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RESEARCH ARTICLE

No islands of entrepreneurship—mapping the trans-local dimension of entrepreneurial ecosystems through networks of accelerator participation

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Abstract This paper explores the geography of entrepreneurial ecosystems (EEs) and provides a typology of how EEs are connected trans-locally. Although the literature has mainly focused on the place-specificities of EEs, there is limited research on the trans-local connections established by entrepreneurial support organizations (ESOs) that foster exogenous dynamics. Exploiting a longitudinal dataset of European startups participating in accelerator programs embedded within EEs, this study disentangles patterns of temporary relocation and maps the centrality of EEs through both network and cluster analysis. Our results support the notion of startups being locally embedded but also emphasize the flow of knowledge and resource exchange across different EEs. Eventually, the spatial network of temporary relocations highlights a mix of EE profiles, indicating that trans-local exchange through accelerator participation is the norm rather than the exception within EEs. This study contributes to a deeper understanding of the interconnectedness of EEs and the role of accelerators in facilitating and shaping trans-local entrepreneurial activities.

Plain English Summary Startups are not just staying local, but regularly travel between cities for accelerator programs, creating a powerful network of knowledge exchange between Entrepreneurial Ecosystems. Exploring the location choices of startups for accelerator participation, we discovered that they frequently travel to participate in accelerator programs in other cities. This creates a web of connections where knowledge, resources, and ideas flow between different startup hubs. Rather than being isolated, entrepreneurial communities are deeply interconnected through these temporary relocations. This

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finding challenges the traditional view that entrepreneurial ecosystems are primarily local phenomena. For researchers, it opens new avenues to study how knowledge flows between entrepreneurial ecosystems affect innovation. For practitioners, it suggests that accelerator programs play a crucial role in connecting different startup communities and should be considered key players in ecosystem development.

Keywords Entrepreneurial ecosystems · Accelerators · Entrepreneurial support organizations · Spatial network analysis · Trans-local entrepreneurship

JEL Classification D85 · L26 · R30

1 Introduction

Entrepreneurial ecosystems (EEs) have been identified as a complex web of spatially bound interactions among multiple economic and non-economic actors, institutions, and coordinating entities, such as accelerators, coworking spaces, and maker spaces, serving as arenas for knowledge generation and sharing (Acs et al., 2018; Malecki, 2018). Existing literature emphasizes the place-specific nature of EEs (Stam and Van de Ven, 2021; Leendertse et al., 2022), underlining the important role of systemic conditions (e.g., networks, leadership, talent) and resource endowments (e.g., financial capital, infrastructure) in supporting new venture creation and attractiveness. However, less attention has been paid to the trans-local connections enabled by entrepreneurial support organizations (ESOs), which often act as intermediaries connecting multiple EEs (Goswami et al., 2018; Roundy & Fayard, 2019). ESOs are important nodes that set up connections within and between EEs (Goswami et al., 2018; Kuebart & Ibert, 2019; Roundy & Fayard, 2019; Van Rijnsoever, 2020) and represent important "infrastructures" for EEs (Bliemel et al., 2019; Harris, 2021; Kuebart, 2022). Among the most prominent ESOs in EEs are accelerators (Autio et al., 2018; Brown & Mason, 2017). Since being introduced about 20 years ago (Drori & Wright, 2018), accelerators have been proliferating widely and are now a mainstay of entrepreneurial support in most EEs. Accelerators offer collaborative workspaces, training opportunities, and seed investments to early-stage ventures, enabling also the temporary relocation of these ventures to participate in accelerating programs away from their home location (Brown et al., 2019; Kuebart, 2022; Kuebart & Ibert, 2020). This temporary relocation phenomenon complements the traditional notion of new ventures being anchored and embedded in their home place (Stam, 2007), suggesting a growing trend towards greater trans-locality in entrepreneurship.

Despite scholars' attention to the place-specificity of EEs, these ecosystems are not isolated spatial systems (Schäfer, 2021; Stam & Van de Ven, 2021), and investigating EEs as self-contained spatial systems oversimplifies the complex interplay between various elements that contribute to the growth and development of entrepreneurial activities. Indeed, accelerators may foster dynamics that extend beyond geographic boundaries, influencing the spatial configuration of entrepreneurship and redefining how resources, knowledge, and opportunities flow between EEs. Despite its importance, studies on how trans-local linkages define entrepreneurial geographies remain limited (Brown & Mason, 2017; Fischer et al., 2018), with most evidence drawn from case studies. Hence, there is a need to empirically map the spatial patterns of how EEs are connected through trans-local pipelines (Harris & Menzel, 2023; Schäfer, 2021; Wurth et al., 2022).

To address this gap, this paper examines the extent to which EEs are bound to their places and how they are integrated through globally dispersed ESOs. Specifically, this study aims to investigate how startup relocation outlines the geographies of ties between EEs across Europe. The research questions guiding our paper are as follows: (1) To what extent are accelerators able to connect different EEs through trans-local networks? (2) What patterns can be identified within the network of European EEs?

Taking advantage of a unique dataset that includes 10,811 startups,[1] we analyze the origins, destinations, and patterns of these relocations to map the topology of trans-local ties based on accelerator participation within the European EE landscape.

The paper is structured in five sections. In the following section, we explore the previous literature on inter-ecosystems linkages and the role of accelerators

[1] https://startupheatmap.eu/list/

in EEs. Section 3 presents the methodology and data. In Section 4, we describe the results and their implications for understanding the relationship between the different EEs. The final section opens to discussion and conclusions, describing the main limitations of this study and possible new research directions.

2 Literature review

2.1 Intra and inter-ecosystems linkages: the complex web of entrepreneurship

The concept of EEs emphasizes that entrepreneurial dynamics emerge from a collective process within a suitable environment (Autio et al., 2018; Stam & Van de Ven, 2021; Spigel, 2017). It demonstrates the relevance of environmental specificities for successful entrepreneurship, in addition to individual and personality-based features (Van de Ven, 1993). Literature underlines that the formation of new companies depends on geographically bounded knowledge spillovers and supportive formal and informal institutions that underpin high-growth entrepreneurial dynamics (Audretsch & Belitski, 2021; Audretsch & Lehmann, 2005). Some places become hubs of startup activity based on their unique place-specific conditions (Acs et al., 2018; Malecki, 2018; Spigel, 2017; Stam & Van de Ven, 2021; Wurth et al., 2022). These findings resonate with the agglomeration economies literature, which explains place-based mechanisms enabling organizations to access and leverage knowledge through geographical proximity (Scott & Storper, 1987; Saxenian, 1990; Becattini, 1991). In the context of EEs, knowledge creation plays a crucial role, occurring through both serendipitous learning in physical co-presence and more organized forms of knowledge exchange (Fiorentino, 2019; Scheidgen, 2021; Bliemel et al., 2019; Kuebart & Ibert, 2020). While the benefits of "being there" (Bathelt et al., 2004) explain much of the agglomeration of economic activities, knowledge production spaces extend beyond a dualistic understanding of proximity and distance (Grabher et al., 2018; Ibert, 2007; Rutten, 2017).

In contrast to the agglomeration economies literature, research on knowledge in EEs has largely remained on the level of individual EEs, so that the specificities of trans-local knowledge creation have been less in focus in EEs. This has been criticized recently by Harris & Menzel, (2023), who argue in favor of considering such multi-scalar and relational aspects when conceptualizing EEs. In EEs, not all ties through which knowledge is sourced by localized organizations are local (Bathelt et al., 2004; Grabher & Ibert, 2014). EEs are even actively promoted through place branding activities to attract startups, talents, and capital (Corradini et al., 2023). Therefore, entrepreneurs, investors, and other stakeholders are not confined by borders; they actively engage in cross-border collaborations, partnerships, and exchanges. In EEs, trans-local ties facilitating knowledge creation emerge across personal, organizational, and financial dimensions, encompassing individual mobility, inter-organizational collaboration, and investment flows (Bathelt & Henn, 2014; Schäfer & Kuebart, 2024). Evidence for such ties has been found in several domains including transnational entrepreneurship (Schäfer & Henn, 2018), startup relocation (Weik et al., 2024), venture capital (Kuebart, 2019; Schäfer et al., 2024), and accelerator participation (Brown et al., 2019; Kuebart & Ibert, 2019). The personal dimension of ties has been analyzed thoroughly in the form of migrant entrepreneurship (Schäfer & Henn, 2018), and venture capital firms have been found to widen their role as "knowledge brokers" (Zook, 2004) to the trans-local dimension (Kuebart, 2019; Schäfer et al., 2024). In the realm of knowledge exchange and dynamics, these insights challenge the traditional notions of spatial confinement within EEs. This implies that the dynamics of entrepreneurship are not solely determined by the localized characteristics of a particular EE.

Crucially, EE quality influences the extent to which startups engage in trans-local dynamics. High-quality EEs are more likely to establish strong trans-local pipelines, as they possess the resources, networks, and institutional support necessary to connect with other ecosystems (Schäfer, 2021). For example, ecosystems that rank highly in terms of leadership, talent, and network connectivity are better positioned to attract and retain startups while also enabling them to benefit from external knowledge and financial flows. This trans-local knowledge creation is often mediated through communities of practice (Müller & Ibert, 2015), temporary clusters like trade fairs (Bathelt & Gibson, 2015; Maskell et al., 2006), or anchored in

specific places such as open creative labs (Schmidt & Brinks, 2017). In EEs, specialized intermediaries, such as ESOs, actively facilitate these processes, fostering knowledge production and entrepreneurial growth (Spigel & Harrison, 2018; Autio et al., 2018).

Further, case studies have highlighted the temporal mobility of startups facilitated by ESOs, which support new ventures beyond their immediate EE, introducing an exogenous element to be investigated (Kuebart & Ibert, 2019; Brown et al., 2019; Kuebart, 2022). ESOs are important "infrastructures" for EEs and their places (Bliemel et al., 2019; Goswami et al., 2018; Harris, 2021; Kuebart & Ibert, 2019; Roundy & Fayard, 2019; Van Rijnsoever, 2020), co-locating entrepreneurs in specific places. These ESOs include incubators, coworking spaces, and accelerators.

Considering voluntary knowledge sharing at the very heart of EEs (Autio et al., 2018), the role of ESOs as intermediaries in knowledge creation processes can hardly be underestimated. However, as noted by Leendertse et al. (2022), not all EEs are equally robust in their systemic conditions or in their ability to leverage trans-local connections. Variations in quality across ecosystems create uneven landscapes of opportunity, where startups from lower-quality ecosystems may struggle to access the same level of support and resources as those from higher-quality ones. This disparity highlights the importance of mapping and understanding the spatial patterns of trans-local linkages, particularly in terms of how ESOs can serve as hubs that drive entrepreneurial activity across broader regions, designing a new geography of EEs.

However, while case studies have emphasized the role of ESOs, specifically of accelerators, to facilitate exogenous linkages, the structure of the linkages between EEs remains understudied. The following section focuses on how accelerators facilitate knowledge creation between EEs through temporal mobility.

2.2 The role of accelerators within entrepreneurial ecosystems

In the context of EEs, ESOs and particularly accelerators have been described as "key structural elements" (Autio et al., 2018), and important "infrastructures" (Bliemel et al., 2019) for EEs. Accelerators have emerged as a new form of ESO over the past 20 years (Drori & Wright, 2018). The accelerator model aims to enhance the speed of development of newly formed ventures by combining intermediation, mentoring, education, rapid product development, networking, and funding, during a fixed-term period (usually from 3 to 6 months) and cohort-based (Cohen et al., 2019; Moschner et al., 2019).

In the literature, four functions of accelerators in EEs have been highlighted. Firstly, accelerators have a relational function since they have been found to be important "ecosystem intermediaries" (Goswami et al., 2018) that help establish networks among entrepreneurs, mentors, and other stakeholders of EEs (Motoyama & Knowlton, 2016). Thus, accelerators act as "bridges" between entrepreneurs and resources (Goswami et al., 2018) by "brokering" connections (Caccamo & Beckman, 2022) among different members of the EE. This is achieved through "choreographies" of meetings, in which the different groups (e.g., startup mentors, trainers, investors) are involved during programs (Kuebart & Ibert, 2020). Secondly, accelerators allocate financial resources, either by acting as seed investors themselves (Pauwels et al., 2016) or by curating startups for VC investors (Hoffman & Radojevich-Kelley, 2012). Thirdly, accelerators are involved in knowledge production and learning within EEs (Caccamo & Becker, 2022), both by actively sourcing knowledge for the participating startups and by facilitating exchange between different groups of stakeholders of EEs. They operate as "knowledge brokers," that not only connect members of EEs but also facilitate meaningful exchange to stimulate knowledge production (Kuebart & Ibert, 2019). Finally, accelerators have been found to connect EEs through linkages crossing the boundaries of EEs. By integrating migrant entrepreneurs into EEs' places (Brown et al., 2019) and hosting significant proportion of startups from non-local EEs during the programs (Kuebart, 2022), accelerators facilitate the exchange between EEs. In this regard, Caccamo and Becker (2022) distinguish between two archetypes of accelerators driving knowledge dynamics: "knowledge center" and "knowledge network." In the knowledge center model, startups typically relocate their entire teams, often permanently, to the accelerator's location (Caccamo and Becker, 2022). In contrast, the knowledge network model enables startups to remain within their original EE while leveraging the accelerator as a knowledge pipeline (Caccamo and

Becker, 2022), facilitating the knowledge exchange among geographically dispersed EEs. This networked approach particularly benefits laggard EEs, leading to higher levels of innovation within the startups' origin EE (De Noni et al., 2018).

The geographic reach of participating startups can be regional, national, and international depending on the selection criteria of the accelerator (Clarysse et al., 2015; Kramer et al., 2023), as well as industry-specific (Isabelle, 2013). Specifically, despite being described as a rather recent phenomenon, the accelerator model has quickly proliferated globally (Cohen & Hochberg, 2014; Kramer et al., 2023), concentrating mainly in large, well-developed EEs (Brown & Mason, 2017) but also operating in smaller EEs (Cohen et al., 2019). While the inter-linkages between EEs and the flows of startups facilitated by accelerators have primarily been examined through qualitative case studies, this paper extends the discussion by employing a larger-scale, quantitative analysis. By systematically mapping the spatial and network configurations of trans-local ties across multiple EEs, this study aims to provide a more comprehensive understanding of the dynamics underpinning these interconnections. Such an approach not only builds on the insights gleaned from previous qualitative research but also introduces a broader empirical basis to uncover patterns, hierarchies, and the structural roles of accelerators in shaping trans-local knowledge flows and entrepreneurial mobility.

3 Methodological approach

3.1 Data

This paper relies on an empirical analysis of the spatial patterns of temporary relocations of startups participating in accelerator programs in Europe. Our dataset is extracted from the 2024 Startup Heatmap Europe list.[2] After filtering out virtual accelerator programs, our sample includes 11,864 accelerator participations of 10,811 distinct startups that have participated in 162 accelerator programs across Europe between 2015 and 2023. This is a large sample, considering that the overall number of venture-backed startups in Europe is estimated to be around 50,000 in 2023.[3] The dataset includes the startups' city of origin, the destination city of the join accelerator programs, and the type of industry or sector to which the startup belongs. For the analysis, all locations were geocoded and aggregated to functional urban areas (FUA),[4] which we employ as the dimension of individual EEs. While the accelerators are located in 82 different EEs across Europe, the startups originate from 1098 different localities in 444 FUAs from about 80 countries all over the world.

We distinguished between *internal participation*, which is the rate of startups participating in accelerator programs in their own EE, *national participation* as the rate of startups participating in accelerator programs within the same country but not in their own EE, and *international participation*, which is the rate of startups participating in accelerator programs in a different country.

3.2 Network analysis

Firstly, we applied a network analysis approach to map the geographies of ties through temporary relocations between EEs in Europe. This method allowed us to unfold the extent to which accelerators connect EEs through trans-local networks, addressing our first research question. By exploring the relationships and centralities within the startup relocation landscape, we visualized and analyzed if there are either islands of entrepreneurship or there was a trans-local dimension of EEs and how this trans-local dimension was characterized. This analysis also had the purpose of revealing patterns of startup relocation and identifying hubs of entrepreneurial activity. Secondly, carrying out a cluster analysis allowed to uncover clusters of interconnected EEs. This analysis contributed to understanding the broader trans-local dynamics of EEs and enabled the creation of a typology of EEs based on their connectivity patterns. This approach provided a clear answer to the second research question.

A network analysis was performed based on the relocation patterns of startups, which were considered

[2] https://startupheatmap.eu/list/

[3] https://discover.dealflow.eu/

[4] We base the FUAs on the dataset created by Schiavina et al. (2019).

directional ties in a network of EEs. This approach followed the established method of analyzing intercity business flows in the context of research on global and world cities (e.g., Alderson & Beckfield, 2004; Neal, 2011; Taylor, 2005). While most studies in this field use office locations of advanced producer service firms to establish ties, Pažitka et al. (2021) propose to focus on actual connections in joint projects. We focused on temporary relocations of startups for joining accelerator programs. Thus, EEs were considered nodes in the network if they hosted an accelerator program or were the origin of one or more startups participating in an accelerator. More central EEs thus could have several forms of different brokerage roles (Sigler et al., 2023). Analyzing linkages between EEs using network analysis techniques was thus useful to identify the patterns of interconnectedness among European EEs, as well as to explore the EEs hierarchy based on the frequency and directionality of startup relocations.

The network analysis was performed in two steps. The first step included all EEs in the dataset, including not just EEs with accelerators but also all additional EEs of origin for the startups. This resulted in a directed network with 444 nodes and 1926 edges. The second step included only the "core" network of EEs in Europe, defined as EEs with either a "coreness" metric[5] above four or with more than 100 accelerator participations. This resulted in a directed network with 34 nodes and 494 edges. Network metrics were calculated using the "tidygraph" package (Pedersen, 2023) both on the network level (i.e., number of mutual, asymmetric, non-existent ties, which form together the link density, as well as the average indegree) and on the level of nodes (i.e., indegree centrality, eigenvector centrality, PageRank centrality). Through this, we established the extent of connections of different EEs in the network (Appendix).

In the second part of the analysis, a typology that describes the connection patterns of EEs was established with a cluster analysis for the 66 EEs with ten accelerator participations or more to investigate the roles of EEs within the network of European EEs. The metrics used as input for the cluster analysis included the frequency of participants from the same EE, the frequency of international participants, the eigenvector centrality, and the PageRank centrality. Eigenvector centrality was calculated as the sum of the centralities of the nodes to which a node is connected, meaning that nodes connected to many well-connected nodes will have a high eigenvector centrality. PageRank centrality was the sum of the incoming ties, weighted by the centrality of the connected nodes. A distance matrix was created based on Euclidean distance, and a cluster analysis was performed using the PAM algorithm of the "cluster" package in R (Maechler et al., 2017). A result with three clusters was chosen because this solution offered the best silhouette width. The results of the cluster analysis were useful to understand to what extent accelerators can connect different EEs through trans-local networks and distinguish common patterns of connectivity among the European EEs.

4 Results

4.1 Temporary startup mobility

Our analysis suggests that EEs in Europe are highly interconnected, with approximately half of all accelerator participants in our dataset experiencing temporary relocations. Hence, the flow of startups between EEs creates a network of interconnected and interdependent ecosystems. The startups in the dataset are from a wide variety of industries. Most of the startups in the sample are involved in "digital businesses" (e.g., "Software" $n = 3252$; "Data and Analytics" $n = 1250$). However, also other sectors seem to play a role in shaping the geography of the European EEs (e.g., "Hardware" $n = 959$; "Biotechnology" $n = 388$).

In total, about 54% of the startups in the dataset participated in an accelerator program in a different EE from their EE of origin (i.e., 6420 startups). There are considerable differences in the rate of temporary relocations among the EEs from which the startups in the sample originate. Since startups from EEs without local accelerators must relocate to participate in accelerator programs, the relocation rate for these startups is inherently 100%. The relocation rate becomes more intriguing in EEs where startups have the option to apply to a local accelerator. In these EEs, the relocation rate ranges from less than 10% to

[5] The coreness k of a node is a measure that identifies which nodes belong to a core network, in which all nodes have at least the indegree centrality of k.

over 75% (Fig. 1). Furthermore, no clear relationship exists between the size of an EE and the temporary relocation rate. While a lower temporary relocation rate might be expected in EEs with higher acceleration capacity and a diverse range of accelerator programs, this evidence is not visible in the data. These initial findings provided an initial answer to the first research question, which investigates the extent to which accelerators connect EEs through trans-local networks. These results offer a preview of the geographies of ties via temporary relocations between EEs in Europe.

4.2 Links between entrepreneurial ecosystems

The network characteristics of the complete network of accelerator-related relocations between EEs reveal a relatively sparse structure with low link density. Specifically, less than 1% of the potential connections between cities are in the dataset (Table 1). The low average degree (the number of ties of each node) with a median degree below 1 further emphasizes the sparsity of the network. This sparse configuration is largely caused by the large number of small EEs (nodes) without an accelerator and with only a few startups relocated to EEs equipped with accelerators (Fig. 2a). Despite this, about 42% of all temporary relocations in the dataset involve startups originating from EEs without accelerators, while the majority of relocations (58%) occur between EEs with accelerators.

Table 1 Characteristics of both the full and core network

	Full network	Core network
Number of nodes	444	34
Link density	0.009	0.43
Average indegree	4	14
Median indegree	0	11

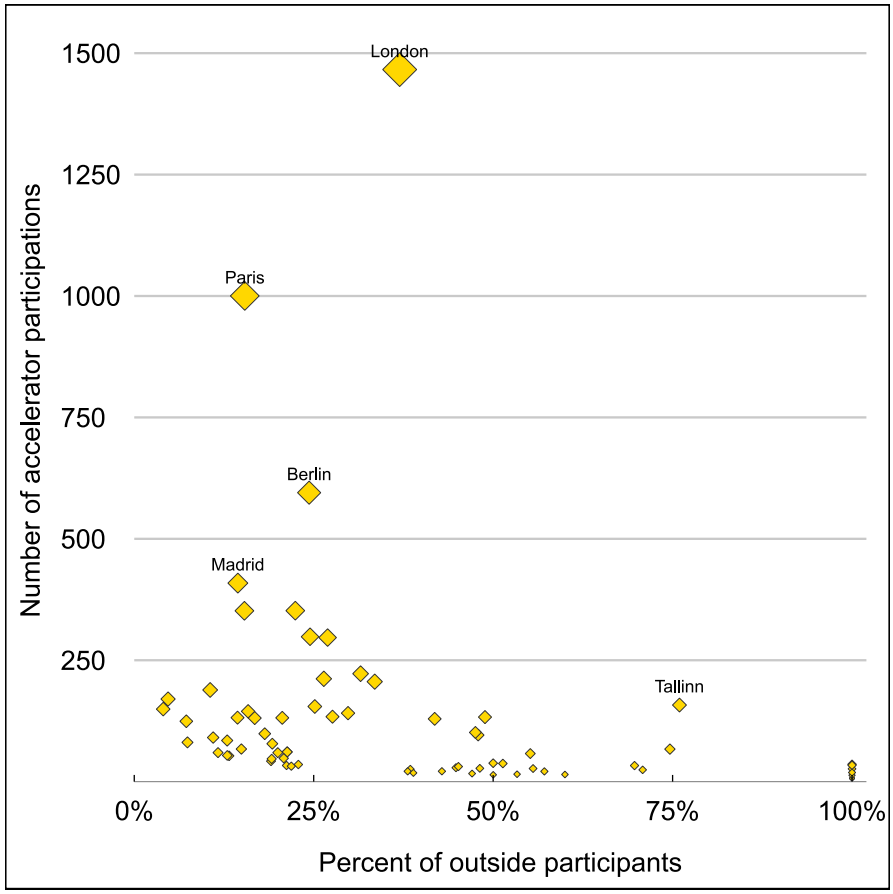

Fig. 1 Size of EE in terms of number of startups originating there and share of temporary relocation for accelerator participation. Note: The share reaches 100% for EEs, in which no accelerator is operating (bottom left). Curiously, even a sizeable share of startups from the largest EEs, in which several accelerators are operating, are participating in accelerators in different places. This share reaches 37% for London, 14% for Paris, and 24% for Berlin, which are the largest EEs in the sample

The core network of more central EEs, which is constituted of 34 nodes, indicates a much denser network structure compared to the full network. This significantly higher link density shows that a larger proportion of potential connections among the core EEs is realized, and the average degree is particularly high in this network of just 34 nodes. The most central nodes within the core network are London and Berlin, which are connected to 31 and 29 of the core network's 34 nodes, respectively. Additionally, 12 EEs reach the highest score on the "coreness" metric, resulting in a dense and highly interconnected international network (Fig. 2b). Curiously, there is only a loose relationship between the size of the EE and the coreness. Some smaller EEs are still among the most central EEs, including Lisbon and Zurich. This finding underlines that despite their limited scale, these EEs demonstrate that factors such as strong institutional frameworks, robust knowledge networks, and the presence of high-performing accelerators or ESOs can compensate for size (Stam and Van de Ven, 2021; Leendertse et al., 2022; Andrews et al., 2022). This finding underscores that being a central player in the network is not solely a function of size but also of strategic positioning, connectivity, and the ability to leverage resources effectively to participate in international entrepreneurial dynamics.

These results suggest that while the core EEs in Europe are highly interconnected, there are notable differences in centrality among them. The analysis reveals a group of highly central EEs, which include both very large EEs (e.g., Berlin, London, and Paris) and smaller EEs such as Cologne or Lausanne. However, when considering the entire network, these central nodes are less dominant than expected. Even the most central nodes account for less than 10% of trans-local accelerator participation, and the distribution reveals a relatively long tail. This indicates that smaller and less central EEs still play a significant role in shaping to the overall network structure, contributing to its connectivity and diversity.

These results enable us to provide an initial answer to the second research question regarding identifiable patterns within the network of European EEs. The findings suggested the potential of grouping these results and uncovering additional patterns through a cluster analysis, as outlined below.

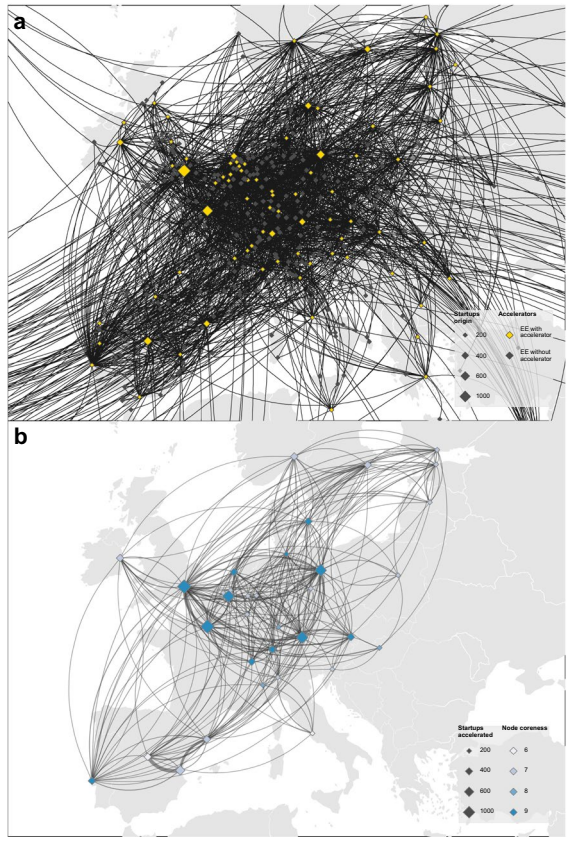

Fig. 2 Network visualizations of the network of accelerator participation in Europe. Note: **a** The full network, including both the EEs with accelerators (orange) and small towns without an accelerator (grey) from which startups originate. **b** Just the core network, with nodes colored by the coreness of the EEs. While a small group of EEs is highly central, others occupy slightly more peripheral positions. Both visualizations were created using the graph package in R (Pedersen, 2022)

4.3 Entrepreneurial ecosystem connectedness profiles

The results of the cluster analysis reveal that there are three distinct types of "connectedness profiles" (Fig. 3), which can be categorized as local (i.e., including startups that remain in their EE for accelerating), national (i.e., including startups that move to another EE in the same country to accelerate), and international (i.e., including startups that move abroad for joining accelerating programs). It is noteworthy that no clear spatial pattern emerges among the three profiles. Similarly, there is also no clear correlation with the core network, as EEs within the core network are represented in each type.

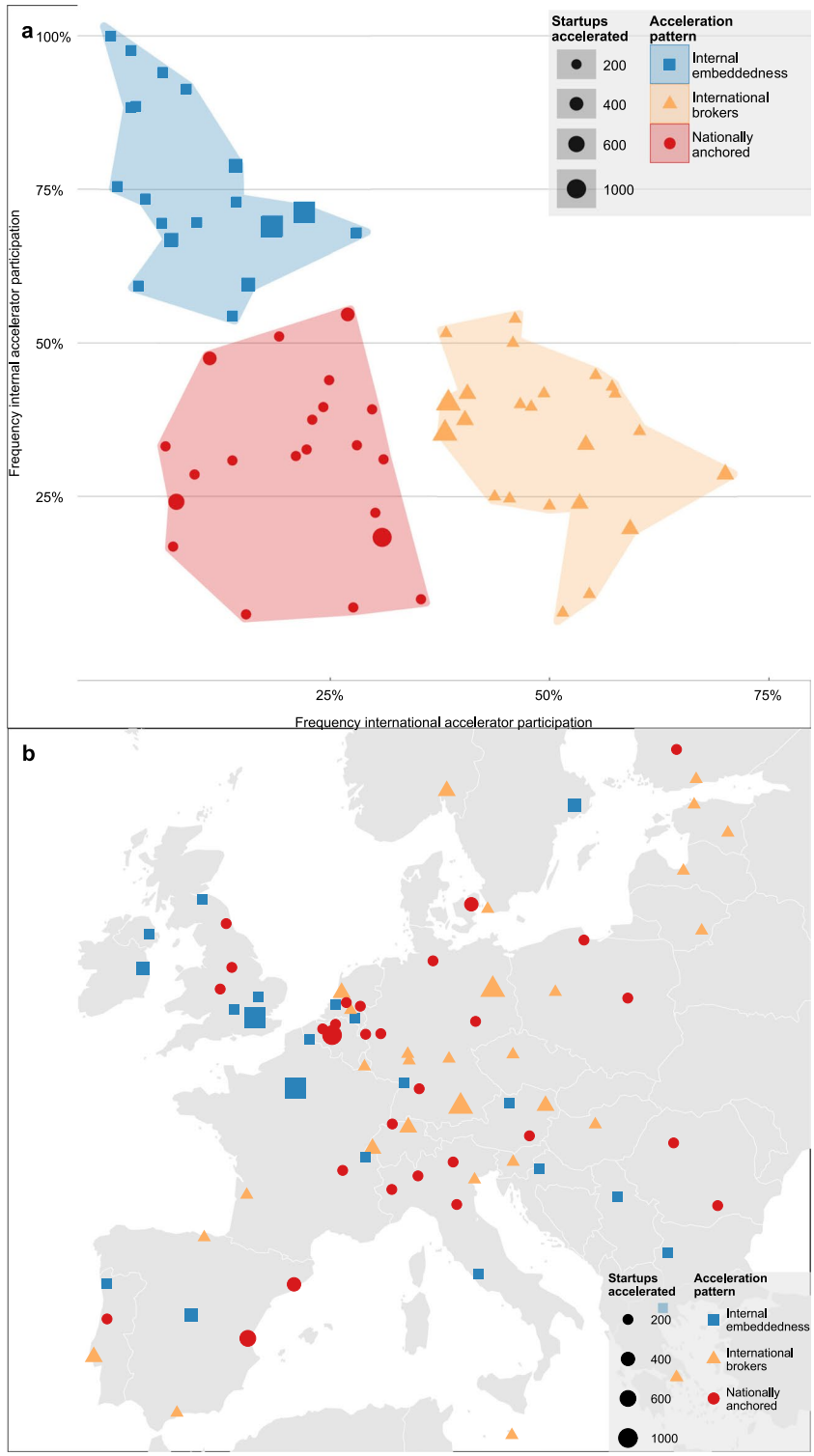

Fig. 3 The three different types of connectedness profiles. Note: **a** The three types by their frequency of internal versus international accelerator participation rate

We identify the first type of profile as "locally embedded," since it features EEs that have a high rate of startups originating internally (i.e., startups participating in their EE of origin). Of the 66 EEs analyzed, 19 (29%) fall into this category. These locally embedded EEs feature a relatively low rate of both international and national participants. The two largest EEs in the dataset, London and Paris, are grouped into this type, likely because startups located in these EEs find the accelerating programs they need locally. However, this EE profile is not limited to the largest EEs but also includes smaller and potentially more peripheral EEs, such as Zagreb and Linz.

We categorized the 25 EEs (38%) of the second type as "international brokers." These EEs exhibit a high rate of international participation, with 35 to 90% of accelerator participants coming from different countries. International brokers include large yet highly interconnected EEs, including Berlin and Amsterdam, as well as many smaller EEs with only a few operating accelerators, like Vilnius or Luxembourg.

The third type of acceleration profile combines a low internal participation rate with a low international participation rate. Most startups participating in accelerators within these 22 EEs (33%) are sourced nationally, leading us to label these EEs as primarily "nationally anchored." The mix of acceleration profiles indicates that trans-local exchange through accelerator participation is more the norm than the exception among EEs. However, there are different types of embeddedness within trans-local networks for these EEs. As stressed above, the size of an EE, measured by the number of startups accelerated, does not appear to be a decisive factor in determining the acceleration program type (Fig. 3a). Instead, consistently with recent literature on the quality of EEs, other factors play a crucial role in defining an ecosystem's ability to attract talent and entrepreneurs.

5 Discussion and conclusion

This study contributes to the growing body of research on EEs by exploring the geographies of ties between EEs in Europe and mapping the trans-local relations among EEs. By recognizing the role of ESOs as hubs that drive entrepreneurial activity across broader regions, we map how accelerators contribute to the emergence of a redefined geography of EEs. Specifically, the temporary relocation of new ventures to participate in accelerators' programs away from their home EE (Brown et al., 2019; Kuebart, 2022; Kuebart & Ibert, 2020) challenges the traditional notion of new ventures being anchored and embedded in their home place (Stam, 2007). Previous research on EEs has deeply investigated endogenous factors that hamper, support, and foster entrepreneurial activities (Acs et al., 2018; Autio et al., 2018; Malecki, 2018; Spiegel, 2017). Trans-local linkages between EEs have been rather neglected (Brown & Mason, 2017; Kapturkiewicz, 2022). Contributing to the debate, this study provides initial evidence of the significant role of trans-local connectivity for EEs, demonstrating that EEs are not islands of entrepreneurship, but rather should be seen as "open regions" (Schmidt et al., 2018). The performance of a network analysis based on the relocation patterns of startups participating in accelerator programs allowed us to identify to what extent accelerators connect different EEs through trans-local networks.

Consistent with recent debates, centrality reflects not just the scale of activity but also the quality of connections and the ecosystem's strategic positioning within the broader network (Stam & Van de Ven, 2021). Larger EEs like Berlin and London naturally occupy central roles due to their sheer volume of activity, but smaller EEs, such as Lisbon and Zurich, also achieve high coreness centrality scores. This suggests that the ability to build strategically high-quality infrastructures fostering knowledge exchange and trans-local connections can compensate for limitations in size. The relatively long tail of smaller EEs demonstrates that size is not a barrier to meaningful participation in the network. High-quality smaller ecosystems contribute to the overall structure by acting as hubs of specialized knowledge and innovation (Leendertse et al., 2022). This aligns with the concept of "open regions," where smaller nodes maintain relevance through strategic linkages (Schmidt et al., 2018).

This variety of EEs' ability to connect trans-locally highlights the importance of mapping and understanding the spatial patterns of trans-local linkages, particularly in terms of how ESOs can serve as hubs that drive entrepreneurial activity across broader regions, designing a new geography of EEs. In this regard, a cluster analysis has been carried out, outlining three "connectedness" profiles. The results of this study return a unique typology of EEs drafted on the possible patterns of startups' mobility, as well as an exogenous characterization of EEs. These configurations

can be added to the range of features that might characterize the quality of the EE in terms of the diversity of participants to accelerator programs, providing a novel "external" perspective to the EE.

Contributing to the accelerator literature as well, this classification of EEs' connectedness profiles may assist in positioning the extant archetypes of accelerators with regard to EEs (Caccamo & Bekman, 2022). While accelerators in locally embedded EEs may be characterized as knowledge centers, allowing the knowledge created to retain in the EE, in nationally anchored and international broker EEs, accelerators can act more as knowledge network hub.

Exploring this aspect is paramount, particularly in light of the ongoing discourse surrounding the enduring disparity between places at the forefront and those trailing behind (Barzotto et al., 2019; De Propris & Bailey, 2020; Corradini et al., 2023). Policymakers should prioritize investments in accelerator programs that facilitate knowledge exchange, talent mobility, and innovation across local, national, and international networks to mitigate the polarization between leading regions and those lagging behind, fostering a more balanced and inclusive entrepreneurial landscape. Tailored policies could address the varying roles of accelerators depending on ecosystem characteristics. For locally embedded EEs, accelerators should function as knowledge retention hubs, fostering localized innovation. Conversely, in nationally anchored or internationally brokering EEs, accelerators can serve as network hubs, facilitating the flow of resources and ideas across boundaries. By adopting a differentiated approach, policymakers can strengthen the connectivity and resilience of ecosystems, ensuring that even smaller EEs remain competitive and integrated into global entrepreneurial networks.

Our explorative approach to analyze linkages between different EEs' places is naturally subject to several limitations. Firstly, we use quantitative, relational data on temporary relocations of startups as a proxy for trans-local links between EEs. While participation in an accelerator program is typically very contact intense, we have no data on the degree of actual exchange of the participation. Secondly, while we use a broad dataset on accelerator participation, it remains open how the pattern revealed here differs from other forms of locational linkages, such as conference participation or collaborations between startups (Schäfer & Kuebart, 2024). Ideally, a more comprehensive approach would include several of these further mechanisms supporting knowledge sharing and opening the EE bounders. Moreover, our findings show that non-European startups originated most likely from the USA, Israel, and India were most likely to participate in an accelerator in one of the most central EEs. This indicates that the trans-local embeddedness of EEs should be considered a global phenomenon, despite the focus on Europe in the analysis presented here. The trans-local embeddedness of EEs goes far beyond accelerator participations, as recent findings on permanent relocations (Weik et al., 2024) and venture capital investments (Schäfer et al., 2024) highlight. The examination of this element is crucial due to the prevailing discussions and concerns regarding the persistent gap in development and performance among different geographic areas. Moreover, considering the importance of the quality of the EE in attracting talent and entrepreneurs from abroad, it would be important to disentangle the causal relation between the EE network structure and the EE quality to understand why startups move and agglomerate in some EEs. This analysis would help understand the centrality of some EEs and the long tail underlined by our work.

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Appendix

Name	Cluster no	Accelerated startups (*N*)	PageRank centrality	From same region (%)	From same country (%)	Moved between cities (%)	Moved internationally (%)
London	1	1212	0.037	71.29%	77.97%	28.71%	22.03%
Paris	1	1159	0.041	69.03%	81.62%	30.97%	18.38%
Berlin	2	759	0.050	40.18%	61.53%	59.82%	38.47%
Brussels	3	677	0.037	18.32%	69.13%	81.68%	30.87%
Munich	2	604	0.045	35.26%	61.92%	64.74%	38.08%
Valencia	3	510	0.014	24.12%	92.55%	75.88%	7.45%
Copenhagen	3	397	0.026	54.66%	73.05%	45.34%	26.95%
Amsterdam	2	362	0.031	33.43%	45.86%	66.57%	54.14%
Lausanne	2	335	0.034	23.88%	46.57%	76.12%	53.43%
Stockholm	1	331	0.007	78.85%	85.80%	21.15%	14.20%
Oslo	2	278	0.010	41.73%	59.35%	58.27%	40.65%
Zurich	2	275	0.028	37.45%	59.64%	62.55%	40.36%
Barcelona	3	240	0.015	47.50%	88.75%	52.50%	11.25%
Dublin	1	230	0.014	59.57%	84.35%	40.43%	15.65%
Vienna	2	227	0.023	28.63%	29.96%	71.37%	70.04%
Lisbon	2	223	0.028	19.73%	40.81%	80.27%	59.19%
Madrid	1	217	0.009	66.82%	93.09%	33.18%	6.91%
Cologne	3	193	0.014	33.16%	93.78%	66.84%	6.22%
Milan	3	193	0.018	32.64%	77.72%	67.36%	22.28%
Warsaw	3	182	0.013	39.56%	75.82%	60.44%	24.18%
Helsinki	2	158	0.014	41.77%	50.63%	58.23%	49.37%
Budapest	2	157	0.021	51.59%	61.78%	48.41%	38.22%
Turin	3	157	0.017	43.95%	75.16%	56.05%	24.84%
Hamburg	3	148	0.023	39.19%	70.27%	60.81%	29.73%
Cambridge	1	135	0.001	75.56%	99.26%	24.44%	0.74%
Riga	2	127	0.007	41.73%	42.52%	58.27%	57.48%
Ghent	3	113	0.009	16.81%	92.92%	83.19%	7.08%
Rotterdam	1	112	0.008	69.64%	90.18%	30.36%	9.82%
Antwerp	3	103	0.011	22.33%	69.90%	77.67%	30.10%
Linz	1	102	0.004	73.53%	96.08%	26.47%	3.92%
Rome	1	101	0.006	54.46%	86.14%	45.54%	13.86%
Ljubljana	2	96	0.009	50.00%	54.17%	50.00%	45.83%
Tallinn	2	96	0.009	39.58%	52.08%	60.42%	47.92%
Leipzig	3	94	0.014	30.85%	86.17%	69.15%	13.83%
Luxembourg	2	89	0.015	53.93%	53.93%	46.07%	46.07%
Stuttgart	3	85	0.019	8.24%	64.71%	91.76%	35.29%
Aachen	3	84	0.015	28.57%	90.48%	71.43%	9.52%
Darmstadt	2	77	0.014	24.68%	54.55%	75.32%	45.45%
Gdansk	3	75	0.009	33.33%	72.00%	66.67%	28.00%
Prague	2	73	0.007	35.62%	39.73%	64.38%	60.27%
Lille	1	69	0.002	69.57%	94.20%	30.43%	5.80%

Name	Cluster no	Accelerated startups (*N*)	PageRank centrality	From same region (%)	From same country (%)	Moved between cities (%)	Moved internationally (%)
Poznan	2	66	0.014	6.06%	48.48%	93.94%	51.52%
Eindhoven	1	63	0.008	73.02%	85.71%	26.98%	14.29%
Reykjavik	1	58	0.001	91.38%	91.38%	8.62%	8.62%
Newcastle upon Tyne	3	58	0.002	6.90%	72.41%	93.10%	27.59%
Lyon	3	52	0.007	5.77%	84.62%	94.23%	15.38%
Basel	3	48	0.007	37.50%	77.08%	62.50%	22.92%
Graz	3	47	0.004	51.06%	80.85%	48.94%	19.15%
Edinburgh	1	43	0.001	88.37%	97.67%	11.63%	2.33%
Geneva	1	43	0.001	97.67%	97.67%	2.33%	2.33%
Vilnius	2	38	0.004	44.74%	44.74%	55.26%	55.26%
Karlsruhe	1	35	0.004	88.57%	97.14%	11.43%	2.86%
Málaga	2	34	0.009	23.53%	50.00%	76.47%	50.00%
Oxford	1	32	0.002	59.38%	96.88%	40.63%	3.13%
's-Hertogen-bosch	2	32	0.007	25.00%	56.25%	75.00%	43.75%
Athens	2	30	0.003	40.00%	53.33%	60.00%	46.67%
Bilbao	2	29	0.006	3.45%	10.34%	96.55%	89.66%
Arnhem	3	29	0.008	31.03%	68.97%	68.97%	31.03%
Zagreb	1	25	0.002	68.00%	72.00%	32.00%	28.00%
Frankfurt am Main	2	24	0.008	0.00%	4.17%	100.00%	95.83%
Valletta	2	21	0.006	42.86%	42.86%	57.14%	57.14%
Coimbra	3	21	0.003	28.57%	90.48%	71.43%	9.52%
Cluj-Napoca	3	19	0.003	31.58%	78.95%	68.42%	21.05%
Belfast	1	17	0.001	94.12%	94.12%	5.88%	5.88%
Newcastle	1	12	0.000	100.00%	100.00%	0.00%	0.00%
Malmö	2	11	0.003	9.09%	45.45%	90.91%	54.55%

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