Accommodating varying capabilities in open design: A layered approach for distributed value creation

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ABSTRACT

Open design challenges the traditional notions of design, innovation, and business by enabling and facilitating collaborative and distributed value creation. However, simply making designs open cannot enable their adoption by others and facilitate distributed production or local circular economies. In pursuit of a novel understanding of how open design can be adopted and utilised to manage distributed value creation, this paper presents the results of eight co-creation workshops conducted with Networked Business Model Canvas for exploring alternative business models and practices in distributed value creation networks. A total of 127 value creation nodes in 11 alternative open design-led distributed value creation networks were conceptualised during the workshops. Their analysis revealed various implications and challenges of open design for managing distributed value creation, which led to the development of a novel layered approach to designing open products that can accommodate varying capabilities and levels of engagement of different stakeholders, from end-users to producers.

Introduction

Open design and distributed production are emerging paradigms that involve stakeholders collaborating to create, share and modify design artefacts and challenge the traditional notions of design, innovation, and doing business. This is different from other co-design methods that seek a final design outcome as a consensus of a group of stakeholders. Open designs can be peer-reviewed and improved by peer-to-peer feedback and can branch or fork towards various new designs that suit the needs, wants and preferences of different groups of people working on them. With the advancement of desktop fabrication tools, such as 3D printers and laser cutters, and their increased accessibility through fab labs and maker spaces, open design creates opportunities for more open collaborative innovation processes (Thackara, 2011), distributed fabrication (Ramos, 2017), self-repair (Bonvoisin, 2017) and the circular economy (Prendeville et al., 2016). These opportunities suggest increased localisation, democratisation and socially and economically empowering processes of production and consumption. However, there are also limitations, such as the physicality and complexity of open design and hardware (Malinen et al., 2011; van der Bij et al., 2013), quality control and safety (Cruickshank & Atkinson, 2014), and required skills and capabilities to partake in open design and distributed value creation processes (Phillips et al., 2013). These

limitations suggest a need for re-thinking open design by challenging the assumptions that making designs open will enable their adoption by others and facilitate distributed production or local circular economies. Rather, it becomes crucial to recognise and respond to the highly varying capabilities of different stakeholders that can potentially partake in distributed value creation processes and envision and accommodate all these different forms of participation. Accordingly, this paper argues for a novel understanding of how open design can be adopted and utilised to manage distributed value creation, as explored in 8 co-creation workshops using the Networked Business Model Canvas.

Background

Open design solutions and open-to-participate processes

Open design refers to both design outcomes that anyone can adopt, alter and fabricate and design processes in which everyone can participate (Bakırlıoğlu & Kohtala, 2019). The openness of design outcomes enables horizontal management of the processes, as well as collaboration by iteration resulting in branching toward novel design directions and outcomes (Tooze et al., 2014). The openness of the process enables peer-to-peer feedback to improve the outcomes via various perspectives beyond disciplinarity. These conceptualised aspects of open design are discussed alongside more open collaborative innovation processes, distributed fabrication, self-repair, and the circular economy (Bonvoisin, 2017; Huizingh, 2011; Prendeville et al., 2016; Ramos, 2017; Thackara, 2011). However, especially physical open design outcomes pose several challenges to the broadening and inclusive innovative potential of open design (van der Bij et al., 2013). The peer review process, which is very effective in finding and correcting bugs and enhancing codes thanks to online sharing and duplication through the copy-paste function in open-source software, does not apply well to more complex, physical open designs (e.g., cars, electricals) where parts and components need to be reconstructed from scratch by everyone who wants to participate (Malinen et al., 2011; Müller-Seitz & Reger, 2010). Also, since the fabrication is distributed and, in theory, everyone can fabricate open designs, the issue of reliability and user safety of open designs emerges due to the lack of oversight in fabrication processes (Cruickshank & Atkinson, 2014). Finally, although everyone is expected to be able to adopt, alter and fabricate these designs, only makers, prosumers and alike, who have the skills and resources, can actually participate in this open design process in real life, especially in their fabrication (Phillips et al., 2013; Reinauer & Hansen, 2021; Woodson et al., 2019). Accordingly, the potential of open design and knowledge sharing is diminished without a lasting horizontal community and alternative business models supporting and mainstreaming it to reinvent and transform existing consumer products (Troxler & Wolf, 2017).

Forms of value creation and stakeholders

The traditional separation among users, designers and producers has long been challenged by various approaches such as participatory design (Björgvinsson et al.,

2010) and codesign (Fuad-Luke, 2013), and the lines among stakeholders are getting increasingly blurry in the past couple of decades, espousing hybrid roles and novel forms of collaboration (Stappers et al., 2011). Open design and distributed production, the way it is conceptualised in this paper, suggests participation in more diffused networks of value creation, localisation of such processes for better, more meaningful design outcomes and value re-capture through local circular economies. However, participation in the stages of design, production/fabrication and post-use processes of products requires highly diversified sets of knowledge, skills and resources that are hard for an individual to possess all. Furthermore, these capabilities also vary greatly among different types of products (Müller-Seitz & Reger, 2010). Considering these, it should also be recognised that individuals do not have the capability to partake in the value-creation processes of all the artefacts they have, nor would have the capacity to do so.

The literature on open design, maker movement and distributed production has utilised various forms of categorisation to represent varying capabilities and engagement of individuals and other stakeholders. These include the taxonomy of active user engagement (Kohtala et al., 2020) identifying four forms of user participation (i.e., use-as-is, active use, user design and user innovation), the forms of DIY practices (Fox, 2014) that distinguish DIY innovation, prosumption, and DIY entrepreneurship that facilitates prosumption, the division between makers as social entrepreneurs/enterprises or makers as dependent social idealists focusing solely on sharing of knowledge and resources (Langley et al., 2017), and local entrepreneurs and individual makers in the context of industry 4.0 (Fiaidhi & Mohammed, 2018). Through a systematic literature review, the author has previously identified a novel conceptualisation of stakeholders in distributed value creation networks according to the ways they can participate in such networks (Bakırlıoğlu & Hasdoğan, 2022). Accordingly, there are two main categories of stakeholders: the ones that create value for themselves and their communities, namely responsible consumers (RC), active users (AU), and prosumers/makers (PM), and the ones that create value for others, i.e., local, regional, and global/mass producers (LP, RP, and GMP) (Bakırlıoğlu & Hasdoğan, 2022). These stakeholders build on top of each other's value creation processes (i.e., design, production/fabrication, and post-use) at the global, regional, local, and individual scales, which can potentially result in resilient networks of distributed production and increasingly localised circular economies.

This paper presents a layered approach to designing through the exploration of alternative value creation nodes as part of the DF-MOD (Distributed Fabrication through Mass-produced Open Designs) project. The explored nodes are facilitated through mass-produced open design parts and products present a potential for the recapture of the added value of parts and components within local circular economies, and account for the diverse skills, knowledge and resources of different value-creation-for-self (VCFS) and value-creation-for-others (VCFO) stakeholders, as well as their active involvement into design, production and post-use within distributed value creation network.

Methodology

Exploring the potential of distributed production that is enabled, facilitated, and sustained by open design involves the exploration of alternative ways of doing business in such networks. However, while the ways the business models are developed vary greatly and bring forward either rational reasoning in business operation (i.e. rational positioning), experimentation and continuous improvements (i.e. evolutionary learning), or uniqueness of perspectives (i.e. cognitive), existing business models tend to be altered in the face of external variables affecting their economic viability rather than conceptualising new ways of doing business (Gudiksen et al., 2014; Martins et al., 2015; Mootee, 2013). The past decade, however, witnessed the emergence and increased use of alternative ideation tools for conceptualising business models, such as the notable Business Model Canvas (Osterwalder & Pigneur, 2010) and its more focused iterations (e.g., Maurya, 2012; Osterwalder, 2016; Osterwalder et al., 2014; Upward & Jones, 2015). In the design field, participatory approaches are being explored in the development of new business model ideas resulting in novel generative tools and techniques (Gudiksen et al., 2014). These frameworks are compatible with the concept of a business model that is centred around a main business/firm, identifies its components, the relations between them and the organisational activities carried out through them (Afuah & Tucci, 2001; Zott & Amit, 2010). However, such a business model concept is not compatible with the networked value creation distributed at global, regional, local, and individual settings, which facilitates numerous businesses and individuals to build value on top of each other.

DF-MOD project aimed to explore the potential for open design-led business models that facilitate distributed value creation with a focus on electrical household appliances. As part of this project, the author introduced a novel conceptualisation of distributed value-creation stakeholders under two main categories, i.e., value-creation-for-self (responsible consumers, active users, prosumers/makers) that create value for themselves and their communities, and value-creation-for-others (local, regional and global/mass producers) that formally operate as businesses through a systematic literature review (Bakırlıoğlu & Hasdoğan, 2022). He, then, conducted an extensive survey to understand the skills, resources, and capabilities of these stakeholders for design, production, and post-use practices in distributed value creation of electrical household appliances in Turkey (Bakırlıoğlu, 2023). Finally, he facilitated eight co-creation workshops facilitated by the Networked Business Model Canvas, which explored potential open design-led distributed value creation networks and nodes in detail, and revealed open design considerations that can enable and manage such distributed value creation networks.

Networked Business Model Canvas

Exploring business models and practices that facilitate, activate, and sustain resilient distributed value-creation networks requires an exploration of the networks themselves and the value-generating relations among value-creation-for-self and value-creation-for-

others stakeholders. For this purpose, the author developed a generative design research tool titled Networked Business Model Canvas (Fig. 1) that aims to imagine and explore alternative ways of doing business in distributed value creation networks managed by open design knowledge (Bakırlıoğlu, 2022). Generative design research methods aim to uncover more profound knowledge by facilitating people's organisation of thoughts and ideas (Hanington, 2007; Sanders et al., 2010), and such methods have been used for the development of new business model ideas espousing novel ways of doing business (Gudiksen et al., 2014). Constructive tools are especially useful for generating and expressing novel ideas, and they can be adapted for individual or group work and can also be implemented online or face-to-face (Sanders et al., 2010).

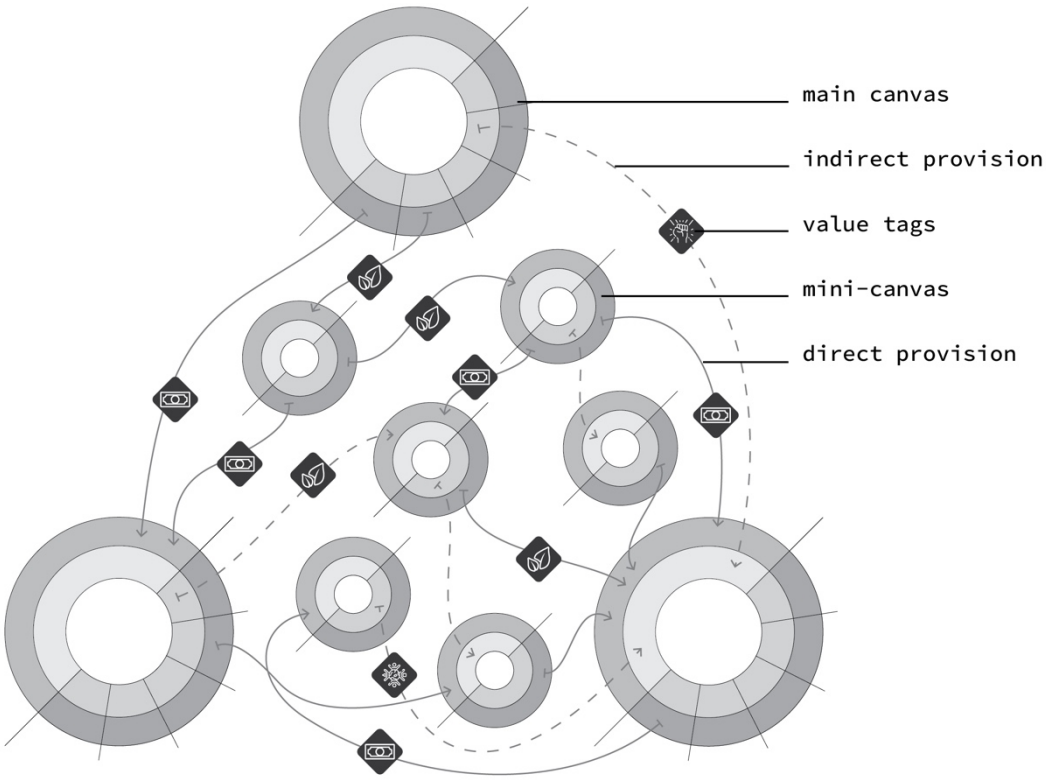

Fig. 1: Parts of the networked business model canvas, namely main canvases, mini-canvases, provision lines and value tags (economic, environmental, social, and cultural). For more details about the tool, refer to Bakırlıoğlu, 2022.

The Networked Business Model Canvas (N-BMC) focuses on distributed value creation networks with numerous stakeholders participating in value creation processes at varying capacities, rather than exploring singular, focal businesses/firms, in order to grasp the complexity of relationships among these stakeholders that take crucial roles in value creation and capture since these processes are conceptualised as *distributed* both geographically and among multiple, and possibly interchangeable, stakeholders. N-BMC consists of four main components: (1) Main canvases for stakeholders the participants

intend to explore in detail, (2) Mini-canvases for other stakeholders in distributed value creation networks, (3) Provision lines to draw the link between one stakeholder's output and another one's input, and (4) Value tags to identify the kind of values generated through these relations. There are four types of value tags, (a) economic, (b) environmental, (c) social, and (d) cultural.

Co-creation workshops

As part of DF-MOD, eight N-BMC workshops were conducted with 38 participants in total. Purposive and snowball sampling was utilised to attract experts with different disciplinary backgrounds, and the participants included designers, engineers, researchers, craftspeople, managers, and other experts. The calls for participation were done through specific communications channels, such as through a workshop session at a national design conference, emails to participants of previous stages of the project, and bulk emails or messages to established DIY and maker communities in Turkey. The inclusion criteria were very straightforward and mostly inclusive, as the calls specified AUs, PMDs and representatives of LPs, RPs and GMPs as targeted participants, yet it was also specified that the sessions would be open to all. The spread of different backgrounds and expertise in workshop sessions was satisfactory for the exploration of distributed value-creation networks throughout the sessions and sparked fruitful group discussions. These workshops resulted in the conceptualisation of 11 different alternative open design-led distributed value creation networks consisting of 127 value creation nodes (for-self and for-others) in these networks, as illustrated in Table 1.

Table 1. Starting points, number of potential distributed value-creation network stakeholders explored in each workshop, and identifiers of value-creation nodes introduced in this paper

		Explored stakeholder types							
		VCFO			**VCFS**				
	Starting points	**GMP**	**RP**	**LP**	**PM**	**AU**	**RC**	**Other**	**Total**
WS1	Air fryer, robot vacuum cleaner	6	5	6	1	2	2		22
WS2	Turkish tea maker/ kettle	1	2	2	1	3	2	1	12
WS3	Energy saving/ gen.	3	3	4	2	1	1	2	16
WS4	Food prep.	2	3	2	1	2	2		12
WS5	Electric pot, air fryer	3	3	2	2	1	1	1	13
WS6	Robot vacuum cleaner, Turkish tea maker/ kettle	6	5	6	1	2	2	2	24
WS7	House cleaning appliances	2	2	3	2	2	1	1	13
WS8	Food preparation appliances	3	3	4	2	1	1	1	15
Total	*11 networks*	*26*	*26*	*29*	*12*	*14*	*12*	*8*	*127*

The nodes explored during the workshops were conceptualised according to (1) their inputs, processes, and outputs (categorised according to (a) resources, objects, and services, (b) licensing, and (c) knowledge), (2) the links between these stakeholders depicting the flow of knowledge and resources in these networks, and (3) the identification of different forms of value generated with these links. Fig. 2 illustrates an

example of such a node: a local parts and components manufacturer for unique needs and preferences that produces one-off kitchen appliances and offers services around it. These revealed various points of analysis regarding the forms of operation and value creation (inputs, processes, and outputs), practices of value (re-)capture (through links), distributed forms of value creation (through multiple stakeholders linked), and types of value generated. Since the analysis was focused on the potential of networked value creation, a secondary analysis of inputs and outputs (i.e., resources, objects, services, licensing, and knowledge) revealed considerations about how open design can facilitate, sustain, and flourish these distributed value creation networks.

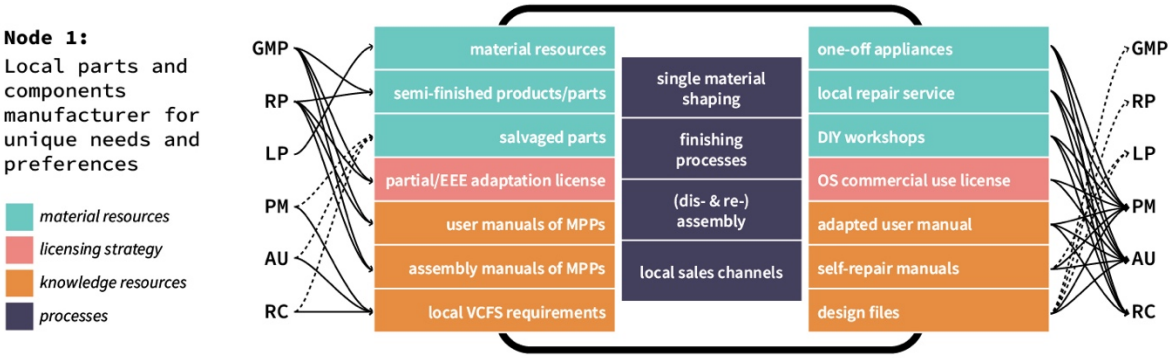

Fig. 2: An example of alternative business models conceptualized during the N-MBC workshops.

Designing for distributed value creation

The Networked Business Model Canvas enabled not only the exploration of alternative open design-led business models in distributed value creation networks but also the exploration of how open designs need to be so that they can operate in such networks. Considering that these business models require a different approach to designing, and horizontal management of distributed value creation networks based on the openness of design outcomes, this paper presents a layered approach to design that can facilitate iterative collaboration.

Layered design outcomes & collaboration by iteration

Various dimensions of business model development can be explored using the networked business model canvas and distributed value creation network conceptualisation of the DF-MOD project. As part of the workshop sessions, participants explored distributed value creation networks that are enabled by open design and production knowledge and explored the various levels of participation in distributed value creation networks from the perspectives of value-creation-for-self and value-creation-for-others stakeholders. It went beyond the concept of a single stakeholder and its business operations. Instead, distributed value creation networks were explored through open-ended design and production processes, with stakeholders creating value

on top of each other's value creation processes through *collaboration-by-iteration* (Bakırlıoğlu & Hasdoğan, 2022) that is neither managed by a primary stakeholder nor oriented towards a predetermined outcome. The prominent, alternative business models and their value creation processes all presented such iterative value creation that either initiates such an iterative process or continuously deploys iterative design and production/fabrication processes as the value offering.

Beyond the business model design in terms of its internal processes, IPR strategies and relations to other stakeholders in distributed value creation networks, such a *collaboration-by-iteration* process also requires a different approach to how things are designed. Outputs of such business models need to accommodate *the capacity to be iterated* in the first place, and by both value-creation-for-self and value-creation-for-others stakeholders that have widely diversified resources, skills, and capabilities. Accordingly, designing a product involves more than the modularity of parts and features; rather, it involves identifying and accommodating stakeholders' varying levels of engagement. A layered approach to open design evolves in this context, in which practitioners layer value offerings according to their levels of engagement.

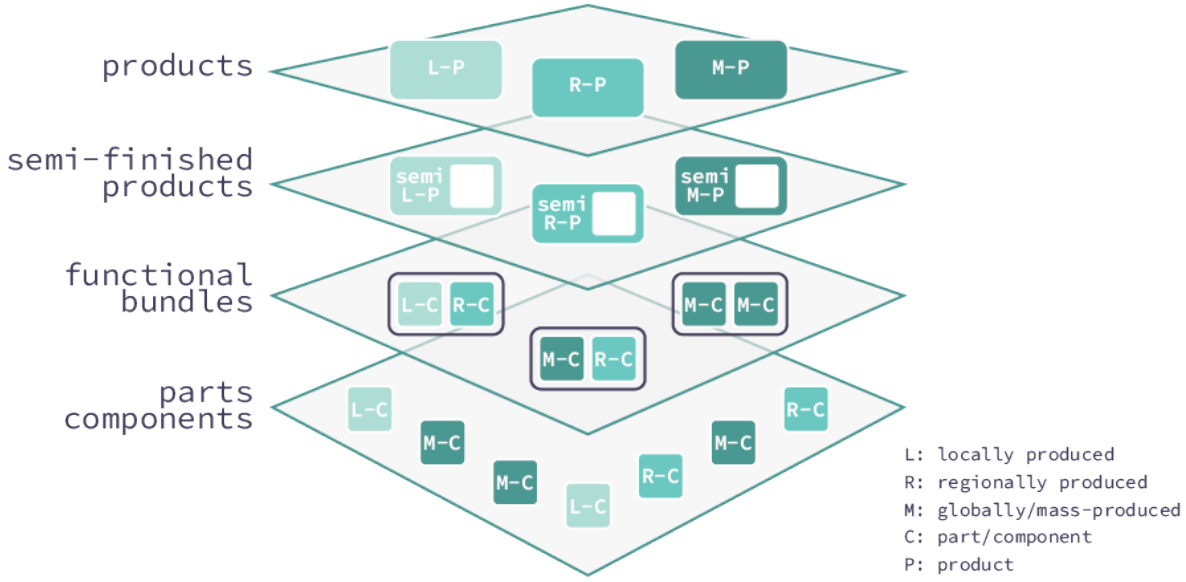

Fig. 3: Open design layers to accommodate varying resources, skills and capabilities of DVCN stakeholders

Accordingly, four broadly defined levels were observed during the workshops that accommodate different levels of engagement (Fig. 3), as follows:

- *End-user products layer* is rather straightforward and refers to fully functional products designed and produced by local, regional or global producers. These outputs are addressed to responsible consumers and active users, and active users can personalise them with add-ons and other external interventions. While

these do not offer much room for design intervention, alternative ecosystems that work with these products can also be designed.

- *Semi-finished products layer* involves products with missing parts or components to be designed, produced/fabricated and assembled by regional and local producers, prosumers/makers or active users. There are nodes that cannot design and produce complete products, but that may not be necessary in distributed value creation networks that enable collaboration-by-iteration. In this case, the 'semi-finished product' in question is a layer of that open design system between functional bundles and products.
- *Functional bundles layer* involves sets of parts, components and software designed to deliver certain functions. They are designed to deliver these functions while bypassing the assembly and testing of individual parts and components. These bundles enable regional and local producers and prosumers/makers who lack certain capabilities to produce/fabricate and assemble certain types of parts and/or assure their quality and safety.
- *Parts/components layer* is also rather straightforward and involves the parts and components produced by local, regional and global/mass producers. These stakeholders can provide these parts on their own and as parts of functional bundles, semi-finished products or end-user products.

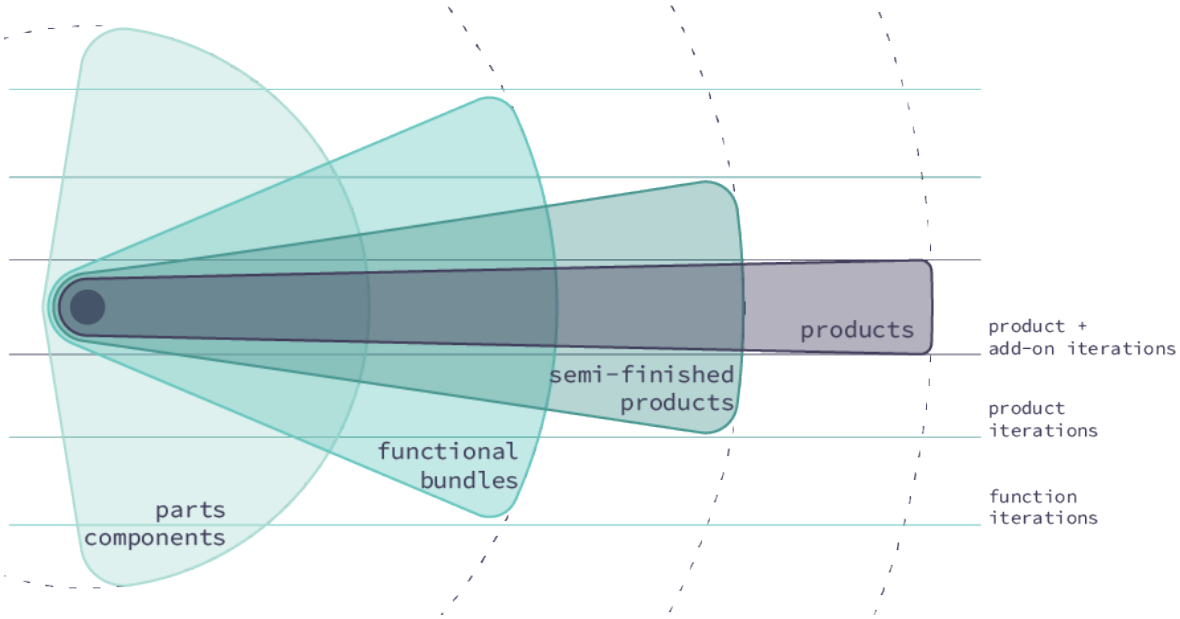

Fig. 4: Reach according to required skills, resources and capabilities & potential for iteration imposed by layers of open design 'things'

In Fig. 4, the potential reach of distributed value creation networks is depicted according to the layers of design present in them. Horizontal lines represent the potential for open design iterations, i.e., inner lines represent products coupled with add-on iterations,

mid-lines represent iterations of a product, and outer lines represent different kinds of products/objects using similar functions. The circular dotted lines represent stakeholders' knowledge, skills and resources, i.e., the innermost dotted circle has the most wide-ranging knowledge, skills and resources, and the outermost dotted circle has the least-ranging knowledge, skills and resources. For example, open design parts and components can be used in the production/fabrication of wide-ranging designs and iterations with different functional and aesthetic features; however, utilising them would require wide-ranging knowledge, resources and skills and thus can be utilised by a smaller number of stakeholders. On the other hand, open semi-finished product designs will not allow such wide-spreading possibilities on their own; they can be used by value-creation-for-others and value-creation-for-self stakeholders with limited resources, skills and capabilities and thus can be utilised by more stakeholders in distributed value creation networks. It is important to consider all layers and provide alternatives for unconstrained iterative design processes as well as more constrained but easily adoptable value creation processes. This may seem like a conflict between the potential for innovation and the potential for inclusivity, but open designs can accommodate both sides by adopting a layered approach and designing for all layers.

Formalising distributed production through open design management

There are numerous stakeholders in the proposed collaborative process, who operate in parallel and iterate value offerings in different directions. The networked business model canvas was developed with this conceptualisation in mind, where numerous value-creation nodes (i.e., value-creation-for-self and value-creation-for-others stakeholders) freely operate within distributed value creation networks and form value-creating links among each other. Thus, singular business models may not be sufficient to manage distributed value creation networks. With appropriate licensing strategies, open design knowledge (both processes and outcomes) can serve as an effective management tool that is transparent, accessible, and responsive to stakeholders' needs and preferences. In this case, the issue is the complicated open-source license landscape caused by existing IPR laws that separate novel functional inventions (e.g., patent laws), original creative work (e.g., copyright laws, design registrations), and source (e.g., trademark laws). Various open-source licensing types and certification schemes were espoused in response to this fragmented landscape, such as CERN Open Hardware License (CERN-OHL) for hardware innovation, Creative Commons (CC) for digital creative work, Open-source Hardware Association (OSHWA) certification for showing appropriate OS licensing of designs, hardware and sources, among many others.

The fragmented nature of the IPR management landscape makes it difficult to navigate for many stakeholders, leading many local producers to avoid it altogether (Bakırlıoğlu, 2023). Additionally, opening designs in terms of not only design knowledge and data but also open licensing of design outcomes that protect their openness, as well as intellectual property rights of their sources, remains an immense barrier against widespread adoption of open design practices, let alone the distributed value creation

networks that localise on-demand production as conceptualised here. It is already a challenge for many open design practitioners and communities to document and share their work, especially open designs of physical objects (Bakırlıoğlu & Kohtala, 2019). It requires additional effort from stakeholders of distributed value creation networks to navigate the existing intellectual property landscape while at the same time protecting the openness of designs and commercialization rights. OSHWA is a good example of how the openness of various aspects of designs can be managed, and how it can assure other stakeholders that they aren't infringing upon the IPR of the initial open design. Even so, it is still an additional step after properly licensing open designs and does not reduce the amount of work involved. In order to geographically expand and localise production through initial open designs and their iterations, stakeholders who create value for others and stakeholders who create value for themselves would also need to go through complex licensing and certification processes.

Depending on the complexity of the product, the safety requirements, and other external factors (i.e., standardisation, policy, etc.), a layered approach to open design can alleviate this fragmented IPR landscape or exacerbate it. Most of the value creation nodes in the co-creation workshops relied on a loosely defined ‘partial adaptation licensing’, which would allow value-creation-for-others stakeholders to engage in limited commercial activities with open designs. However, descriptions of these limits varied greatly in different workshops. Discussions around this during the workshops focused on safety and benefits, and how value-creation-for-others stakeholders can ensure that their open design iterations still meet the safety requirements of electrical appliances. According to these discussions, making designs 'open' by itself may not suffice, and managing distributed value creation networks must involve clearly defined limits, quality control, and assigning responsibilities for parts, functional bundles, and semi-finished products. How these processes can be horizontally managed and enable value-creation-for-others and value-creation-for-self stakeholders to democratically and freely participate in distributed value creation networks requires further exploration through research and practice.

Conclusion

Through an exploration of open design and distributed production for electrical household appliances, this paper proposes a layered approach to designing open products that can accommodate different levels of engagement and capabilities of various stakeholders, from end-users to producers. Using a generative tool, Networked Business Model Canvas, for conceptualising alternative business models and practices in distributed value creation networks based on open design knowledge and processes, eight co-creation workshops were conducted as part of the DF-MOD project, which led to the development of 11 different open design-led distributed value creation networks. These networks consisted of 127 nodes in total, and their analysis revealed various implications and challenges of open design for managing distributed value creation. This led to the development of a layered approach to designing, which involves four layers:

end-user products, semi-finished products, functional bundles, and parts/components. Each layer represents a different degree of openness, customisation, and complexity, and allows different actors to participate in the design and production process according to their preferences and varying capabilities.

The paper contributes to the literature on open design and distributed production by providing a novel framework for designing for open design-led business models, as well as a nuanced exploration of the feasibility and diversity of open design-led distributed value creation networks. The paper reveals future directions for research and practice, such as exploring the impact of open design on environmental sustainability (e.g., through comparative analysis of environmental impact and value re-capture), social inclusion (e.g., through varying levels of involvement in distributed value creation processes at different localities), and innovation diffusion (e.g., through branching and forking of open designs into novel directions), as well as developing methods and tools for evaluating and improving the performance and quality of open products and distributed value creation networks especially in different product sectors. The paper hopes to inspire and inform designers, innovators, entrepreneurs, and policymakers who are interested in harnessing the potential of open design and distributed production for creating value in more collaborative, democratic, and sustainable ways.

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