Manufacturing space for inclusive innovation? A study of makerspaces in southern Ontario

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Abstract
The popular discourse on making and makerspaces is laden with optimistic narratives suggesting that makerspaces act as key institutions that support more inclusive and sustainable forms of local economic development. Despite their popularity, we know little about how makerspaces actually support entrepreneurship and innovation and even less about how they advance the goals of environmental sustainability and social inclusion, particularly in the Canadian context. In an effort to redress these gaps, this paper uses a unique database of makerspaces, complemented with findings from in-depth case studies, to examine the practices of makerspaces in southern Ontario (Canada). Our study finds that while makerspaces offer access to technologies and basic skills training, we find limited evidence that makerspaces generate the promised economic or social outcomes so often attributed to them. Moreover, we find very limited evidence that makerspaces actively seek to be socially inclusive in their membership and programming or encourage environmentally sustainable practices. In other words, the potential of makerspaces, in their current form, to contribute to more inclusive and sustainable forms of local economic and community development is not yet fully realized.

Keywords
Canada, economic development, inclusive innovation, makerspaces, making

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Introduction

Buoyed by growing interest in do-it-yourself (DIY) culture, localism and environmental sustainability, policymakers and urbanists around the world—but especially in advanced economies—have taken interest in the maker economy. Driving this enthusiasm is a belief that makers and makerspaces can renew small-scale, locally embedded manufacturing while facilitating access to more affordable, advanced manufacturing technologies like 3D printers, laser cutters and CNC machines (Davies, 2018; Wolf-Powers et al., 2017). Indeed, the most ardent advocates suggest that makerspaces not only provide foundational and inclusive spaces for acquiring technological literacy and developing skills (National League of Cities (NLC), 2016), but that they form the vanguard of a new industrial revolution (Anderson, 2012), one centered on a form of small-scale, highly individualized manufacturing embedded in global supply chains and marketplaces.

Advocates frame makerspaces as critical intermediary institutions in local innovation ecosystems that connect entrepreneurial makers with the advanced technologies, skills development and financial resources necessary for venture creation (Anderson, 2012; Hatch, 2013, 2018). Existing small businesses also stand to benefit through association with makers and maker-led businesses that can rapidly prototype new products, shortening the product cycle between R&D and market (SGA, 2017), and potentially re-shore manufacturing supply chains (Helper et al., 2020; Lowe and Vinodrai, 2020a). But perhaps the most lauded benefit of the maker economy is its perceived potential to uplift historically marginalized urban communities by providing more inclusive access to advanced design and manufacturing technologies through makerspaces (NLC, 2016, 2017).

This enthusiasm for making and makerspaces, coupled with the rise of digital platforms that connect makers with designers and/or consumers, suggests that makerspaces have the potential to contribute to more equitable, inclusive and sustainable forms of local economic development.

Despite this growing interest in makerspaces, we know relatively little about how makerspaces actually contribute to inclusive economic development, whether through providing access to technology and training, supporting entrepreneurship or embedding social inclusion and sustainability goals and practices into their operations. Much of the research to date has focused on the contributions of makerspaces to traditional local and regional economic development (Troxler and Wolf, 2017; Van Holm, 2017; Wolf-Powers et al., 2016, 2017). While these studies are valuable for revealing how makers and makerspaces participate within local, regional or global markets, they leave largely unexplored the question of whether or not makerspaces actually foster more inclusive forms of economic development. In an effort to deepen our understanding of makerspaces, this paper asks if makerspaces promote inclusive forms of innovation and economic development. And if so, how?

To address these questions, we examine the practices of makerspaces in southern Ontario (Canada) through an analysis of a unique database of 68 makerspaces, complemented with findings from in-depth case studies exploring the economic, social and environmental goals and practices at leading makerspaces. Our study finds limited evidence that makerspaces generate the economic or social outcomes touted by many advocates and anticipated by policymakers. Moreover, we find limited evidence that these spaces actively pursue social or environmental goals in their activities. In other words, while there is a significant body of academic and policy literature on
urban manufacturing and makerspaces that suggests a great potential for these spaces to contribute to more inclusive and sustainable local economic development, these promises are not yet fully realized.

Our paper begins with a discussion of the growing interest in making, makerspaces and micro-, artisanal and craft manufacturing in academic, policy and popular literature. Second, we provide a brief overview of our methods and our approach to exploring the extent to which makerspaces offer an avenue for sustainable and inclusive local economic development. Third, we report on our findings, beginning with a brief snapshot describing the governance and operations of makerspaces in southern Ontario. We focus our analysis and discussion of makerspaces’ potential for sustainable and inclusive local economic development around four major themes, speaking to the roles that makerspaces are anticipated to play in local innovation ecosystems: access to technology; training and skills development; support for entrepreneurship and new venture creation; and social inclusion and environmental sustainability. We conclude by considering the implications of our findings for policymakers, practitioners and scholars, and outline some potential lines of future inquiry.

Makers and makerspaces: Opportunities for inclusive local economic development?

Making has gained traction and popularity over the past 15 years. As Wolf-Powers and Levers (2016) note, the idea of making itself is somewhat nebulous within the literature, variously referring to a distinct mode of production; consumer desire to purchase local products and construct their identity through highly customized, unique goods; a desire to engage and connect with the material world; or embody a particular artisanal lifestyle. Making has come to represent a potent source of individual creativity represented by DIY culture and collective interests in artisanal and craft manufacturing. Scholars have observed that the growing interest in making also draws its momentum from increasingly sophisticated and affordable production technologies, like laser cutters, 3D printers and computer-aided design hardware and software (Vinodrai, 2018). In particular, the miniaturization of these technologies has generated new opportunities for individual makers to manufacture consumer and specialty goods, and to do so in spaces previously unsuitable for traditional manufacturing (Doussard et al., 2017). While the products created in these spaces range from traditional handicrafts to electronics and robotics, they represent a renewed interest in small-scale and place-based manufacturing. Individuals pursuing this new form of production, whether as part of an entrepreneurial, small business or as a personal hobby, have become known as makers, a moniker that has also come to denote a lifestyle or personal identity (Toombs et al., 2015).

The widespread popularity of making is often attributed to the advocacy of a handful of individuals including Chris Anderson (2012), the former editor-in-chief of Wired magazine; Neil Gershenfeld (2005), an MIT Media Lab professor and originator of the concept of Fab Labs; Dale Dougherty (2012), founder of Make magazine and former TechShop CEO, Mark Hatch (2013, 2018). These proponents articulate a vision of making that portrays it as an emancipating and self-empowering lifestyle, centered on the fulfilment of individual ambition. However, they also look beyond the personal benefits of the maker economy to emphasize the economic potential it holds for communities, sometimes casting it as a new industrial revolution that policymakers would be wise to anticipate and
incorporate into economic development strategies (Anderson, 2012).

Alongside advances in manufacturing technologies, the rise of digital communication and global e-commerce platforms, such as Amazon or specialized platforms such as Etsy and The Grommet, theoretically allow makers to produce locally but compete in global markets. And while international market exposure legitimizes the maker phenomenon as important to individuals and local economies, it also brings new challenges to makers, who must find ways to differentiate their products from others in the same digital marketplaces (Dawkins, 2011). One approach is for makers to imbue their products with a sense of local craft traditions by engaging in place-specific branding (Grodach et al., 2017; Kinahan, 2016). To this end, a number of local advocacy organizations like Made in Baltimore, SFMade (San Francisco), Made in NYC and MAKE IT IN L.A. have emerged to brand and promote local manufacturing (Clark, 2014; NLC, 2017). Scholarship has also shown how makers are able to leverage these local resources, and the manufacturing capacities of more traditional design and production industries, to create more fluid and robust product cycles (Wolf-Powers et al., 2017).

Early efforts to understand the maker economy also reveal the contributions of maker-oriented businesses to local and regional economic development (Wolf-Powers et al., 2016, 2017), and suggest that the overwhelming majority of maker-run businesses remain local economic players, with very few becoming internationally competitive. Yet, makers can play a critical role in strengthening the connections between product design, prototyping and manufacturing (Wolf-Powers et al., 2016). Indeed, the interest in making has grown and emerged at a time when deindustrialized economies are beginning to re-shore some forms of advanced manufacturing. This trend may generate opportunities for communities that are more vulnerable and lead to stable, well-paying and highly skilled jobs in traditional sectors (Eisenburger et al., 2019; Grodach et al., 2017; Lowe and Vinodrai, 2020a, 2020b). Others still have suggested that makerspaces might also provide opportunities to uplift historically marginalized communities by drawing upon their key knowledge and skills for a limited renaissance of some manufacturing sectors (Deloitte, 2014).

Following this line of argument, makerspaces are seen as key local intermediaries or institutions that assume new importance as potential hubs of community economic transformation and inclusive innovation, far eclipsing their humble origins as social spaces of hacking and tinkering. So while makerspaces may well cater to a particular lifestyle, leisure activity or community identity, these institutions also have a public function, generating opportunities for economic and community development, albeit with risks related to property-led development potentially undermining these very gains (Schrock and Wolf-Powers, 2019; Wolf-Powers et al., 2017). And while makerspaces may be only one institutional actor in the local innovation ecosystem, they are presumed to be places that might offer an entry point for new entrepreneurs and act as spaces of learning. As Wolf-Powers and Levers (2016) note, makerspaces are a form of social infrastructure, offering spaces for collective learning, knowledge exchange and community building, as well as access to equipment and technologies. Additionally, there is a belief that makerspaces embody more environmentally sustainable manufacturing processes given their potential to shorten supply chains, emphasize local production, and embody the environmental ethos associated with craft-oriented makers (NLC, 2017; Van Holm, 2017; Wolf-Powers et al., 2017).
Policymakers are also beginning to incorporate makerspaces in local and regional economic development strategies (Doussard et al., 2017; Eisenburger et al., 2019; NLC, 2016). These strategies often frame makerspaces as critical intermediary institutions, facilitating knowledge transfer and skills training while providing makers with pathways to access more traditional business incubation and entrepreneurial resources. Yet, despite these aspirational policies, many makerspaces have experienced a fleeting existence, unable to attract sufficient membership to remain financially solvent (Bouw, 2019; Turner, 2018). These struggles may be due, in part, to the diversity of individual motivations amongst makers or the underlying business models adopted by makerspaces. Nonetheless, the volatility and uncertain future of makerspaces does not appear to have tempered enthusiasm for the economic potential of makerspaces amongst policymakers. In recent years, there has been a proliferation of policy documents and reports extolling the values of makerspaces as strategic assets to support entrepreneurship and local economic development (NLC, 2016). Despite this enthusiasm for the potential that makerspaces offer to economic development policymakers, our knowledge of if and how the practices of makerspaces contribute to sustainable and inclusive local economic development remains limited.

**Research design and data**

To address this gap in our knowledge, we employ a study of makerspaces in southern Ontario, which has historically been Canada’s industrial heartland. The region still retains a considerable proportion of Canadian manufacturing jobs, especially in the suburban areas surrounding Toronto (Canada’s largest city) and other second-tier cities in the region (Arku et al., 2020; Vinodrai, 2020). Within the region, local and provincial economic development policies related to manufacturing focus on strengthening traditional manufacturing industries, such as automotive, machinery, and electrical equipment production (PricewaterhouseCoopers, 2018). Moreover, innovation policies and programs set by senior levels of government do not directly address or govern makerspaces. Yet, many of the municipal governments in this region, including those in Toronto, Hamilton, Kitchener and Mississauga identify makerspaces as important institutions in their economic development plans, highlighting their potential contribution to entrepreneurship and access to training and equipment (cf. City of Hamilton, 2016; City of Kitchener, 2015; City of Mississauga, 2020; City of Toronto, 2017).1 Absent, however, are local strategies that bridge the gap between traditional and sector-based manufacturing policies and those intended to encourage local economic development by promoting small-scale and craft manufacturing, including makerspaces.

We developed a unique dataset of makerspaces across the region to understand the existing landscape of makerspaces in southern Ontario. We conducted an extensive Internet search using key terms such as “makerspace,” “hackerspace,” “Fab Lab” and variants thereof, as well as consulted with individuals and experts involved in local manufacturing policy, economic development and the maker community to construct a comprehensive list of makerspaces. Through this search, conducted between May and December 2018, we identified 121 potential makerspaces. However, further investigation revealed that 53 of these makerspaces were not active at the time of the study. A number of these makerspaces were still in the planning or proposal stages and many others had closed, reinforcing the observation that the maker economy is highly dynamic and not yet deeply entrenched within the economic
landscape. Figure 1 shows the geographic distribution of the 68 active makerspaces. The majority of these makerspaces are located in the Greater Golden Horseshoe region, which extends around Toronto and along the northern and western edges of Lake Ontario.

For these 68 active makerspaces, we built a database of key characteristics using publicly available information drawn from the websites of these organizations. Specifically, we collected, categorized and coded data related to operational, business and funding models; governance structures; physical facilities, including equipment and tools; thematic specializations; programming and services; and social media presence. A content analysis of makerspace websites reveals not only what physical resources are available but also how makerspaces promote and support—if at all—missions of inclusivity; technological skills development and learning opportunities; entrepreneurship and innovation; and environmentalism. We analyzed these data to understand broad trends and patterns.

To further contextualize these data, and to understand the nuances of makerspace operations, we conducted in-depth case studies of six leading makerspaces in the region, including interviews with staff, managers or members of boards of directors. We selected cases to span southern Ontario and to include makerspaces in the region’s largest, dynamic urban centers. Our key informant interviews covered a range of topics related to the operations and activities of the selected makerspaces, including access to technology; training and skills development; support for entrepreneurship and new venture creation; and social inclusion and environmental sustainability. We also asked our key informants questions pertaining to their engagement

![Figure 1. Makerspaces in southern Ontario.](image-url)
with other local actors, policymakers and the local policy context, including how these policies shaped makerspace operations and practices. Due to issues around confidentiality, we do not identify the individual makerspaces or the identities of our key informants in our analysis of interview data. Instead, we draw out key themes that emerge from across our content analysis and case studies and provide quotations and examples that best illustrate these key themes.

**Makerspaces in Canada’s industrial heartland**

There is not yet a clear consensus as to what makerspaces should look like or the range of activities occurring within them. Although projects undertaken by makerspace members are diverse, and span such realms as bioengineering, 3D printed food and woodworking, there remains an emphasis on the production of tangible objects. This emphasis distinguishes makerspaces from hackerspaces, in which the focus is usually on creating and modifying computer code and electronics (Davies, 2017; Van Holm, 2017). The sheer diversity of interests embraced by the makerspace model therefore accommodates and necessitates a range of physical infrastructure and resources, including both the spaces themselves and the equipment and tooling within them. As Table 1 reveals, the 68 makerspaces that we examined in southern Ontario present no exception.

An initial understanding of the nature of these makerspaces and their institutional affiliations is important as these characteristics have implications across all areas of our investigation. Table 1 shows that there is a roughly even split between makerspaces that are private, independent operations (n = 29) and those that are affiliated with municipal public libraries (n = 31), including four mobile makerspaces—a maker equivalent of bookmobiles. The remaining makerspaces (n = 8) are affiliated with other publicly funded organizations or institutions such as universities. We draw attention to these institutional affiliations because they have an impact on the financial resources and other supports available to makerspaces for equipment purchases and programming. They also provide indicators as to what areas of policy might influence their operation. For example,
makerspaces embedded within higher education institutions are affected by policies set by senior levels of government more than local policies. Similarly, a high proportion of makerspaces are part of public library systems, meaning they are subject to local government decisions and municipal funding related to that realm. While support and resources can arrive in the form of direct financial contributions, more often it takes the form of in-kind support, including the provision of space in municipal libraries, website hosting or advertising (Davies, 2017; Wang, et al., 2016). As we discuss below, the availability of stable funding has considerable implications for the ability of makerspaces to provide programming, purchase equipment and attract new members. It also limits the capacity of makerspaces to engage with policymakers and other actors in the local innovation ecosystem. Spaces without stable sources of funding or other forms of support often struggle in these areas. The remainder of our discussion focuses on the available resources and operational practices of makerspaces as they pertain to the questions of if and how makerspaces foster access to technology, provide opportunities for training and skills development, support entrepreneurship and adopt practices to encourage social inclusion and environmental sustainability.

Access to technology

Manufacturing technologies play an important role in any form of making, but the discourse on makerspaces tends to emphasize the association between making and sophisticated manufacturing technologies. Advocates routinely emphasize how makerspaces can provide communal access to technologies that would otherwise be unaffordable or impractical for individual members to own (Gershenfeld, 2005; Hatch, 2013). They further argue that by providing access to, and training with, these advanced technologies, makerspaces can play a critical role in building technological literacy and skills within communities (Anderson, 2012; NLC, 2017). Indeed, our research reveals that makerspaces do provide access to a broad range of tools. However, this breadth is not always paired with depth or a specialization in one or more fields of making. While our findings confirm that at least 43 of the 68 makerspaces in our study offer technologically advanced equipment like 3D printers, laser cutters and digital recording equipment, only four declare thematic specializations—three in woodworking and one in ceramic arts. About two-thirds (43) of the makerspaces provide tools for digital fabrication (which is often considered the quintessential technology of DIY making), and roughly half (33) of the makerspaces offer tools for general arts and crafts or low-tech manufacturing. Our findings also reveal that makerspaces with this broader set of crafting tools tend to be affiliated with public libraries, where they provide equipment that—understandably given space and user constraints—focuses on exposure to technology and small-scale making.

Yet, despite this limited access to specialized manufacturing equipment, our content analysis of makerspace websites reveals that many makerspaces emphasize access to advanced and emerging technologies within their mission statements. These website descriptions are important, as they often represent a point of first contact and so shape public perceptions of the role of makerspaces and their contributions to the local economy. Makerspace websites frequently emphasize the opportunities within makerspaces for personal creativity and the underlying importance of technology to the creative process. For example, the Makery at the Niagara-on-the-Lake Public Library offers a space where users can “access and learn a variety of software
that can help you to create anything you can dream up, then you can use our 3D printers, carving machine, and embroidery machine to make those dreams and designs a reality” (The Makery, n.d.).

This initial exposure and training with advanced manufacturing equipment does not always translate into sustained learning or commercially viable use of these technologies. The availability of a broad set of tools may satisfy many emerging makers, but it may not be sufficient for those with more advanced requirements or those seeking to turn complex ideas into tangible products. An additional benefit of providing access to a specialized set of tools is that it is often accompanied by members with substantial related skill, knowledge and expertise. As Davies (2017) notes, the human capital embodied in these experienced members is at least as valuable as the equipment itself. This expertise is necessary to derive maximum value from these technologies and to develop a thorough understanding of their capabilities and limitations. This intimate familiarity with manufacturing processes is routinely cited as a requirement for generating industrial innovation—one of the outcomes sought by advocates and policymakers (Pisano and Shih, 2012). However, as our research suggests, while makerspaces provide exposure to a wide range of tools and technologies, there is a limit to the depth of this technological capacity and therefore learning potential within these spaces.

This broad but shallow range of available technologies in many makerspaces may be due to their origins as hobbyist spaces, and not as institutions with explicit objectives related to skills training and development or technological diffusion. Our case studies revealed narratives of privately operated makerspaces emerging from the interests of an already tech savvy group of founders. One makerspace director noted the hobbyist origin of the space, remarking that it had a “vague beginning because...a bunch of people got together and wanted a place...where people who were working in technology could come together to learn from each other, but also have a place where they could make things together.” This theme was echoed by the president of another makerspace in a mid-sized city, who explained its serendipitous beginning,

well it would be nice to have a place to do something fun on the weekend, and there’s a bunch of technology people that were friends, and I guess they were meeting for a while and they found a space and incorporated and started.

Of particular importance in these narratives is the absence of motivations amongst makerspace operators to fashion makerspaces as intermediaries that translate and apply economic development policies intended to encourage technological literacy and inclusive economic development. This speaks strongly to the aforementioned and persistent disconnect between policymakers’ aspirations for makerspaces to generate more inclusive economic development and the often insular and exclusionary nature of these spaces. The happenstance origin of many makerspaces is also a theme echoed in the scholarship of the hacker and maker movements. As Davies (2017: 33) notes, many North American hackerspaces emerged in 2007 soon after a group of hobbyist hackers returned from a visit to Germany’s Chaos Computer Club’s Chaos Communication Camp. Inspired by what they encountered, these enthusiasts founded a number of hackerspaces, of which NYC Resistor and San Francisco’s Noisebridge are two notable examples. But these efforts were undertaken largely to satisfy an urge for communal spaces for creativity, and not necessarily to build skills, expand technological literacy or commercialize inventions.
Given the hobbyist origins of many makerspaces, it is not surprising that the equipment and technologies available in these spaces is often based upon the interests of its members. A makerspace director noted that “membership generally guides where tools come from. [It is the] will of the membership.” Another interviewee speculated that the popularity of woodworking equipment in makerspaces, for example, may be due to the demise of vocational programs in public schools and the desire to become familiar with these technologies and to engage in acts of creative production. These motivations do not reflect the image—so dominant in local policymaking—of makerspaces as drivers of industrial innovation and economic development. That makerspaces provide training in the basic use of technologies may speak to the extent of unfamiliarity with simple tools—a fundamental obstacle to policymakers’ aspirations for these spaces. The director of one public makerspace remarked on this need for basic education: “we were encountering students who had never used scissors before. They are not familiar with a lot of traditional technologies.” While improving basic technological literacy is important, there is a wide chasm between this kind of basic skills training and the experience necessary to push the frontiers of advanced technologies. It also raises the question of whether or not makerspaces are the appropriate venues for this kind of training.

Skills development and training

Despite offering limited access to sophisticated and specialized manufacturing technologies, makerspaces do provide some structured training, particularly related to the safe operation of equipment. Of the 68 makerspaces in our study, 43 require the completion of a training course before members are permitted to use machines independently. Others offer less formal training, opting instead to provide online tutorials or permitting only staff to operate equipment. But hands-on training generally leads to greater user confidence with technologies and the ability to take on more complex projects, in turn becoming a greater resource to the makerspace community. One interviewee commented at length on this phenomenon:

there’s a very definite pattern for people who stay involved with the makerspace, which is that they initially come in and need a lot of personal attention. A lot of them have never used tools before, especially in the downtown core. So there’s the initial phase where we’re sort of trying to get them to the point where they’re a little bit self-sufficient. … If they stay at this point where they’re just sort of doing their own thing, they’ll probably sort of just disengage. So what we do is try and stimulate them with getting involved.

The knowledge acquired through this hands-on, active learning also allows individuals to determine the best tool to use for a particular task. For example, an inexperienced maker wishing to produce a widget at a community makerspace might decide to use a 3D printer, since it is the most ubiquitous—and sometimes the only—piece of manufacturing technology available in makerspaces. These 3D printers extrude heated plastic filament through a computer controlled printing head to produce 3D objects. This technology is often used to create out-of-production replacement parts, produce essential supplies in locations where manufacturing infrastructure does not exist or is unable to respond timely, create prototypes or generate small production runs. However, 3D printing is not always the appropriate or best technology to use in a given circumstance. Moreover, 3D printing involves
sophisticated modeling software, which itself requires considerable skill to use proficiently. As we note above, while many makerspaces provide a general introduction to these technologies they often lack the specialized staff to train individuals in their more advanced use. This results in more passive use of machines like 3D printers, with new users often limited to downloading printable files from an online database and then sending the file to the printer for production, severely limiting the use of this technology and the engagement of the user. Without exposure to a wide range of technologies and assistance from staff with deep knowledge of the capabilities of the technologies, makers may not know that a table saw, or a rotary carver or a bandsaw, for example, would be a more appropriate choice. Thus, while makerspaces offer exposure to advanced technologies, they may be quite limited in their ability to encourage meaningful engagement with these resources.

Beyond orientation training, skills development in makerspaces often assumes an informal character that emerges in association with ad hoc mentorships. Our case studies reveal that efforts to establish formal mentorships and educational programming are frequently hindered by the informal operational practices in makerspaces, and by the lack of capacity, funding and expertise. As one director observed, “there’s not a lot of [formal] mentoring going on... [but there is] a lot of collaboration and sharing of ideas.” Another director suggested a more explicitly hands-off approach to training and an emphasis on learning by doing, with occasional interjections of expert guidance:

[you can solve] somebody’s problem, which is good, but then when you’ve solved it then you’re kind of at the end. That’s it. But the other way of doing it is helping people’s needs... So in the space like this solving a problem means you give them space, you give them tools, you let them do their thing. Solving their needs though is like helping to inspire them, to show them ideas, and approaches, introducing them to new people, showing them community projects that they can be contributing on with their new skills.

Similar to the technical expertise in makerspaces, the value of this mentorship is heavily dependent upon a diverse and knowledgeable membership, which may be less present in those makerspaces that adopt a more generalist approach to technology and training.

**Entrepreneurship and venture creation**

In addition to their perceived contributions to technological literacy and skills development, makerspaces are also framed as key intermediaries that support entrepreneurship and new venture creation amongst makers. Advocates point to the advanced technologies and communities of like-minded individuals within makerspaces as creating ideal environments for nurturing emerging entrepreneurs and providing infrastructure for product and venture creation. The mobile credit card reader Square is often cited (Hatch, 2013) as an example of the transformative and disruptive technologies that can emerge from makerspaces if users are free to fully avail themselves of these communal resources. Indeed, many makerspaces themselves articulate mission statements that suggest an economic imperative in their operations. For example, the mission of the Pickering Public Library’s (PPL’s) makerspace is to “inspire creativity, foster innovation and empower our residents to meet the demands of an ever-changing global economy” (PPL, 2012). While aspirational, these kinds of statements set an expectation with respect to the resources and programming that these
makerspaces have to support their claims related to career preparation and entrepreneurial empowerment. But, as we illustrate in our earlier analysis of the technologies and associated human capital available in makerspaces, this is routinely not the case.

Our research also reveals that there is little active support or training within makerspaces for aspiring entrepreneurs. This contrasts with popular and policy discourse that imagine makerspaces as key access points to emerging pathways of product ideation and marketing (Anderson, 2012; Hatch, 2013, 2018). Instead, we regularly encountered a hands-off approach towards commercialization and entrepreneurialism. Most of the makerspaces that we examined do not encourage commercial making or permit private businesses to operate within the spaces. This is not to suggest that makerspace operators are necessarily opposed to commercialization, rather they prefer that commercial-oriented activities be confined to early stage R&D and prototyping. While we found that makerspace operators are supportive of such possibilities, they do not view makerspaces as having any additional roles in aiding venture creation; individual makers and members are left to take their own initiatives in this regard. As one director told us, “if you came in here and developed some crazy, awesome idea and were able to sell it. Have a good time!” But beyond this passive tolerance, the challenges associated with bringing a new or improved product to market remain the purview of individual makers. In our interviews, makerspace operators indicated that there were no formal pathways for makers to follow to other local innovation, entrepreneurship or business development programs or organizations. Moreover, there was minimal engagement with local policymakers or economic development officials and few formal or informal relationships between makerspaces and other local innovation ecosystem actors, such as business incubators.

While makers are free to explore their own entrepreneurial projects, supporting this process poses a challenge for makerspaces, whose operations are severely limited by budgetary and staffing constraints. As one interviewee explained, makerspaces tend to focus on their core operations by “...keeping the tools running and keeping the membership open.” Despite the growing prominence of makerspaces within economic development policies and discourse, there remains a disconnect between policy aspirations and the support available to makerspaces. As we discuss in greater depth below, limited support at the municipal and regional levels result in uncertainty about the future prospects of individual makerspaces. Compounding this scarcity of formal support, our informants also emphasized the cyclical and unpredictable nature of public interest in makerspaces, the high turnover of membership and the ever-changing interests of makers. In this context, makerspaces often remain focused on maintaining cash flow to pay rent and have minimal capacity or resources to develop entrepreneurial support or incubation programs or work with local economic development officials and policymakers (see also Schrock & Wolf-Powers, 2019). This is especially true of privately operated makerspaces that lack the stability that comes with institutional affiliations. As one director succinctly remarked, “it’s hard to do a lot of things with not a lot of money.”

Social inclusion and environmental practices

As we note above, advocates extol the potential of makerspaces to contribute to more democratized production and promote widespread access to advanced manufacturing technologies. Such assumptions presume the existence of robust, open
and diverse social networks within these spaces that facilitate entrepreneurship and innovation. Similarly, there are prevailing assumptions that makerspaces inherently promote environmentally conscious manufacturing. Our findings question both of these assumptions.

The mission statements of the makerspaces in our study reveal how these makerspaces position themselves as collaborative spaces, in which the product of sharing and the communal use of advanced technologies exceed the sum of individual contributions. For example, Diyode (Guelph) frames itself as a community of like-minded individuals “who like to get their hands dirty, and are always willing to lend a hand to anyone that wants to learn something new” (Diyode, n.d.). The importance of sharing is emphasized by Ottawa’s Makerspace North, where members “meet and work with like-minded creators, and find unexpected collaborations in an environment with a supportive community that is happy to share ideas and resources and celebrate wins” (Makerspace North, 2020). And Toronto’s Sprouts makerspace suggests a connection between collaboration and creativity: “diversity and cross-pollination of activities are critical to the design, making and exploration process, and they are what set makerspaces and tech labs apart from single-use spaces” (Sprouts, n.d.). Despite this narrative, our research reveals that many makerspaces struggle to maintain a robust and diverse membership, often due to many of the limitations previously noted, such as limited funding and staff capacity, as well as the difficulty of establishing makerspaces as community destinations. Compounding this, expensive membership fees, costly materials and limited hours of operation may actively exclude individuals from participating in these spaces.

Although we did not collect statistical data on the membership of makerspaces, our key informants described the membership of their makerspaces as being predominantly male, in some cases estimating that 90% of their members were male. There are some exceptions; for example, one makerspace touted that it had “strong female leadership,” and a board of directors that is “fifty percent female.” Another director made a distinction between the target demographic for the makerspace and the composition of its staff:

coders...you know. So if you get that sort of picture of a geeky, middle-aged white man, that is definitely the target audience. But interestingly enough, a lot of the governing body of the organization were women, and the staff have always been women.

Another interviewee noted that “we know that we would become a better organization by being diverse.... There is a push for diversity because we know that it makes us better, makes us stronger.” However, makerspaces were hard-pressed to identify specific programs or actions that they were taking to shift the demographic composition of their membership base. As one director stated, “the members we have are the members that have wanted to be there,” noting that if a group approaches the makerspace requesting specific programming that the space will make an effort to accommodate them. Finally, our interviewees sometimes interpreted the concept of diversity rather broadly, with one director speaking to the advantages of having a diversity of technical backgrounds within the makerspace. In this case, the benefit to the makerspace is being able to repair a tool in-house, for example, rather than sending it away for repair, potentially saving weeks of downtime, and therefore keeping the tool available for members and for safety certifications. Our interviewees did not articulate an explicit connection between this diversity...
of backgrounds and expanded learning opportunities for new members.

We also identified a number of common factors that may impede individuals from joining makerspaces or making use of the available resources, including financial barriers. Because of their affiliation with public institutions, such as libraries, 40 of the 68 makerspaces did not charge a membership fee. In these spaces, a library card is often the only requirement to enter and use the makerspace. Among the privately operated makerspaces, 27 required membership fees, and one makerspace had a “pay-what-you-can” model. Of those makerspaces with membership fees, the average monthly fee was approximately $96 CAD (as of December 2018), including a wide range between the lowest ($10 CAD/month) and highest ($299 CAD/month) fees. Although modest at the lower end, the higher fees constitute a significant entry barrier to these makerspaces. Yet, it is the privately operated makerspaces that generally have a wider selection of equipment and greater expertise within their membership, further disadvantaging individuals who are unable to access these spaces. Although makerspaces affiliated with libraries are more accessible, the tool selection and programming is often quite limited, as mentioned above, and the spaces themselves often focus on general crafting instead of the more sophisticated forms of making found in privately operated spaces. The cost of materials presents another barrier that may limit one’s full participation within a makerspace community. For example, plastic filament for 3D printers can be costly, and only 16 of the makerspaces examined included materials with membership, whether paid or unpaid. Finally, although affiliation with public libraries may come without the burden of membership fees, use of these spaces are confined to the operating hours of the libraries. As noted by one director, “something as simple as our space closing when the library closed hindered users from accessing when it was convenient for them.”

Due to issues related to staff capacity and funding, makerspaces were only able to undertake minimal outreach to generate interest and new members, including limited use of social media platforms. Nearly all of the makerspaces in our study used at least one form of social media, with the majority using Facebook, Twitter and Instagram. Of the 68 makerspaces in our study, 63 operated Facebook accounts, 60 had Twitter accounts, 47 had Instagram accounts and 31 operated YouTube accounts. We observed that makerspaces used Facebook and Twitter as general communication platforms, noting events and engaging with larger maker communities. Instagram was frequently used as a platform for documenting and sharing projects and makerspace updates, while the content on YouTube varied considerably from virtual tours to safety tutorials. The frequency and intensity of social media use varied based upon capacity and the need for makerspaces to advertise programming or recruit new members. One makerspace director noted the conscious use of particular imagery on social media platforms for targeted outreach:

we'll adjust our marketing so that we're showing more girls. We will adjust our workshops so that there's more emphasis on the A in STEAM. We find that that A really allows for us to better connect with the STEM topics.

Despite this particular instance of a makerspace suggesting that it would tailor its use of social media to engage underrepresented groups, we did not find any evidence of makerspaces actively using social media in efforts to increase the diversity of their membership. This further highlights makerspaces’ struggles to generate the inclusive
economic development promoted by maker advocates and sought by policymakers using the severely limited resources available to sustain their operations.

Finally, while there is an emphasis on reuse and environmentalism within the discourse on making and makerspaces (cf. Wolf-Powers and Levers, 2016), we found no evidence of systematic efforts to promote sustainability within makerspace operations. While our key informants revealed their awareness of the connection between making, environmentalism and sustainability, they did not provide any evidence of efforts to encourage sustainable material choices or the reuse or recycling of materials in the operations of the makerspace facilities. Only one makerspace indicated that they have a “strong environmental focus”; however, when asked to elaborate, they were unable to identify specific environmental or sustainability-related initiatives. When pressed further on the lack of sustainability initiatives in makerspaces, another director explained that insufficient funding and staffing prevented such efforts:

From a personal business perspective, I wish I could do more for the environmental stuff. I wish I had...a fund where I could hire a person to help me deal with certain things. So I go as far as I can based on what my capacity is. ...So the board is busy ratifying events, and onboarding new members, and making sure the space is running. It’s very difficult for us to then say that we need a better recycling program... it’s just beyond capacity, I think.

Moreover, our content analysis reveals extremely limited engagement with environmental and sustainability practices, with only a few passing references to repair and upcycling. Although makerspace operators were keenly aware of the potential of these spaces to contribute to more sustainable patterns of production and consumption, their ability to realize this potential was hampered by budgetary, staffing and programming limitations. Most of the makerspaces studied simply lacked the capacity and resources to pursue more than the most basic sustainability practices, such as recycling. This is because makerspace staff must first ensure that the core mandates of the makerspaces are fulfilled and that the spaces themselves remain operational, leaving little time to develop sustainability initiatives.

Conclusions

While there is potential for makerspaces to offer an alternative path for local economic development—one that could promote more inclusive and sustainable forms of local economic development—the evidence from our study suggests that makerspaces fall short of achieving this objective. Advocates and policymakers frame makerspaces as key intermediaries that connect entrepreneurial makers with the technologies, skills development and financial support needed to generate meaningful contributions to local economic development. However, our findings suggest that the actual contributions of makerspaces to local economies fail to realize this vision. The makerspaces in our study of southern Ontario do provide access to making technologies and some basic skills training. However, there were few opportunities within these spaces for formal skills development beyond introductory and compulsory training. And, access to—and training with—more advanced making technologies was uneven. We also found no examples of new venture creation, connections to the local innovation ecosystem, or formal pathways to other local economic development programs intended to support entrepreneurs or new businesses. Our study also found very limited evidence of
environmental practices or strong engagement with diverse communities, indicating a substantial gap between the promise and practices of makerspaces. Overall, there is a disconnect between the optimistic narratives of makerspaces in public policy and popular discourse and the ability of makerspaces to generate desired economic, social and environmental outcomes.

For practitioners and policymakers interested in creating and supporting makerspaces as actors in local innovation ecosystems and as pathways to more inclusive forms of local economic development, our study offers some important lessons. Rather than dismissing makerspaces based on the observation that they fall short in generating desired outcomes, it might be more important to recognize both the actual contributions of these spaces and consider whether some of these desired outcomes—related to new venture creation and skills development—could be addressed through changes to existing programming, strategic policy interventions to connect local actors, or through additional funding. This could include developing partnerships or bridges between makerspaces and other local innovation actors, such as business incubator and accelerator programs to provide a pathway for entrepreneurs. Indeed, our findings highlight that these connections are not well-articulated in practice. Nuance is also needed in any policies intended to facilitate such linkages in order to ensure that makerspaces have the appropriate resources and necessary supports. This is also true if makerspaces are to engage with underrepresented groups. Community outreach, diverse programming and accessible facilities are all prerequisites to the more inclusive economic development sought by advocates and policymakers alike. Makerspaces located within public libraries may be particularly well suited to this function. Examining the differences between makerspaces embedded within public institutions (e.g. libraries, universities) and privately operated organizations was beyond the scope of this paper, but merits future analysis given the growing interest in the contribution of these public institutions to local development (Sullivan, 2020).

However, policymakers and scholars also need to recognize the more fundamental limits of conceptualizing makerspaces in narrow terms that celebrate their potential contributions to local economic development, tempering these expectations against contemporary manifestations of makerspaces. For example, researchers should direct more attention to the financial and skill requirements necessary to gain entry to these spaces and to maximize the use of their resources. It is relatively expensive to access makerspaces that have advanced, leading edge equipment and tools. Moreover, more advanced technologies also require a greater depth of knowledge and skills to realize their fullest potential, further isolating these technologies from a wider audience. To this end, practical consideration should be given to initiatives that reduce barriers to entry, whether through funding mechanisms or partnerships with other local institutions such as colleges.

Our findings also suggest that many makerspaces have limited capacity to provide meaningful and sustained engagement with advanced technologies, and instead focus on providing foundational exposure to basic tools. Downloading a design file from the Internet and sending it to a 3D printer for fabrication, for example, constitutes a fairly passive relationship with advanced manufacturing technology. And while a 3D printer can create many interesting and useful objects, it may not always be the best tool for a particular application—a determination dependent upon one’s familiarity with the limitations of the technology. There remains the need to critically examine and understand the active versus passive
learning dynamics in makerspaces, which may lead to a greater appreciation for how these spaces can foster knowledge exchange and innovation.

Overall, rather than dismissing the potential of makerspaces to contribute to innovation and economic development, we would argue that these spaces and the communities they house still have the potential to act as key institutions that can contribute to local economies. A recent example emerging from one of our case studies during the COVID-19 global pandemic illustrates this point. During the early stages of the pandemic, a Kitchener-based tech firm pivoted to producing personal protective equipment (PPE). The firm was able to quickly scale up production by drawing on the skills and equipment of the local makerspace and its members (Lowe and Vinodrai, 2020a; Vinodrai et al., 2020). In this case, the local makerspace was able to coordinate initial access to a set of existing skills and technologies in the community, including engaging another local makerspace based at the public library. This initial support from the makerspaces proved critical to both the firm and region, allowing the company to rapidly increase its production and satisfy an urgent need among local hospitals and healthcare workers for PPE. Local policymakers only stepped in to assist with securing contracts, identifying funding and providing other business supports after the firm’s initial success, suggesting that leveraging makerspaces may not be on the radar as part of the economic development toolkit; this also aligns with our earlier observation that there was minimal formal engagement between makerspaces and local policymakers and economic development officials.

Nonetheless, the above example reminds us of the sometimes surprising and unexpected ways that local institutions can contribute to economic development and innovation processes. Guided by the insight that makerspaces can bring together and make visible latent skills and resources in local economies, we advocate for more intentional and active local policy and programmatic engagement with makerspaces. For example, economic development officials could forge connections between makerspaces and other local innovation ecosystem players and integrate makerspaces into their entrepreneurial and business support programs, while also recognizing the limitations associated with such efforts. And stable public funding might reduce or remove barriers related to capacity and resources, thereby allowing makerspaces to realize some of the potential imagined by policymakers. In other words, through carefully crafted interventions, policymakers can elevate the role of makerspaces as institutional vehicles for promoting local economic development and inclusive innovation.

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Note
1. We explore how making and makerspaces are positioned within Canadian urban economic development policies in greater depth elsewhere (Vinodrai et al., 2019).

References
Anderson C (2012) Makers: The New Industrial Revolution. New York, NY: Crown Business.
Arku G, Cleave E and Easton M (2020) Geographic differences in the distribution of manufacturing firms in Ontario. *Area* (2020): 1–12.

Bouw B (2019) Makerspaces under pressure to revamp business models. *The Globe and Mail*. Available at: www.theglobeandmail.com/business/small-business/managing/article-maker-spaces-under-pressure-to-revamp-business-models/ (accessed 26 June 2020).

City of Hamilton (2016) Economic development action plan 2016–2020. Available at: https://investinhAMILTON.ca/wp-content/uploads/2019/07/Hamilton-2016-2020-Ec-Dev-Action-Plan.pdf (accessed 27 June 2020).

City of Kitchener (2015) Make it Kitchener. Available at: www.makeitkitchener.ca/about/makeitkitchener_aoda-compliant-pdf_final-july-2016.pdf (accessed 27 June 2020).

City of Mississauga (2020) Mississauga economic development strategy 2020–2025. Available at: www.thefutureisunlimited.ca/wp-content/uploads/2020/03/Mississauga-Economic-Development-Strategy-2020-25-Strategic-Framework.pdf (accessed 27 June 2020).

City of Toronto (2017) From concept to commercialization: A startup eco-system strategy for the City of Toronto. Available at: www.toronto.ca/legdocs/mmis/2015/ed/bgrd/backgroundfile-78748.pdf (accessed 27 June 2020).

Clark J (2014) Manufacturing by design: The rise of regional intermediaries and the re-emergence of collective action. *Cambridge Journal of Regions, Economy and Society* 7(3): 433–448.

Davies SR (2017) *Hackerspaces: Making the Maker Movement*. Malden, MA: Polity Press.

Davies SR (2018) Characterizing hacking: Mundane engagement in US hacker and makerspaces. *Science, Technology, & Human Values* 43(2): 171–197.

Dawkins N (2011) Do-it-yourself: The precarious work and postfeminist politics of handmaking (in) Detroit. *Utopian Studies* 22(2): 261–284.

Deloitte (2014) *Impact of the Maker Movement*. Deloitte: Deloitte Centre for the Edge.

Diyode (n.d.) About Diyode. Available at: www.diyode.com (accessed 5 July 2020).

Dougherty D (2012) The maker movement. *Innovations* 7(3): 11–14.

Doussard M, Schrock G, Wolf-Powers L, et al. (2017) Manufacturing without the firm: Challenges for the maker movement in three U. *Environment and Planning A: Economy and Space* 50(3): 651–670.

Eisenburger M, Doussard M, Wolf-Powers L, et al. (2019) Industrial inheritances: Makers, relatedness and materiality in New York and Chicago. *Regional Studies* 53(11): 1625–1635.

Gershenfeld NA (2005) *Fab: The Coming Revolution on Your Desktop*. New York, NY: Basic Books.

Grodach C, O’Connor J and Gibson C (2017) Manufacturing and cultural production: Towards a progressive policy agenda for the cultural economy. *City, Culture and Society* 10: 17–25.

Hatch M (2013) *The Maker Movement Manifesto: Rules for Innovation in the New World of Crafters, Hackers, and Tinkerers*. New York, NY: McGraw Hill Education.

Hatch M (2018) *The Maker Revolution: Building a Future on Creativity and Innovation in an Exponential World*. San Francisco, CA: Maker Media.

Helper S, Gray J and Osborn B (2020) Retool U. S. supply chains to address weaknesses exposed by new coronavirus. *Washington Center for Equitable Growth*, 10 March. https://equitablegrowth.org/retool-u-s-supply-chains-to-address-weaknesses-exposed-by-new-coronavirus/

Kinahan KL (2016) Design-based economic development: Understanding the role of cultural institutions and collections of industrial and product design. *Economic Development Quarterly* 30(4): 329–341.

Lowe N and Vinodrai T (2020a) Reflections on retooling for the COVID-19 pandemic. *Metropolitics*. Available at: www.metropolitiques.eu/Reflections-on-Retooling-for-the-Covid-19-Pandemic.html (accessed 19 June 2020).

Lowe N and Vinodrai T (2020b) The maker-manufacturing nexus as a place-connecting strategy: Implications for regions ‘left-behind’. *Economic Geography* 96(4): 315–335.

Makerspace North (2020) Welcome to Makerspace North. Available at: https://makerspacenorth.com (accessed 5 July 2020).
National League of Cities (NLC) (2016) *How Cities Can Grow the Maker Movement*. Washington, DC: National League of Cities.

National League of Cities (NLC) (2017) *Discovering Your City’s Maker Economy*. Washington, DC: National League of Cities, Etsy, Recast City, and the Urban Manufacturing Alliance.

Pickering Public Library (PPL) (2012) Makerspace. Available at: www.picnet.org/makerspace (accessed 4 July 2020).

Pisano GP and Shih WC (2012) *Producing Prosperity: Why America Needs a Manufacturing Renaissance*. Boston, MA: Harvard Business Review Press.

PricewaterhouseCoopers (2018) The future of manufacturing – Canada. Global Manufacturing & Industrialisation Summit. Available at: https://gmisummit.com/knowledge-hub/2018/the-future-of-manufacturing-canada

Schrock G and Wolf-Powers L (2019) Opportunities and risks of localised industrial policy: The case of ‘maker-entrepreneurial ecosystems’ in the USA. *Cambridge Journal of Regions, Economy and Society* 12(3): 369–384.

Smart Growth America (SGA) (2017) *Made in Place*. Washington, DC: Smart Growth America.

Sprouts (n.d.) About sprouts maker space tech lab. Available at: www.sproutsmakerspace.ca/about (accessed 5 July 2020).

Sullivan M (2020) How a New Haven library is connecting residents to the city’s innovation economy. Available at: www.brookings.edu/blog/the-avenue/2020/10/26/how-a-new-haven-library-is-connecting-residents-to-the-citys-innovation-economy/ (accessed 21 April 2021).

The Makery (n.d.) About the Makery. Available at: https://notlpubliclibrary.org/themakery (accessed 4 July 2020).

Toombs A, Bardzell S and Bardzell J (2015) Becoming makers: Hackerspace member habits, values, and identities. *Journal of Peer Production* 5: 1–8.

Troxler P and Wolf P (2017) Digital maker-entrepreneurs in open design: What activities make up their business model? *Business Horizons* 60: 807–817.

Turner F (2018) Millenarian tinkering: The puritan roots of the maker movement. *Technology and Culture* 59(4): S160–S182.

Van Holm EJ (2017) Makerspaces and local economic development. *Economic Development Quarterly* 31(2): 164–173.

Vinodrai T (2018) Planning for cool: Millennials and the innovation economy of cities. In: Moos M, Pfeiffer D and Vinodrai T (eds) *The Millennial City: Trends, Implications and Prospects for Urban Planning and Policy* (pp. 27–38). London: Routledge.

Vinodrai T (2020) The new economy of Canadian cities: Employment, creativity and industrial change. In: Moos M, Vinodrai T and Walker R (eds) *Canadian Cities in Transition: Understanding Contemporary Urbanism*. 6th edition. Toronto: Oxford University Press.

Vinodrai T, Attema D and Moos M (2020) COVID-19 and the economy: Exploring potential vulnerabilities in the Waterloo region. Report for the Region of Waterloo. Available at: https://t.co/SJCEyhLO0O?amp=1 (accessed 21 April 2021).

Vinodrai T, Nader B and Casey P (2019) *Making Spaces: Planning for New Spaces of Urban Production*. Greenville, SC: Association of Collegiate Schools of Planning.

Wang F, Wang W, Wilson S, et al. (2016) The state of library makerspaces. *International Journal of Librarianship* 1(1): 2–16.

Wolf-Powers L, Schrock G, Doussard M, et al. (2016) *The Maker Economy in Action: Entrepreneurship and Supportive Ecosystems in Chicago*. Portland, OR: Portland State University.

Wolf-Powers L, Doussard M, Schrock G, et al. (2017) The maker movement and urban economic development. *Journal of the American Planning Association* 83(4): 365–376.

Wolf-Powers L and Levers A (2016) Planning, social infrastructure and the maker movement: The view from New York City. *Carolina Planning Journal* 41: 38–52.