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INSTITUTIONALISATION AND INFORMAL INNOVATION IN SOUTH AFRICAN MAKER COMMUNITIES

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This article explores the current modalities at play in respect of institutionalisation and informal innovation within maker communities in South Africa. A national scan in 2016-17 generated data on more than 20 maker communities across South Africa. The data provide insights into a number of management, spatial and activity variables present in the practices of the maker communities and their members. This article focuses on two of the dimensions found to be present when looking across the management, spatial and activity variables: institutionalisation and informal innovation. Institutionalisation is conceptualised as resulting in, and from: (1) formalisation of maker communities' practices; (2) partnerships between maker communities and formal organisations; and (3) embedding of maker communities in formal organisations. Informal innovation is conceptualised as manifesting in: (1) constraint-based innovation; (2) incremental innovation; (3) collaborative innovation; (4) informal approaches to knowledge appropriation; and (5) innovation in informal networks/communities in informal settings. Our data show that since the emergence of the maker movement in South Africa in roughly 2011, there has been an increase in institutionalisation of, and within, maker communities. At the same time, we find that there continues to be a strong spirit of informality in the communities, with most of the communities, including the relatively more-institutionalised ones, actively seeking to preserve emphasis on informal-innovation modalities. Our conclusion is that, in the present stage of evolution of the South African maker movement, elements of institutionalisation appear be largely offering synergies, rather than tensions, with the ethos of informal innovation. Such synergies are allowing South African maker communities to play an intermediary, semi-formal role, as mediating entities between formal and informal elements of the country's innovation ecosystem.

Keywords: maker movement, South Africa, maker communities, innovation, institutionalisation, formalisation, informal innovation, constraint-based innovation, incremental innovation, knowledge appropriation, informal networks, informal communities

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INTRODUCTION

Vocal proponents of the maker movement, notably in the United States, position the movement in largely utopian terms, as an adoption of do-it-yourself (DIY) approaches to innovation, and as a means through which consumers become creators (*Make*, n.d; Dougherty, 2012). Through tinkering and learning in hands-on environments, makers are said to be re-appropriating the production ideals of pre-industrial times. Anderson (2012) has declared that the movement represents the "New Industrial Revolution". The origins of these narratives lie in the launch of *Make* magazine in 2005 and in the first Maker Faire a year later, both in the US state of California. Other largely uncritical works are those by Hatch (2014) and Doorley et al. (2012).

While there is indisputable value in these US-originated founding narratives of the maker movement, their applicability is far from universal. They skew towards a developed-world, middle-class

(even upper-class, in some contexts) orientation (see Maker Faire, 2014). There is, meanwhile, an emergent body of work that takes a jaundiced view of the narrowness (see maxigas & Troxler, 2014; Mozorov, 2014) of the founding narratives, and literature that seeks to interrogate the meanings and modalities of making beyond middle-class, developed-country settings. Murray and Hand (2014) analyse the position of making in the Indian "digital humanities" context by examining, inter alia, the practice known as "*jugaad*", which, they argue, "while having similarities to hacking, should be understood in its culturally and historically specific contexts [...] rather than being forced into a Western template" (Murray & Hand, 2014, p. 152). Braybrooke and Jordan (2017) compare the prevailing Western casting of the maker movement with narratives around making in certain contexts in in Peru, India and China, finding that Western narratives may, inter alia, have the effect of rendering "Global South and non-Western perspectives invisible" (Braybrooke & Jordan, 2017, p. 2). The maker movement in developing-country contexts (India, South America) also receives treatment as a manifestation of "grassroots innovation" in the Smith et al (2016) volume.

The research we describe and analyse in this article contributes to the broadening of maker movement narratives, in our case through exploration of the activities and orientations of maker communities in the South African context. In South Africa, a country of stark disparities of wealth, we find a wide variety of narratives present in the minds of its makers. All the narratives bear traces of the founding US narrative, but in most cases the traces are faint, and in many cases extremely faint. We find in our contact with South African makers a strong sense of the uniqueness of the South African case. In this article we demonstrate and interrogate some of the particularities of the South African case through presentation of data and analysis in respect of two dimensions of the movement: its growing institutionalisation and its adherence to an ethos of informal innovation. Our focus on these two dimensions is grounded in the work of the research collective of which we are part, the Open African Innovation Research (Open AIR) network. Among Open AIR's core aims is to explore potential tensions between formalising and informalising trends in respect of innovation, knowledge management, knowledge appropriation, and linked phenomena.

Accordingly, it is our view that research into the emergent maker movement in African national settings must look closely at the degree to which informal innovation modalities are at home in the evolving South African movement, which is becoming increasingly institutionalised. In this article, we call the innovation and knowledge appropriation practices typical of informal sectors "informal innovation". We explore the ways in which informal-innovation modalities are, at present in South Africa's maker communities, interacting with the trends—in some respects countervailing, in other respects synergistic—towards increased institutionalisation.

Our exploration is based on a national scanning exercise we conducted in South Africa in 2016-17, which generated primary data on the management, spatial and activity characteristics of more than 20 maker communities across five of the country's provinces. The data allow us to identify a range of sustainability themes that warrant further investigation in the South African and other national contexts: stability of funding and revenue model; establishment of niches, reputations and brands; knowledge appropriation and intellectual property (IP); elements and degrees of institutionalisation; robustness of communities of practice; embeddedness in broader networks; orientations towards innovation and enterprise development; and socioeconomic inclusion. Each of these themes is given broad-spectrum treatment in an Open AIR working paper (see De Beer et al., 2017). In this article, we home in on institutionalisation, and its potential implications for informal innovation.

We consider evidence of institutionalisation as manifested by: (1) formalisation of maker communities' practices; (2) partnerships between

maker communities and formal organisations; and (3) embedding of maker communities in formal organisations. We consider evidence of informal innovation as manifested by: (1) constraint-based innovation; (2) incremental innovation; (3) collaborative innovation; (4) informal approaches to knowledge appropriation; and (5) innovation in informal networks/communities in informal settings, i.e., either physical (e.g., clusters) or virtual (e.g., online) networks/communities. This analysis illuminates several key characteristics of South Africa's maker movement, and exemplifies an approach that could also be useful for research into the maker movement in other African contexts, in other developing-world contexts, and in developed-country contexts.

The next section of our article introduces select literature relevant to institutionalisation and informal innovation in the maker context, and outlines our conceptual framework for interrogating institutionalisation and informal innovation as exhibited by South African maker communities. The third section elaborates on our data collection methodology for the national scan and how we ordered the collected data. Section four provides our findings in respect of the maker communities' degrees of institutionalisation and their orientations towards informal innovation. The final section provides our analysis and conclusions in respect of institutionalisation, informal innovation, and related dynamics in the South African maker movement.

RELEVANT LITERATURE

Making and Institutionalisation

The aforementioned founding, US-originated narrative of making is ambiguous in respect of institutionalisation, simultaneously extolling the virtues of non-institutional home-garage-based making and the virtues of nationally-franchised, for-profit, user-fee-based TechShops. The ambiguousness of the founding narrative in respect of institutionalisation is illustrated by the range of iterations, depending on who is writing or talking, that are given the status of "makerspace". When a small group of people decides to have weekly maker meetups in someone's garage, the group may soon start to speak of the garage as a makerspace. At the same time, hackerspaces, FabLabs and TechShops are all also typically awarded makerspace status. As Cavalcanti (2013) points out, the oldest of these labels, "hackerspace", has its origins in software-hacking (and thus for some people should not be conflated with a makerspace, which typically has a pronounced hardware element). The FabLab and TechShop brands, meanwhile, are much more recent. The FabLab ("Fabrication Laboratory") brand originated at the Massachusetts Institute of Technology (MIT), and a FabLab is supposed to be free (or very low-cost) to the user. TechShops, which began in California, are for-profit franchises that have been established in several US cities (Cavalcanti, 2013). Because of its emphasis on free or low-cost use (but with quite clear specifications regarding which equipment should be present), the MIT-conceived (and widely exported, including to South Africa) FabLab model is more institutionalised than the aforementioned garage makerspace but at the same time less institutionalised than the TechShop model with its user-fee-centric approach. The tools typically associated with makerspaces are 3D printers, laser-cutters and CNC (computer numeric control) machines, as well as trade tools such as sewing machines, woodworking tools, and welding equipment (Wang et al., 2015; Lorinc, 2013).

Making and Informal Innovation in Africa

The first African Maker Faire, coordinated by a Ghanaian entity separate from the aforementioned US-based Maker Faire brand, was staged in Ghana's capital, Accra, in 2009 (Maker Faire Africa, n.d.). Four more Maker Faire Africa gatherings followed, in Nairobi (2010), Cairo (2011), Lagos (2012), and then South Africa's commercial capital, Johannesburg (2014). The US Maker Faire brand has also found its way to Africa, including two South African appearances: the 2015 Maker Faire Cape Town and the 2016 Mini Maker Faire Cape Town.

Ekekwe (2015) and Yoder (2015) write about how the maker movement in Africa provides an opportunity for growth across the continent, through entrepreneurship and through skills development for problem-solving. Hersman (2013) discusses the interface between makerspaces and innovation in Africa. Waldman-Brown et al. (2013) posit that Ghana's informal-sector innovators can benefit, and avoid stagnation, through linkages with formal governmental and NGO actors, and, accordingly, Waldman-Brown et al. (2014) find that Ghana's FabLabs and makerspaces, as relatively formalised technological workshops, need to build strong linkages with informal-sector artisans' workshops.

Valuable existing research into innovation dynamics in Africa's informal sectors is present in Ndemo and Weiss (2017), De Beer et al. (2014, 2016), De Beer and Armstrong (2015), De Beer and Wunsch-Vincent (2016), De Beer et al. (2016), Kraemer-Mbula (2016), and Kraemer-Mbula and Wunsch-Vincent (2016). In addition, the Open AIR network is actively researching and writing about Africa's maker movement, via ongoing research in Ghana, Egypt and Kenya as well as developed-developing country comparisons via companion research in Canada. Open AIR has produced two Working Papers on the South African maker movement, the first an in-depth look at maker communities in Gauteng Province (Kraemer-Mbula & Armstrong, 2017), the second outlining results from the 2016-17 national scan that produced the data for this article (De Beer at al., 2017). Open AIR's work has led to a conceptualisation of the maker movement as cutting across its thematic research areas of *informal-sector innovation*, *high technology hubs*, and *indigenous and local entrepreneurs*, and thus providing fertile ground for exploring dimensions of institutionalisation and formality/informality (Open AIR, n.d.).

Making, in our view, has the potential to focus and channel some of the abundant informal-sector innovation on the continent towards 3D-printing, CNC-machining and other digitally-enabled hardware. Moreover, as its name suggests, the Open AIR network has an interest not only in innovation generally but also, more particularly, in modes of innovation oriented towards openness and open collaboration among groups of innovators. We find that the work of Von Hippel (2005, 2016) and Benkler (2006), while grounded in developed-world experience, is relevant to African maker contexts, through its emphasis on user innovation (Von Hippel, 2005). User innovators exist in a dynamic ecosystem of peer production (Benkler, 2006) characterised by open collaborative innovation (Baldwin & Von Hippel, 2011). This kind of open innovation is, however, not to be confused with an alternative conception in which the *firm* is open to licensing intellectual property (IP) with others (see Chesbrough, 2006). The sort of open innovation we see as associated with African makers typically has little to do with formalised IP concerns, and is akin to what Von Hippel (2016) has recently labeled "free" innovation.

Institutionalisation Modalities

In framing the notion of institutionalisation, we were guided to a great extent by the conceptualisation implied by the *Journal of Peer Production (JoPP)* call for submissions on "Institutionalisation of Shared Machine Shops", as follows:

> The dilemmas of institutionalisation (regarding both the *formalization* of practices and the fact that many practice-based spaces are now being *embedded* within larger organizations like museums, municipalities and businesses) provide us with an opportunity to critically examine networks, spaces and futures that may be assembling in this new phase. (*JoPP*, 2017, italics in original)

In line with this JoPP conceptualisation, two elements of institutionalisation that we consider in the data analysis for this article are: formalisation of maker communities' practices and embedding of

maker communities in formal organisations. Additionally, due to evidence from the national scan of a large and growing number of collaborations and funding relationships between the South African maker communities and formal entities, we include an additional conceptualisation of institutionalisation: maker communities' partnerships with formal organisations (such as universities, government/state entities, private-sector entities, non-profits). In sum, the three institutionalisation modalities we focus on are:

- formalisation of maker communities' practices;
- partnerships between maker communities and formal organisations; and
- embedding of maker communities' in formal organisations.

The listing of the institutionalisation modalities in this order—from internal practices, to partnerships, to embeddedness—reflects what we see as a hierarchy of institutionalisation, i.e., increased institutionalisation of a community's internal practices is unlikely to have as strong an institutionalising influence as embedding of the community in a formal entity.

Informal-innovation Modalities

In conceptualising the notion of informal innovation, we draw to a great extent on the work of De Beer et al. (2016) and Kraemer-Mbula (2016) in the edited volume The Informal Economy in Developing Nations: Hidden Engine of Innovation? (Kraemer-Mbula & Wunsch-Vincent, 2016). De Beer et al. (2016) speak of innovative behaviour in the informal economy as being characterised by, among other things: "constraint-based innovations", "[i]ncremental rather than radical innovations", innovations taking place "in geographically concentrated regions in a collaborative manner", and "lack of effort or methods to appropriate techniques, designs and final outputs" (2016, pp. 80-81). Kraemer-Mbula (2016) analyses, inter alia, the "incremental" and "collaborative" modes of innovation practised by South African informal-sector manufacturers of products for home and personal care (2016, p. 162). Drawing on these conceptualisations, the five informal-innovation modalities we focus on are:

- constraint-based innovation;
- incremental innovation;
- collaborative innovation;
- informal approaches to knowledge appropriation; and
- innovation in informal networks/communities in informal settings, i.e., either physical (e.g., clusters) or virtual (e.g., online) networks.

METHODOLOGY

Methods

We collected our primary data on South African maker communities in 2016-17 via the following means:

- desk analysis of each community's online presence, supplemented by email correspondence;
- in-person site visits to maker community premises, including attendance at certain communities' weekly meet-ups;
- informal in-person and videoconference discussions with participants in communities;
- formal., in-depth research interviews with participants, conducted in-person and via videoconference;
- convening of a South African Maker Movement Workshop in Pretoria in March 2017, attended by 50 participants including representatives of South African maker communities from three provinces and representatives from South African government departments, state agencies and NGOs;
- video-recorded interviews with makers during and after the Pretoria workshop; and
- scrutiny of post-workshop documents distributed via email by the South African Maker Collective.

Maker Communities Examined

A "snowball" (accumulative) sampling method generated referrals from one maker or maker community to another. When our research began in early 2016, we were initially only aware of maker communities present in the country's four largest urban areas: Johannesburg, Pretoria, Cape Town, and Durban. In the course of the research, we became aware of additional communities in the cities of Port Elizabeth, Bloemfontein and Ekuherleni, and in the town of Knysna. We also witnessed the emergence of new maker communities during the course of our research in and around Johannesburg and Ekuherleni—e.g., Made In Workshop, ZS6COG Fablab, Tsakane FabLab, Duduza FabLab and Soweto eKasi Lab—and still more maker communities in their planning stages, e.g., Vosloorus FabLab and the maker facilities planned for eKasi Lab Alexendra, eKasi Lab Mohlakeng and eKasi Lab Sebokeng. By the time this article is published in 2018, it is likely that there will be additional communities, in existence or in their planning stages, that we had no awareness of during our research. Such is the dynamism and momentum of the movement in South Africa. Table 1 below provides a provincial breakdown of the 25 maker communities on which we collected data, and a listing of our primary data sources for each.

Province	Maker Community	City/town	Year of formation	Sources of primary data

Gauteng province	House4Hack	Centurion	2011	online presence, email correspondence, site visit, informal discussions, formal interviews, national workshop, video interview at workshop
	Binary Space	Vanderbijlpark	2012	online presence, email correspondence, site visit, informal discussions, formal interviews, workshop participation, video interview at workshop
	Tinker Space, University of Johannesburg (UJ) Resolution Circle tech hub	Johannesburg	2012	site visit, informal discussion
	Makerlabs	Johannesburg	2013	online presence, site visit, formal interviews
	Geekulcha Makers	Pretoria	2014 (Geekulcha founded in 2013, its Geekulcha Makers programme in 2014)	online presence, email correspondence, site visit, informal discussions, formal interviews, national workshop, video interview at workshop
	Sebokeng FabLab, Vaal University of Technology (VUT) tech hub	Sebokeng	2014	online presence, site visit, informal discussion
	Ekuherleni FabLabs (Thokoza, Tembisa, Tsakane, Duduza)	Ekuherleni	2011-16	online presence
	Digital Innovation Zone (DIZ) Maker Space, University of the Witwatersrand (Wits) Tshimologong tech hub	Johannesburg	2015	online presence, site visits, informal discussions, formal interview, national workshop, video interviews at workshop
	University of Pretoria (UP) MakerSpace	Pretoria	2015	online presence, site visits, informal discussions, formal interviews, national workshop, video interview at workshop
	eKasi Lab Ga-Rankuwa	Ga-Rankuwa	2015 (Lab established in 2014, maker-type work in 2015)	online presence, site visit, informal discussions, formal interviews, national workshop
	I Make Makers Lab, Makers Village	Irene	2015 (Makers Lab established in 2015 as part of existing Makers Village)	online presence, site visit, informal conversations, formal interviews, national workshop, video interview at workshop
	Made In Workshop	Johannesburg	2016	online presence, site visit, informal discussion
	eKasi Lab Soweto	Johannesburg	2016	online presence, site visit, informal discussion
	ZS6COG Fablab (formerly BNT Masinga Trading and Projects)	Heidelberg	2016	online presence

Western Cape Province	Kluyts MakerSpace	Knysna	2012 (in present factory location since 2015)	online presence, email correspondence, informal Skype discussion
	Craft and Design Institute (CDI) Product Support Space	Cape Town	2013 (the broader CDI was established, as the Cape Craft and Design Institute (CCDI), in 2001)	online presence, site visit, informal discussion
	Workspace	Cape Town	2013	online presence, site visit, informal discussion
	Curiosity Campus *	Cape Town	2013	site visit, informal discussion
	The Bank	Cape Town	2014	online presence, site visit, informal discussion
	Maker Station	Cape Town	2014	online presence, email correspondence, site visits, informal discussions, national workshop, video interview at workshop
	Modern Alchemists, Women in Tech Cape Town, Arduino Cape Town (all coordinated by KATO Technology)	Cape Town	2014	online presence, informal discussions, national workshop, video interview at workshop
	University of Cape Town (UCT) Maker Society*	Cape Town	2015	online presence, email correspondence, site visit, informal discussions, national workshop, video interview at workshop
Kwazulu-Natal (KZN) province	The MakerSpace	Durban	2013	online presence, email correspondence, site visit, informal discussions, formal Skype interview, national workshop, video interview at workshop
Free State Province	Bloemfontein FabLab, Central University of Technology (CUT) tech hub	Bloemfontein	2006 (not a vibrant makerspace until recent years)	online presence, site visit, informal discussion
Eastern Cape Province	WERK	Port Elizabeth	2014	online presence

Table 1: Communities Consulted, and the Sources of Primary Data

* the Curiosity Campus and UCT Maker Society in Cape Town were no longer active at the time of finalisation of this article in early 2018. Source: De Beer at al. (2017)

Though we collected some form of data on 25 maker communities, we draw our findings and analysis only from data collected on communities with whom we made direct contact. We exclude from our findings and analysis those communities for whom our only data source was the community's online presence. We also exclude Curiosity Campus from our analysis because it shut down very shortly after our 2016 site visit and informal discussions. We do, however, retain the UCT Maker Society in our analysis because it only shut down in the latter half of 2017 and one of its representatives attended the March

2017 Maker Movement Workshop in Pretoria. Thus, in our view, it represented a meaningful part of the South African maker ecosystem during the period of our study. Accordingly, our findings are based on data from 21 communities (see Table 3 below).

We consistently refer to "makers", we acknowledge the fact that some of the communities we study—e.g., the eKasi Labs and the Craft and Design Institute (CDI) Product Support Space in Cape Town—do not position themselves first and foremost as making communities. Rather, to the best of our understanding, these communities see making as one of the mix of activity dynamics present in their communities. Also, it must be noted that for some of the communities studied, their years of formation were difficult to state with precision, because the communities were initially established with a non-making-centric purpose, e.g., as an enterprise incubator or accelerator, and only later evolved to include a makerspace element.

Other Entities Consulted

In addition to data on the above-listed maker communities, we also collected data on initiatives and bodies that support the South African maker movement. The three key entities in this category, and the primary data sources used for each, are listed in Table 2 below:

Entity	Location	Source of primary data
South African Maker Collective	nationally dispersed network	online presence, email correspondence, informal discussions, formal interviews, national workshop
Maker Library Network (MLN)	internationally dispersed network	online presence, informal discussions with MLN partner makerspaces
htxt.africa	online news site, managed from Johannesburg	online presence, informal discussions, formal interview, national workshop

Table 2: Supporting Entities Consulted, and the Sources of Primary Data

Data Ordering

The research team identified a set of descriptive variables that emerged from the data we had collected, which we clustered into a set of 12 management, spatial and activity variables, as represented in Figure 1 below. In the course of our data collection—looking at the ways in which the communities presented themselves online, and communicating with the communities via email and in-person—these were the 12 variables that we found arose most frequently.

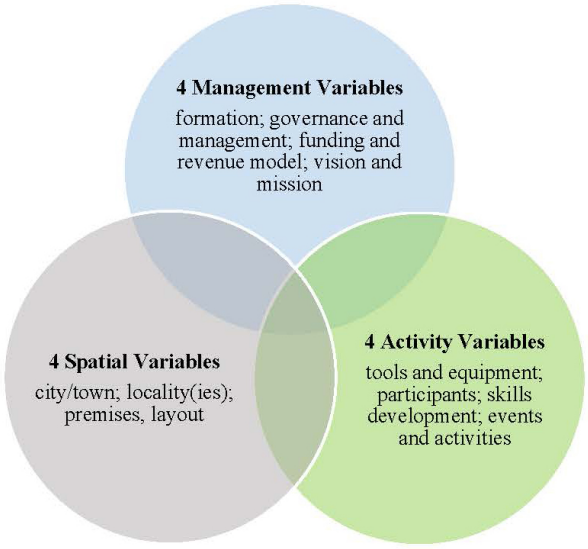

Figure 1: The 12 variables that emerged from the data

The determination of the 12 variables, and the setting out of the data according to the variables, was a descriptive exercise. The outputs from our analytical and conceptual work for this article are covered in the "Findings" and "Analysis and Conclusions" sections that follow this section. Tables outlining the descriptive data that generated the 12 variables can be found in De Beer et al. (2017), and data collected from formal interviews with eight of the Gauteng communities (referred to as "collectives" during that stage of the research) are analysed in detail in Kraemer-Mbula and Armstrong (2017).

For the purposes of this article, it useful to reproduce, from De Beer et al. (2017), the table (see Table 3 below) providing the data for 21 maker communities in respect of the four management variables: (i) formation; (ii) governance and management; (iii) funding and revenue model; and (iv) vision and mission.

Maker Community	Formation	Governance and Management	Funding and Revenue Model	Vision and Mission
House4Hack	2011	governed and managed by member volunteers	member donations, fees from course offerings, fees from corporate partnerships	"an initiative to bring together technology specialists and entrepreneurs in an informal setting […] trying to combine concepts from hackerspaces and innovation incubators" (www.house4hack.co.za/about)
BinarySpace	2012	governed and managed by member volunteers	member donations, membership fees, fees from course offerings, corporate sponsor	"a space where people with common interests in technology, science and electronic art, can meet, socialize and/or collaborate" (www.binaryspace.co.za)
Tinker Space, University of Johannesburg (UJ) Resolution Circle tech hub	2013	governed and managed by university-owned company	funded by university-owned company	Resolution Circle, of which Tinker Space is part "is a technology ecosystem that commercialises technology and develop engineering skills" (www.facebook.com/pg/ResolutionCircle)
Makerlabs	2013	governed and managed by member volunteers	member donations, membership fees, fees from course offerings	community "of makers, of open software (opensource) and open hardware. Home to 3D printing, Repraps, electronics, Arduino, RaspberryPie, Python and a bit of beer brewing" (www.meetup.com/en-AU/Makerlabs-co-za)

Geekulcha Makers	2014	governed and managed by paid Geekulcha staff	project partnerships with governments (foreign, national, provincial, local), private sector, universities, schools	"enables Digital Makers with tools, innovation platforms and a network for collaboration and co-creation […] to stimulate the notion of More Consumers than Producers […] building the world we want to see. It's about Collaboration and Co-creation" (http://makers.geekulcha.com/about)
Sebokeng FabLab, Vaal University of Technology (VUT) tech hub	2015	governed and managed by the university	university funds, membership fees	"enable grassroots inventions by providing a platform where communities can have access to advanced tools that can help people make products to address local needs" (www.vut.ac.za/fablab/)
University of Pretoria (UP) MakerSpace	2015	governed and managed by the university	university funds	"a creative laboratory where people with ideas can get together with people who have the technical ability to make these ideas become a reality" (www.library.up.ac.za/makerspace)
eKasi Lab Ga-Rankuwa	2015	governed and managed by government (provincial and local)	government funds (provincial and local)	"take innovation to the people by establishing co-creation and innovation spaces in the townships where local communities are able to access the services and facilities […] for the community and unemployed youth so that employment is created in their area of residence through skills and enterprise development" (www.facebook.com/pg/ekasilabs)
I Make Makers Lab, Makers Village	2015	governed and managed by non-profit foundation	proceeds from Makers Village (design and production services craft sales, restaurant, entertainment venue), funds from government, private sector	"the perfect place to gain skills on digital fabrication. Whether you use it as an individual, or in a workshop through your school, or as an inventor or entrepreneur, it helps you put your dreams and ideas into real [life]" (www.facebook.com/pg/imakersvillage)
Made In Workshop		governed and managed as a private business	membership fees, sale of consumables, proceeds from training offerings	"a shared fabrication studio and makerspace. We provide access to tools and industrial machines to people and business who would normally not have access to such facilities" (http://madeinworkshop.co.za)

eKasi Lab Soweto		governed and managed by government (provincial and local)	government funds (provincial and local)	"take innovation to the people by establishing co-creation and innovation spaces in the townships where local communities are able to access the services and facilities […] for the community and unemployed youth so that employment is created in their area of residence through skills and enterprise development" (www.facebook.com/pg/ekasilabs)
Kluyts MakerSpace	2012	governed and managed as a non-profit by Eden Community Initiative; also linked to a private business (Kluyts & Co. furniture store)	space rental fees	"We celebrate artists, craftsmen and product makers. We believe communities add value in workshops and real economies are built on building things of value. We enable makers by networking, equipping, resourcing and supporting them in a collaborative space" (www.facebook.com/pg/kluytsmakerspace)
Craft and Design Institute (CDI) Product Support Space	2013	governed by multistakeholder CDI Board, managed by paid CDI staff	government funds (national, provincial, local)	The CDI is "a craft and design sector development agency with a mission to develop capable people and build responsible creative enterprises trading within local and international markets" (www.thecdi.org.za/?page=about_us) The CDI Product Support Space is "an assisted DIY facility empowering and helping craft producers, designers, students, and other individual businesses to develop new, and refine existing product" (www.thecdi.org.za/?page=dev_product)
Workspace	2013	governed and managed by non-profit organisation	start-up funding from the British Council's Maker Library Network (MLN), project partnerships with local NGOs, donations, membership fees, space rental fees	"a platform for knowledge and skills exchange across the social, cultural and generational divides […] resources for all people from all backgrounds, ages and abilities to use "making" as a tool for empowerment, economic opportunity and the building of social capital […] a creative space for makers to engage, make and display their crafts" (www.workspace.org.za/about)
The Bank	2014	governed and managed as a private business	member donations, membership fees, space rental fees	"contemporary design space promoting innovation, collaboration, mentorship, idea exchange and business development" (www.wdccapetown2014.com/projects/project/464)
Maker Station	2014	governed and managed as a private business	user fees, membership fees, rentals, workshops, training, events	"a shared Maker, DIY, Hacker, Hobbyist, Designer, Prototyping, Art, Craft, and creative space, to build your projects of any size" (www.facebook.com/pg/makerstation.co.za)

Modern Alchemists, Women in Tech Cape Town, and Arduino Cape Town (all coordinated by KATO Technology)	2014	governed and managed by KATO Technology (a private business)	project partnerships, member contributions	Modern Alchemists: "Anyone that is into coding, gaming, electronics, music, making, etc come to these meetups to meet like minded people, skill swop, learn, make, watch, ask for advice" (www.linkedin.com/in/robynfarah) Women in Tech Cape Town: "a community designed to empower females who are in tech or want to learn more about tech" (www.kato.global/wit)
University of Cape Town (UCT) Maker Society	2015	governed and managed by students	member contributions	"aims to connect multiple disciplines across the university in creating and inventing together. We focus on workshops, build days and exhibitions designed to help students grasp the practical aspect of building and designing" (www.facebook.com/pg/UCTmakersociety)
The MakerSpace		hybrid: governed and managed by member volunteers alongside a private business	hybrid, including donations, start-up funding from the British Council's Maker Library Network (MLN), membership fees, member donations, fees from course offerings, aligned commercial projects and services.	"is about lowering the barriers of entry for people to express their creativity in a physical way. It is about people getting together, working creatively, inspiring each other, engaging with new technology, and building a 'bottom-up economy' " (http://themakerspace.co.za/what-we-are-about)
Bloemfontein FabLab, Central University of Technology (CUT) tech hub	2006	governed and managed by the university	university funds	"enable grassroots inventions by providing a platform where anyone can have access to advanced tools that can help people make products to address local needs [...] peer-to-peer learning which enables anyone with or without a technical background to learn and have a space to experiment" (www.cut.ac.za/fablab)

Table 3: Data for the four management variables

Source: De Beer et al. (2017)

In Table 3 above, it is the data for the "governance and management" and "funding and revenue model" variables that are of particular relevance to this article. In these two columns of the table, one can see substantial diversity in the paths being followed by South Africa's maker communities. There are many potential lenses through which one can seek to analyse these dimensions. At a broad level, as we have argued in De Beer et al. (2017), one needs to view the data for these two variables, and the other 10 variables, through a lens of sustainability. In this article, we focus on a sub-

dimension within considerations of sustainability: possible the impacts of institutionalisation, including its potential impacts on the ethos of informal innovation.

The analytical work to produce the findings, analysis and conclusions presented in the next two sections of this article has both deductive and inductive elements. We deduce the extent and dynamics of both institutionalisation and informal innovation in terms of our chosen conceptual frameworks (outlined earlier) for these two dimensions. At the same time, in a largely inductive fashion drawing on elements of situational analysis and grounded theory-building, we interrogate the degree to which increased institutionalisation is proving to be compatible with the communities' informal-innovation dynamics.

FINDINGS

Growing Institutionalisation of the Maker Communities

When the maker movement took hold in South Africa in 2011, the pioneer was House4Hack in Centurion (Tshwane). House4Hack was established as a loosely-organised, club-like, largely non-institutionalised grouping of tech enthusiasts and hobbyists. House4Hack in turn spawned two other communities with a similarly non-institutional, club-like orientation, BinarySpace in Vanderbijlpark and Makerlabs in Johannesburg. And in class terms, all three of these spaces began as, and still largely are, middle-class in their membership and based in middle-class suburbs in their respective cities. Thus, in its beginnings, the South African movement was largely non-institutional and, at the same time, largely middle-class.

Today in early 2018, the South African maker movement is significantly more diverse, in several respects, than it was at its origins roughly seven years ago. Many of the newer communities are significantly more institutionalised than House4Hack, BinarySpace and Makerlabs, and also much less middle-class-centric. To some developed-world readers, this correlation between increasing institutionalisation and increasing class diversity among users may seem counter-intuitive; but in the South African context, this correlation is not particularly surprising, due to conditions described below.

- Growing institutionalisation of South African maker communities is apparent in respect of each of the three institutionalisation modalities in our conceptual framework as outlined earlier in this article:
- formalisation of maker communities' practices;
- partnerships between the maker communities and formal organisations; and
- embedding of the maker communities in formal organisations.

Formalisation of Maker Communities' Practices

Fees for Membership, Use, Training and Space Rental

Several of the South African maker communities in existence today have membership-fee structures, including Made In Workshop, the DIZ MakerSpace, and Makerlabs (all in Johannesburg); BinarySpace in Vanderbijlpark; and Maker Station in Cape Town (interviewees 1, 2 and 5, 2016).

There are also maker communities that charge user fees for use of certain tools and facilities, including Made In Workshop in Johannesburg and Maker Station in Cape Town. Some communities, including House4Hack, charge fees for certain training programmes they provide (an illustration of the fact that even the club-like, hobbyist-oriented, founding South African maker community, House4Hack, is more institutionalised than it was at its establishment.) Another element of formalisation found in some South African maker communities is space rental/leasing. Communities charging rental fees to enterprises working out of their premises include Maker Station and Workspace in Cape Town,

Kluyts MakerSpace in Knysna, and House4Hack in Centurion (which had one on-site enterprise paying rent at the time our data collection).

Links to Formalised Market Opportunities

Several of South Africa's maker communities prioritise links to formalised market opportunities, including I Make Makers Lab in Irene (Tshwane), Kluyts MakerSpace in Knysna, the DIZ Maker Space in Johannesburg, and House4Hack in Centurion (interviewees 15 and 21, 2016). The I Make Makers Lab is situated within an entity called Makers Village, and one of the aims of the Village is to bring informal-sector artisans into contact with formalised marketing opportunities. Artisans linked to the Village are able to: sell products via the Irene Trading Post store at the Village; sell services and products to clients procuring fabrication services from the Village; and sell services and products to the Village's restaurant and entertainment venue, the Railways Café. At the Kluyts MakerSpace in Knysna, the space is twinned with the Kluyts and Co. wooden furniture store, which provides the enterprises who rent space in the MakerSpace with opportunities to supply services and products to Kluyts and Co. clients. At the DIZ Maker Space in the University of the Witwatersrand (Wits) Tshimologong Precinct in Johannesburg, the space is coordinated by a private company, African Robot, which produces items on a commercial basis in addition to managing the space and providing training and facilitation to member users.

Formation of a National Association

There are also elements of formalisation in evidence in the efforts of South African makers to organise themselves at national level via an association. The association, which first began to take shape in early 2016, is the South African Maker Collective. At the time of the South African Maker Movement Workshop we convened in Pretoria March 2017, the Collective was still nascent, and largely being driven by The MakerSpace in Durban (which provided both in-person and video presentations to the March 2017 workshop). The workshop brought together Collective members from Gauteng Province (Johannesburg, Pretoria, Vanderbijlpark), Cape Town and Durban who do not often have opportunities to meet face-to-face. We gave control of the late-afternoon session of the one-day workshop to the Collective, so that it could facilitate breakaway sessions that generated ideas for how the South African movement could operate at local, provincial, national and international levels. Later that same month of March 2017, a leader in the Collective sent out an email message to all workshop attendees asking attendees: to give inputs on a written record of the meeting's outcomes; to provide information about their work; and to consider formalising their membership in the Collective. That email stated that:

> [w]e are excited to get The South African Maker Collective up and running more formally. […] The idea of the collective is to minimize admin on makers while maximising their impact, influence and access to resources. (South African Maker Collective, 2017)

In early 2018, as this article was being finalised, another Collective member sent out an email, to the Collective's national email list, entitled "SA Makers Collective formalization: Draft Constitution doc & Maker weekend planning" with the draft Constitution attached and a message reading as follows:

> I encourage, urge and implore you to have a read through our DRAFT of a Constitution Document for the Collective, and share your input, suggestions and critique - it's a COLLECTIVE, after all. The aim of this document is to ultimately represent us as the SAMC so we can register the Collective as a legal entity within the next 3-6 months […] and run it full-time as our "Industry body" – the objectives WHY are in the document. ;-). (South African Maker Collective, 2018b)

Among the objectives of forming a formalised

Collective, as stated in the draft Constitution, are the creation of "a contact point" the country's maker communities", building the "credibility" of the national maker "network", providing a "collective bargaining" dimension, sharing knowledge, collaborating, engaging in collective fundraising, and engaging in collective community/social responsibility activities (South African Maker Collective, 2018a).

Partnerships between Maker Communities and Formal Organisations

Partnerships with South African Government Entities

Several of the maker communities have substantial partnerships with government entities. Geekulcha, the umbrella initiative under which the Geekulcha Makers project falls, partners with national government, the Gauteng Provincial Government, the Northern Cape Provincial Government, the City of Tshwane, and the City of Johannesburg. The Craft and Design Institute in Cape Town, under which the CDI Product Support Space falls, has funding partnerships with local, provincial and national government. Among the I Make Makers Lab's multiple partnerships are an equipment support partnership with the national Industrial Development Corporation (IDC) and a training partnership with the state- and industry-funded national Sector Education and Training Authority (SETA) for Media and Information and Communication Technology (the MICT SETA). Meanwhile, the DIZ Maker Space partners with the City of Johannesburg on annual #Hack.Jozi Challenge hackathons. This desire by government entities to partner with South African maker communities was also apparent in the participation, in the March 2017 South African Maker Movement Workshop in Pretoria, by representatives of the national Department of Science and Technology (DST), the aforementioned national IDC, and the aforementioned Gauteng-Government-led Innovation Hub.

At the same time, even with all of the existing partnerships between the maker communities and government entities, there was a view expressed at the Maker Movement Workshop that government entities need to be more proactive in seeking partnerships with makers, most of whom lack experience in dealing with government funding and procurement modalities. In the words of one of the DIZ Maker Space presenters who spoke at the workshop:

> The trouble we have is how do we actually take it to the next step? […] Ok great, like, come up with this big proposal [to government], but that's not what we're good at. We are good at making, we are good at inventing, we are good at hardware. We are geeks. We need support from government, to say "This is what we need, our ROI [return on investment] is x, y, z. How can you guys help establish that?" (DIZ Maker Space, 2017)

Partnerships with Schools

Several South Africa's maker communities partner with schools in order to give school children access and exposure to maker tools and techniques. Making is viewed, by the maker communities and schools alike, as a powerful vehicle for building of science, technology, engineering and mathematics (STEM) skills, and science, technology, engineering, art and mathematics (STEAM) skills. In the words of one of the makers interviewed at the South African Maker Movement Workshop in Pretoria:

> I think in terms of the maker movement in the South African context, education […] comes to the forefront. I think our education system needs to change drastically, and I think the maker movement is an absolute shining light in this sector. (interviewee 30, 2017)

Maker communities that have partnered with schools include Geekulcha Makers, DIZ Maker Space, I Make Makers Lab, and House4Hack.

Partnerships with Foreign Government Entities

The UK-Government-funded British Council, through its international Maker Library Network (MLN) initiative, has partnered with several South African maker communities, by providing initial start-up funding and resources. MLN supports provision by maker communities of a makerspace, a maker library, and a gallery to display and sell maker products, and each MLN maker community is given linkages to other communities in the global MLN movement. South Africa maker communities that have partnered with MLN include Durban's The MakerSpace, Cape Town's The Bank, Workspace in Hout Bay, and Geekulcha in Tshwane. Geekulcha has also partnered on some of its training with the US State Department, and the UP MakerSpace has partnered with a US Agency for International Development (USAID) programme, ResilientAfrica Network (RAN), for UP student innovation competitions.

Partnerships with Private-sector Bodies

Geekulcha frequently partners with private-sector firms in delivery of its programmes. House4Hack sometimes hosts innovators sponsored by the South African Breweries Foundation (SAB Foundation) Social Innovation Awards Programme. Made In Workshop has partnerships with some of its equipment suppliers.

Partnerships with the Non-profit Sector

One of the maker communities we studied—the I Make Makers Lab—is embedded in a non-profit entity governed by a foundation. We also identified interest from certain small-enterprise-support NGOs in partnering with maker communities in incubating innovative enterprises. Representatives from two such NGOs, Awethu Project and The Hope Factory, participated in the South African Maker Movement Workshop in Pretoria in March 2017.

The South African Maker Collective's Openness to Partnerships

A March 2017 email message from the South African Maker Collective to participants in that month's national workshop in Pretoria proposed five possible "membership levels" for the Collective, as follows:

- Founder members – Key members responsible for the formation of the collective
- Organisational Members – Maker Spaces, Hacker Groups, Universities, Clubs, etc
- Partners – Sponsors, brands, companies making a financial contribution
- Members – Regular makers supporting the cause
- Associated Members – people sitting on the fence not currently willing to contribute. (South African Maker Collective, 2017)

Here in this proposal for consideration of "Sponsors, brands, companies making a financial contribution" as potential "Partners" with membership status in the Collective, we see the Collective's apparent openness to private-sector institutional linkages.

Partnership with the Open AIR network

A partnership of some sort has emerged between members of the South African Maker Collective and Open AIR research network. The South African Maker Collective includes one of the Open AIR South Africa maker team members (who is also one of the authors of this article) in the Collective's email list, thus keeping Open AIR abreast of the Collective's activities and offering the Open AIR the opportunity to input on the Collective's documents, including the aforementioned February 2018 South African Maker Collective draft Constitution. (Open AIR has to date chosen not to input on the documents shared by the South African Maker Collective.) As well, both before and after the Pretoria workshop of March 2017, one of the maker communities in the Collective proposed ideas for more formal partnerships in the future with Open AIR on research, advocacy and policy engagement matters. Following the Pretoria workshop, the Open AIR Egypt researcher team invited one of the drivers of the South African Collective to participate in its own workshop in Cairo. It is probable that the introductions made

during and around that workshop could also lead to collaborations, perhaps even partnerships, between South African makers and Open AIR researchers (and makers) in Kenya, Ghana, Canada, and elsewhere.

Embedding of Maker Communities in Formal Organisations

Embedded in Government Entities

Maker communities fully embedded in government structures include the eKasi Labs of Ga-Rankuwa (Tshwane) and Soweto (Johannesburg) and the FabLabs of the City of Ekurhuleni (next to Johannesburg). The eKasi Labs are co-creation, innovation and entrepreneurship hubs funded by the Gauteng Provincial Government's Innovation Hub. eKasi Lab Ga-Rankuwa is housed in the Ga-Rankuwa Arts and Crafts Centre, which is owned and run by the City of Tshwane. The maker collective is housed in the Manufacturing section of the Centre. (The Centre used to be craft-focused but is now a multipurpose municipal facility, with the eKasi Lab as the anchor initiative.) The Soweto eKasi Lab is housed in the Soweto Empowerment Zone, an entrepreneurship support hub owned and run by the City of Johannesburg. The maker activities at that eKasi Lab, still at only their very early stages at the time of the data collection, are in the eKasi Lab's FabLab room.

Partially Embedded in a Government Entity

Another maker community, Geekulcha Makers, is headquartered at the Gauteng Provincial Government's Innovation Hub in Tshwane, but in many respects it is not truly embedded in the Innovation Hub. The Geekulcha Makers community, part of a suite of Geekulcha programmes, funds its activities through a wide range of partnerships with entities outside of the Gauteng Government, and conducts most of its activities away from the Innovation Hub.

Embedded in a Government-funded Entity

The CDI Product Support Space is a unit of the larger Craft and Design Institute (CDI), which is government-funded (with national, provincial and local government funds) but governed by a multistakeholder Board that includes non-government members.

Embedded in Universities

One collective is embedded in a university campus: the UP MakerSpace housed in the Merensky Library on the Hatfield Campus of the University of Pretoria (UP). The UCT Maker Society was also embedded in a university, the University of Cape Town, but disbanded in the second half of 2017 due to the core members graduating.

Embedded in University-linked Technology Hubs

Several of the communities are embedded in university-linked tech hubs. Johannesburg's DIZ Maker Space is situated in the Tshimologong Digital Innovation Precinct, a development spearheaded by Wits University in partnership with government and private-sector partners. The University of Johannesburg (UJ) Tinker Space is in UJ's Resolution Circle tech hub; the Sebokeng FabLab is part of the Vaal University of Technology (VUT) Southern Gauteng Science and Technology Park; and the Bloemfontein FabLab is part of the Central University of Technology (CUT) Science Park.

Embedded within Non-profit Foundation Entity

The I Make Makers Lab is embedded in the Makers Village in Irene (Tshwane)—but with the I Make mobile lab allowing the I Make project to also operate in locations away from the village, including rural locations very far from Irene, in Limpopo, Mpumalanga and KwaZulu-Natal Provinces. The I Make Makers Lab project, as with the entire Makers Village, is governed by a non-profit foundation and funded from a range of sources.

We now turn to our findings in respect of the maker communities' informal-innovation modalities.

The Maker Communities' Orientation towards Informal Innovation

We found numerous examples in the data of maker community adherence to all five of the modalities in our informal-innovation conceptual framework:

- constraint-based innovation;
- incremental innovation, i.e., adopting, adapting and improving of available ideas, practices, technologies to solve problems;
- collaborative innovation;
- informal approaches to knowledge appropriation; and
- innovation in informal networks or communities in informal settings, i.e., either physical (e.g., clusters) or virtual (e.g., online) networks/communities.

Constraint-based Innovation

The makers we interviewed made frequent reference to a strong tradition, in South Africa, of innovation in response to constraints. In the words of a member of the DIZ Maker Space, "I do think true innovation happens […] out of necessity, and I think South Africa has a lot more of that necessity than, say, places in Europe (interviewee 1, 2016). Several interviewees made reference to the Afrikaans-language saying "'n Boer maak 'n plan" ("A farmer makes a plan"), referring to the perceived tradition in South Africa of responding to scarcity by making do with what one has at one's disposal. As one interviewee explained:

> […] we don't have the broad population having the kind of luxury of living in the so-called "First World conditions" where everything is organised. And therefore, you know, we have a saying in Afrikaans, which says " 'n Boer maak 'n plan". […] And if I could tell you some of the stuff my father did […] He was a maker of note, he was an improviser, because we didn't have much financial means […] We lived on a small farm […] I could [tell] you stories about his inventions and maker talent that could keep you busy for a long time. (interviewee 23, 2016)

In the words of another maker, who presented at the South African Maker Movement Workshop in Pretoria:

> The significance of making in the South African context is that it's just part of who we are. We need to find ways to solve problems, we need to find the path of least resistance, because either we don't have resources, or we don't have the time, or we don't agree with the way it's being done formally. So, we make a plan. We're inventive, resourceful, that way, and if you don't have everything at your disposal, you figure out how to do it with what you have. (interviewee 32, 2017)

The low-cost Morgan 3D Printer, developed by a member of the House4Hack collective, seems clearly to be an innovation born of constraint. It is a "rep rap" (replicating rapid prototyper) printer that can largely self-replicate by printing most of the parts needed to assemble a copy of itself. According to interviewee 21 (2016), a key motivation for development of this printer was that imported 3D printers were initially prohibitively expensive in South Africa, thus prompting the developer to make a product that could "put a high-quality machine into the hands of [South African] makers" at an affordable price.

Two of the makers who attended the Maker Movement Workshop spoke of their innovations as driven by adversity. The first, a student doing his making at the UP MakerSpace, spoke of how his alternative-energy-production innovation is grounded in the need to address electricity-access challenges facing many South Africans (interviewee 31, 2017). Another innovator, working out of the DIZ Maker Space, spoke of how his "smart pavement" brick innovation aims to help South Africans prevent household crime by being alerted, via sensors in bricks, to unusual activities in their driveways (interviewee 33, 2017). In the words of one of the

Geekulcha presenters at the Pretoria workshop, "at the end of the day, we need to step up to national problems. We need to step up to the needs" (Geekulcha, 2017).

Incremental Innovation

We also found a strong ethos of incremental innovation among the makers interviewed. As one member of the Makerlabs collective in Johannesburg explained, "I don't think as a maker that there's anything really that you are doing that's, like, brand-spanking-new […] there's something very similar out there. You've just got a different twist on it (interviewee 20, 2016). A House4Hack interviewee exemplified the spirit of incremental innovation when describing House4Hack's PiScope project, through which the collective built an astrophotography unit using parts of a telescope, a Raspberry Pi, and a Raspberry Pi Camera. "It has been done before, so I wouldn't say it's like unique", the interviewee said, but "it hasn't been done in the way we are doing it, and we've come up with great ideas of what it can do that [have] never been tried before" (interviewee 15, 2016).

Several respondents spoke of South Africans' talent for incremental innovation grounded in recycling and re-purposing of existing items. In the words of one interviewee, "we [South Africans] basically take technology, whether it's cutting edge or not, and we repurpose it" (interviewee 15, 2016). According to another: "To a real maker, something broken isn't broken, it's just parts for a new project, and definitely that has a huge, huge impact […] recycling [is] very much a big part of it" (interviewee 1, 2016). Another maker put it this way: "in the South African context […] using some of the recyclable materials and all that, we just can come up with new [ideas] and build some of the new things" (interviewee 4, 2016).

Collaborative Innovation

We also found frequent reference to the power of collaboration—as an engine of innovation, and of learning and skill-sharing. In the words of a maker in the BinarySpace collective in Vanderbijlpark,

> [f]or a lot of guys, the reward is the learning experience, especially for me. I don't mind helping you with something. I don't mind even developing your whole project for you. Because for me, learning something out of it, is the goal, or, is the reward. (interviewee 7, 2016)

As an interviewee from the DIZ Maker Space explained it, "the most connecting thing is this idea of sharing knowledge, and I think that you can almost tell immediately when you meet with someone whether they have that kind of mindset or not" (interviewee 1, 2016). Another DIZ Maker Space member, in his presentation to the Pretoria workshop, described the workings of collaborative innovation in makerspaces in the following terms:

> Just to be in that environment, you know, where ideas are shared every day, where you collaborate on so many things, we found it to be quite helpful. […] We came into the space with an idea, you know, but what we are now is totally different. Because somehow guys have helped us shape what we are doing and what we are about. (DIZ Maker Space, 2017)

Informal Approaches to Knowledge Appropriation

We found that respondent attitudes towards knowledge appropriation also largely fit with the assumptions in our informal-innovation conceptual framework. The vast majority of interviewees made statements suggesting they saw little or no value in attempts at formalised knowledge appropriation via tools such as patents or copyrights. Interviewee 4 (2016), when describing the innovations Geekulcha has developed in respect of installing tracking devices into skateboards, and teaching high school students to do the same via its "SkateHack" programme, spoke of the skateboard-tracking as an "open idea". He stated that, when introducing the idea to students, "it was a new idea to them, so it

was just like a 'wow' thing. […] It was […] an open idea, so everybody who's willing to actually build a skateboard like that […] can actually build it as well."

Another example of a lack of concern with formal appropriation emerged from the interview with interviewee 15 (2016), from House4Hack. He told this anecdote about House4Hack winning two competitions with a remote-control innovation:

> A lot of people came to us and said, like, "okay, so have you patented this thing, are you gonna sell it?" […], and I was like, "you know what, all the code is on […] an open source repository. You can go and download it, and you can go make it yourself, and you can go sell it. Go have fun" […] I had zero interest in trying to build a company out of this.

According to another House4Hack member (interviewee 14, 2016), making and formalising intellectual property do not fit well together, because, he said, making is based on a "philosophy of generosity, of giving", rather than a "scarcity mentality". He said that "we sometimes do get people that come here with the scarcity mentality, and how you identify them is the first thing they want you to do is sign an NDA [non-disclosure agreement]. And then pretty much at that point, we can tell them to go away, […] that's not who we are."

An interviewee from BinarySpace in Vanderbijlpark stated his belief that seeking a patent for an innovation can become a "barrier" because of the cost and time involved. He and colleagues at BinarySpace agreed that the key goal of a small-scale innovator seeking to commercialise something needs to be getting the product to market as soon as possible, not worrying about the innovation being copied. Often much of the economic value, they felt, will come not from selling the product but from boosting one's reputation and from the ability to charge for servicing the product (interviewees 5-8, 2016). An interviewee from House4Hack, who developed a low-cost 3D printer that he now manufactures on a small scale and sells, said he never had an interest in patenting the design and had made the design specifications freely available online. His said his view is that as soon as one seeks to keep a product innovation secret, or to patent or copyright it, one merely draws unhelpful attention to the innovation from people who may then seek to copy and commercialise the same product or something very similar (interviewee 21, 2016).

An interviewee from the DIZ Maker Space portrayed South African makers' approach to knowledge in this way:

> Especially in the past, they were like "this is my idea, but I mustn't share it because then that guy is just going to take it and make money off it". Whereas the big change is in like "cool I just figured out how to do this completely new thing, hey, let me show you and then you can do it because you might discover something that I wouldn't because your background's slightly different, then you'll share that back to me". (interviewee 1, 2016)

Innovation in Informal Networks/Communities in Informal Settings

We found that several of the communities had forged strong links to grassroots innovators operating in low-income, informal settings. For example, at eKasi Lab Ga-Rankuwa, the entrepreneurs we interviewed had all begun as grassroots, informal innovators, and had entered the Lab's innovation incubation and commercialisation programme (funded by the Gauteng Government's Innovation Hub) in response to a public call for applications that had been circulated in Ga-Rankuwa, a low-income community. We also saw evidence at eKasi Lab Soweto, which had only recently been established at the time of our visit, of connection with low-income, informal-sector innovators. And Geekulcha has forged links to the grassroots through, among other things, its work with informal-sector entrepreneurs at eKasi Lab Ga-

Rankuwa (interviewee 3, 2016).

Workspace in Hout Bay (greater Cape Town) has strong links to people, particularly youth, living in Hout Bay's low-income informal settlements. Workspace's outreach to the local youth is via a project it calls The Employable Nation (TEN). The TEN programme seeks to build a set of 10 skills seen as necessary to increased employability, with the skills built through participants engaging in projects ranging from cooking and jewellery-making to welding and woodworking. Another Cape Town-area maker community, Maker Station, has also forged links with low-income, informal-sector innovators, through offering low-cost access to tools applicable to a wide range of fabrication methods (including both digitally-mediated and analogue methods).

The I Make Makers Lab has a strong focus on linking with innovation by grassroots craftspeople from low-income areas (interviewee 18, 2016). The I Make mobile unit is used to work with rural craftspeople in Limpopo, Mpumalanga, and KwaZulu-Natal Provinces (interviewee 18, 2016). According to an I Make interviewee: "Basically, we run a pilot project to obtain the data to see how we can influence job creation in South Africa, by putting together really informal […] individuals from various areas in South Africa with technology within the Makers Lab" (interviewee 29, 2017).

We also found that three of the maker communities embedded in university-led tech hubs—DIZ Maker Space, Sebokeng FabLab and Bloemfontein FabLab—are managing to draw in informal-sector innovators from nearby low-income townships. And Kluyts MakerSpace in Knysna is tapping into that town's informal-sector woodworking innovators.

ANALYSIS AND CONCLUSIONS

Gradations of Institutionalisation

While the overall trend in the South African maker movement is towards greater institutionalisation, it must at the same time be emphasised that there is significant diversity in the communities' degrees of institutionalisation.

At the lowest level of institutionalisation sit BinarySpace in Vanderbijlpark and Makerlabs in Johannesburg, both of which continue to operate largely as they operated at their inception: as small, club-like groupings of hobbyists. Apart from charging nominal membership fees, these two communities exhibit very little institutionalisation. The evidence we collected suggests that these two maker communities will seek to remain largely non-institutionalised.

The BinarySpace representative who attended the Maker Movement Workshop in Pretoria in 2017 stated clearly, during plenary discussions, that BinarySpace did not want to dilute its non-institutional ethos, and that there should not be attempts by the national movement to create a one-size-fits-all model for maker communities (BinarySpace, 2017). BinarySpace's attitudes towards institutionalisation may have been coloured by an experience that one of its members described during our 2016 interviews—an experience wherein partnership talks between BinarySpace and a local tertiary institution broke down because the institution appeared to be setting too many conditions for the partnership.

The other still-largely-non-institutional maker community, Makerlabs, also seems to be determined to remain largely free of institutional modalities. In 2017, Makerlabs tried a model whereby its weekly meet-ups were held at Made In Workshop, which is in the same suburb of Johannesburg (Randburg) as the location of Makerlabs meet-ups but which is much more institutionalised. (Made In Workshop is modelled on the US TechShops, providing membership-fee-based and user-fee-based access to extremely high-quality fabrication equipment.) By the end of 2017, Makerlabs had reverted to its original model, holding its meetups in much-less-institutionalised, and much-less-well-equipped premises—an apparently strong testament to the incompatibility of the

Makerlabs ethos and a more institutionalised ethos.

Sitting very near to BinarySpace and Makerlabs on the non-institutionalised end of the institutionalisation continuum is the founding South African makerspace, House4Hack, which shares many of the club-like, hobbyist traits of BinarySpace and Makerlabs—which is unsurprising given that BinarySpace and Makerlabs were started up by former House4Hack members. But House4Hack has, in recent years, introduced some clear institutional features that are not present in its two offshoots. House4Hack has a fee-based training programme; it rents space to a 3D-printer-making business; and it hosts innovation interns via a funded arrangement with the South African Breweries social responsibility unit.

Sitting near the fully institutionalised end of the institutionalisation spectrum are the eKasi Labs of Ga-Rankuwa and Soweto, the UP MakerSpace, Made In Workshop, and the CDI Product Support Space. The eKasi Labs are government-funded and hosted in government-owned facilities, and the participants in their programmes are aspiring innovators who have applied, and been selected for, incubation support from the Gauteng Provincial Government's Innovation Hub. The UP MakerSpace is housed in a University of Pretoria Library, managed by university employees, staffed by university students paid by the university, and is accessible only to university students. Made In Workshop is a private business following a model akin to a US TechShop franchise, providing access to high-end equipment and professional support to paying members. The CDI Product Support Space is part of the broader Craft and Design Institute, which, though governed by a multistakeholder board including non-government representatives, is to a great extent accountable to government by virtue of receiving funding from local, provincial and national government. We see all of these maker communities as highly institutionalised because they meet at least two of our institutionalisation criteria: formalisation of practices, partnerships with formal organisations, embedding in formal organisations.

Also highly institutionalised are the maker communities embedded in university-led tech hubs: the DIZ Maker Space, the Tinker Space, the Sebokeng FabLab, and the Bloemfontein FabLab. All of these communities meet the embeddedness criterion in our institutionalisation framework, and tech hubs are by their very nature based on partnerships among formalised entities. Thus all of the maker communities working out of university-led tech hubs meet two of our three institutionalisation criteria: embeddedness and partnerships. And the DIZ Maker Space also charges nominal user fees, thus meeting our other institutionalisation criterion: formalisation of practices.

For all of the other maker communities from which we used data in our findings and analysis, it was difficult to know where to place them on the institutionalisation continuum. And this we came to regard as a key strength of the South African maker movement in its present stage of evolution. There are at present myriad models being followed, with many of the communities adopting hybridised approaches that allow them to be both somewhat institutionalised and somewhat non-institutionalised at the same time. The Geekulcha initiative, for instance, under which the Geekulcha Makers community falls, has its offices at the Gauteng Government's Innovation Hub, but Geekulcha does not behave in an embedded fashion, with most of its training and outreach projects taking place away from the Innovation Hub, in partnership with a wide range of formalised government and corporate partners. And perhaps because it has so many partnerships with so many different formalised entities, Geekulcha seems to be able to avoid institutional rigidity. And Geekulcha does not blindly accept every partnership. According to interviewee 3 (2016) of Geekulcha, the community refused an event collaboration with a software firm because the firm insisted that only its software be used at the event.

Several of the communities have found their fluid versions of institutionalisation through hybrid

funding arrangements, as shown in the "funding and revenue model" column in Table 3 above. For example, the I Make Makers Lab and Kluyts MakerSpace both operate on a non-profit basis but are twinned with initiatives that include commercial elements. Durban's The MakerSpace runs has a mix of non-for-profit and commercial activities.

Class Orientations

We saw above in the literature review that one of the critiques levelled at the maker movement in the developed-world context is its tendency to be skewed towards serving middle-class users and interests. In the South African context, we found that only six of the 21 spaces for which we extracted findings and analysis could be categorised as middle-class-oriented: BinarySpace, Makerlabs, House4Hack, Made In Workshop, UP MakerSpace, and UCT Maker Society.

BinarySpace, Makerlabs and House4Hack all meet in privately-owned spaces in middle-class suburbs. Made In Workshop's middle-class orientation is a function of its location in a middle-class Johannesburg suburb and its aforementioned adoption of a TechShop-style model based on membership fees and user fees. For its part, the UP MakerSpace, embedded in the University of Pretoria campus, is only mandated to the university student body, the majority of whom are from middle-class backgrounds. And the UCT Maker Society at the University of Cape Town was, before its closure in the second half of 2017, geared towards the student body which, as with UP's student body, is largely middle-class.

With the other 15 maker communities, we identified significant latitude, and intent, to reach out to, serve, and collaborate with, innovators from a wide range of backgrounds, including low-income and impoverished innovators. And we found this outreach to be present in communities exhibiting a range of degrees of institutionalisation, including both highly-institutionalised communities (e.g., the eKasi Labs and the maker communities in university-led tech hubs) and the myriad communities following hybridised approaches that allow a mix of institutional and non-institutional dynamics.

Thus it was only in the largely non-institutionalised category of communities—as represented by BinarySpace, Makerlabs, House4Hack—that we found an absence of class diversity in the participants. Thus it would appear that institutionalisation, as it is presently operating in the South African maker movement context, is having a positive impact on class inclusiveness.

Informal-Innovation Modalities

It could be supposed that institutionalisation modalities conflict with informal-innovation modalities, and vice versa. However, that is not what we found in the South African case. We found strong adherence to informal-innovation values and practices across all the communities from whom our data findings and analysis were drawn. The previous section of this article provided numerous examples of South African maker communities valuing and nurturing informal-innovation modalities. The examples were drawn from maker communities situated all along the continuum between non-institutionalisation and institutionalisation: from the largely non-institutionalised communities, through to the hybrid communities balancing non-institutional and institutional elements, through to the large institutional communities. Unlike class inclusiveness, which we found dropped off in certain settings, particularly non-institutional ones, we found no significant dilution of the informal-innovation ethos in any of the 21 communities on which we based our findings.

Accordingly, our conclusion is that, in the South African case, informal-sector innovation modalities in a maker community are, at present, neither significantly undermined nor significantly strengthened by institutionalisation modalities. When significant elements of institutionalisation are present in a South African maker community—as is

the case in the clear majority of the communities—the increased formality inherent in many elements of institutionalisation does not conflict with informal innovation. Rather, the two sets of modalities can co-exist, and coexist fruitfully.

At the same time, we are not suggesting that the informal-innovation ethos is generic across South African maker communities. A key distinction can be made, in our view, based on the degree to which a maker community has to date managed to forge strong links to low-income, grassroots, informal-sector innovators. In the communities with these kinds of strong links—i.e., the ones mentioned in the final subsection of the "Findings" section above (the two eKasi Labs, Geekulcha, Workspace, Maker Station, I Make, three of the tech-hub-embedded communities, and Kluyts MakerSpace)—one inevitably finds a certain number of innovators with strong livelihood needs linked to their innovation efforts. While low-income and middle-class innovators may share, as we found they do, an adherence to the informal-innovation ethos, there is no doubt that, at certain points, a low-income innovator's objectives will diverge from those of a middle-class innovator. (The low-income innovators drawn into South African maker communities will inevitably, in our analysis, have more pronounced needs than middle-class makers at the level of socio-economic inclusion—and follow-on Open AIR research already underway is seeking to explore the socio-economic dimensions of making in the South African context.)

Formal-informal Intermediation

Many South African maker communities appear to provide clear example of the reality, as found in previous research (Kraemer-Mbula & Wamae, 2010; Kraemer-Mbula & Wunsch-Vincent, 2016) and as explained in De Beer et al. (2016), that a strong feature of innovative behaviour in African and other developing-world informal settings is synergy between informal innovative behaviour and formal-economy elements. As De Beer et al. (2016) write:

> Innovations in the informal economy have various connections with the formal sector. Knowledge, skill, capital, people and other types of resources can sometimes flow both ways. (De Beer et al., 2016, p. 80)

Our findings suggest that: (i) there is a substantial, and growing, two-way flow of resources of various kinds between South African maker communities and formal-sector entities; and (ii) that both South African maker communities and formal entities see the need for these flows to continue and strengthen.

The JoPP call for submissions on "Institutionalization of Shared Machine Shops", cited above, speaks of "[t]he dilemmas of institutionalisation" for communal fabrication communities, of which maker communities are an example. Our finding is that, in the current South African maker context, elements of institutionalisation appear to present more opportunities than dilemmas—and that South African maker communities appear to be, in general, favourable towards, and able to harness, those opportunities.

A sentiment voiced by several stakeholders at the 2017 South African Maker Movement Workshop in Pretoria was that South African maker communities need to continue to seek, and strengthen, mutually beneficial partnerships with government and other formal entities. There appears to be a clear sense that such partnerships, and other elements of institutionalisation via elements of formalisation, can be pursued in a manner that does not detract from the core informal-innovation power of making. There also seemed to be a sense, present at the workshop, that linkages between maker communities and the formal sector offer communities the potential to increasingly function as part of developmental, multi-stakeholder ecosystems in the country—ecosystems that can contribute to alleviating South Africa's shortfalls in areas such STEM/STEAM education, youth employment, and enterprise development.

Viewed in this manner, South Africa's maker

communities can potentially be seen as new, emerging intermediaries in South Africa's innovation ecosystem: intermediaries between actors in the formal and informal sectors/economies. We have seen this intermediary role in other African contexts studied by the Open AIR network. Kawooya's (2014) research into the innovation dynamics of Ugandan informal-sector auto parts fabricators in Kampala identified an intermediary "semi-formal" entity, Gatsby Garage, which was a linking-point for the informal-sector artisans and staff and faculty at Makerere University. And soon-to-be-published research by our Open AIR network colleagues Oluseye Jegede in Nigeria and Yaw Adu-Gyamfi in Ghana has also found evidence of intermediary actors bridging formal and informal modalities/entities/sectors. This theme of informal-formal intermediation is potentially central to understanding the role of the maker movement in African, developing-world, and even developed-world, national innovation systems. South Africa's maker communities, we conclude, appear to demonstrate that institutionalisation dynamics in innovation settings can, and ideally should, be dynamics characterised by two-way flows, between formal and informal modalities.

REFERENCES

Baldwin, C. & Von Hippel, E. (2011) 'Modeling a paradigm shift: from producer innovation to user and open collaborative innovation', *Organization Science,* 22(6), pp. 1399-1417.

Benkler, Y. (2006) *The wealth of networks: how social production transforms markets and freedom*. London: Yale University Press.

BinarySpace (2017) Inputs to South African Maker Movement Workshop, Pretoria, 3 March.

Braybrooke, K. & Jordan, T. (2017) 'Genealogy, culture and technomyth: decolonizing Western information technologies, from open source to the maker movement', *Digital Culture & Society*, 3(1), pp. 25-46. Available at: https://www.degruyter.com/view/j/dcs.2017.3.issue-1/dcs-2017-0103/dcs-2017-0103.xml

Chesbrough, H. (2006) 'Open innovation: a new paradigm for understanding industrial innovation', in Chesbrough, H., Vanhaverbeke W. and West. J. (eds), *Open innovation: researching a new paradigm*. Oxford: Oxford University Press.

De Beer, J., Armstrong, C., Oguamanam, C. & Schonwetter, T. (eds) (2014) *Innovation and intellectual property: collaborative dynamics in Africa*. Cape Town: UCT Press.

De Beer, J. & Armstrong, C. (2015) 'Open innovation and knowledge appropriation in African micro and small enterprises (MSEs)', *The African Journal of Information and Communication (AJIC),* 16, pp. 60-71. Available at: https://doi.org/10.23962/10539/19315

De Beer, J., Fu, K. & Wunsch-Vincent, S. (2016) 'Innovation in the informal economy', in Kraemer-Mbula, E. & Wunsch-Vincent, S. (eds), *The informal economy in developing nations: hidden engine of innovation?* Cambridge, UK: Cambridge University Press.

De Beer, J., Armstrong, C., Ellis, M. & Kraemer-Mbula, E. (2017) *A scan of South Africa's maker movement*. Ottawa and Cape Town: Open African Innovation Research (Open AIR). Available at: http://www.openair.org.za/publications/a-scan-of-south-africas-maker-movement/

DIZ Maker Space (2017) Presentation to South African Maker Movement Workshop, Pretoria, 3 March.

Dougherty, D. (2012) 'The maker movement', *Innovations,* 7(3), pp. 11-14.

Ekekwe, N. (2015) 'Africa's maker movement offers opportunity for growth', *Harvard Business Review*.

Available at: https://hbr.org/2015/05/africas-maker-movement-offers-opportunity-for-growth

Geekulcha (2017) Presentations to South African Maker Movement Workshop, Pretoria, 3 March.

Hatch, M. (2014) *The maker movement manifesto: rules for innovation in the new world of crafters, hackers, and tinkerers*. New York: McGraw Hill. Available at: http://www.techshop.ws/images/0071821139%20Maker%20Movement%20Manifesto%20Sample%20Chapter.pdf.

Hersman, E. (2013) 'The need for both makerspaces and incubators in Africa' *Ventureburn*. Available at: http://ventureburn.com/2013/02/the-need-for-both-makerspaces-and-incubators-in-africa/

Journal of Peer Production (JoPP) (2017) 'The institutionalization of shared machine shops: new spaces, networks + practices', *JoPP,* 12. Available at: http://peerproduction.net/cfp-jopp-special-issue-12-the-institutionalization-of-shared-machine-shops-new-spaces-networks-practices/

Kawooya, D. (2014) 'Informal-formal sector interactions in automotive engineering, Kampala', in De Beer, J., Armstrong, C., Oguamanam, C. & Schonwetter, T. (eds). *Innovation and intellectual property: collaborative dynamics in Africa* (pp. 59-76). Cape Town: UCT Press.

Kraemer-Mbula, E. (2016) 'Informal manufacturing of home and personal care products in South Africa' in Kraemer-Mbula, E. & Wunsch-Vincent, S. (eds), *The informal economy in developing nations: hidden engine of innovation?* Cambridge, UK: Cambridge University Press.

Kraemer-Mbula, E. & Wamae, W. (2010) 'Adapting the innovation systems framework to Sub-Saharan Africa', in Kraemer-Mbula, E. & Wamae, W. (eds), *Innovation and the development agenda*. Paris and Ottawa: OECD and IDRC.

Kraemer-Mbula, E. & Wunsch-Vincent, S. (eds) (2016) *The informal economy in developing nations: hidden engine of innovation?* Cambridge, UK: Cambridge University Press.

Kraemer-Mbula, E. & Armstrong, C. (2017) *The maker movement in Gauteng Province, South Africa.* Ottawa and Cape Town: Open African Innovation Research (Open AIR). Available at: http://www.openair.org.za/wp-content/uploads/2017/06/WP-6-Maker-Movement-in-Gauteng-Province-South-Africa.pdf

Lorinc, J. (2013) 'Makerspaces: the future of innovation', *Profit Guide*. Available at: http://www.profitguide.com/industry-focus/manufacturing/the-future-of-innovation-57873/2

Make. (n.d.). Website. Available at: http://makezine.com.

Maker Faire. (2014) *Attendee study: Maker Faire Bay Area 2014*. Available at: http://makermedia.com/wp-content/uploads/2013/01/MFBA-2014-research-deck_FINAL.pdf

Maker Faire Africa. (n.d.). Website. Available at: http://makerfaireafrica.com

maxigas & Troxler (2014) 'Digitally-operated atoms vs. bits of rhetoric: a mashup', *Journal of Peer Production*, 5. Available at: http://peerproduction.net/issues/issue-5-shared-machine-shops/editorial-section/digitally-operated-atoms-vs-bits-of-rhetoric/

Morozov, E. (2014) 'Pick up a spot welder and join the revolution', *New Yorker*. Available at: https://www.newyorker.com/magazine/2014/01/13/making-it-2?currentPage=all

Murray, R.P. & Hand, C (2015) 'Making culture: locating the digital humanities in India', *Visible Language* 49(3), pp. 140-155. Available at: http://visiblelanguagejournal.com/issue/172

Ndemo, B. & Weiss, T. (eds) (2017) *Digital Kenya: an entrepreneurial revolution in the making*. London: Palgrave. Available at: https://www.palgrave.com/us/book/9781137578808

Open African Innovation Research (Open AIR) (n.d.). 'Research'. Available at: http://www.openair.org.za/research

Smith, A., Fressoli, M., Abrol, D., Arond, E. & Ely, A. (2016) *Grassroots innovation movements*. London: Taylor & Francis.

South African Maker Collective (2017) 'Maker Collective feedback' [email], 29 March.

South African Maker Collective (2018a) 'South African Maker Collective Constitution' [draft], 3 February.

South African Maker Collective (2018b) 'SA makers collective formalization: draft constitution doc & maker weekend planning' [email], 5 February.

Von Hippel, E. (2005) *Democratizing innovation*. Cambridge, MA: MIT Press.

Von Hippel, E. (2016) *Free innovation*. Cambridge, MA: MIT Press.

Waldman-Brown, A., Obeng, G.Y. & Adu-Gyamfi, Y. (2013) 'Innovation and stagnation among Ghana's technical artisans', paper presented at the 22nd Conference for the International Association of Management of Technology, Porto Alegre, Brazil.

Waldman-Brown, A., Obeng G.Y., Adu-Gyamfi, Y., Langevin, S. & Adam, A. (2014) 'Fabbing for Africa's informal sector'.

Wang, D., Dunn, N. & Coulton, P. (2015) 'Grassroots maker spaces: a recipe for innovation', paper presented at the 11th European Academy of Design Conference, Paris Descartes University.

Yoder, B. (2015) 'Let's talk about the maker movement in Africa', *Parisoma*. Available at: http://www.parisoma.com/blog/posts/the-maker-movement-in-africa-must-be-built-by-africans

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