbes & Kirsch, 2011; Gustafsson et al., 2016; Teruel-Carrizosa et al., 2018), defining a closed list of emergent industries is a complex task beyond the scope of this paper.

One of the main advantages of the directory is that it provides information on the main industries in which start-ups operate. To classify the start-ups in our sample, we group the forty-three initial industries to which the start-ups in directory were associated by applying a multivariate statistical method. We applied a principal component analysis (PCA) to identify patterns of association across the different industries. After extracting the optimal number of main components, we applied an orthogonal rotation to enhance interpretability (Kline, 1994). The results show that start-ups can be classified into six broad groups: Creative, Ecological, Experiences, Mobility, Health, and Industry 4.0. Indeed, this classification is close to the proposition of the European Commission (European Cluster Observatory, 2012; European Commission, 2012). Table 1 provides the classification of start-ups in emergent industries. This classification allows us to evaluate whether start-ups operating in different emerging industries show different location patterns.

The dataset of the seventy-three neighbourhoods' characteristics comes from diverse sources. First, to identify the agents of the entrepreneurial ecosystem of the Barcelona neighbourhoods (including investors, accelerators, incubators, co-working spaces, talent generated by universities,

TABLE 1 Classification of Start-ups by emergent industries

Emergent industries	Start-ups 2012–15
Creative	117
Ecological	37
Experiences	33
Mobility	35
Health	50
Industry 4.0	188
Total start-ups entries	460

business schools and technology and research centres) we use information from the Barcelona Startup Map, *Catalunya Emprèn* and the Catalonia Trade & Investment agency.[5] Finally, we use open data on Barcelona neighbourhoods' socioeconomic composition provided by the Statistics Department of Barcelona City Council for the year 2011. These data sources provide information at the neighbourhood level (or at micro-geographic level in some cases, i.e., plain coordinates). Then, to homogenise the geographical units of analysis, the geolocalized variables were transformed by using a GIS contour routine at neighbourhood level.

3.2 | Barcelona: the Catalan context

The start-ups in this dataset are located in Barcelona, the capital of Catalonia, an autonomous region in north-eastern Spain. Barcelona has an area of 101.9 km^2 and a population of more than 1.6 million people. In economic terms, it accounts for 31% of the Catalan, and 6% of the Spanish GDP. Barcelona is composed of ten districts and seventy-three neighbourhoods (see Figure A1).

The Catalan economy is based on a strong industrial tradition with a high rate of business activity that combines talent, creativity, and entrepreneurial culture—an economic model that is strengthened, on the one hand, by the presence of prestigious technical and business schools, and on the other, by the constant promotion of public and private support programs and services for entrepreneurship. In recent years, the Catalan territory has experienced a progressive transition to a new economic model with a high awareness of the global challenges arising from climate change, the impact of activity human resources, the scarcity of natural resources and the health of society (Boix, 2012). Indeed, thanks to the good positioning of the Barcelona brand, the city has a great capacity to attract multinationals, talent, fairs, and congresses that has allowed the city to become a leading city in start-ups.[6] In the metropolitan area, for example, there coexists a dense and innovative industrial community of small and medium-sized enterprises and an active presence of large multinationals, especially in the biomedical, agri-food, automotive and telecommunications. Another sign of the consolidation of Barcelona as a start-up hub is the fact that companies interact and collaborate with each other with the aim of finding new solutions to common challenges. An example of this collaboration, which encourages dynamism in Catalan start-ups, is the Barcelona Tech City technology cluster, which brings together around one hundred digital and technology companies aimed at mobile telecommunications, e-commerce, and videogames and software.

3.3 | Location factors explaining the creation of start-ups

Given that the location decision of a start-up can largely be explained by the degree of attractiveness of the neighbourhood, it is necessary to control for different factors that could explain the competitiveness of a neighbourhood in terms of its social and economic conditions, as well as a set of specific factors that could favour the creation of innovative start-ups (Kitson et al., 2004). In our model to explain the location determinants of the location of start-ups in Barcelona, we include the following groups of explanatory variables for substantive and statistics reasons: (a) agglomeration economies, (b) disruptive innovation ecosystem, and (c) socioeconomic conditions. Table 2 summarises main descriptive statistics and sources and Table A1 shows the correlation results.

First, the concentration of population and economic activity in big cities (Arauzo-Carod & Viladecans-Marsal, 2009; Woodward et al., 2006) can be proxied by population density (POP_DENS) and the proximity of other firms. For this reason, we use the number of incumbents in knowledge intensive services (LOC_ECO). Both variables can be seen as proxies for urbanisation and localisation economies, as well as a market size and potential, which is relevant when deciding where to locate a new business.

Second, the development of start-ups in emergent industries relies, to a great extent, on the surrounding entrepreneurial and innovative ecosystem. Consistently, the quality of an entrepreneurial and innovative ecosystem is proxied by an ecosystem index focusing on the more tangible factors available by neighbourhood. In the case of Barcelona, for example, we include a dummy indicating whether a neighbourhood is located in the 22@ innovation district (henceforth, 22@).[7] See the next section for further details.

Fourth, social and economic conditions are proxied by two variables. The unemployment rate (UNEMP) and the population with at least degree-level qualifications (UNI).

3.3.1 | Ecosystem Index

To better represent the quality and importance of the elements of the start-up ecosystem (Stam & van de Ven, 2021), we have constructed an ecosystem index focusing on the more tangible factors available in each neighbourhood. A composite index is a tool for assessing the performance of territories as it provides a simple representation of complex and multidimensional phenomena (OECD, 2008). Such indexes provide simple comparisons between spatial units and, consequently, are increasingly used in the comparative analysis of territorial benchmarking such as our neighbourhoods (Saltelli, 2007).

The construction of the ecosystem index is carried out in three steps. First, it requires the selection of variables representative of the quality of an entrepreneurial and innovative ecosystem. This choice stems, on the one hand, from the relevance of the variables regarding the dimension concerned and, on the other hand, from the availability of data at the neighbourhood level. In this case, a set of seven elements per neighbourhood have been included on the index: the number of incubators (INCUBATORS), private and public high-education institutions providing postgraduate programmes specialised in emergent industries (TALENT), coders (CODERS), investors (INVESTORS), science, and technological parks (SCI_PARK), coworking spaces (CWS) and fablabs (FABLAB).

Second, since different indicators usually have different units and are defined on different scales, normalization of the data is necessary prior any aggregation. We normalized within the range [0, 100], using the min-max method, where values for a variable representing more

TABLE 2 Descriptive statistics

	Variable	Definition	Source	*N*	Mean	Sd	Min	Max
Dependent variable	*SUPS*	Overall start-up entries 2012–2015	ACCIÓ	73	6.2	11.4	0	70
	SUPS_crea	Start-up in creative emergent industries entries 2012–2015	ACCIÓ	73	1.6	2.7	0	14
	SUPS_eco	Start-up in ecological emergent industries entries 2012–2015	ACCIÓ	73	0.5	1.2	0	8
	SUPS_exp	Start-up in experiences emergent industries entries 2012–2015	ACCIÓ	73	0.5	1.3	0	10
	SUPS_mob	Start-up in mobility emergent industries entries 2012–2015	ACCIÓ	73	0.5	1.1	0	6
	SUPS_health	Start-up in health emergent industries entries 2012–2015	ACCIÓ	73	0.7	1.1	0	4
	SUPS_ind4	Start-up in industry 4.0 emergent industries entries 2012–2015	ACCIÓ	73	2.6	5.1	0	28
Agglomeration economies	*LOC_ECO*	Incumbent firms in Knowledge Intensive Sectors (KIS)	SABI database (2010)	73	37.66	72.39	0	486
	LOC_ECO_0.5km	Incumbent firms in KIS within the first 0.5km from the neighbourhood centroids	SABI database (2010)	73	23.36	31.61	0	191
	LOC_ECO_0.5–1 km	Incumbent firms in KIS between 0.5 and 1km from the neighbourhood centroids	SABI database (2010)	73	35.18	31.71	0	154
	LOC_ECO_1–5 km	Incumbent firms in KIS between1 and 5km from the neighbourhood centroids	SABI database (2010)	73	988.03	369.91	134	1449
	POP_DENS	Population density	Barcelona City Council (2011)	73	3	0.9	0.1	4.1

(Continues)

TABLE 2 (Continued)

	Variable	Definition	Source	*N*	Mean	Sd	Min	Max
Entrepreneurial Ecosystem	*22@*	22@ district dummy	Authors	73	0.1	0.3	0	1
	ECOSYTEM_INDEX	Composite Index of the elements of the Start-ups Ecosystem	Authors	73	1.21	1.33	0	4.26
	EE_1km	Number of elements of the Entrepreneurial Ecosystem within the first km from the neighbourhood centroids	Authors	73	11.54795	16.12	0	67
	SCI_PARK	Number of science and technological parks	www.xpcat.net (2011)	73	0.1	0.2	0	0.7
	TALENT	Number of centres specialized in promoting entrepreneurship	Barcelona Startup Map, Catalunya Emprèn and the Catalonia Trade & Investment (2011)	73	0.3	0.6	0	2.2
	INCUBATORS	Number of incubators and accelerators	Barcelona Startup Map, Catalunya Emprèn and the Catalonia Trade & Investment (2011)	73	0.3	0.6	0	2.6
	INVESTORS	Number of investors (business angels, venture capital, seed fund, crowfunding, etc)	Barcelona Startup Map, Catalunya Emprèn and the Catalonia Trade & Investment (2011)	73	0.2	0.5	0	2.1
	CODERS	Number of coders academies	Barcelona Startup Map, Catalunya Emprèn and the Catalonia Trade & Investment (2011)	73	0.1	0.2	0	1.1
	CWS	Number of coworking-spaces	Diff. sources: catalonia.com; Barcelona City Council, barcelonanavigator.com (2011)	73	0.6	0.8	0	3.3
	FABLAB	Number of Fabrication Laboratory (Fab lab)	Barcelona Startup Map, Catalunya Emprèn and the Catalonia Trade & Investment (2011)	73	0.1	0.3	0	1.4
Socioeconomic factors	*POP*	Population	Barcelona City Council (2011)	73	9.7	1	6.2	11
	UNEMP	Unemployment rate	Barcelona City Council (2011)	72	0.2	0.1	0	0.7
IV	*UNI*	Population with graduate studies or more	Barcelona City Council (2011)	73	7.8	1.4	3.2	9.8
	HOUSING_90	Number of housing units in 1990	Barcelona City Council (1990)	73	3149.534	1649.622	500	5854
	POP_70	Population in 1970	Barcelona City Council (1970)	73	183,379.2	54,619.87	58,162	324,337

desirable outcomes. The main advantage of this method is its ability to gauge performance based on the best and the worst performance, while the main drawback is the need to recalibrate when additional data are added. Alternative methods are distance to reference, and standardization. The main drawback of the former is that the results obtained may be extremely sensitive to the benchmark chosen, while for standardization the main problem is that the sample size should be sufficiently large, and recalibration is needed when new data are added. However, min-max is the most used method (Ang et al., 2015) and the best approach given the nature of our data.

The last step is the weighting and aggregation of the normalised indicators. We have conformed to common practice and conducted an additive aggregation (arithmetic average) by assigning equal weighting (with certain exceptions) to each indicator (Ang et al., 2015; OECD, 2008). The robustness of the results is assessed by using alternative weights. The results do not vary significantly, either in terms of values or in the positions of the neighbourhoods, when classified according to the index value.

The results for the EE index are shown in Column 3 of Table 3.

3.4 | Methods

To test the hypothesis given in Section 2, we model the dependent variable $SUPS_i$ as a function of the characteristics of neighbourhood i.

$$SUPS_i = \alpha + \beta_1 LOC\_ECO_i + \beta_2 POP\_DENS_i + \beta_3 22@_i + \beta_4 ECOSYSTEM\_INDEX_i + \beta_5 UNEMP_i + \beta_5 UNI_i \varepsilon_i$$

where $SUPS_i$ is the count of start-ups created in neighbourhood i between 2012 and 2015 as a function of the previously explained covariates and ε_i is an error term. Our empirical strategy consists of estimating seven models with different dependent variables but sharing the same set of explanatory variables. For each neighbourhood we thus have seven categories: (*SUPS*), creative (*SUPS_crea*), ecological (*SUPS_eco*), experiences (*SUPS_exp*), mobility (*SUPS_mob*), health (*SUPS_health*) and Industry 4.0 (*SUPS_ind4*). This strategy allows us to test whether the location determinants vary by emerging industries. All explanatory variables refer to 2010 and 2011, and all variables have been log transformed.

The discrete and non-negative nature of such a dependent variable suggests adopting estimation techniques for count data models (CDMs). These models are commonly used when dealing with location phenomena from a spatial point of view i.e., how the local characteristics of different sites (e.g., neighbourhoods, municipalities, regions) can influence start-ups' decisions. These CDMs include the Poisson model (PM), the negative binomial model (NBM), the zero inflated Poisson model (ZIPM) and the zero inflated negative binomial model (ZINBM). The classical PM serves as a starting point, but it may present two main problems: overdispersion and excess of zeroes. These can be addressed using NBM, ZIPM and ZINBM. Following Cameron and Trivedi (2010), we determine which specifications are best for the data used in this chapter according to the Akaike information criterion (AIC), the Bayesian information criterion (BIC), and the Vuong test.

4 | RESULTS

This section provides evidence for the geographical distribution of start-ups in emergent industries in Barcelona, the results for our model explaining their intra-urban location determinants, and a set of robustness checks.

TABLE 3 Top 15 neighbourhoods with the highest Start-up Ecosystem Index

#	Neighbourhood	Ecosystem_ Index	*N.* of Ecosystem Elements	Incubators	Talent	Coders	Investors	Science parks	CWS	Fablabs	Start-up entries 12–15
1	*la Dreta de l'Eixample*	69.64	6	13.79%	13.73%	28.57%	22.58%	0.00%	18.24%	5.56%	70
2	*el Parc i la Llacuna del Poblenou*	67.84	7	20.69%	15.69%	14.29%	6.45%	12.50%	5.41%	11.11%	42
3	*Sant Gervasi - Galvany*	39.29	5	13.79%	3.92%	14.29%	22.58%	0.00%	6.08%	0.00%	49
4	*Pedralbes*	30.21	5	3.45%	9.80%	0.00%	6.45%	12.50%	0.68%	0.00%	8
5	*la Vila de Gràcia*	28.50	5	1.72%	3.92%	0.00%	3.23%	12.50%	9.46%	0.00%	11
6	*Sant Pere, Santa Caterina i la Ribera*	25.85	4	0.00%	0.00%	0.00%	3.23%	12.50%	6.08%	5.56%	6
7	*la Vila Olímpica del Poblenou*	21.76	3	0.00%	5.88%	28.57%	0.00%	0.00%	2.70%	0.00%	6
8	*Sant Gervasi - la Bonanova*	20.89	5	1.72%	1.96%	0.00%	3.23%	12.50%	2.03%	0.00%	12
9	*el Barri Gòtic*	20.83	3	0.00%	1.96%	0.00%	0.00%	12.50%	6.08%	0.00%	7
10	*la Maternitat i Sant Ramon*	20.43	4	0.00%	3.92%	0.00%	3.23%	12.50%	0.68%	0.00%	11
11	*l'Antiga Esquerra de l'Eixample*	20.10	4	3.45%	13.73%	0.00%	3.23%	0.00%	4.05%	0.00%	27
12	*les Corts*	20.09	4	1.72%	0.00%	0.00%	6.45%	0.00%	0.68%	16.67%	10
13	*la Barceloneta*	16.60	4	8.62%	5.88%	0.00%	0.00%	0.00%	0.68%	5.56%	12
14	*la Nova Esquerra de l'Eixample*	15.86	4	6.90%	5.88%	0.00%	3.23%	0.00%	4.73%	0.00%	18
15	*el Turó de la Peira*	14.29	1	0.00%	0.00%	0.00%	0.00%	12.50%	0.00%	0.00%	0

Source: Authors using ACCIO and Barcelona Open Data.

4.1 | Spatial distribution of start-ups in emergent industries in Barcelona

To give an initial overview of the geographical distribution of the start-ups in each of the six emergent industries that located in Barcelona between 2012 and 2015, Figure 1 shows a heatmap where the start-up density is indicated by the red hotspots.[8] Clearly, almost all start-ups are clustered around the most central neighbourhoods overlapping Barcelona's main axis, a pattern that remained static between 2012 and 2015. The two main hotspots found are in the central segments of Diagonal Avenue (A) and in 22@ (B), areas that stand out for their concentration of facilities, public services (i.e., administrative, and financial support), and agents defining the innovative start-up ecosystem.

To obtain more details of this distribution, Figure 2 shows the geographical distribution of start-ups across the seventy-three neighbourhoods of Barcelona over the entire observed period. It shows that the overall number of innovative start-ups is nontrivial; overall, 82% of neighbourhoods had at least one innovative start-up. Start-ups, however, were clearly clustered in the most central neighbourhoods of the city as *Dreta de l'Eixample*, *Vila de Gràcia, Esquerra de l'Eixample* and *el Parc i la Llacuna del Poblenou*, neighbourhoods with 70, 49, 42 and 27 start-ups entries, respectively.

Figure 3 shows the spatial distribution of several elements defining an emergent start-up entrepreneurial ecosystem. The elements clearly agglomerate in the most central neighbourhoods (7, 26, 31), as well as in 22@ (66).Thus, there is a clear relationship between a higher number of start-ups entries and the factors enabling the ecosystem.

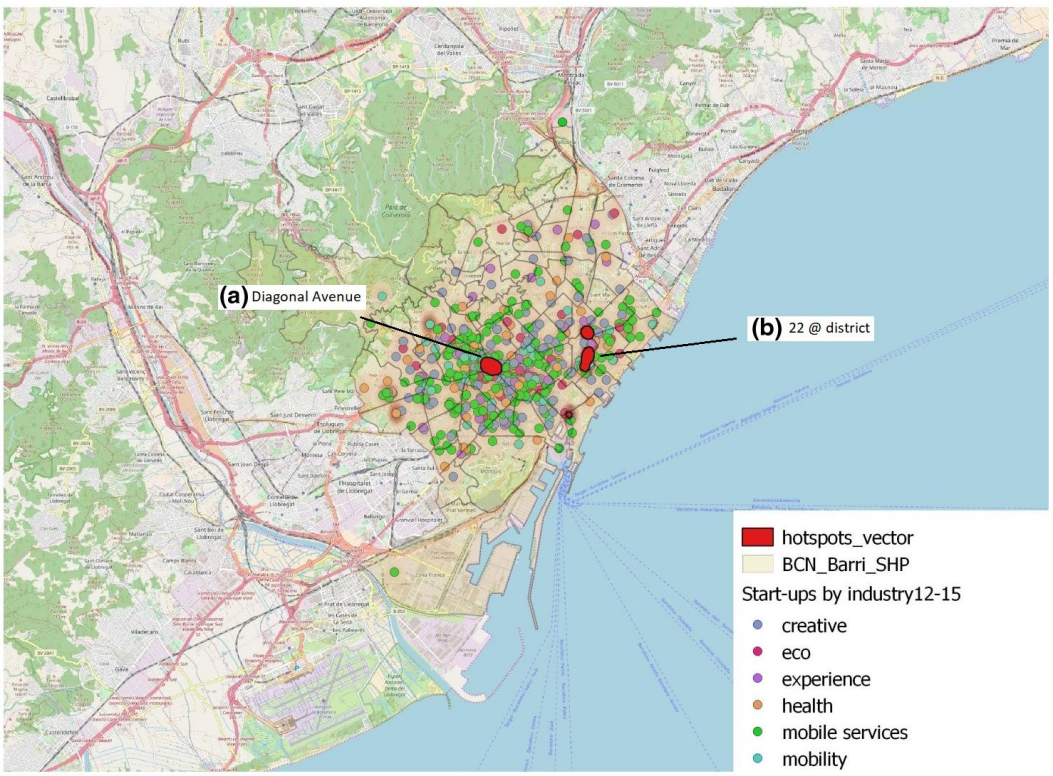

FIGURE 1 Hotspots for start-ups by emergent industries in Barcelona (2012–2015). Source: Prepared by the authors based on ACCIÓ data

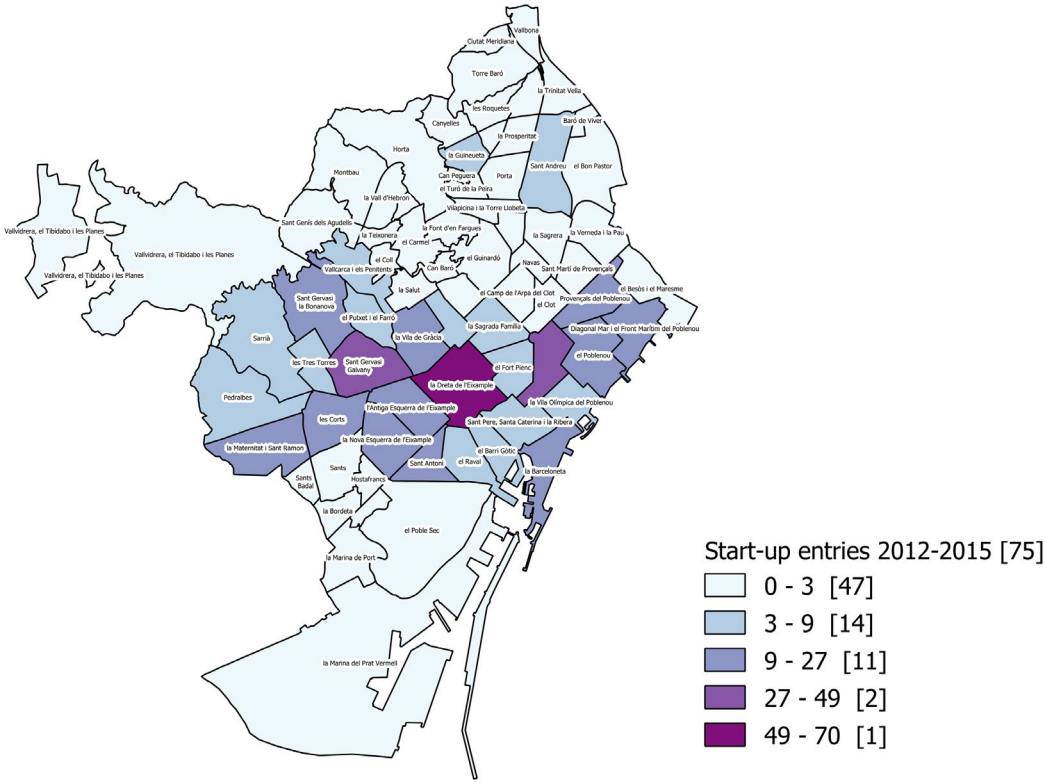

FIGURE 2 Geographical distribution of the overall emergent start-ups (2012–2015). Source: Prepared by the authors based on ACCIÓ data

Table 3, which ranks the top fifteen neighbourhoods having all seven elements of an entrepreneurial ecosystem confirms the findings of Figure 3. In general terms, the results show that those neighbourhoods with more elements have a higher number of start-ups. For Barcelona, only the *Parc I la Llacuna del Poblenou* neighbourhood (66) has all the required elements. Table 3 shows the percentage of each factor in relation to the overall number of elements in Barcelona, which can be considered a proxy for a specialization measure in each element for neighbourhood. Thus, neighbourhoods like el Parc i la Llacuna del Poblenou (66) and Dreta de l'Eixample (7) are those with the most elements and we conjecture that this is one of the main factors for explaining their success in creating start-ups.

The above results are confirmed in Figure 4. A good start-up ecosystem is a key element for boosting new firms, however not all seventy-three neighbourhoods count on a vibrant ecosystem (Figure 4). Forty percent of neighbourhoods have no element as measured by number of incubators, access to talent, coders, investors, scientific parks, coworking spaces or Fablabs. These neighbourhoods show few or no start-ups while others with a diversity of elements have a greater number of start-ups. For instance, the neighbourhood with most start-ups, *Dreta de l'Eixample*, has a high presence of incubators and access to human capital and talent.

Because of the potential heterogeneity of the location patterns of emergent industries, Figure 5 provides a deeper analysis for each of the six industry classes considered. In general, start-ups are located in the same neighbourhoods, the central neighbourhoods crossing the Diagonal Avenue and 22@. Nevertheless, the location of start-ups in certain emergent industries differ. Even though

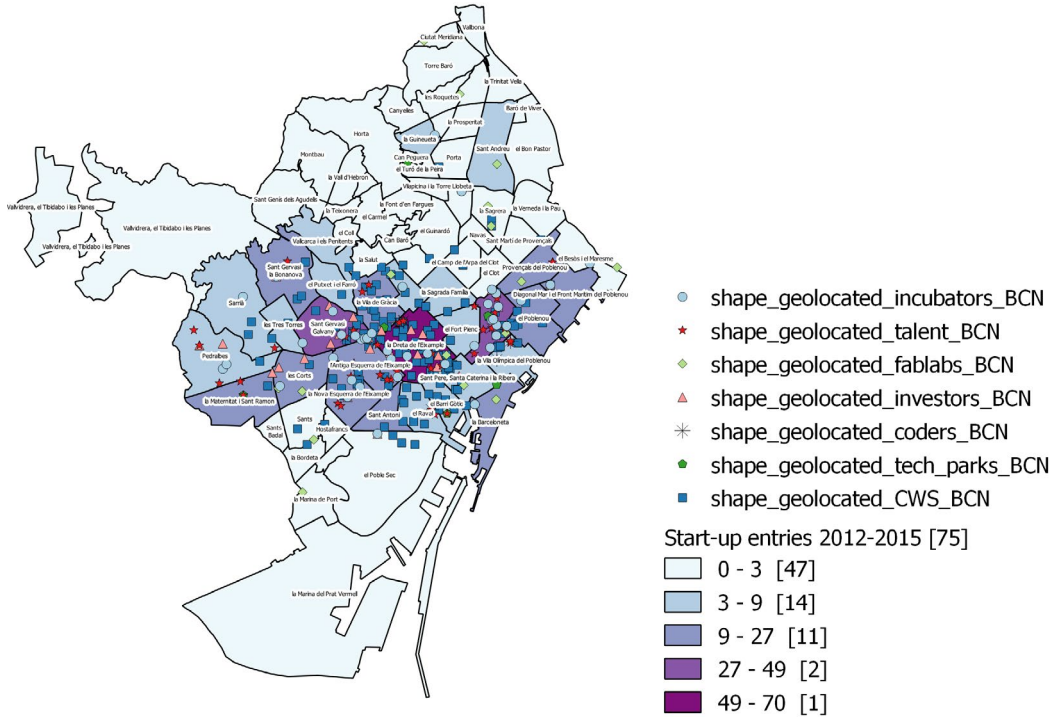

FIGURE 3 Geographical distribution of the elements of the start-up ecosystem and start-ups entries (2012–2015). Source: Prepared by the authors based on ACCIÓ and the Statistics Department of the Council of Barcelona data

they tend to locate in the core neighbourhoods, Creative (a) and Health (d) start-ups are dispersed throughout all the Diagonal Avenue as well as in the *Barceloneta (3)* neighbourhood, while Experiences (c) start-ups seem to be attracted to the northwest part of the city which stands out as containing the neighbourhoods with the highest income levels. Industry 4.0 (f) is the most dispersed group in the city, perhaps because of a considerable number of interrelations with a wide range of sectors. In addition, we observe start-ups in Industry 4.0 tend to locate in areas with a high presence of coders (*Dreta Eixample, Sant Gervasi, Galvany* and *el Parc i la Llacuna del Poblenou*).

4.2 | Location determinants for start-ups in emergent industries

To choose the most appropriate CDM to explain the count of start-ups in emergent industries in Barcelona's neighbourhoods, we estimated a baseline specification and selected the one with the best fit using the Akaike information criterion (AIC), the Bayesian information criterion (BIC) and the Vuong test (Vuong, 1989). Table 4 shows the results for these statistics for the creation of the various categories of start-ups.

Although the Vuong tests suggest the use of an inflated model (but at only at a 10% level of significance), the Poisson model is the one that performed best on the AIC and BIC criteria. Thus, due to the small number of zeroes in our sample and the poor significance level for the Vuong test, the Poisson is used for all the models for the sake of comparison across different start-ups specifications.[9]

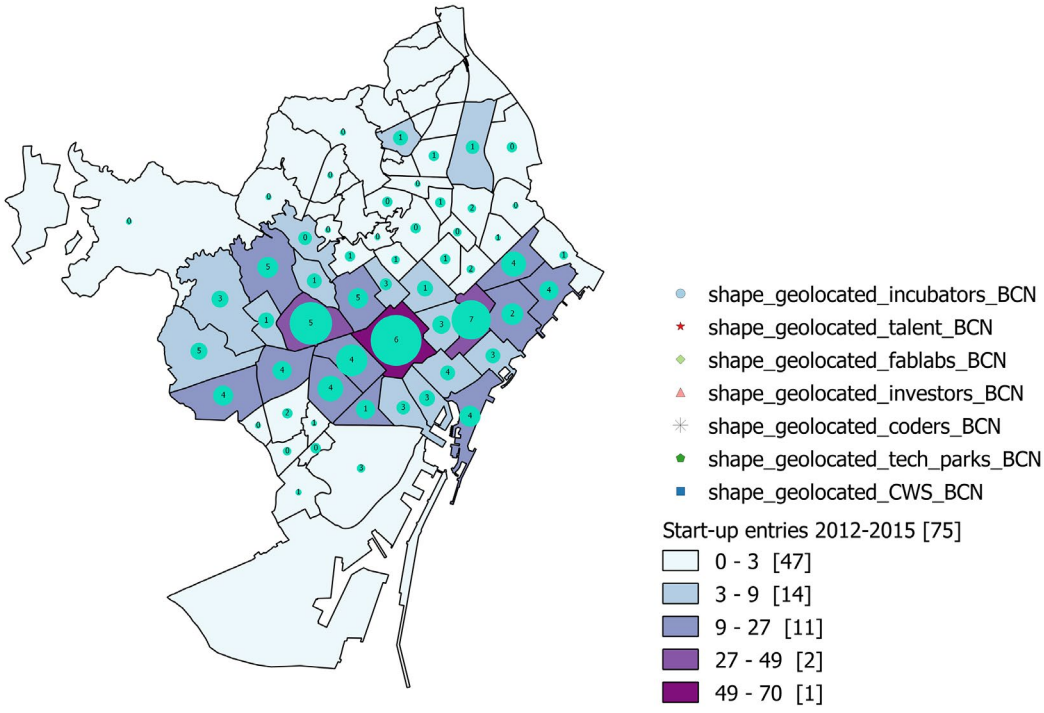

FIGURE 4 Number of elements of the Barcelona start-up ecosystem by neighbourhoods. Source: Prepared by the authors based on ACCIÓ data

The baseline estimates are shown in Column (1) of Table 5. The results suggest that neighbourhoods with an important presence of incumbent firms operating in knowledge intensive industries, and where we can easily find almost all the elements of an EE may have more advantages in attracting start-ups. This is the case of 22@ which, as public initiative providing networking, workspace facilities, administrative and granting support, clearly seems to attract the location of start-ups in its neighbourhoods. These results may reflect a greater need for localisation economies in terms of knowledge spillovers and networking effects and proximity to capital and infrastructure related elements of the EE. Proximity to elements such as incubators, accelerators, or venture builders, are crucial in providing them with support during their initial growth and along their disruptive path.

The baseline model is also estimated by start-ups in each of the six emergent industries (Table 6). Although the specificities of each emerging industry, results do confirm the evidence found for all the sample of start-ups and are in line with the above results on the location patterns for these industries. The most significant difference across the six categories of emerging industries, is found for the Ecological (column 2), Health (column 5) and Industry 4.0 (column 6) start-ups. We can highlight the fact that Ecological and Health start-ups are not significantly associated with densely populated areas (POP_DENS), while start-ups mainly operating in Industry 4.0 are positively and significantly associated with 22@, the technological and innovative district. Localisation economies, in terms of a higher presence of incumbent firms operating in the KIS industries, is a significant location factor for all type of start-ups, except for Ecological and Health emergent industries. This may be because location determinants rely on specific local characteristics not included in the previous specifications. For instance, these start-ups may be closely related to agricultural or manufacturing industries that are less present in the KIS. Finally, the effect of the EE index on

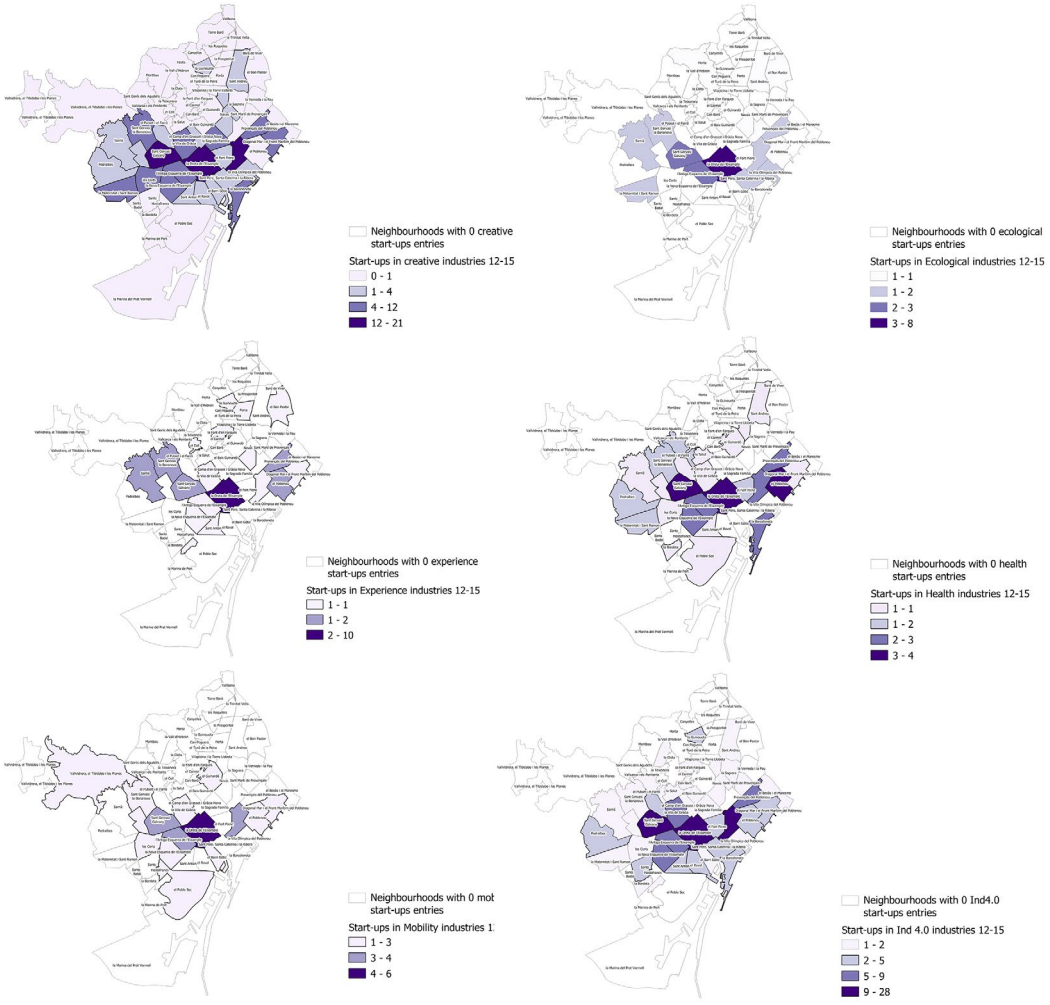

FIGURE 5 Geographical distribution of start-ups by emergent industries (2012–2015). (a) Creative; (b) Ecological; (c) Experiences; (d) Health; (e) Mobility; (f) Industry 4.0. Source: Prepared by the authors based on ACCIÓ data

the location of start-ups is highly significant for Creative, Ecological and Industry 4.0 start-ups. Although we expected to find a positive and significant effect for all type of emergent industries, these results may suggest that there are some external elements among the ones considered for the construction of the index that are less relevant for these industries.

4.3 | Spatial results

4.3.1 | Accounting for spatial spillovers

First, as Viladecans-Marsal (2004) and Viladecans-Marsal and Arauzo-Carod (2012) suggested for Barcelona, agglomeration externalities may expand beyond neighbourhoods. Consequently, if we do not consider this possible spatial dependence in our model, the results may be biased

TABLE 4 Model selection statistics

	AIC	BIC	Vuong test
Model 1 (All start-ups)			
PM	299.925	315.95	—
NBM	296.751	315.07	—
ZIPM	292.712	315.61	1.851**
ZINBM	296.16	321.35	1.678*
Model 2 (Creative)	AIC	BIC	Vuong test
PM	187.792	203.825	—
NBM	189.792	208.116	—
ZIPM	187.079	207.693	2.09*
ZINBM	189.079	211.983	—
Model 3 (Ecological)	AIC	BIC	Vuong test
PM	105.898	121.931	—
NBM	107.898	126.221	—
ZIPM	108.912	129.526	0.1652
ZINBM	108.714	131.618	—
Model 4 (Experiences)	AIC	BIC	Vuong test
PM	110.204	126.237	—
NBM	111.867	130.19	—
ZIPM	—	—	—
ZINBM	—	—	—
Model 5 (Mobility)	AIC	BIC	Vuong test
PM	92.146	108.179	—
NBM	94.146	112.469	—
ZIPM	95.956	116.57	0.238
ZINBM	97.956	120.86	—
Model 6 (Health)	AIC	BIC	Vuong test
PM	128.324	144.357	—
NBM	130.324	148.648	—
ZIPM	—	—	—
ZINBM	—	—	—
Model 7 (Industry 4.0)	AIC	BIC	Vuong test
PM	222.836	238.869	—
NBM	222.718	241.041	—
ZIPM	—	—	—
ZINBM	—	—	—

***$p < .01$; **$p < .05$; *$p < .1$.

and inconsistent. To account for spatial dependence, we also considered the spatial lag of the independent variables (Spatial Lagged Model in the X [SLX]). Specifically, these are estimated as follows: W_Z = WZ, where Z is a matrix of the independent variables and W is an appropriate

TABLE 5 Poisson results for the location of start-ups (2012–2015)

Dep. Var.: *SUPS*	**(1)**	**(2)**	**(3)**
Variables	**Non-spatial**	**Spatial lags**	**Spatial decay**
Agglomeration economies			
LOC_ECO	0.682***	0.573***	—
	(0.0854)	(0.108)	
LOC_ECO_0.5 km	—	—	0.273***
			(0.0881)
LOC_ECO_0.5–1 km	—	—	0.221***
			(0.0844)
LOC_ECO_1–5 km	—	—	0.270
			(0.282)
POP_DENS	−0.173	−0.282*	−0.798***
	(0.119)	(0.159)	(0.187)
Ecosystem			
22@	0.427***	0.365**	0.222
	(0.133)	(0.147)	(0.158)
ECOSYTEM_INDEX	0.217***	0.211***	0.356***
	(0.0669)	(0.0682)	(0.0650)
Socioeconomic factors			
UNEMP	−1.880	−2.354	−0.867
	(1.652)	(1.832)	(1.940)
UNI	0.122	0.189	0.633***
	(0.120)	(0.139)	(0.124)
Spatial lagged X's			
WLOC_ECO	—	0.0426	—
		(0.237)	
WPOP_DENS	—	0.109	—
		(0.260)	
WECOSYTEM_INDEX	—	0.112	—
		(0.138)	
WUNEMP	—	3.456	—
		(2.470)	
WUNI	—	0.135	—
		(0.276)	
Constant	−1.291	−3.544	−5.197***
	(0.902)	(2.185)	(1.943)
N	73	73	73
Pseudo R^2	0.7244	0.7326	0.7027
AIC	293.180	291.464	327.540
BIC	313.794	323.530	352.736

Note: Robust standard errors in parentheses.

***$p < .01$; **$p < .05$; *$p < .1$.

TABLE 6 Negative Binomial results for the location of start-ups for emerging industries subgroups (2012–2015)

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Creative**	**Ecological**	**Experiences**	**Mobility**	**Health**	**Ind 4.0**
Agglomeration economies						
LOC_ECO	0.558***	0.163	1.084***	0.989***	0.453	0.780***
	(0.173)	(0.370)	(0.301)	(0.329)	(0.286)	(0.135)
POP_DENS	−0.0828	−0.738*	−0.542	−0.480	−0.610**	0.231
	(0.224)	(0.395)	(0.441)	(0.498)	(0.309)	(0.204)
Ecosystem						
22@	0.419	0.824	0.616	0.348	0.658	0.454**
	(0.261)	(0.543)	(0.485)	(0.550)	(0.401)	(0.204)
ECOSYTEM_INDEX	0.288**	0.522**	−0.179	0.0269	0.0763	0.282***
	(0.129)	(0.255)	(0.253)	(0.275)	(0.194)	(0.106)
Socioeconomic factors						
UNEMP	−0.425	0.404	−1.859	−8.988	−1.604	−2.997
	(2.632)	(4.720)	(6.131)	(8.903)	(4.233)	(2.920)
UNI	0.166	0.921	0.211	0.116	0.644	−0.208
	(0.234)	(0.569)	(0.408)	(0.521)	(0.392)	(0.191)
Constant	−3.240**	−8.314**	−4.341	−2.525	−5.559**	−0.924
	(1.645)	(4.079)	(3.246)	(4.316)	(2.793)	(1.456)
N	73	73	73	73	73	73
AIC	187.75	110.28	112.96	98.79	136.95	228.19
BIC	215.24	137.77	140.45	126.28	164.43	255.68
Pseudo-R^2	0.4983	0.4340	0.3815	0.5135	0.3710	0.6108

Note: Robust standard errors in parentheses.

***$p < .01$; **$p < .05$; *$p < .1$.

(row-standardised) spatial-neighbour matrix. Because of the size and proximity of neighbourhoods in Barcelona, we use a contiguity spatial matrix.

Column 2 in Table 5 shows the results of an enlarged location decision model to account for inter-neighbourhood spatial externalities. Almost all the key location determinants remain significant as in Column (1) when the spatial effect are not considered. This is the case for the localisation economies and the EE, which remain one of the most relevant factors explaining their location. However, adding spatial lagged variables reveals several interesting facts, one of which is that the coefficient of population density remains negative but becomes significant at the local level. This result may suggest the existence of some disagglomeration economies, associated with the higher rental prices and congestion that may hamper start-up productivity.

We have also applied spatial analysis to explain whether the location determinants of start-ups vary by emergent industries (see Table A2). Results are consistent with the full sample of start-ups and previous results in shown in Table 6. Interestingly, we find that certain spatial lagged variables are significant. This is the case for population density (WPOP_DENS) for Ecological start-ups, unemployment rate (WUNEMP) for Experiences and Industry 4.0 start-ups.

TABLE 7 IV Poisson results for the location of start-ups (2012–2015)

Dep. Var.: *SUPS*	Endogenous variable: *ECOSYTEM_INDEX*		Endogenous Variable: *LOC_ECO*		Endogenous variables: *ECOSYTEM_INDEX and LOC_ECO*	
Variables	**(1) Poisson**	**(2) IV Poisson**	**(1) Poisson**	**(2) IV Poisson**	**(1) Poisson**	**(2) IV Poisson**
Agglomeration economies						
LOC_ECO	—	—	0 0.870***	1.006***	0.681***	0.708**
			(0.059)	(0.306)	(0.085)	(0.247)
POP_DENS	−0.0474	−0.065	−0.305**	−0.260*	−0.172	−0.181
	(0.121)	(0.200)	(0.109)	(0.148)	(0.119)	(0.151)
Ecosystem						
22@	0.615***	0.622**	0.537***	0.508*	0. 0.426***	0.433
	(0.137)	(0.316)	(0.125)	(0.284)	(0.133)	(0.277)
ECOSYTEM_INDEX	0.560***	0.522***	—	—	0 0.217***	0.158
	(0.052)	(0.219)			(0.066)	(0.279)
Socioeconomic factors						
UNEMP	−6.369***	−6.22*	−1.062	−1.122	−1.880	−1.799
	(1.904)	(3.26)	(1.435)	(2.679)	(1.652)	(2.692)
UNI	0.586***	0.609**	0.185*	0.053	0.121	0.128
	(0.126)	(0248)	(0.110)	(0.358)	(0.120)	(0.219)
Res (1st Step)	—	0.046	—	−0.174	—	0.071
		(0.221)		(0.359)		(0.302)
Constant	−3.097**	−3.204	−1.865**	−1.311	−1.290	−1.333
	(1.056)	(1.962)	(0.808)	(2.005)	(0.902)	(1.492)
N	73	73	73	73	73	73
Instruments						
Housing_1970	No	Yes	No	Yes	No	Yes
pop_1990	No	Yes	No	Yes	No	Yes

Note: Bootstrap standard errors in parentheses. [a] and [b]: 400 simulations.

***$p < .01$; **$p < .05$; *$p < .1$.

Both effects are positive which may imply that start-ups operating in these industries may avoid crowded and less dynamic neighbourhoods.

The most relevant implication of the above results is that location decisions of start-ups seem to be taken mainly at the local (neighbourhood) level.

4.3.2 | The attenuation of agglomeration economies

Still, relying on this traditional spatial analysis can bring to the Modifiable Area Unit Problem (MAUP), which may lead to empirical results biased across geographical scales (Arbia, 1989).

Moreover, agglomeration effects are likely to attenuate rapidly over space (Arzaghi & Henderson, 2008; Rosenthal & Strange, 2005, 2008). This seems critical in the light of recent contributions which find that the spatial extent of agglomeration economies for creative and knowledge intensive firms ranges between 0 and 1 km, (Arauzo-Carod et al., 2017; Coll-Martínez, 2019; Coll-Martínez et al., 2019).

Results in Column (3) of Table 5 consider the count of incumbent firms in KIS with origin at the centroid of each neighbourhood to check for the attenuation of localisation economies. In this case, the attenuation of localisation economies is confirmed for all start-ups. However, this effect turns out to be non-significant at 1 km. This result also confirms the fact that start-ups have a clear need of spatial proximity to similar firms and collaborators in the industry.

4.4 | Robustness checks

It is worth noting that, given the potential endogeneity problems, these results should not be taken as complete evidence of a causal relation.

4.4.1 | Accounting for endogeneity

To deal with this potential reverse causality, we follow Cameron and Trivedi (2010) who propose a structural-model approach to control for endogeneity when estimating CDM. More specifically, we apply a bootstrap for Poisson two-step estimations (see Cameron & Trivedi, 2010, pp. 592–595 for further details). To do so, we make use of two instrumental variables (IV): the number of housing units in 1990, and the urban population in 1990, which are usually found to be extremely relevant, indicating major inertia in the distribution of population over space.

Table 7 compares the Poisson results to estimates making use of a bootstrap two-step procedure for Poisson. We may suspect two variables, the EE index (ECOSYTEM_INDEX) and localisation economies (LOC_ECO), to be endogenous to the model. Columns (1) and (2) depict the results considering the EE index as endogenous whereas, in columns (3) and (4) localisation economies is the endogenous variable, and finally, in Columns (5) and (6) both are considered. The results confirm, even when using this alternative empirical approach, the positive and significant effect of the proximity to the set of elements of the EE and localisation economies on the location of start-ups in a neighbourhood. Controlling for endogeneity has a substantial effect on start-ups entries explained by an exogenous change in the EE elements and the number of incumbent firms in the related industries because its coefficient is now higher.

4.4.2 | Other considerations

Recent contributions suggest that the impact of EE cannot be deduced from a knowledge function of its elements which not consider the complexity and interrelatedness of qualitative dimensions (Lange & Schmidt, 2020; Stam & van de Ven, 2021). For this reason, we proposed measuring the quality of the EE in a composite index. However, bearing in mind the heterogenous distribution of the elements of the EE in Barcelona, and our results suggesting that start-ups really account for the proximity to the attributes of the neighbourhood,

we estimated the impact of each of the tangible elements of EE on the location of start-ups in terms of accessibility. That is the reason we considered each of the elements of our EE for Barcelona and computed a set of variables counting the number of the tangible elements of the ecosystem within a kilometre of each neighbourhood's centroid. The results for this specification appear in Table A4. They suggest that, as those authors suggested, the decomposition of the EE may not reflect the interdependent relation between the elements of the ecosystem. Notwithstanding, when using an alternative definition of the EE, the count of the number of elements of the EE within a kilometre of the neighbourhood's centroid, the results remain positive and significant.

5 | DISCUSSION

This paper provides empirical evidence on the role played by the local attributes, proximity to the elements of the EE and to nearby economic activity in the location of ambitious start-ups in emerging industries.

Start-ups in emergent industries present different characteristics to those of traditional firms since they represent a high-risk model, with a high turbulence and volatility that has led to a specific value chain, with the support of local actors, public policies, investors and, the interaction with (creative) talent that are much more likely to be drawn to big cities, especially in neighbourhoods with more dynamic ecosystems (Florida & Mellander, 2016). Nevertheless, the empirical literature on the location of start-ups has devoted most of its attention to bigger areas as regions or metropolitan without considering local context specificities (Lange & Schmidt, 2020; Stam & van de Ven, 2021) and the heterogeneous spatial distribution of the elements of the EE within the city. Such a limitation in terms of spatial boundaries hampers the accurate design of urban policies aimed at favouring the location of start-ups. To address this, rather that only examine this issue within neighbour administrative boundaries, this paper goes one step further and considers the role of proximity and the actual spatial distribution of the elements of the EE by using spatial econometrics techniques and GIS.

Concretely, our results show that the location decision of start-ups is driven by the proximity to heterogenous factors including the primary elements of the start-up eco-system (i.e., coders, access to financing, talent, coworking spaces), as well as knowledge spillovers in terms of the proximity to incumbent firms operating in related industries (KIS). Moreover, they confirm that the spatial extent to which start-ups may take their location decisions is quite bounded (within the first km from the centre of each neighbourhood). In doing so, we shed light on how agglomeration economies may still play and important role in the development of innovative activities (Fritsch & Wyrwich, 2020a, 2020b) as such carried out by start-ups in some emerging industries. These findings also add to previous papers focusing on the location of high-tech firms in Barcelona (Arauzo-Carod, 2021; Viladecans-Marsal, 2004; Viladecans-Marsal & Arauzo-Carod, 2012) and confirm the attenuation of localisation economies for innovative and creative activities such as start-ups in emergent industries (Arauzo-Carod et al., 2017; Coll-Martínez, 2019; Coll-Martínez et al., 2019).

A second issue that deserved our attention is the potential reverse causality when it comes to analyse the impact of the EE on the creation of start-ups (Stam & van de Ven, 2021). To deal with that, this paper examines the impact of entrepreneurial ecosystems in the creation of start-ups as set of interdependent elements (expressed as a composite index) at different geographical scales. Our results confirm that, after controlling for a potential downward causality on the analysis, the

quality and proximity to the elements of the EE still matter but they must be adapted to the local context and considered as a whole system.

For policymakers, this study gives novel insights on location determinants of start-ups within cities and emphasizes the emerging industries dimension. First, the public sector needs to adapt their innovation policies to the specificities of emerging industries in which start-ups operate. Second, in dynamic cities like Barcelona, neighbourhood characteristics matter; public administrations should take them into account when designing policies for attracting start-ups. Still, as our results show, not all kinds of start-ups value in the same way the proximity to the elements of EE and agglomeration economies. Finally, public initiatives providing networking, workspace facilities, administrative and granting support seem to clearly attract the location of start-ups in its neighbourhoods, like is the case of the 22@ district. However, this type of policy may lead to the concentration of innovative activities in some few points of the city, limiting in this way the potential externalities associated to these activities in the neighbourhoods.

There are several issues that are beyond the scope of this analysis and that could be object of fruitful future research. First, the database provides certain original information that common databases do not incorporate. However, we do not have information of the location of firms which are not start-ups. We should also acknowledge that our EE index may not capture the full set of actors defining a fully developed EE. Second, our database is defined as a cross-section dataset. Hence, it would be worthwhile to include spatial-time dynamics particularly to examine the shock of the Covid-19 pandemic. Third, notwithstanding the use of spatial lagged explanatory variables and IV to reduce any potential endogeneity in our estimates, further studies may be required to shed more definite light on the causal relationships in our findings. Finally, future work will focus on analysing the survival of start-ups and their (re)location once they have grown and are acquired.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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ENDNOTES

[1] It is worth saying that some recent papers argue that agglomeration economies are much less important for innovation activities (in terms of patents or inventors) as is suggested by most contributions to the literature and that the same pattern may not hold for all regions and countries (see for instance, Fritsch and Wrwich 2020a,b).

[2] To offer a clearer picture of the Barcelona situation with respect to international benchmarks we present some statistics. According to the European Start-up Hubs, London is clearly leading the ranking when it comes to the number of start-ups and the size of capital invested with 4.70 billion euros and 8,974 start-ups. The second biggest start-up hub in Europe is Paris with 2.35 billion euros invested and 2,750 start-ups. Finally, close behind, we found that Berlin had 2,330 and 2,17 billion euros capital invested (Mobile World Capital Barcelona 2018; Catalonia Trade and Investment, 2022).

[3] Unfortunately, this data is not available at the local scale such as Barcelona neighbourhoods.

[4] ACCIÓ, the organisation in charge of this database, includes start-ups in this list when a company satisfies the aforementioned requirements. Hence, the inclusion of a new start-up in the directory is under the judgement of the technical staff in charge of the innovation activity of the Catalan Government. For more information on this definition, please visit the official site: Startups in Catalonia.

[5] The Barcelona Startup Map is a web platform promoted by *Barcelona Activa* and *Catalunya Emprèn*. Barcelona Activa is the executive organization of the economic promotion policies of the Barcelona City Council and *Catalunya Emprèn* is a framework program of the Government of Catalonia that promotes and encourages public and private value actions for the entrepreneur, providing them with direct support and assistance.

[6] The international fairs and congresses held in Barcelona in recent years include the Mobile World Congress (MWC), the 4YFN, the Barcelona Startupweek, the IoT Solutions World Congress, the Smart City Expo World Congress, and the Barcelona Games World.

[7] The 22@ district was created in 1998 as a public initiative to encourage the concentration of activities closely related to innovation and creativity by providing networking and workspace facilities and granting support. Among the measures adopted, the city council opened a business service office to simplify the granting of activity licenses as well as tax incentives and facilities (Pareja-Eastaway and Piqué 2011; Viladecans-Marsal and Arauzo-Carod 2012). For more details, please visit: 22@.

[8] Heatmaps have been computed with QGIS, by implanting a bounding of 500 meters.

[9] The results for the Poisson are extremely close to that of the ZIP, both in terms of coefficients and of significance. Results for the ZIP are shown in Table A3.

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How to cite this article: Coll-Martínez, E., Jové-Llopis, E., & Teruel, M. (2022). The city of start-ups: Location determinants of start-ups in emergent industries in Barcelona. *Growth and Change*, 00, 1–36. https://doi.org/10.1111/grow.12618

ANNEX

FIGURE A1 City of Barcelona by neighbourhoods (73). Source: Own elaboration.

TABLE A1 Correlation between explanatory variables

	1	2	3	4	5	6
1. LOC_ECO	1					
2. POP_DENS	0.3132*	1				
3. 22@	0.1508	0.0487	1			
4. ECOSYTEM_INDEX	0.6859*	0.1481	0.1728	1		
5. UNEMP	−0.4368*	−0.0017	0.1645	−0.2644*	1	
6. UNI	0.7762*	0.5907*	0.1021	0.5300*	−0.4178*	1

*Indicates significance at the 5% level.

TABLE A2 Spatial results for the location of start-ups for emerging industries subgroups (2012–2015)

Variables	(1) Creative	(2) Ecological	(3) Experiences	(4) Mobility	(5) Health	(6) Ind 4.0
Agglomeration economies						
LOC_ECO	0.372*	−0.231	1.495***	0.632	0.391	0.794***
	(0.206)	(0.450)	(0.509)	(0.423)	(0.331)	(0.178)
POP_DENS	−0.183	−1.200**	−0.601	−1.062	−0.642	0.279
	(0.322)	(0.506)	(0.589)	(0.665)	(0.415)	(0.278)
Ecosystem						
22@	0.359	0.783	0.711	0.711	0.543	0.384*
	(0.285)	(0.606)	(0.538)	(0.703)	(0.445)	(0.224)
ECOSYTEM_INDEX	0.261**	0.617**	−0.276	0.0549	0.0572	0.280**
	(0.129)	(0.294)	(0.294)	(0.277)	(0.195)	(0.110)
Socioeconomic factors						
UNEMP	−0.490	−3.562	−3.101	−5.308	−1.901	−3.898
	(2.815)	(7.548)	(7.879)	(9.124)	(4.688)	(3.359)
UNI	0.204	1.444**	0.323	0.327	0.613	−0.237
	(0.275)	(0.695)	(0.514)	(0.585)	(0.449)	(0.226)
Spatially lagged variables						
W_LOC_ECO	−0.0769	−0.246	0.119	0.555	0.122	0.0963
	(0.458)	(0.921)	(1.043)	(1.005)	(0.685)	(0.376)
W_POP_DENS	0.154	1.615*	−0.585	0.690	0.125	−0.430
	(0.525)	(0.913)	(0.959)	(1.130)	(0.720)	(0.428)
W_ECOSYTEM_INDEX	0.370	0.521	−0.816	−0.172	0.223	−0.126
	(0.260)	(0.490)	(0.656)	(0.654)	(0.407)	(0.220)
W_UNEMP	2.986	−2.930	14.28*	−4.504	−0.00320	7.832**
	(4.692)	(10.58)	(8.179)	(14.47)	(7.550)	(3.577)
W_UNI	0.367	−0.765	0.382	0.210	−0.152	0.397
	(0.546)	(1.022)	(1.055)	(1.360)	(0.742)	(0.445)
Constant	−7.145*	−7.504	−9.567	−6.829	−4.780	−4.395
	(4.203)	(9.654)	(8.085)	(12.24)	(6.297)	(3.298)
N	73	73	73	73	73	73
Pseudo-R^2						

Note: Standard errors in parentheses.

***$p < .01$; **$p < .05$; *$p < .1$.

TABLE A3 Zero-inflated Poisson results for the location of start-ups (2012–2015)

Dep. Var.: *SUPS*	**(1)**	**(2)**	**(3)**
Variables	**Non-spatial**	**Spatial lags**	**Spatial decay**
Agglomeration economies			
LOC_ECO	0.851***	0.799***	—
	(0.108)	(0.131)	
LOC_ECO_0.5 km	—	—	0.287***
			(0.0895)
LOC_ECO_0.5–1 km	—	—	0.228***
			(0.0843)
LOC_ECO_1–5 km	—	—	0.256
			(0.283)
POP_DENS	0.799***	−0.306**	−0.803***
	(0.131)	(0.154)	(0.187)
Ecosystem			
22@	0.247*	0.135	0.160
	(0.148)	(0.162)	(0.165)
ECOSYTEM_INDEX	0.157**	0.130*	0.358***
	(0.0700)	(0.0721)	(0.0648)
Socioeconomic factors			
UNEMP	−0.989	−0.878	−0.936
	(1.587)	(1.707)	(2.017)
UNI	−0.128	−0.211	0.575***
Spatial lagged X's	(0.146)	(0.183)	(0.132)
WLOC_ECO	—	0.166	—
		(0.237)	
WPOP_DENS	—	0.0249	—
		(0.267)	
WECOSYTEM_INDEX	—	0.0549	—
		(0.140)	
WUNEMP	—	3.572	—
		(2.424)	
WUNI	—	0.185	—
		(0.279)	
Constant	0.341	−1.398	−4.614**
	(1.029)	(2.204)	(1.975)
Inflated variables			
POP	−0.0142	−0.0141	−0.0137
	(1.082)	(0.979)	(0.983)
Constant	47.13	46.97	44.99
	(3,878)	(3,449)	(3,426)
N	73	73	73
LR-Chi2	578.35	590.07	547.99

Note: Standard errors in parentheses.

***$p < .01$; **$p < .05$; *$p < .1$.

TABLE A4 Proximity to the elements of the ecosystem for the location of start-ups (2012–2015)

Dep. Var.: *SUPS*				
Variables	**(1)**	**(2)**	**(3)**	**(4)**
LOC_ECO	0.768***	0.682***	0.816***	0.775***
	(0.0587)	(0.0809)	(0.0755)	(0.0924)
INCUBATORS_1 km[a]	—	—	0.232*	0.256*
			(0.138)	(0.138)
TALENT_1 km[a]	—	—	0.200	0.166
			(0.125)	(0.127)
CODERS_1 km[a]	—	—	0.0988	0.0357
			(0.184)	(0.212)
INVESTORS_1 km[a]	—	—	−0.0201	−0.0363
			(0.138)	(0.139)
SCI_PARK_1 km[a]	—	—	0.132	0.143
			(0.189)	(0.188)
CWS_1 km[a]	—	—	−0.181*	−0.118
			(0.0999)	(0.119)
FABLAB_1 km[a]	—	—	−0.0148	0.0225
			(0.103)	(0.107)
POP_DENS	—	−0.406***	—	—
		(0.115)		
22@	—	0.332**	—	—
		(0.139)		
EE_1 km[a]	0.249***	0.269***	—	—
	(0.0692)	(0.0781)		
UNEMP	—	−1.286	—	−3.129*
		(1.586)		(1.864)
UNI	—	0.182	—	−0.0562
		(0.117)		(0.0952)
Constant	−1.560***	−1.429	−1.327***	−0.200
	(0.174)	(0.882)	(0.249)	(0.888)
N	73	73	73	73
Pseudo R^2	0.6987	0.7257	0.7098	0.7130

Note: Standard errors in parentheses.

[a]The count of the number of the tangible elements of the ecosystem within the first 1km from the centroid of each neighbourhood.

***$p < .01$; **$p < .05$; *$p < .1$.