The Management and Implications of DIY Laboratories for Innovation and Society: Taking Stock and Charting the Future

Abstract

DiY science, as a field of research and practice, has grown rapidly over the past few decades. However, a significant portion of the DiY corpus focuses on technical issues in engineering and health disciplines, which limits our knowledge about the administration of DiY innovation and other related topics. To further advance the field, this special issue examines the management and implications of DiY laboratories for innovation and society. It contributes to a better understanding of the contextual and individual antecedents, operations, governance, business models, and strategies of DiY labs. The chosen papers, representing a mix of review, conceptual, and qualitative methodologies from across Africa, Asia, and Europe, provide different approaches and views that extend the current boundaries of extant knowledge regarding DiY labs and science. This special issue also highlights what remains to be pursued and outlines some interesting future research directions.

Introduction

The link between innovation, firm performance and economic growth is an interesting topic among researchers, practioners and policymakers. Several studies have reported significant positive impacts of innovative activities on competitive advantage (Hashi & Stojcic, 2013; Li & Atuahene-Gima, 2001; Wadho & Chaudhry, 2018) and national productivity (Avila-Lopez, Lyu, & Lopez-Leyva, 2019; Edo, Okodua, & Odebiyi, 2019; Pandey & Banwet, 2018). Whereas there are inconsistencies and disagreements about the fundamentals, definitions and typologies of innovation (Klarin, 2019), there has been some sense of unequivocality regarding the sources of innovation. Historically, innovation has always come from expensive, structured, and well-resourced laboratories funded or owned by universities, public research centres and large companies. However, in recent times, there has been a proliferation of Do-It-Yourself laboratories (hereafter, referred to as DIY labs) across developed and developing countries. These laboratories are often established by science enthusiasts and "garage-style entrepreneurs" (Grohn et al., 2015) to learn, experiment and engage in the advancement of science, technology, and innovation.

DiY labs are a rapidly growing phenomenon that present an additional model of innovation to expand the pace of technological advancement (Galvin, Burton, & Nyuur, 2020). They are organized around open-source innovation governance architectures and are characterized by loose and relaxed structures that encourage participation from volunteers, communities, venture capitalists and angel investors in unconventional settings such as museums (Ellis & Waterton, 2005), pubs (Secord, 1996), and private homes (Meyer, 2013). As DIY labs serve as alternative homes for local talent (Sleator, 2016), they pose competitive challenges to traditional innovation stalwarts such as universities and companies. Perhaps, their greatest competitive advantage comes from their low start-up costs and low cost-cost

operating models (Grohn et al., 2015), which make them more efficient than traditional laboratories without compromising their potential for new discoveries. Representing platforms for technological innovation at the grassroots and embodying democratization, they allow people to experiment and test ideas (Meyer, 2013).

Today, DiY labs are open to tinkering and experimentation among amateurs and novices (Sarpong, Ofosu, Botchie, & Clear, 2020), but they were first founded by professional scientists to counter the rigid and bureaucratic systems that surround mainstream research and innovation (Lhoste, 2020). In these labs, they could produce technological knowledge more freely without the stringent controls and peer evaluation that fraught conventional research practices in academic settings. They used the labs as avenues to express their critique of traditional innovation models while also establishing a counterculture characterized by openness, excellence, anti-establishment, and single-handedness (Dance, 2017; Delgado, 2013; Delgado & Callén, 2016; Ferretti, 2019). DiY labs are therefore characterized by civic technoscience and participatory research, serving as incubators for social, democratized, and frugal innovation (Burnside et al., 2019; Edwards-Schachter, Matti, & Alcántara, 2012; Gibney, 2016; Rajan, 2021; Seyfried, Pei, & Schmidt, 2014; Wylie, Jalbert, Dosemagen, & Ratto, 2014). They demystify science, encourage interdisciplinary collaborations at the grassroots, and provide a springboard for diverse forms of knowledge production that straddle the boundaries between academic, practitioner and citizen research (Lhoste, 2020; Sarpong et al., 2020).

The growing proliferation of DiY labs can be situated in the "open science" movement which seeks to democratize science by allowing non-scientists or non-technical people to be involved in scientific projects (Fecher & Friesike, 2014). Open science is "based on openness and connectivity, on how research is designed, performed, captured, and

assessed" (Vicente-Saez & Martinez-Fuentes, 2018: 428). It thrives on partnerships and alliances, open processes, open tools, open business models, open trade of intellectual property, and open culture (Friesike, Widenmayer, Gassmann, & Schildhauer, 2015; Woelfle, Olliaro, & Todd, 2011). Its goal is to offer a novel method for scientists to communicate directly with diverse audiences and provide a route for the public to gain direct access to original work (David, 1998, 2004; Grand, Wilkinson, Bultitude, & Winfield, 2012). More importantly, it aims to repair the broken trust between scientists and the public. Distrust of scientists has been rampant due to several cases of denialism and retractions of scientific knowledge (Mirowski, 2018), entrenchment of partisan and demographic divergences in opinions about science in the wider society (Chayinska et al., 2021; Freeman et al., 2020; Gauchat, 2012; Lamberty & Imhoff, 2018; Lewandowsky, Oberauer, & Gignac, 2013; Simpson & Rios, 2019), and the catastrophes of science-related disasters (Braun, 1999; Millstone & van Zwanenberg, 2000).

DiY projects, in consistence with "open science" traditions, are open sourced and participatory, thereby facilitating amateur-expert collaborations. This does not only increase trust in scientific knowledge and inventions, but it also increases the pool of ideas for effective and efficient innovation. As such, DiY labs generate advantages for society. For instance, they create bottom-up and patient-driven medical solutions that fill healthcare gaps through the provision of low-cost biomedical technology and equipment (Carrera & Dalton, 2014; de Lorenzo & Schmidt, 2017; Dolgin, 2010). With DiYers mostly being individuals – i.e., curious citizens, entrepreneurs, and hobbyists - the technology and equipment they create are appropriate and applicable to their needs and those of wider society (Lee, Hirschfeld, & Wedding, 2016). DiY labs also help in the mass education and sensitization of the public on diverse issues (Sarpong et al., 2020). In healthcare, "garage biology" fosters citizen science' for the empowerment of ordinary people" (Meyer, 2013: 118) by giving them "access to their

own biological data in the most direct way possible" (Wolinsky, 2009: 684). Information is shared and disseminated via various media and channels including blogs, forums, videos, and events for public consumption (Fox, 2014; Kuznetsov & Paulos, 2010). It is even argued in some quarters that DiY labs increase students' understanding of concepts by allowing them to gain character shaping and intellectual building experiences from hacking (Sheridan et al., 2014). DiY is associated with experiential learning, especially in STEM subjects (Chowrira, Smith, Dubois, & Roll, 2019; Parisi, Rognoli, & Sonneveld, 2017; Ruslan, Bilad, Noh, & Sufian, 2021).

Rationale for this Special Issue

Both the promise and challenges of DiY labs have received some scholarly attention (Keulartz & van den Belt, 2016; Landrain, Meyer, Perez, & Sussan, 2013), but mainly in non-management disciplines such as health and engineering. While business and management research has extensively investigated innovation in traditional companies, incubators, and research centres (e.g., Kolympiris & Klein, 2017; Rothschild & Darr, 2005; Sá & Lee, 2012; Xiao & North, 2018), the corpus has not kept pace with other organizational forms such as DiY labs. In fact, DiY labs can be likened to incubators, but even works on entrepreneurial and technology incubation including those published in *Technology Analysis and Strategic Management* (e.g., Clausen & Rasmussen, 2011; Kiran & Bose, 2020; McAdam, Galbraith, McAdam, & Humphreys, 2006; Nair & Blomquist, 2019) have steered clear of these labs. Consequently, we know little about the operations and management of DiY labs. Yet, a thorough understanding of how DIY labs operate is crucial to help policymakers and other stakeholders realize their full potential.

In the same vein, despite the promise of DiY labs as important source of innovation (Seyfried et al., 2014), diverse concerns have emerged about their operations (Ferretti, 2019;

Wolinsky, 2005), their ethical implications (Wexler, 2016), and their threat to public health and environmental safety due to frequently operating under regulatory radars (Gorman, 2011). DiY labs are therefore double-edged "hackspaces" that can promote science, innovation, and technology, but are also prone to abuses that can endanger whole societies and countries. Despite the foregoing, there is still limited research about the multiple facets of these labs, ranging from their emergence to their management.

This special issue therefore aimed to deeply develop our conceptual and empirical understanding of the management and implications of DiY labs for innovation and society, and consolidate divergent but related issues inherent in DiY. In doing so, this special issue further strengthens *Technology Analysis and Strategic Management's* rich history of publishing research at the nexus of technology and strategy, especially extending its current coverage of business incubation and innovation (e.g., Clausen & Rasmussen, 2011; Kiran & Bose, 2020; McAdam et al., 2006; Nair & Blomquist, 2019) to the DiY realm. In this respect, we invited rigorous and multidisciplinary contributions from researchers and policy experts.

The call for papers captured several themes intended to provide a holistic coverage of DiY labs from internal and external perspectives (see Fig 1). Internally, we wanted to understand the antecedents and evolution of DiY labs, their competitive strategies, and their impact on businesses and society. We also wanted to understand how DiY labs protect and diffuse their innovation and technology, how they attract talent, how they are governed, and the ethicality of their operations. Externally, we wanted to understand how DiY labs manage stakeholders in their social and political environments, how they gain or manage legitimacy, and how they are affected by government policy, actions, and inactions.

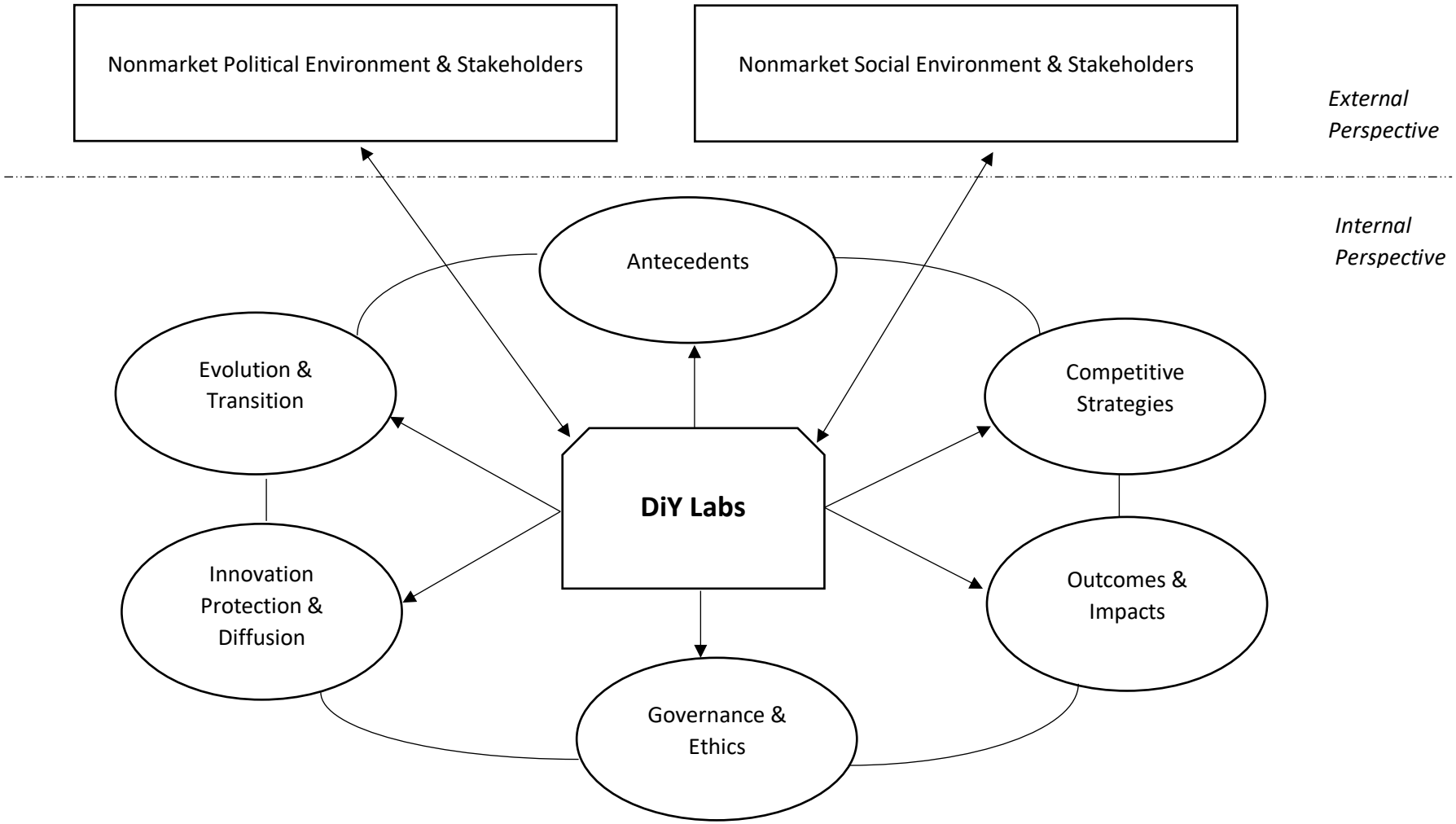

Figure 1. Conceptualization of the Special Issue

Overview of the Papers in this Special Issue

We received a broad array of submissions spanning conceptual, review, and empirical (quantitative and qualitative) papers, which testifies the growing interest in DiY research and the richness of the works that are currently being conducted on the DiY phenomenon. This special issue contains 10 papers that shed light on several important topics about DiY labs. The papers, which adopt diverse theoretical underpinnings and methodological approaches but are united by their ambition to further our knowledge on DiY (see summary in Table 1), nicely connect with and complement or extend other special issues published in *Technology Analysis and Strategic Management* (e.g., Banda & Huzair, 2021; Kale & Niosi, 2017, 2017; Volberda, Oshri, & Mom, 2012) and other journals (e.g., Atkinson, 2006; Finn, 2014). They live up to the high academic standards of *Technology Analysis and Strategic Management* and thereby push the boundaries of DiY innovation within the business and management discipline.

In the first paper - *Challenges and Competencies of Entrepreneurial Leaders in Driving Innovation at DIY Laboratories,* Ahmed and Harrison (2021) acknowledge the lack of management literature about DiY labs and establish the pertinence for exploring leadership skills and competencies required for driving DiY innovation. They link entrepreneurial performance with leadership capabilities, arguing that DiYers need human, social and institutional capital to succeed. Drawing on entrepreneurial leadership models, they conduct a narrative literature review and present a comprehensive and integrated competency framework from a DiY perspective. Their paper explicates the challenges faced by DiY labs and outlines how they can be mitigated with personal, functional, interpersonal, technological, ethical, and environmental competencies. A key takeaway from this work work is that it provides insights to help current and prospective DiYers understand the capabilities they need to successfully foster innovation and creativity.

Table 1. Papers in this Special Issue

Authors	Research Aim	Level of Analysis	Theoretical Lens	Methodological Approach & Context	Main Finding/Argument	Main Implication
Fida Ahmed & Christian Harrison	Identify the challenges of DIY labs and to develop a competency model for entrepreneurial leaders in DIY labs	Individual	Entrepreneurial leadership competencies	Review	There are six essential entrepreneurial leadership competences that are required for successful innovation in DIY labs.	DIY entrepreneurs can build the trust of government and other regulatory bodies by developing leadership competencies
Morgan Meyer	Understand what is experimented in low tech labs and how they are documented	Projects in a DiY Lab	Science and technology corpus	Case study; France	Tutorials, videos, and reports are used to document low-tech experiments	DiY labs can use documentation to legitimize their operations and spell their importance to society.
Mengwei Hu & Albrecht Fritzsche	Understand how the design of open labs affect engagement in innovation processes	Projects in an open lab	Concepts of boundary objects and affordances	Case study; Germany	The work environments in the laboratory facilitate different kinds of interaction at syntactic, semantic, and pragmatic boundaries.	The design of the DiY lab environment matters for exchange engagement in the innovation process
Felix Arndt, Wilson Ng & Tori Huang	Understand why and how DiY labs are and can become drivers of innovation	DiY labs	Communities of Practice	Conceptual	DiY labs are driving open innovation due to the growing digitalization allowing the formation of online communities of practice.	Digital environments contribute to a process of democratising innovation in and beyond DIY labs
Weimu You, Mira Valkjarvi	Examine the profiles and characteristics of	Individual	Entrepreneurial founding	Content analysis; USA, Spain & France	A DiY bio lab founder is someone most likely to be highly educated with	It is important to have either well-rounded individuals

& George Ofosu	the founders of DiY labs				experience and research expertise in the field of science. Additionally, founders have entrepreneurship experience and strong open science ideologies.	or a team of individuals with complementing talents even from the founding stage of DiY labs.
Oluwaseun Kolade, Victor Atiase, William Murithi & Natasha Mwila	Understand the business models of tech hubs.	Tech hubs	Triple-layered model of organisational value creation	Case study; Ghana & Kenya	The business models of tech hubs in Africa have inherent weaknesses that prevent them from scaling up	Africa tech hubs need to develop new revenue streams, especially in international markets and be more conscious about their environmental impact.
Pengfei Hu	Understand the governance models of makerspaces and how they are institutionalized.	Makerspaces	Modalities of governance institutionalization	Case study; China	Chinese makerspaces adopt a 'subtle top-down' governance model, serving as the State's instruments for economic transition and modernisation.	Government has a role to play in the success of the maker movement, but there must be line between government intervention and interruption
Buddhi Pathak & Michael Dzandu	Scope and synthesize the literature to foster a holistic understanding of DiY labs	DiY labs	N/A	Systematic literature review	The emergence of DiY labs is driven by the need for extra income, experimenting with new ideas and the pursuit of hobbies outside formal work settings. Key challenges include access to finance.	DiY labs have great potential but their contributions and governance are yet to be integrated into government policy in both developed and developing economies.

					The strategies used to diffuse innovations are social networking, partnerships, and divestiture	
Peter Galvin, Anton Klarin, Richard Nyuur & Nicholas Burton	Review the DiY science literature and map a future research agenda	DiY science	N/A	Bibliometric content analysis	DiY science research is fragmented	To integrate DIY labs/science into STI policy, further research about how, when, and why DiY labs succeed is required.
Isaac Damoah & David Botchie	Explore DiY trends and identify research gaps	DiY labs	N/A	Systematic literature review	DIY activities may be global but DiY research is predominantly based in Western countries. Some DIY activities are also carried out by (semi-) professionals. DiY labs do not challenge existing traditional labs	More research is needed to provide empirical evidence for the promise of DiY labs and to cover non-Western contexts

In the second paper – *Experimenting and documenting low tech*, Meyer focuses on laboratories for low technologies – i.e., technologies that are simple and easy to use and cheap to produce. Arguing the lack of research on experimentation and documentation in DiY labs, Meyer explores the constitution and nature of experiments conducted in low-tech labs and the kinds of practices that are used to document low technologies. The author, analysing two projects at *The Low-tech Lab* in France, reports that documentation mobilises different practices and various formats, namely tutorials that present 'cookbook recipes' for low techs, reports that assess experimentations in a scientific way, and videos that stage low techs as key actors in ecological lifestyles and part of modern adventures. This paper seeks to further our understanding of the making, testing, and sharing of low techs by capturing the heterogeneity of documentation in the DiY space and the techniques of affect that are used to embed low techs within larger lifestyles and emotional landscapes.

Hu and Fritzsche, in the third paper - *Innovation, the Public and the Third Space: Understanding the Role of Boundary Objects in Open Laboratory Work* – investigate how the design of work environments in open laboratories affects the engagement of visitors in innovation processes. Drawing on the concepts of affordances and boundary objects and following an embedded case study approach, the authors explore JOSEPHS laboratory in Germany to identify appliances and equipment in an open laboratory that have a potential to become boundary objects and to observe the roles that these items play as syntactic, semantic, and pragmatic boundaries. They report that open laboratories, as spaces for interaction between different organisations and communities, can spur multiple perspectives on innovation and diverging attributions of meaning. Their work generates insights into how different elements of a lab's appliances and equipment can serve as boundary objects and thus structure the interactions between participants in innovation projects.

In the fourth paper - *Do-It-Yourself laboratories, communities of practice, and open innovation in a digitalised environment* - Arndt, Ng, and Huang explore the nexus of digitalization, practice-led communities of practice (COPs), and the DiY phenomenon. In this conceptual paper, they discuss why and how DiY labs have become drivers of innovations in some industries through the production of better quality and lower priced products or via the creation of entirely new products to meet un-served needs. They argue that these labs have flourished because of their easy access to democratised COPs, which is facilitated by digital proliferation and online exchange of information between technocrats and novices. Following a critical review of the literature, Arndt and colleagues present five propositions about the interrelationships between digitalization, COPs and DiY labs. Among other things, the propositions show how digitalization affects operational issues regarding trust and power and fosters innovation in DiY labs.

While the DiY literature has, to some extent, addressed antecedents, the profiles and characteristics of those pioneers who established DiY labs remain under-researched. The fifth paper by You, Valkjarvi and Ofosu - *What it takes to make it: profile and characteristics of DIY bio laboratory founders* - addresses this gap through a content analysis of secondary data on 23 founders and eight DiY bio labs. They found that DiY lab founders are highly educated (often to PhD level) and tend to have research experience and expertise in science. Interestingly, most of them come from traditional research settings and have published works in peer-review research. They also have an ideology that supports open science, open education, and the democratisation of science. These interesting findings increase our understanding of the typical profiles of people who pioneer DiY labs and citizen science.

The sixth paper - *The business models of tech hubs in Africa: implications for viability and sustainability,* by Kolade, Atiase, Murithi and Mwila explores the common business models employed by tech hubs to value, and how these business models mediate the link

between technological innovations and hubs' survival, viability, and competitiveness. Using data from two hubs in Kenya and Ghana, they delineate the hubs' business models along several economic, social, and environmental dimensions in the value creation process. They note that the growing technological capabilities of the hubs are not matched with enough attention on innovative business models that can enable better value capture, expansion of the domestic market, and competition on the international stage. Critiquing the current status quo, the authors do not only provide a holistic and integrated view of how African tech hubs create value for stakeholders and how they capture value for themselves, but they also proffer recommendations for tech hub business model innovation beyond the two focal cases.

Fu, in the seventh paper - *From bottom-up to top-down: governance, institutionalisation, and innovation in Chinese makerspaces* – explores governance and institutionalisation in makerspaces. Existing research has framed the governance model of makerspace mainly through two approaches, namely the bottom-up common-based peer production community model (members are volunteer and equally participate in the governance and running of the community) and the top-down public policy-based governance model (i.e., situating the makerspace within a broader urban governance framework). Examining three maker communities in China, Hu finds that Chinese makerspaces do not adhere to either of the two governance models, but rather adopt a 'subtle top-down' model that accounts for 1) the dialectics between the government and its governing approaches and 2) the involvement of various non-government actors aligning with public policy goals. Interestingly, these makerspaces are used by the State to address structural inequalities and transition the country from an industrial to a service-based economy.

The eighth, ninth and tenth papers in this special issue - *DiY laboratories, their practices, and challenges - a systematic literature review* by Pathak and Dzandu, *A bibliometric content analysis of do-it-yourself (DiY) science: where to from here for*

management research by Galvin, Klarin, Nyuur and Burton, and *Do-It-Yourself (DIY) Laboratories and Science, Technology and Innovation (STI): Trends, Implications and Future Research* by Damoah and Botchie are reviews of the DiY literature. We included the three reviews in the issue because they focus on different aspects of the corpus. Pathak and Dzandu's paper reports synthesized findings about the purpose, context, theories, and methods used in DiY studies. They also discuss DiY antecedents, governance systems, challenges, success levers, and strategies for innovation diffusion and commercialization. While they go on to outline the implications of their review for theory and research, the compelling thing about their paper is its capture of the current state of knowledge of diverse issues about DiY labs, as reflected in our call for papers. Galvin and colleagues, in contrast, adopt an approach that foregrounds future research mapping. Their paper classifies DiY literature into four clusters pertaining to DiY science culture, DiY science operationalization, DiY technologies, and DiY science education. For each of first three clusters, they outline a series of future research questions that will help researchers build new and interesting research trajectories to advance the field. Finally, Damoah and Botchie's paper overlaps the two other reviews in some respects but diverges into other themes like the geographic context of DiY research, region of authorship, sources of funding, modes of operational support, and professional involvement. All three review papers complement one another to paint a clearer picture of the state of DiY research.

Synthesizing the Contributions

The contributions made by the papers in this special issue can be delineated along three major themes – i.e., the antecedents of DiY labs, the operations of DiY labs, and the strategies of DiY labs (see figure 2). First, works by Arndt et al. (2021), You et al. (2021) and Ahmed and Harrison (2021) reveal two levels of determinants that affect the emergence and success of DiY labs - i.e., contextual and individual. Contextual antecedents are macro-level influences

while individual antecedents are the personal attributes of DiYers or DiY pioneers. Papers in this special issue demonstrate how exogenous macro phenomena such as increasing internet penetration, the internet of things, and digitalization of communities of practice (COPs) have spurred open science and the proliferation of DiY labs. Leveraging the view that modern technologies and platforms allow novices and technocrats to share ideas and exchange cheap equipment needed for their operations (Kwon & Lee, 2017), these papers complement extant studies that have tried to account for the emergence of hackerspaces and maker movements (Dougherty, 2012; Sarpong et al., 2020; Tocchetti, 2012).

Besides contextual antecedents, papers in this issue also show how personal attributes and characteristics affect DiY lab founding and DiY success. Ahmed and Harrison's (2021) competency model generates insights to help us understand the capabilities required to become effective DiY entrepreneurs. Similarly, You et al. (2021) shed light on the typical profile of DiY lab founders. Their findings help prospective DiYers to appreciate the paths and ideologies of DiY pioneers, subsequently equipping them with knowledge to audit their own capabilities and determine what paths they need to take to develop the competencies they need to succeed. The paper by You and colleagues addresses the role of ideology in DiY lab founding, resonating the view that DiY science is a "protest" against the traditional and bureaucratic system of science and innovation that occurs within the confines of rigid regimes in universities and researcher centres (de Lorenzo & Schmidt, 2017; Delgado & Callén, 2016).

Second, this special issue contributes to a better understanding of the operations in DiY labs along three areas – interaction and engagement, documentation, and governance. Whereas boundary objects have received some research attention, their role in DiY has been overlooked. Particularly, how the interior layout or arrangement of open labs affect interaction spaces for engagement among DiYers is less understood. Hu and Fritzsche's

(2021) provide a peak into how materials and lab layout create different types of boundaries that affect how DiY actors interact, negotiate, and engage. Essentially, DiY lab environments matter for the effectiveness of the labs' innovation. In the same vein, DiY labs are often regarded as rudimentary and unsophisticated, hence the important issue of how knowledge is documented in these labs is usually overlooked. Meyer (2021) shows that experiments in low tech labs are documented in diverse ways to not only build a tinkering repository but to also help legitimize low tech as reasonable and desirable in society. This portrays a conscious use of documentation to mitigate the legitimacy challenges faced by hackerspaces and DiY labs (Landrain et al., 2013; Pagano, 2013; Powell, 2016). Further, while the governance of hackerspaces has received some attention, there appears to be fixation on two dominant governance models. Fu (2021) extends the scope of the current governance models by explicating how social and cultural complexities in any given context feed into institutional varieties and lead to the development and use of unique hybrid governance structures in DiY labs.

Finally, this special issue addresses the business models of tech hubs, contributing to a better understanding of how they create, deliver and capture value. Until recently, business and management scholars did not give attention to DiY science. Innovation studies mainly focus on products and processes in traditional laboratories and organizations, which partly explains why strategy in DiY labs is currently under-researched. Kolade et al. (2021) extend previous studies (e.g., Atiase, Kolade, & Liedong, 2020) by critically appraising the economic, social and environmental dimensions of tech hubs' business models, providing suggestions for how they can be improved. The systematic and bibliographic reviews in this issue provide further backdrop and support for the above contributions.

The Pursuit Continues: Towards a Future Research Agenda

Though the papers included in this special issue make important contributions that deepen our conceptual and empirical understanding of DiY labs and science, the field still presents interesting and exciting opportunities for researchers. For instance, we now know how experiments are documented in DiY labs, but this creates an opening to further probe the link between documentation and the effectiveness or quality of innovation in these labs. Future research could draw from knowledge/talent management literature to frame documentation as enterprise information management and explore its role in DiY outcomes. Additionally, there is still a broad scope for investigating the governance of DiY labs. While we now understand some of the governance models deployed in these labs, it will be important to know what other models exist, how they evolve, their antecedents, and their relative or differential impacts on DiY outcomes.

Tapping into mainstream corporate governance literature, we believe it will be insightful to understand the board structures and dynamics of DiY labs and their implications for DiY outcomes. Issues such as board independence, board diversity and board committees will be worthy topical candidates for this line of enquiry. Beyond the DiY governance models that we currently know, future research could also examine the organizational architectures of DiY labs, including the types of groupings (functional, divisional, matrix, team, network, and horizontal structures), chains of command, span of control, etc. that are used to integrate human activities, allocate and coordinate tasks to achieve desired outcomes and performance in these labs. Topics around the types of cultures in DiY labs and their implications for DiY operations and outcomes will equally illuminate the field.

This special issue has touched on the profiles and characteristics of DiY founders and pioneers. A next possible step is to leverage upper echelons theory (Carpenter, Geletkanycz,

& Sanders, 2004; Finkelstein & Hambrick, 1996) to investigate the links between founder attributes and a range of DiY topics including innovation, governance, business models and strategy. Because top executives view business situations through their own personalized lenses, organizational outcomes are partially predicted by managerial characteristics (Hambrick & Mason, 1984). In this sense, the operations, strategy, and performance of DiY labs could be reflective of the values, preferences, and biases of the labs' founders and managers. Related to this is the need for future research to delve beyond the leadership competencies required for successful DiY and explore how the competencies are developed or examine the relationship between specific leadership competencies and styles and DiY outcomes.

It is worth highlighting three themes in our special issue call for which we did not receive any contributions. They are: 1) Nonmarket political strategy of DIY laboratories; 2) Nonmarket political strategy of DIY laboratories; and 3) The ethicality of DIY laboratories. We were hoping there would be ongoing research about how DiY labs engage and manage political stakeholders, how they participate in STI policymaking, how they manage their contributions to, and effects on society, the nature of their social responsibility and environmental sustainability, and how they manage the health and environmental implications of their activities on society. The lack of contributions on the above topics poignantly suggests the need for more research on the nonmarket aspects of DiY labs.

Organizations operate within market and nonmarket environments (Baron, 1995). The former entails actors that make immediate contributions to the economic aspirations and performance of an organization, such as employees, customers, suppliers, financiers, shareholders, etc. The latter concerns stakeholders in the contextual political and social environments of an organization, such as civil society, communities, and politicians (Frynas, Child, & Tarba, 2017; Liedong, Rajwani, & Mellahi, 2017). Nonmarket market strategy

therefore refers to an organization's concerted plans to manage the political and social contexts of its economic competition (Mellahi, Frynas, Sun, & Siegel, 2016). DiY labs have political and social stakeholders, in that their activities affect and are affected by political and social dynamics. They may therefore engage in nonmarket strategy through CSR or lobbying to manage their exposure to political and social risks, especially considering the legitimacy challenges that they face (Ferretti, 2019; Wolinsky, 2009). In developed countries where regulatory and enforcement institutions are relatively more effective, the quest for political and social legitimacy may still be strong for DiY labs due to the strong competition posed by traditional sources of innovation such as incubators, research labs, universities, and large organizations. In developing countries, the quest for industrial development may cause governments to prioritize traditional and oft-scalable innovation over DiY innovation. The foregoing foreground the importance of political and social strategies, which makes us hope that future research will pursue the nonmarket interactions and strategies of DiY labs.

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