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# Knowledge inflows and outflows in collaborative spaces. The study of makerspaces in Central European countries

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## ABSTRACT

In recent years, a multitude of novel work environments have developed throughout Europe. Among these is the makerspace (MS), a new kind of collaborative space that fosters a do-it-yourself ethos. In its nature, MS has the potential to facilitate strong knowledge interactions. Therefore, the objective of this paper is to examine the significance of local knowledge inflows and outflows from and to MSs in the selected Central European countries, including the Czech Republic, Slovakia, and Poland. Instead of the conventional examination of intra-MS knowledge flows, the authors investigate external knowledge flows and typologies of their spatial scales within the context of an exploratory research approach. Furthermore, the paper examines the underlying causal conditions that facilitate local knowledge interactions. To this end, the authors conducted 22 in-depth interviews and carried out three case studies of various MSs. A fuzzy-set qualitative content analysis (fsQCA) was employed to ascertain the potential determinants of stronger local interactions. It has been determined that local knowledge ecosystems are developing within MSs operating in both metropolitan and non-metropolitan regions. Establishing global pipelines is not a prerequisite for MS success, particularly in non-metropolitan areas, where it may be superseded by national or local buzz.

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## Introduction

In contemporary post-modern society, individuals, particularly those who are younger and better educated, often lead hobby-driven and tech-savvy lives (Van Holm 2017). This approach has played a significant role in fostering a do-it-yourself (DIY) lifestyle, emphasizes self-sufficiency, enabling individuals to accomplish tasks independently (Gelber 1997). The aforementioned paradigm has given rise to the maker movement, which involves building, modifying, and repairing with respect to the principles of craftsmanship drawn from the natural environment (Mallon 2014). Consequently, it has

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fostered the rise of product creation, particularly among urban makers (Lowe and Vinodrai 2020). All of these above-mentioned phenomena made a good ground for new physical spaces of DIY-driven production such as makerspaces (MSs), fab labs (Gershenfeld 2005) or open worklabs (Lange and Burkner 2018) which have been recently classified as makerspaces *lato sensu* (Micek, Baycan, and Lange 2024). In this paper, by MSs, we understand collaborative physical spaces whose members follow the DIY lifestyle and do not largely concentrate on profit-making. We deliberately exclude fab labs, which are typically equipped with specific machinery (such as 3D printers, lasers, and robots), primarily aimed at research, K-12 education, or highly innovative production (Micek, Baycan, and Lange 2024). We primarily analyse non-entrepreneurial MS, which gather makers as individuals who co-create for personal use or crafts, and exclude MS that are built around and driven by developing micro-enterprises. Contrary to Braga and Guttman (2019), **we argue non-business-driven MSs play a significant role in localized knowledge ecosystems** (see the discussion by Yang, Yuan, and Wang 2019). Referring to Sieg, Wallin, and Von Krogh (2010) MSs can be identified as knowledge facilitators and knowledge gatekeepers due to their potential for sharing information along with building knowledge linkages. Besides its main tasks of self-realization, design and production, MSs facilitate cooperation, learning and, consequently, knowledge flows (interactions). Knowledge in MSs may be created through socialization, internalization, externalization, and combination of explicit and tacit knowledge (Sharma and Halder 2023). MSs serve as prime examples of environments where the local dynamism of knowledge (Capdevila 2017a) is driven both by intended and unintended knowledge flows. Shi and Chen (2022), who analysed the MSs knowledge ecosystem, pointed to a multi-stage orchestrating process occurring in the analysed spaces. Based on the model in question, there are four evolutionary stages of the orchestrating process, which include knowledge exchange, knowledge coordination, knowledge cooperation, and knowledge orchestration. We argue it is worth studying MSs as they are hub agents that embed themselves in the knowledge ecosystem.

Whereas both scholars and practitioners addressed the role of MSs for innovation (D'Ovidio 2021), development (Mattioli 2021; Sharma 2021), and engagement (Mersand 2021), works focussing on knowledge flows in MSs are scarce. Moreover, the previous research was based on the studies of collaboration between MS users (Braga and Guttman 2019) and avoided exploring the external knowledge links. Given the limited investigation into this latter domain, **the objectives of the current study are twofold**. First, the paper focuses on spatial scales of knowledge interactions. Although existing literature has begun to illuminate how knowledge is exchanged among MS users (Braga and Guttman 2019), there is a dearth of understanding regarding the spatial contexts in which knowledge is shared by managers and founders of MSs. We argue these are important agents that share knowledge with external organizations. Hence, in this paper we abandon commonly studied individual (maker) (Oswald and Zhao 2021; Parrino 2015) and community (Capdevila 2017a) perspective, but investigate knowledge relationships of managers treated as representatives of MSs. Hence, applying interviews and case studies we pose the **first research question (RQ1): what is the role of local knowledge flows in external knowledge interactions?** We would like to compare and contrast the usage of local knowledge sources in comparison to non-local (e.g. international and national) ones. Hence, in the paper we identify the most popular

combinations of spatial scales of dominant knowledge inflows and outflows, provide their typology, and describe their representatives among CSs. Based on the local specificity of numerous MS we argue there is a need to draw the characteristics of locally-driven MSs and study determinants of local knowledge flows. Hence, in addition to mapping the spatial dimensions of knowledge flows, this paper aims to investigate the factors that influence the intensity of local knowledge inflows and outflows in MSs. Consequently, the **second research question (RQ2) is posed: What are the determinants of local external knowledge interactions in MSs?** To sum up, we would like to investigate what drives the MS knowledge ecosystem. To address this problem, we apply fuzzy qualitative comparative analysis (fsQCA) based on information from both primary (interviews) and secondary sources such as companies' websites and various industrial reports.

The paper reflects on the call for evidence-based planning and design, considering the future role of these spaces and maker programmes in Europe (Vuorikari, Ferrari, and Punie 2019). Furthermore, we aim to generate insights to guide policymakers and educators in designing programmes and allocating resources for collaborative spaces effectively by entangling the knowledge ecosystem of makerspaces. Additionally, we introduce a novel approach that could redefine knowledge embeddedness of communities and their maker movement regarding sustainable competitiveness (a domain identified in European Skills Agenda). Examining knowledge flows aligns with global priorities of advancing the lifelong learning through a variety of stakeholders, ensuring its broader relevance reflected in continuous skill development, which remains fuzzy in collaborative spaces.

The paper offers several **novelties**. Although there are numerous articles on knowledge flows in collaborative spaces (see review by Kraus et al. 2022), there is still a noticeable neglect to analyse this topic from an MS perspective. Examining knowledge flows in MSs is important due to the vibrant knowledge dynamics, the interplay of informal and formal learning experiences, and the – diverse spatial scales of knowledge exchange, all of which contribute to the resilience of MSs (El Houssamy and Rizk 2020). Sharma and Haldar (2023) point out in their literature review on innovation dynamics within MSs and fab labs that existing research fails to address critical elements influencing innovation, such as collaborative learning and knowledge sharing. Hence, addressing the above-mentioned call in the paper we focus on drivers of knowledge flows in MSs. It is worth to study the determinants of local knowledge relations, because they may play a crucial role in strengthening the local development (Mattioli 2021; Van Holm 2017) and also boost innovation-related and entrepreneurial outcomes (Oswald and Zhao 2021; Van Holm 2017). As mentioned above, there is a significant body of literature on knowledge interactions in entrepreneurially-based makerspaces (Rieken et al. 2020), while for DIY-oriented makerspaces we identified a significant gap in studies of their knowledge interactions. We argue that such makerspaces represent the first step towards an entrepreneurial collaborative space, and therefore DIY-oriented makerspaces are worth studying. In the paper, we go against the most common perspective of analysing intra-MS knowledge links (Braga and Guttman 2019; Zakoth, Mauroner, and Emes 2024) and focus on the neglected external knowledge links of MSs. We argue that the knowledge relations of MS with external partners form the basis for the future growth of MS, helping them to connect to the technical and business knowledge ecosystem.

To study knowledge flows in MSs, we have selected the specific spatial context of Central Europe (CE) known for the rapid expansion of collaborative spaces (Rafaj et al. 2024). We have selected three countries, namely Czechia, Poland, and Slovakia, that experienced different scales of post-socialist transformations (Lengyel 2017). First two of these countries have a long history of manufacturing and making. These countries remain negligible considering studies on MSs, as most studies are centred on developed countries (Sharma 2021). In addition, these countries are labelled as emerging innovators according to European Innovation Scoreboard, meaning they are below average innovation potential compared to the EU. This underlines the struggle to effectively tap in the knowledge bases, primarily symbolic one, which is based on exploration and experimentation in knowledge communities. The contextual background of these countries highlights post-socialist development and transition from planning to market economies that is characteristic for transition into more entrepreneurial mindsets.

## 2. Conceptual and theoretical background

In our approach we combine **three research perspectives**. **First**, we contribute to the studies of MSs, their users and governance modes (Capdevila 2013, 2017a) conducted in the field of management economics. **Second**, we build upon the economic geography literature on the knowledge dynamics (Benner 2022; Gong and Hassink 2019; Tödtling et al. 2013) and the concept of local buzz-global pipelines (Bathelt, Malmberg, and Maskell 2004) by acknowledging there is a plethora of knowledge flows, not limited only to global and local scale (Capdevila 2017a). Our paper goes along with the findings of Capdevila (2017a) who identified the large role of local and global buzz in the makers community and moves further to acknowledge national buzz between MSs. **Third**, the paper refers to studies in knowledge management finding inspiration in the research of intra-MS knowledge flows occurring in collaborative spaces studied by Parrino (2015) and Braga and Guttmann (2019). While their work elucidates the nature of these intra-MS knowledge exchanges, our research advances this discourse by examining the spatial dimensions of external knowledge flows and identifying their determinants, particularly focusing on the causal factors influencing local knowledge flows.

### 1.1. Makerspaces, their users and governance

MSs can be situated in various physical locations (Lowe and Vinodrai 2020). Traditionally, typical MSs exist as workshops run by bottom-up open, decentralized, community-owned, and non-profit initiatives (Fu 2021). However, in the US and to some extent in Western European context, MSs operate predominantly in different schools (as the element of preK12 and K12 STEM education; Schad and Jones 2020; Rouse and Rouse 2022) or libraries (Kim, Jung, and Choi 2022) and the large share of MSs was conceived based on top-down programmes.

In addition, the literature distinguishes two main models influencing MS governance, which include the **bottom-up** and **top-down models** (Capdevila 2017b). The first refers to the sharing and co-determination capabilities of MS users, while the second outlines the strong influence of public policy in creating and influencing functioning MS

(Pengfei 2021). Considering the analysis of the model of shared spaces, which includes MS, Capdevila (2017b), based on the examples of Barcelona and Paris, reflected that they mainly fit into the top-down type of governance. Similarly, the governance models of shared-innovative workplaces, including MS, in Milan, described by Mariotti, Pacchi, and Di Vita (2017), indicate a high level of involvement of public entities in creating spaces. In contrast to the discussed examples from Western and Southern European countries, in Eastern European countries, most often in terms of the MS development model, the involvement of local leaders or residents is indicated (see the example for the Czech Republic and Hungary – Rafaj et al. 2024). Moreover, the involvement of grassroots initiatives built by universities or non-profit organizations is also significant (for the case of Polish MSs – see Gądecki and Piziak 2022).

It is commonly accepted that MSs enable multiple knowledge flows between various stakeholders (Giusti, Alberti, and Belfanti 2020; Sedini et al. 2021; Wei, Zhang, and Chen 2022). Knowledge partners include not only other MSs and innovation centres and maker communities (Capdevila 2017a), but also local public organizations such as universities, schools and pupils (Sedini et al. 2021), municipal offices (Diaz, Mariona, and Lefebvre 2020) which are often recipients of knowledge generated in MSs. These various stakeholders cultivate the knowledge ecosystem, especially through the exchange of tacit knowledge regarding the expertise and know-how in the maker movement (Aryan, Bertling, and Liedtke 2021). This knowledge ecosystem may be local in scale, although non-local knowledge interactions may also enrich it.

### **1.2. Knowledge dynamics and spatial variety of knowledge flows in MSs**

Referring to the first research question, the literature review reveals that in MSs knowledge is sometimes obtained and disseminated across various spatial dimensions. Therefore, it is essential to transcend the simplistic binary frameworks that categorize knowledge flows, such as the local buzz versus global pipelines model (Bathelt, Malmberg, and Maskell 2004). Although this concept has been used so far to analyse the relations occurring during trade fairs (Schuldt and Bathelt 2011) or, more generally, interactions between enterprises, the paper makes a step further in adapting and revising it in the discussion of external knowledge flows from/to MSs.

The term ‘buzz’ refers to informal, often serendipitous (Moriset, 2014), almost automatic encounters, represented, for instance, by simple chats and interactions. Buzz is sometimes understood as the effect of urbanization economies (Bathelt, Malmberg, and Maskell 2004), and hence, the concept is often used on the local scale. Pipelines represent formal knowledge interactions (e.g. contracts), which in most cases are not limited locally but entail international relations. However, both buzz and pipelines do not have to be associated with a specific bounded territory (Micek 2019). Buzz may be limited to the relations of members of one organization, community represented by their social network. It could even be argued that ‘global buzz’ emerges (Moodysson 2008; Schuldt and Bathelt 2011). The knowledge-intensive relations leading to innovation occur internationally and link various places in the globe. Such formalized relations are called pipelines. However, these links do not only exist in a global scale, but also connect local and national stakeholders (Tödting, Lengauer, and Höglinger 2011).

It has already been mentioned that knowledge interactions, as a social phenomenon require more nuanced than dichotomous perspective. While studying knowledge interactions of IT companies in CE, Tödting et al. (2013) and Micek (2019) called for introducing national scale of knowledge flows as one of the major in terms of knowledge intensity. Gong and Hassink (2019) and Benner (2022) opted to include more scales (regional, national, supranational and global) in studying the coevolution of industries and institutions, with possible extension down to the local level (Benner 2022). Hence, in the paper, we follow Capdevila (2017a) and Sedini et al. (2021) call to study variety of spatial scales of knowledge sources in MSs and consequently also opt for a geographical multiscale (including various spatial scales of knowledge flows) conceptual framework of knowledge flows that goes further than Bathelt, Malmberg, and Maskell (2004) dichotomy.

MSs are believed to contribute to local economic development (Lowe and Vinodrai 2020; Van Holm 2017), and local development is triggered by non-local relations (Asheim and Isaksen 2002; Bathelt, Malmberg, and Maskell 2004; Moodysson 2008), so it is often acknowledged that national and global knowledge flows are crucial for the survival and success of MSs (Braga and Guttmann 2019). Having global links allows to avoid the cognitive lock-in through tapping into foreign expertise in the maker movement. However, we cannot neglect local links, because they may be crucial in the survival of MSs – in some cases most of the MS' users come from the local ecosystem (Cattabriga 2019). To sum up, there is an ambiguous evidence on the role of local knowledge flows in external knowledge interactions (see the first research question).

### **1.3. Determinants of local and non-local knowledge flows**

Referring to the second research question, the evidence on what factors influence the local and global knowledge exchanges involving MSs remains scarce and fragmented. **Therefore, we pose the second research question on the determinants of local knowledge flows in MSs.** Based on the literature review there are some clues to identify determinants behind local and non-local knowledge flows. **First**, MSs differ regarding their belonging to specific corporate chains (Rieken et al. 2020). The affiliation of an MS to a specific corporate chain is hypothesized to generate knowledge spill-overs to more distant partners (Rieken et al. 2020). It is because such MSs may cooperate with more international partners than independent, non-corporate MSs. **Second**, the influence of the nature of MS initiatives – whether bottom-up or top-down – on knowledge flows is still not fully understood. Li and Gao (2021) reveal that bottom-up initiatives generate both regional and local knowledge flows, but their research is specific for Chinese context. **Third**, it is sometimes be argued that young MSs do not have enough time to establish long-distance knowledge relations, so they depend on local knowledge sources. **Fourth**, MSs occupy both metropolitan and rural areas (Rafaj et al. 2024), yet it can be posited that urban areas with stronger connectivity offer better access to essential knowledge resources. **Fifth**, in MSs, pay-per-use or subscription-based access to tools and workshops helps to establish stronger informal knowledge flows rather on local scale (Montes, Batz, and Serrano Cárdenas 2024; Zheng, Shi, and Jiang 2022). **Sixth**, events are seen as a trigger and starting point for further more permanent local knowledge flows,

especially in the case of coworking spaces (Capdevila 2013). For MSs, there is the large role of local gatekeepers and external stars in enlarging the knowledge network (Giusti, Alberti, and Belfanti 2020). To sum up, some determinants of local knowledge flows are not studied (e.g. age of the MS). The other studied factors remain not confirmed in the specific post-socialist CE context.

## 2. Methodology

The paper is designed as an exploratory study to investigate research questions concerning external knowledge flows. Its first step was to conduct desk research and create a database of MSs in Czechia, Poland, and Slovakia. The database, consisting of 46 active (open) MSs, contains basic information such as the year of establishment, belonging to chain MS/independent MS, ownership, bottom-up MS/top-down MS, hybrid/non-hybrid MS, location, and contact details of MS. The database of MSs addressed in the paper was compiled by the desk research method using available websites and social media, such as fablabs.io and facebook.pl, and then further expanded based on the list of identified so-called creative workshop spaces (that include MSs) in Poland (Gądecki and Piziak 2022). The uneven distribution of MSs in the sample is reflected in the overall number of MSs in each country. The research conducted shows the largest number of observed MSs functions in Poland (31), followed by the Czech Republic (11) and Slovakia (4). Poland also boasts a more established history of operating MSs, while the Czech Republic and Slovakia are still in the nascent stages of the maker movement. A common feature of these countries regarding MSs is the supportive mechanism for their development through local and regional policies (Kraus et al. 2022; Micek, Baycan, and Lange 2024). The context for comparison is based on MSs that are primarily related to the maker movement as organized workshops, where participants may work together to create, co-create, absorb, and share knowledge in physical space (Mersand 2021). Creating and co-creating in MSs can often take on an entrepreneurial nature in communities with the potential to develop micro businesses. Hence, this signifies the knowledge flows concerning DIY lifestyle, from educators to makers (freelancers/micro businesses) and vice-versa. Such context makes these countries comparable, even though the overall number varies. The database of MSs in CE was the basis for the exploratory research data collection through semi-structured interviews.

In the subsequent phase, data collection was conducted through interviews and was designed to explore knowledge flows in a detailed and holistic manner, allowing the respondents to share their experiences, attitudes, and opinions. The interviewees were representatives from various MSs, who were contacted directly based on desk research. The criteria for their selection were rooted in their organizational proficiency in knowledge management, specifically as managers or founders of these spaces. Representatives of all MSs operating in the studied countries were contacted. Crucially, the interview questions addressed key areas related to knowledge flows, including the internal environment, users, networks, proximity, social norms, stakeholders involved, determinants of knowledge flows, the impact of the COVID-19 pandemic, and the socioeconomic challenges MSs face. We asked MSs to identify their main knowledge providers and stakeholders using their knowledge. Next, we assigned a specific location for both types of

knowledge partner locations. Finally, the scale of knowledge interactions was identified. We included both one-directional and bidirectional relations when knowledge partners are both recipients and senders.

The subsections of the interview questions were intended to inquire about the challenges and pitfalls of dynamics in makerspaces. The primary data collected during the interviews were recorded and transcribed to create a database for coding and to ensure that no information was missing for subsequent data analysis. In total, 22 mainly online interviews (fourteen in Poland, six in Czechia, and two in Slovakia) were based on an extensive questionnaire and spanned multiple periods, specifically from February 2022 to February 2023 in Poland and from February to May 2023 in Czechia and Slovakia.

The first step of data analysis was based on a deductive approach to coding as a process to narrate and describe the data using the theoretical input of knowledge flows and networks (Giusti, Alberti, and Belfanti 2020). The frequency distribution was carried out with MaxQDA to continuously compare the occurrences in the data. Refined codes and categories describe the major knowledge partners and spatial scales of external knowledge flows from/to MSs.

Upon identifying the potential factors influencing knowledge inflows and outflows during the coding process, we juxtaposed these factors against the findings from the literature review and selected them from the comprehensive database of variables. To test their robustness, we applied the fuzzy-set Qualitative Comparative Analysis (fsQCA), which is used for samples from 5 to 50 cases. Qualitative comparative analysis (QCA) is an asymmetric data analysis technique that combines the logic and empirical intensity of qualitative approaches rich in contextual information with quantitative methods that deal with large numbers of cases and are more generalizable (Pappas and Woodside 2021; Ragin 1987) than symmetric theory and tools. This ability to bring together basic concepts from both qualitative and quantitative techniques of analysis differs substantially from traditional methods of quantitative analysis that are often variance-based and employ null hypothesis significance testing. QCA can identify logically simplified statements that describe different combinations (or configurations) of conditions indicating a specific outcome (Pappas and Woodside 2021; Ragin 2008). Fuzzy-set QCA can help identify sets of causal conditions leading to a specific outcome, and in many cases, it is more worthwhile to perform than structural equation modeling because fsQCA reveals more findings about conditions (in)sufficient or (un)necessary to explain the outcome (Pappas and Woodside 2021). For instance, this method has been used by researchers studying relationships between knowledge transfer performance and collaborative innovation networks (Xie, Fang, and Zeng 2016). We used fsQCA 4.0 software (Ragin and Davey 2022) to identify significant associations of causal conditions (determinants) of both local knowledge inflows and outflows and tested five variables reflecting these determinants, such as:

- Belonging to MS chain (chain; dummy variable)
- Youth of the MSs (youth; year of establishment; 2021 set as 1, 2011 set as 0)
- Hybridity of MS (hybrid; dummy variable)
- Governance mode (bottom-up initiative; dummy variable)
- Location in the metropolitan area (metropolitan; dummy variable)

Based on the insights gathered from the interviews, the authors delineated primary and secondary paths for knowledge inflows and outflows. Next, supported by these dominant and auxiliary spatial scales of knowledge flows for each of the 22 studied MS, the indices of the locality of knowledge inflows (*locality\_inflows*) and outflows (*locality\_outflows*) were calculated. To grasp different intensities of using local knowledge flows, we applied six-value fuzzy sets, where 1 represents purely local flows, 0.8 represents local (main flows) and regional or national (secondary) flows; 0.6 represents main regional and secondary local flows or main local and secondary global flows; 0.4 represents purely regional flows; 0.2 represents purely national flows; and 0 represents pure global or pure national flows. We argue that a high value locality index may contribute to a strong **local knowledge ecosystem**.

In the research, we applied standard analysis, because, in QCA, this is the only way to derive the intermediate solution (Ragin 2017). Haesebrouck and Thomann (2022) argue that the preferred QCA solution type should be the intermediate one, in which some redundant factor values are eliminated. That's why the authors decided to use intermediate solutions, even though some critique of these solutions as not easily benchmarked was recently delivered (Baumgartner 2022). A frequency threshold of 1 was applied to the data, and due to the small size of the sample ( $n = 22$ ), all configurations that do not have any observations were eliminated. We selected a consistency threshold of 0.8, as suggested by Ragin (2017).

The final step of the exploratory study was to explain a combinations of knowledge inflows and outflows in MSs using three case studies of MSs (Table 1). In the paper, we address the call by Giusti, Alberti, and Belfanti (2020) to study knowledge flows in MSs and operationalize their magnitude and factors behind it using the case studies. Case studies are based on interviews with MS managers and they differ in terms of their location, mode of foundation, and ownership. This step contributes to the exploratory research design, especially by emphasizing the variety of knowledge flows that could be reflected in regional and local policy implications. Additionally, these cases were selected identify the modes MSs are embedded in knowledge ecosystems and to identify policy implications to reduce the uncertainty of public policies in designing programmes and allocating resource effectively.

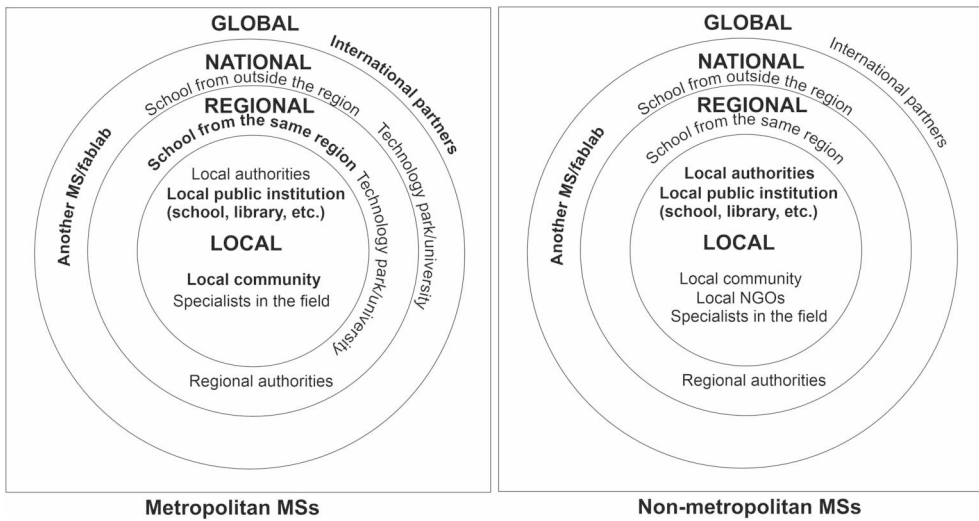
### 3. Analysis and results: spatial scales of knowledge flows and their determinants

Our research shows that in the studied region, MSs operated mainly in metropolitan areas, although over 40% of MSs functioned in cities with fewer than 250,000 inhabitants (see Appendix). The dominance of non-hybrid (without housing additional functions such as a fab lab or a coworking space), bottom-up (Capdevila 2019), and independent (Bouncken et al. 2018; non-corporate) MSs has been observed. The knowledge partners of MSs include various stakeholders (Figure 1). Among the local partners, numerous institutions (including local municipality offices) may be found. Some MSs function at primary schools, libraries, and community centres. Local makers are also common partners – they both provide knowledge and acquire knowledge from MSs. In contrast to the Western European MS landscape, MSs in the studied countries rarely function in high schools and universities, although they do provide knowledge to young locals (both teenagers and young adolescents).

**Table 1.** Summary table with characteristics of analysed case studies.

Country	Name of MS	City	Year of foundation	General location	Specific location	Mode of governance	Ownership	Type of knowledge flows combination
Poland	Makerspace Orange Foundation Bulkowo	Bulkowo	2020	Non-metropolitan area	Peripheral	Bottom-up	Private	A (national-local intermediary)
Czechia	DEPO2015 Makerspace	Pižeň	2015	Metropolitan area	City centre	Mixed	Public	B (global-local intermediary)
Poland	Urban Workshop	Gliwice	2018	Metropolitan area	Urban zone	Bottom-up	Private	C (local hub)

Source: own elaboration.



**Figure 1.** Types of knowledge partners by dominant spatial scale of knowledge flows and type of area. Source: Own elaboration based on frequency of listed types of knowledge agents.

Note: The bold indicates the partners with the most frequent knowledge flows.

### 3.1. Spatial scales of knowledge flows

Addressing **RQ1**, we decided to concentrate on four spatial scales of knowledge flows: local, for all knowledge interactions occurring with partners located in the same city or county area; regional, for flows within a single NUTS-2 region; national, for flows of domestic scale; and global, describing knowledge inflows or outflows with international partners.

Table 2 illustrates the combinations of dominant spatial scales of knowledge inflows and outflows. It seems that knowledge largely outflows from MSs to the local ecosystem (Table 2), while MSs acquire knowledge more multiscalarly, which is confirmed by the higher number of companies having mixed directions of knowledge inflows compared to outflows. In the next paragraphs, we identify the most popular combinations of spatial scales of knowledge inflows and outflows (Table 2) and describe their representatives among MSs.

**Table 2.** Matrix with the number of MSs with their combination of the main spatial scales of knowledge inflows and outflows.

Dominant outflows	Dominant inflows				Total
	Local	Regional	National	Global	
Local	<b>3***</b>	2	<b>6*</b>	<b>4**</b>	14
Regional	2	1	0	0	3
National	1	0	2	1	4
Global	1	0	0	0	1
Total	7	3	8	4	22

Note: the most common combinations of knowledge inflows and outflows are marked in **bold**.

\* – type A

\*\* – type B

\*\*\* – type C

Source: own elaboration.

The most commonly MSs acquire their knowledge on the national level and share it locally (type A), sometimes ‘(...) *work strongly with the municipalities (...)*’ (I5) and other local stakeholders, e.g. schools, cultural centres and inhabitants. It is well reflected in the case of the Orange MSs. The primary objective of Makerspace Orange in Bulkowo is to provide training and education to local young people, thus demonstrating a strong commitment to community engagement. However, given its peripheral location, it is essential for the organization to collaborate with knowledgeable partners in larger cities to acquire the necessary expertise. In this case one of the key knowledge providers for the entire Orange-led project<sup>1</sup> is the FabLab Gdańsk Association, a source of nationwide knowledge that provides substantive support. ‘(...) *as part of such cooperation, we were given the opportunity for someone to come and run a workshop at our studio (...)*’ (I7). Furthermore, they raise the digital competencies: ‘(...) *opportunities that opened up to us, we started to develop towards new technologies*’ (I7) of those responsible for the functioning of MSs Orange, which allows them to transfer the potential of the equipment to subsequent local individuals. Orange-supported MSs cooperate with several local charities, local authorities, and schools engaged in the development of the local knowledge ecosystem. An example would be ‘(...) *charity events, someone has a need, someone has an idea, some charity needs some gadgets. And someone creates these gadgets here under the guidance of our cooperators, instructors*’ (I6). We call such the most common MSs **national-local intermediaries (type A)**, because they transfer nationally acquired knowledge to the local knowledge ecosystem.

The second most popular type (type B in the [Table 2](#)) is represented by MSs with the dominance of global knowledge inflows and local knowledge acquisition. The best example of such a type is DEPO15 in Prague. The overarching objective of Depo21 is to establish a global network of localized professional networks specialising in DIY. In pursuit of this objective, the organization has a strategic orientation towards sourcing from international knowledge partners. DEPO15 was established as a grassroots initiative under the European Capital of Culture and aims to foster an open community of makers through European networks. Its primary focus is on facilitating cooperation among European capitals of culture, universities, and independent centres with similar missions. This space developed the Creative Incubator programme, which offers a mentorship programme with foreign experts to disseminate knowledge for makers. They can benefit from expertise and mentorship through various workshops (including metal, electrical, and classical graphics). The knowledge flows are enhanced by a specific programme for artists that was designed to support cultural exchange and open the cultural scene. Two permanent studios are dedicated to students of design and arts who gain practical skills from other users. This MS is a place to disseminate projects and outcomes of the maker movement for the local community through events such as exhibitions, concerts, and gastronomy. To sum up, the type B of MSs play a role of **global-local intermediary** that acquire knowledge on the global scale and share it locally.

The third most popular type (type C in the [Table 2](#)) represents the combination of dominant local knowledge inflows and outflows. In this respect, a good example is Urban Workshop – an MS located in the city of Gliwice (180,000 inhabitants) – that organized a ‘*flying workshop*’ (R19), where meetings were held ‘in the open air’ under tents or in halls. Not until 2020 ‘(...) *since we actually have premises in the first place (...)*’ (R19) as premises rented from the resources of the City of Gliwice, which allowed the creation of a publicly accessible workshop due to the members of the

association. Thanks to their own labor and efforts, with financial support from public grants, donations, and contributions, they managed to develop a stationary workshop, which is equipped with tools and machines that can be used by local and regional residents. In addition, Urban Workshop in Gliwice carries out numerous projects for local partners, cultural institutions, and NGOs. This MS is located in a large metropolitan area (with over 2.1 million inhabitants), where all the necessary knowledge may be acquired. As the objective of Urban Workshop is to provide working and training opportunities for local people, similar MSs distribute knowledge in a local milieu, improving the local knowledge ecosystem and representing **local knowledge hubs** (type C).

Referring to RQ1 and based on the analysis of the most common three types of MSs (A, B, and C) we argue the studied MSs serve the local community – all of the types predominantly share their knowledge with local partners forming local knowledge ecosystems. However, the knowledge sourcing is diverse. It must be recognized that the objective of the MS has a direct impact on the scale of local and non-local knowledge flows. It is evident that distinct MS possess varied objectives, strategic partners and users, consequently resulting in diverse ranges of use for both local and external knowledge.

### 3.2. Determinants of local knowledge flows

To identify the most common characteristics of CSs leading to higher local inflows and outflows the truth table analysis was performed for the locality indices of both knowledge inflows (Table 3) and outflows (Table 4).

The solution for **knowledge inflows** provided moderate results (especially in terms of coverage), with selected associations (four paths) accounting for 42% of the sum of the local knowledge inflows. The paths (MSs) that are open to local knowledge inflows are as follows:

**Table 3.** Truth table analysis for the locality index of knowledge inflows.

Model (associations)	Raw coverage	Unique coverage	Consistency
~chain*youth*~hybrid*~bottom-up*~metropolitan*~locality_outflows	0.1521740	0.1521740	0.875000
~chain*~youth*~hybrid*bottom-up*metropolitan*~locality_outflows	0.0978260	0.0978260	0.818182
~chain*~youth*hybrid*~bottom-up*~metropolitan*locality_outflows	0.0869564	0.0869564	1.000000
chain*~youth*~hybrid*~bottom-up*~metropolitan*locality_outflows	0.0869564	0.0869564	0.800000
Solution coverage: 0.423912; Solution consistency: 0.866667			

Source: own calculations in fsQCA 4.0.

**Table 4.** Truth table analysis for the locality index of knowledge outflows.

Model (associations)	Raw coverage	Unique coverage	Consistency
~youth*~hybrid*bottom-up*~locality_inflows	0.4746830	0.0696201	0.925926
~chain*~youth*~hybrid*bottom-up*~metropolitan	0.2911390	0.0569620	0.901961
~chain*~hybrid*bottom-up*metropolitan*~locality_inflows	0.2025310	0.0443037	0.842105
~chain*~youth*~hybrid*metropolitan*~locality_inflows	0.1835340	0.0000000	0.828571
~chain*youth*~hybrid*bottom-up*~metropolitan	0.0949366	0.0443037	0.882353
chain*~youth*~hybrid*bottom-up*~metropolitan*locality_inflows	0.0506329	0.0379747	1.000000
~chain*~youth*hybrid*bottom-up*~metropolitan*locality_inflows	0.0506329	0.0506329	1.000000
Solution coverage: 0.759493; Solution consistency: 0.902256			

Source: own calculations in fsQCA 4.0.

MSs which are independent, relatively young, non-hybrid, top-down, non-metropolitan, with limited local knowledge outflows,  
 MSs that are independent, relatively old, non-hybrid, bottom-up, metropolitan, with limited local knowledge outflows,  
 MSs which are independent, relatively old, hybrid, top-down, non-metropolitan, with strong local knowledge outflows, and  
 MSs which are chain-led, relatively old, non-hybrid, top-down, non-metropolitan, with strong local knowledge outflows.

Let us concentrate on the first, the most common (see coverage measures) path that represents strong local knowledge inflows. It is also characterized by young, independent, non-hybrid, top-down MSs that are located outside metropolitan areas. Such MSs acquire their knowledge from the local ecosystem. Regarding **RQ2**, for the majority of significant paths, local knowledge inflows are stimulated by relatively old, independent, non-hybrid, top-down initiatives in non-metropolitan locations. Hence, old MS initiatives acquire knowledge locally which means they improve their assets based on the local knowledge resources. Local knowledge acquisition is also often associated with non-corporate MSs that have probably local origins with their founders being often DIY-enthusiasts. However, such MSs are sometimes driven by non-local (often public) funds and organizations. On top of that, knowledge is acquired locally in some non-metropolitan locations. On first sight, it seems to be weird, since peripheral location requires external knowledge sources, but it may mean non-metropolitan MSs are located in local knowledge centres where knowledge is already available.

The solution for the locality of **knowledge outflows** provided more robust results (with a total coverage of 0.75) and indicated seven paths to a high locality index of knowledge outflows (a strong local knowledge ecosystem). The most common are two associations that enhance local knowledge outflows:

old, non-hybrid, bottom-up MSs with limited local knowledge inflows,  
 independent, old, non-hybrid, bottom-up, non-metropolitan MSs.

The first type reflects on **grassroots initiatives** within the DIY movement that share knowledge with local partners, although the knowledge acquired by MSs mainly comes from non-local sources (intermediaries – types A and B from the section 3.1). This model attracts local institutions, especially the administration and agencies, which are increasingly involved as knowledge recipients. The **second type of MSs is relatively similar to the first one, but it differs in terms of stronger local knowledge inflows and its location in non-metropolitan areas**. These are MSs that both source from and build the local knowledge ecosystem in smaller cities and towns (local hubs; see the type C in the section 3.1): *‘we work strongly with the Municipality (...) along with the local associations’* (R5). To sum up, regarding RQ2, for strong local knowledge outflows, the most common local knowledge disseminators include old, **bottom-up, non-hybrid initiatives**. It means that in the mature phase of operations, MSs enhance their local knowledge sharing and distribute their knowledge to local various partners. It is typical for bottom-up, local initiatives oriented towards DIY movement.

## 4. Discussion and conclusions

This research **aimed** to reveal and explain a plethora of knowledge inflows and outflows in MSs in Central Europe in terms of knowledge providers and users, spatial scales and determinants of knowledge interactions. Notably, we have found out that a significant proportion of MSs is located in non-metropolitan regions, reinforcing the notion of the model's maturity in this area. Furthermore, most of the studied MSs are established through grassroots initiatives (bottom-up governance model), contrasting with the prevalent top-down approach typical for Western European nations.

Established theories on the spatial scales of knowledge flows are frequently dichotomous, overlooking the multiscalarity of knowledge flows. Notably, national knowledge flows are often neglected. This paper underscores the significance of this spatial scale, particularly in larger countries. Consequently, it provides novel insights into metropolitan and non-metropolitan spatial settings and the determinants of knowledge flows through the maker movement. Furthermore, it delineates MS as agents embedded in knowledge ecosystems, especially by highlighting the differences between bottom-up (grassroots) and top-down governance. This adds to the policy implications of targeting multi-stakeholder communities by creating synergies between local and national knowledge flows (towards resilience and sustainable competitiveness through maker communities).

The knowledge shared by MSs comes from a variety of sources – there is a large differentiation of knowledge inflows and multiplicity of knowledge sharing combination. Among knowledge providers we may find other MSs and fab labs, whereas the local knowledge partners include local municipality offices, primary schools, libraries and community centres. Findings from fsQCA and case studies indicate that MSs situated in peripheral areas derive their knowledge from their local environments, as well as from non-regional sources, and frequently disseminate this knowledge to local partners, particularly institutions and communities. In such a way local knowledge ecosystem is being enhanced, what has a large impact on both metropolitan (see the type B) and non-metropolitan locations (see the type A). To sum up, the results of fsQCA confirmed the typology of spatial scales of knowledge flows combinations (see section 3.1.).

Knowledge inflows are multiscalar in both metropolitan and non-metropolitan areas; there is no large dominance of either local or global inflows (**RQ1**). National knowledge inflows are of similar importance to local and global ones. The most commonly MSs acquire their knowledge on the national level and share it locally playing the role of national-local knowledge intermediaries (type A; Shi and Chen 2022). A dominance of local knowledge outflows is observed. Non-metropolitan MSs establish mainly local knowledge outflows, whereas metropolitan MSs share their knowledge across more diverse spatial scales, becoming sometimes global-local intermediaries (type B). MSs located in peripheral areas acquire knowledge from multiscalar sources, but more often share their knowledge with local partners.

It is often acknowledged that national and global knowledge flows are crucial for the survival and success of MSs (Braga and Guttmann 2019), while our results show that having local direct knowledge links may be a prerequisite for the MSs location. Hence, non-international sources of knowledge used by MSs may also be viable, and establishing global pipelines is not necessary, particularly in non-metropolitan areas. This is the national or even local buzz among major stakeholders that helps them enhance local knowledge ecosystems. It aligns with the findings of Capdevila (2017a), who identified

the significant role of local buzz within the makers community and further acknowledges national buzz among MSs. Hence, MSs play a role of knowledge agents that both source and share knowledge from the local knowledge ecosystems (Cattabriga 2019; Yang, Yuan, and Wang 2019) maintaining the national and rarely global knowledge sources.

Addressing the **RQ2** on the determinants of local knowledge interactions, for knowledge inflows, they include the MSs not belonging to chains, non-hybridity, top-down initiatives, and non-metropolitan locations. The age of MSs and the strength of local knowledge outflows do not matter for local knowledge inflows. Knowledge is shared locally by MSs that are **old, non-hybrid (as for the inflows), and bottom-up initiatives**. The latter is represented by long-term grassroots initiatives within the DIY movement. Fuzzy-set QCA has also allowed to draw a conclusion that is evolutionary in its nature. We argue that in the local knowledge ecosystem MS firstly acquire its knowledge from various spatial scales (including a local one), whereas in next stages of operations they strengthen their local knowledge dissemination.

The findings of this study have several **implications for policy** that could seek to target multi-stakeholder communities at a local level through MSs. The knowledge ecosystem surrounding MSs revolves around volunteer groups in the DIY movement, local cultural institutions, and public administration, indicating a multi-agent structure (Shi and Chen 2022). Targeting local initiatives to support networking for knowledge flows could be considered in designing programmes and allocating resources for collaborative spaces effectively. These initiatives support collective actions such as European Skills Agenda by building resilience and sustainable competitiveness through maker communities. Furthermore, we suggest that mentoring and incubating multidisciplinary programs are beneficial for makers to develop the necessary knowledge, skills, and contacts as prerequisites for the innovation diffusion discussed by Zakoth, Mauroner, and Emes (2024). Entangling knowledge embeddedness leads to policy implications to nurture local knowledge flows to international levels to capture drivers of change. This could potentially lead to further connections between local MSs and foreign counterparts and help avoid cognitive lock-in through benefits from global expertise in the maker movement.

## Note

1. In 2019, the Orange Foundation developed a project called "Makerspace in Orange Workshops", allowing the establishment of makerspaces, i.e. laser, 3D printing, sewing, or electronic studios in rural areas and relatively small towns (up to 40,000 residents). These MSs have a very extensive educational offer aimed mainly at children and young people, implementing projects on environmental and high-tech topics with innovative use of robots.

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## Appendix

**Table A1.** Descriptive statistics of the characteristics of MSs (general population vs sample).

Variable	Min	Max	Average
Year of establishment (general population)	2011	2023	2017.89
Year of establishment	2014	2021	2017.68
Bottom-up initiative	0	1	0.818
Metropolitan area (general population)	0	1	0.543
Metropolitan area	0	1	0.545
Hybridity	0	1	0.136
Chain MSs (general population)	0	1	0.217
Chain MSs	0	1	0.136
Locality of knowledge inflows	0	1	0.418
Locality of knowledge outflows	0.2	1	0.718

Note: Data for the sample (n=22) in **bold**.

Source: own elaboration