Deliverable 5.2

Open design-led business model explorations in distributed value creation networks

Yekta Bakırlıoğlu

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Abstract

This deliverable presents the outcomes of DF-MOD workshop sessions aiming to explore alternative, demand-driven, open design-led business models for distributed production and local circular economies, facilitated through mass-produced open design parts and the active involvement of value-creation-for-self (i.e., responsible consumers, active users, prosumers/makers/DIY-ers) and value-creation-for-others (i.e., local, regional, and global/mass producers) stakeholders in their design, production and post-use. A generative design research tool titled 'Networked Business Model Canvas' was developed to facilitate the workshops. A total of 38 stakeholders participated in 8 workshop sessions and explored the value creation and (re-)capture of 127 nodes in distributed value creation networks. 6 prominent alternative value creation nodes were observed, which reveal potentials for the creation of various forms of economic, environmental, social, and cultural value in such networks. These processes require a *layered approach* to open design and *collaboration by iteration*. The openness of design presents opportunities for horizontal management of distributed value creation networks; however, there are other considerations in terms of quality control, safety standards, and accommodating varying knowledge, skills and resources of stakeholders.

This report constitutes Deliverable 5.2, for Work Package 5 of the DF-MOD project.

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For more information

yektab@metu.edu.tr

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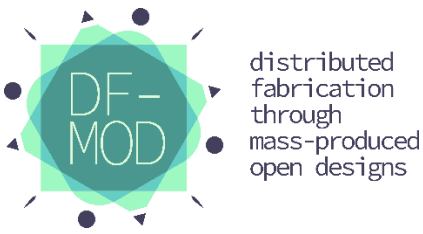

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List of Abbreviations

Abbreviation	*Word/phrase*
AU	active user
B2B	business-to-business
BBP	black-box product
CAD	computer-aided design
DIY	do-it-yourself
DVCN	distributed value creation network
EE	electrical and electronic
EEE	electrical and electronic equipment
F/OSS	free and open-source software
GMP	global/mass-producer
IPR	intellectual property rights
LP	local producer
MaaS	manufacturing-as-a-service
MPP	mass-produced parts and products
OS	open source
OSS	open-source software
P&P	plug-and-play
PMD	prosumer/maker/DIY-er
RC	responsible consumer
RP	regional producer
VCFO	value-creation-for-others
VCFS	value-creation-for-self
WEEE	waste electrical and electronic equipment
nas	normalized accessibility score (see deliverable 4.2)
nns	normalized necessity score (see deliverable 4.2)
WMS	waste management system
WS	workshop session / can be complemented with number to indicate specific sessions (e.g., WS1, WS2, etc.)

1. The purpose of D5.2

Work package 5 aimed to explore alternative, demand-driven, open design-led business models for distributed production and local circular economies, facilitated through mass-produced open design parts and the active involvement of value-creation-for-self (VCFS) [i.e., responsible consumers (RCs), active users (AUs), prosumers/makers/DIY-ers (PMDs)] and value-creation-for-others (VCFO) [i.e., local producers (LPs), regional producers (RPs) and global/mass producers (GMPs)] stakeholders in their design, production and post-use *through co-creation workshops*.

As part of WP5, a generative tool named 'Networked Business Model Canvas' (N-BMC) was developed (deliverable 5.1, Bakırlıoğlu, 2022c) and a workshop schedule was developed around it. Through calls for participation made to DF-MOD survey participants (WP4), other stakeholders of METU ID, and the researcher's network of makers and prosumers, 8 co-design sessions were conducted. The development and implementation of N-BMC are explained in *Section 2 - Networked Business Model Canvas.* A total of 127 value creation nodes in alternative distributed value creation networks (DVCNs) were explored in these sessions; 81 of which were VCFO stakeholders (26 GMPs, 26 RPs, 29 LPs) and 38 were VCFS stakeholders (12 PMDs, 14 AUs, 12 RCs). Detailed information about the sessions can be found in *Appendix 1 – DF-MOD workshops information*.

The analysis of outcomes revealed 6 different forms of open design-led value creation nodes that can emerge in different DVCNs and are representative of the potentials of such networks in the creation and (re-)capture of economic, environmental, social and cultural value. *Section 3- Exploring business models in distributed value creation settings* introduces these value creation nodes (5 VCFO, and 1 VCFS) and analyses them according to (1) knowledge and resource inputs required, (2) internal process and outputs, (3) value creating relations and value recapture, and (4) existing roles and capabilities from deliverable 4.2 (Bakırlıoğlu, 2022d). The deliverable concludes with an overview of value creation and re-capture potentials of DVCNs, the opportunities and limitations of current VCFS and VCFO stakeholders, and discussions on designing products and services in DCVNs and open design as a horizontal management tool.

2. Networked Business Model Canvas

2.1. Developing the Networked Business Model Canvas

There are various perspectives on how business models are developed and how they change, which can be roughly categorised into three categories – or schools of thought – namely *rational positioning*, *evolutionary learning*, and *cognitive* schools (Martins et al., 2015). The *rational positioning perspective* considers regards business models as purposefully designed systems reflecting rational choices and modes of operation made by management (Amit & Zott, 2001; Gavetti & Rivkin, 2007; Teece, 2010); the *evolutionary learning perspective* puts more emphasis on experimentation and continuous fine-tuning on an initial business model (Gavetti & Rivkin, 2007; McGrath, 2010; Sosna et al., 2010); and, *cognitive perspective* puts more emphasis on owner/managers' unique, distinct perspectives on reality and the ways these provide the most influential input into the business model development (Gavetti & Rivkin, 2007; Sosna et al., 2010). Regardless of the schools, however, business models are considered to change mostly in response to external changes affecting their economic viability (Chesbrough, 2010; Martins et al., 2015; Teece, 2010), and they focus less on ways of ideating and/or developing new, alternative business models (Gudiksen et al., 2014; Martins et al., 2015; Mootee, 2013).

Over the past decade, alternative tools for ideating business models started to emerge, the most notable of them being the original Business Model Canvas (Osterwalder & Pigneur, 2010). The business model canvas is based on nine building blocks of a business grouped under *infrastructure* (i.e. key activities, key resources, partners/network), *offering* (i.e. value propositions), *customers* (i.e. customer segments, channels, relationships) and *finances* (i.e. cost structure, revenue streams). This earlier business model development tool has been iterated in many ways to respond to different challenges such as the Lean Canvas for start-ups (Maurya, 2012), Value Proposition Canvas to address the product-market fit (Osterwalder et al., 2014) or Mission Model Canvas for organisations with predefined budgets (Osterwalder, 2016). A more notable example can be the Flourishing Business Canvas that facilitates the conceptualisation of economic, social and environmental aspects (Upward & Jones, 2015). 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). 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).

Design research has been an integral part of the design process, reflecting the changes in design practice from the mere form-giving to artefacts towards a more human-centred understanding of design (Hanington, 2007; Mitchell, 1995). Especially with the emergence of participatory design, stakeholders affected by designs are considered as collaborators in designing things, democratising innovation practices (Björgvinsson et al., 2010). People's participation in design research affects the depth of knowledge that can be gained, as their tacit knowledge and latent needs cannot only be retrieved from what they say. It is possible to get a deeper understanding of people's knowledge, feelings, and dreams by using generative research tools and techniques (Sleeswijk Visser et al., 2005). Generative design research methods can uncover more profound knowledge, and they can facilitate people's organisation of thoughts and ideas as well (Hanington, 2007; Sanders et al., 2010).

There are two kinds of generative tools and techniques: projective and constructive (Hanington, 2007). The goal of projective tools and techniques is to encourage people to describe their thoughts and experiences in more detail. A few examples of these tools and techniques are diaries, text- or image-based cards and their sorting, and daily logs. Constructive tools and techniques aim to enable people to make tangible things that represent their thoughts and experiences and include Velcro modelling, collages and mind-mapping (Martin & Hanington, 2012). 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). Various combinations of these tools and techniques can be selected to enable the development of outcomes most suitable to the purposes of design research or ideation processes.

Novel generative tools and techniques have the potentials for broadening people's understanding of design and enriching their creativity in the problem-solving process (Bakırlıoğlu et al., 2016; Yeo, 2012). These tools can respond to calls for further engagement of people in different stages of product development, use and post-use (Kohtala et al., 2019), such as user-led innovation practices (von Hippel, 2006), DIY making (Salvia & Di Milano, 2016), personalization (e.g. Bernabei & Power, 2017; Mugge et al., 2009), self-repair (e.g. Getto et al., 2014; Getto & Labriola, 2016). Especially when faced with more complex problems with multifaceted factors compounding, generative tools can help organise and contemplate them, creating opportunities for developing novel and applicable ideas. For example, ambitions towards sustainable and just futures involve a plethora of actors (Escobar, 2018), interventions at all levels of societal change (i.e., products, services, systems, policies) (Manzini & Rizzo, 2011) and many challenges stemming from social, economic and political structures. The grassroots development of diverse future visions, the steps necessary to get there, and advocating for the support structures to help them realize these, might be the only viable way to initiate and sustain such a societal transformation (Manzini & Rizzo, 2011). Considering the exploratory nature of the DF-MOD project, such a generative design tool was developed that can facilitate the development of alternative, open design-led business models. The following

lines outline the development and implementation of the Networked Business Model Canvas.

The Networked Business Model Canvas (N-BMC) is developed as a generative design research tool that aims to imagine and explore alternative ways of doing business in distributed value creation networks managed by open design knowledge. From a management perspective, it differs from the above-mentioned business model development tools due to the following reasons. Firstly, it focuses on *distributed value creation networks* with *numerous stakeholders* participating in value creation processes at varying capacities. The exploration of a singular, focal business/firm cannot 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 sometimes interchangeable, stakeholders. Secondly, the DF-MOD project offers a different categorisation of stakeholders that goes beyond the business/firm-customer divide (Bakırlıoğlu, 2022b; Bakırlıoğlu & Hasdoğan, 2022). In this conceptualisation, all stakeholders partake in value creation and (re-) capture processes at varying levels depending on their varying knowledge, skills and capabilities with however small contributions (Bakırlıoğlu, 2022a). Thirdly, this generative research tool is developed to explore an alternative economic paradigm with a different intellectual property rights regime through open sharing of design knowledge. Thus, existing assumptions regarding intellectual property and production licensing needs to be dismantled and explored with N-BMC.

N-BMC consists of four main components:

1. **Main Canvas** *(presented in Figure 1):* Main canvases are large canvases for stakeholders the participants intend to explore inputs, outputs and processes. The upper left side of the canvas is for inputs. These can be in the forms of resources, objects, services and knowledge. The lower right side of the canvas is for outputs. These can be in the forms of resources, objects, services and knowledge. This side is divided into five so that you can group the outputs for different stakeholders. The outer circle of the canvas (darker) is for placing *resource, object and service* inputs and outputs. The middle circle of the canvas (lighter) is for placing *knowledge* inputs and outputs. The inner circle of the canvas (white) is for identifying any processes of the stakeholder to transform inputs into outputs. The main canvases are for value-creation-for-self (i.e. responsible consumers, active users, prosumers/makers/DIY-ers) and value-creation-for- others (i.e. local, regional or global/mass producers) stakeholders.

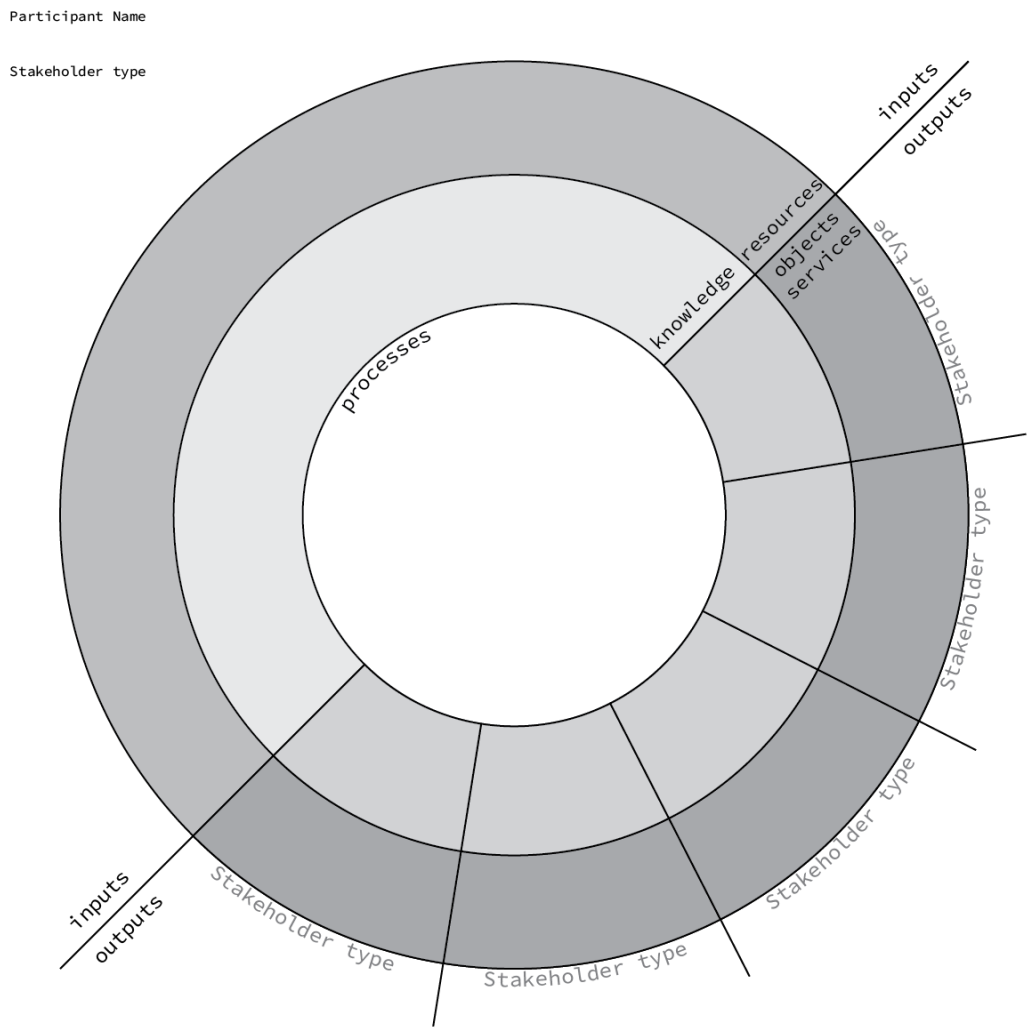

Figure 1. Main Canvas of Networked Business Model Canvas generative tool

2. **Mini-canvas** *(presented in Figure 2):* Mini-canvases are smaller versions of main canvases and are for other stakeholders in distributed value creation networks. The upper left side of the canvas is for *inputs.* These can be in the forms of resources, objects, services and knowledge. The lower right side of the canvas is for *outputs.* These can be in the forms of resources, objects, services and knowledge. The outer circle of the canvas (darker) is for placing *resource, object and service inputs and outputs.* The middle circle of the canvas (lighter) is for placing *knowledge inputs and outputs.* The inner circle of the canvas (white) is for identifying *any processes of the stakeholders to transform inputs into outputs. These are not for detailed exploration; hence, participants should only consider inputs, outputs and processes relevant to the main canvasses. These can be used for value-creation- for-self and value-creation-for-others stakeholders, as well as other stakeholders not falling into these categories.*

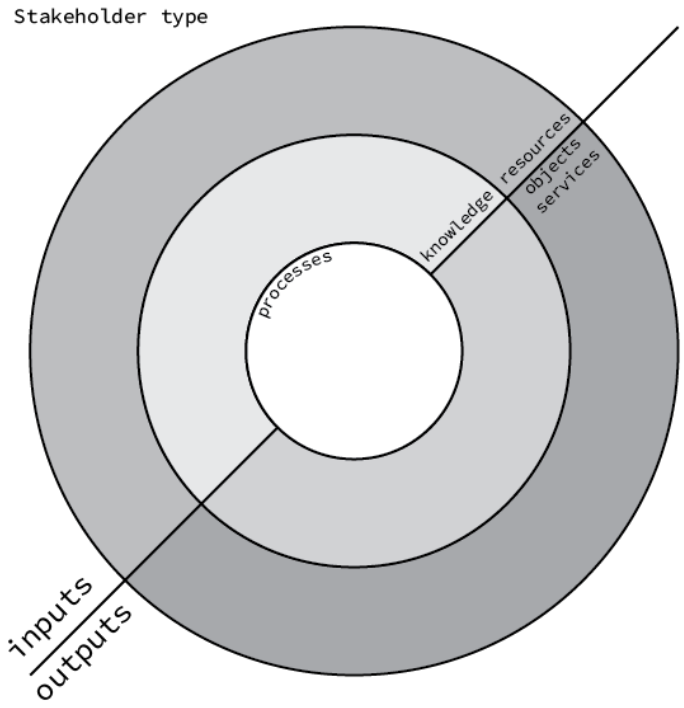

Figure 2. Mini-canvas of Networked Business Model Canvas generative tool

3. **Provision lines:** These lines are to draw the link between one stakeholder's output and another one's input. There are two types of provision lines, namely *direct* and *indirect*. Direct links are solid lines with an arrowhead on the input side, and they are for what is directly provided by an output, e.g., material resources, products, and direct communication. Indirect links are dashed lines with an arrowhead on the input side, and they are for knowledge or resource as part of an output that is not its direct purpose, e.g., openly shared knowledge, parts developed for other purposes.

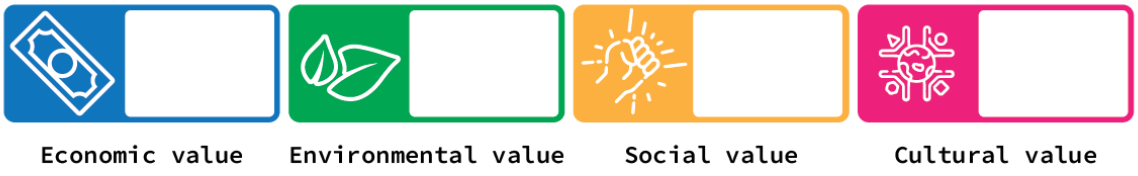

Figure 3. Value tags of Networked Business Model Canvas generative tool

4. **Value tags** *(presented in Figure 3):* These tags are to be used on direct and indirect provision lines among main and mini canvasses. You can place tags and describe how these kinds of values are being created with that relation. There are four types of value tags: (a) *economic values* can be monetary gains or savings, (b) *environmental values* can be the reduction of resource loss, CO2 emissions, reuse of products, etc., (c) *social*

values can be the empowerment of communities, local businesses, underserved communities (e.g. minorities, migrants, disabled, women, etc.), and (d) *cultural values* can be accommodating cultural needs and preferences, novel cultural practices, etc.

N-BMC was developed in the Summer of 2022 and released open access in August 2022 (Bakırlıoğlu, 2022c).

2.2. Implementing the Network Business Model Canvas

The generative design research tool, N-BMC, was developed to be utilised by multiple stakeholders in the context of design workshops, as well as by a singular stakeholder. Design workshops are sessions that aim at exploring design ideas and solutions with designers and non-designers. Projective and constructive generative tools and techniques are typically used during design workshops in order to initiate and facilitate the exploration of various ideas within the scope of an assigned topic (Martin & Hanington, 2012). The workshops are also used in educational settings for participants to learn and experience certain methods, tools or concepts (Pretty et al., 1995; Turgut & Cantürk, 2015), in which case, some *learning outcomes* are set, and they are assessed by the knowledge gained by participants. Participants share their insights on the assigned topic during workshops, discuss the insights of others, and produce outcomes that reflect them. Workshop results are generally qualitative in nature, and generalizable conclusions cannot be drawn from them since the number of participants is limited. Design workshops present participants with a variety of generative tools and techniques (e.g. collages, diaries, and mind maps) that are selected based on the expected outcomes of the workshop.

The planning of design workshops requires rigorous consideration of a variety of factors that need to be reflected upon while preparing a participatory workshop (Chambers, 2012), including a clear definition of the purpose, participants, ways of participating, setting, and so on. The prominent factors for DF-MOD workshops are as follows:

- *Purpose*: Enabling comprehensive stakeholder mapping of value-creation-for-self and value-creation-for-others stakeholders in potential distributed value creation networks to explore new, alternative business models.
- *Participants and their possible expectations:* An open-ended range of participants who identify as active users, prosumers/makers/DIY-ers, and actors from local, regional or global/mass producers. Topic-wise, the participants would be interested in distributed production paradigm, open (source) design, design for sustainability and circular economy. Considering more practical implications, the participants would be interested in novel stakeholder relations in increasingly localised production settings, designing

for production and consumption at different scales, circular design, and entrepreneurship.

- *Method of participating:* The participants are expected to develop comprehensive distributed value creation networks with value-creation-for-self and value-creation-for-others stakeholders using the N-BMC generative design research tool and identify (1) new ways of doing business, (2) potential ways of operating, and (3) different kinds of value created within that network for different stakeholders.
- *Role of the facilitator:* The facilitator is the designer/researcher who designed the N-BMC tool and the workshop process, who guides participants throughout the process, documents the outcomes of the workshop and reflects on those outcomes for research purposes.
- *Setting:* Online through the use of a whiteboarding application (i.e. Miro) that is easy-to-use for participants not familiar with it and that enables the modification of complex mind-maps and alike, and video conferencing software. The use of digital means, rather than physical printouts, post-its and similar mediums, enabled the participants to quickly modify the parts they have worked on through each other's insights and feedback.
- *Time and planning:* Each session takes roughly 4 hours to ensure potential participants' attendance to it (i.e. not longer than half a day). The stages of the workshop are detailed in the next section.
- *Outcomes:* The outcomes of the workshop are complex maps of distributed value creation networks with individual, local, regional and global actors. The participants develop these maps to explore potential forms of value creation and capture within the network and espouse alternative business models. Another outcome is the reflections of the participants on the business models they designed, the real-life implications of these business models, and their perception of open design and distributed production gathered through group discussions at the end of the workshop.

While the above-mentioned list provides some details about the DF-MOD workshops, the following lines further explicate the workshop settings, schedule and outcomes.

2.2.1. Using N-BMC in different settings

There are two different settings N-BMC can be set up and utilised, according to the involved stakeholders in the business model development process and their intentions (i.e., exploring opportunities for multiple businesses in distributed value creation networks or exploring the distributed value creation network of a singular business model in depth). Throughout the DF-MOD workshops, both settings were implemented according to the preferences of the participants.

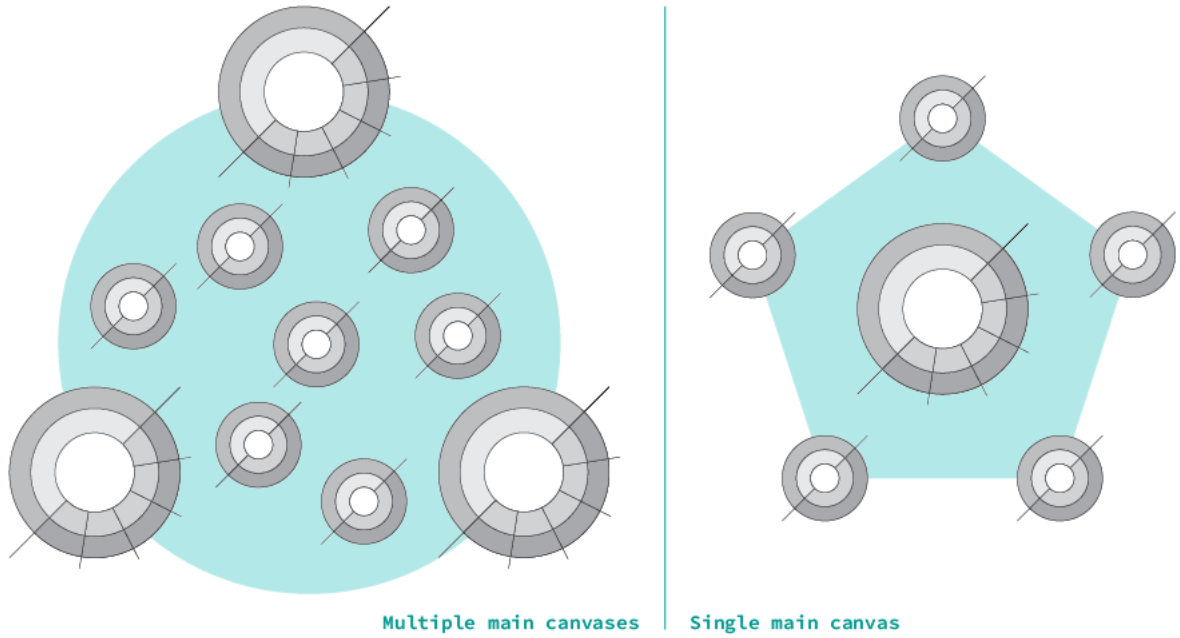

Figure 4. Multiple main canvases (left) and single main canvas (right) settings of Networked Business Model Canvas generative tool

Multiple main canvases setting (Figure 4, left) is suitable when a group of representatives of different stakeholders are trying to explore alternative business and/or value creation practices for themselves in distributed value creation settings. It is practical for exploring the contours of business models and value creation practices of multiple stakeholders, and how they can operate in relation to each other as well as other stakeholders. While it is demonstrated with 3 main canvases in Figure 4, the number can be increased to 5 main canvases. *Using more than 5 canvases may result in an ineligible mapping of stakeholders with too many provision lines drawn among them.* For this setting, the main canvases can be for value-creation-for-self and value-creation-for-others, to initiate meaningful participatory sessions.

Single main canvas setting (Figure 4, right) is the best setting suitable when trying to explore alternative business practices of a singular stakeholder in distributed value creation settings. It is practical for in-depth exploration of the distributed value creation network of a single business model and how it can operate in relation to other stakeholders in said network. For this setting, selecting a value-creation-for-others stakeholder (i.e. local, regional or global/mass producer) for the main canvas is advised. While only five mini-canvases are depicted in Figure 4 (right), the number can be increased as much as necessary to cover multiple value-creation-for-self and value-creation-for-others stakeholders with different needs, preferences, capabilities and motivations. As the number of other stakeholders increases, the depth of the mapping

increases as well and presents potential for alternative channels for value creation and (re-)capture within the network.

2.2.2. Workshop structure

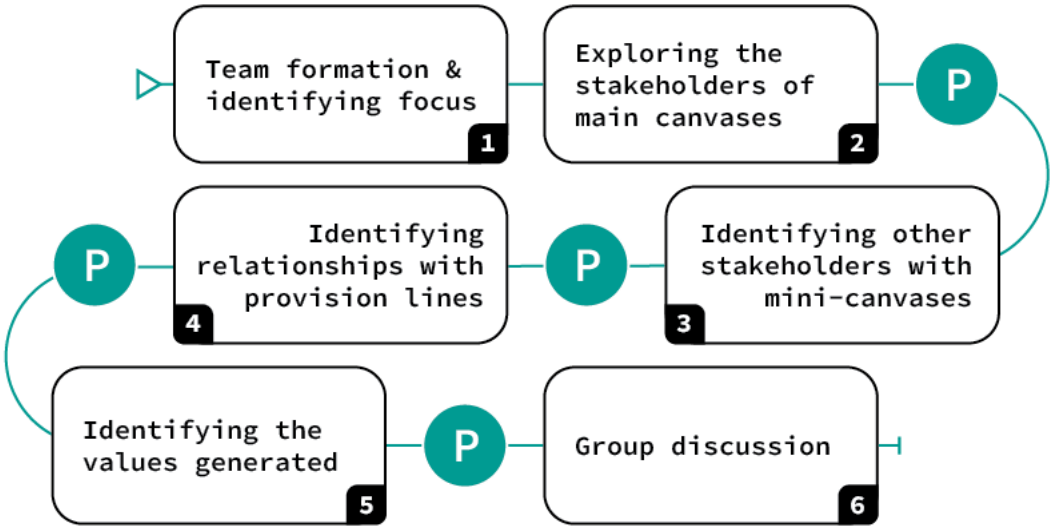

Figure 5. The rough structure of DF-MOD workshops

DF-MOD workshops followed the rough outline summarised in Figure 5. The numbered boxes indicate the steps of the workshop, and the green circles identify where participants briefly present their work to other participants. A DF-MOD workshop session takes appx. 4 hours, or half-a-day. In the below lines, the steps of the workshop are explained.

0. **Welcome, introductions, presentation, and Q&A** *(appx. 45 mins)*
   The participants are welcomed, everybody briefly introduces themselves (an icebreaker can be used), and the facilitator makes an introductory presentation about distributed production, open design and business models. Then, the facilitator introduces Networked Business Model Canvas and the workshop schedule. The participants ask questions regarding the topic and the workshop.
1. **Team formation and identifying focus** *(appx. 20 mins)*
   The participants are divided into teams of three, four or five, according to the number of participants in a workshop session and the N-BMC setting utilised. The teams then decide on their foci or starting points, which can be a product type or a product-service system.
2. **Deciding on main stakeholder(s) and exploring their inputs, outputs, and processes** *(appx. 45 mins)*

After identifying their foci, the teams decide on their main stakeholder(s). In multiple main canvasses settings, the main stakeholders can be value-creation-for-self (i.e. responsible consumer, active user, prosumer/maker/DIY-er) and value-creation-for-others (i.e. local, regional or global/mass producer) stakeholders. In the single main canvas setting, the main stakeholder should be a value-creation-for-others (i.e. local, regional or global/mass producer) stakeholder.

After deciding on the main stakeholder(s), the team members populate the main canvasses with main stakeholders' inputs, processes, and outputs as much as possible using digital post-its. Inputs and outputs should be divided into resources/objects/services & knowledge.

Types of inputs, processes and outputs vary greatly according to stakeholder type. E.g. For a value-creation-for-self stakeholder, inputs can be products, services, community knowledge, etc. and outputs can be personalised products, the things created using products (e.g. meals made with kitchen appliances), sharing of DIY process, etc. For a value-creation-for-others stakeholder, inputs can be material resources, parts or components from other producers, equipment, user feedback, etc. and outputs can be products, services, spare parts, manuals, etc.

Main canvases can initially be filled by individual participants who then share the canvasses with other team members and further develop them, or they can be filled as a team from the beginning. The former streamlines the process and is more suitable for time management, while the latter enables more in-depth exploration of the main stakeholders' processes. This stage is finalised with brief team presentations of their main canvasses to the remainder of the workshop participants.

3. **Identifying other stakeholders and exploring their inputs, outputs, and processes** *(appx. 30 mins)*

   The teams then explore different kinds of value creation processes that can be set up among the main stakeholders and identify other stakeholders that enable such processes within the distributed value creation setting they are focusing on. The teams utilise mini-canvasses for this purpose and populate them with those stakeholders' inputs, outputs, and processes relevant to the teams' foci. This stage is finalised with brief team presentations of these stakeholders' and their roles in the distributed value creation network to the remainder of the workshop participants.

4. **Identifying relationships with direct and indirect provision lines between inputs and outputs** *(appx. 30 mins)*

   The teams then identify the relationships among all the stakeholders in the distributed value creation setting they are exploring, using two types of provision lines. Direct provision lines are for what is directly provided by an output (e.g., material resources, products, direct communication). Indirect provision lines are for knowledge or resource as part of an output that is not its direct purpose (e.g., openly shared knowledge, parts developed for other purposes). Links can only be drawn from output into input, i.e., one stakeholder's output can be other stakeholders' input. *There should be no input-input or output-output relations.* This stage is finalised

with brief team presentations of key relations among the stakeholders to the remainder of the workshop participants.

5. **Identifying the values generated for each link** *(appx. 30 mins)*
   At this stage, the teams identify the different kinds of value that can be generated by each relation using the value tags, which can be economic, environmental, social and cultural values. The value tags are placed on direct or indirect links, and there is space to briefly explain how that kind value is generated with keywords. *An output that is not linked to an input does not generate value.* This stage is finalised with brief team presentations of values generated by the newly explored distributed value creation setting to the remainder of the workshop participants.
6. **Group Discussion** *(appx. 45 mins) – explained in section 2.3.4.*

2.2.3. Calls for participation and sampling

The sampling for the workshop sessions was a combination of purposive and snowball sampling. It was purposive as the calls for participation were done through specific communications channels as outlined below:

1. Through a workshop session as part of National Design Research Conference 2022,
2. Emails to DF-MOD survey (WP4) participants,
3. Calls made through relevant networks (e.g., Pop-Machina H2020 project, Zemin İstanbul makerspace),
4. Calls made through researcher's professional network

It also involved snowball sampling, as the participants were asked to spread the word about DF-MOD project, N-BMC and workshop sessions. The criteria for inclusion were very straightforward and mostly inclusive. The call for participation started with a brief explanation of distributed production, outlined the aim of the workshop, and 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. There was no additional confirmation of participants' backgrounds; that information was accepted as stated. The participants included designers (12 industrial/ product designers, 4 UX/UI designers, 2 service designers, 2 design students), engineers (1 mechanical engineer, 1 electronics engineer, 1 waste management system engineer), researchers (3 design researchers, 1 architecture researcher), craftspeople (1 ceramics, 1 leather), managers, officers and other experts (1 design director, 1 Technology Transfer Office manager, 1 internal operations officer, 1 HR officer, 1 municipality outreach officer, 1 CSO representative, 1 makerspace coordinator, 1 marketing expert, 1 communications expert/entrepreneur). The spread of different backgrounds and expertise (see Appendix 1) was satisfactory for the exploration of DVCNs throughout the sessions and sparked fruitful group discussions.

2.2.4. Group Discussions

After the workshop, the insights of participants are gathered through facilitating a discussion on networked value creation settings and new business model concepts emerged throughout the workshop, N-BMC generative tool, and the implementation of the workshop. These are conducted as group discussions, which are conducted with a group of participants through the facilitation of an in-depth discussion on topics of interest (Glesne, 2016). The objective of group discussions is to uncover individuals' opinions regarding topics of interest and to explore data and insights through the interaction between participants (Flick, 2019). It is possible to use group discussions to complement other research methods and tools to gather participants' insights about an earlier study (Morgan, 1997). In this study, group discussions are used to gather insights about participants' insights about distributed value creation networks and their experiences of using N-BMC and participating in DF-MOD workshops. The discussion was structured as follows:

- Networked value creation and open design-led business models: Reflecting on the potentials for and limitations against value creation processes enacted by distributed stakeholders, the management of these processes, the role of openness of design knowledge and data, implications for designing parts, components and products, diffused collaborations emerged and different forms of value potentially generated.
- Networked Business Model Canvas: Reflecting on the clarity and usefulness of N-BMC, especially in terms of developing alternative business models and identifying value creation and (re-)capture processes in distributed value creation networks.
- DF-MOD workshops: Discussing the structuring and conduct of DF-MOD workshops, including presentation, time management, participation, etc.

The outcomes of the group discussions enabled the researcher to reflect on the insights and considerations of the participants regarding open design-led business models in distributed production settings, and if and how they perceive the opportunities and limitations of distributed value creation settings involving a multitude of stakeholders.

2.2.5. Analysis of the Workshop Outcomes

The expected outcomes of the workshops were (1) alternative value creation nodes in alternative DVCNs consisting of various VCFS and VCFO stakeholders, conceptualised according to their inputs, processes and outputs categorised according to (a) knowledge and (b) resources, objects and services, (2) the links between these stakeholders depicting the flow of these knowledge and resources in DVCNs, and (3) the identification of different forms of value generated with these links. These revealed various points of analysis with regard to the forms of operation and value creation (inputs, processes and outputs), practices of value (re-)capture (through links) and distributed forms of value creation (through multiple stakeholders linked), and types of values generated.

The analysis involved bringing together similar value creation nodes explored in different sessions. Some of these nodes were not necessarily novel or did not reveal fundamental changes to business-as-usual, but revealed minor changes to their operation that would enable novel business models to operate in DVCNs. Such nodes were analysed in relation to the six novel business models that emerged from the analysis. These six business models were analysed according to four analysis categories. The first one was about understanding the knowledge and resource inputs required for that value creation node to operate, which stakeholders provide those inputs, how they provide them and if any form of licensing/IPR is required. The second one focused on the internal operations of the new business models, features of the knowledge and resource, the object and service outputs it possibly generated, and the licensing/IPR strategy it adopts. The third category analyses the economic, environmental, social and cultural value generated in DVCN through the involvement of the analysed value creation node with other VCFS and VCFO stakeholders. This analysis involved not only the value the node captures itself but also the value captured by others. Finally, these were assessed according to the existing roles and capabilities of VCFS and VCFO stakeholders in Turkey presented in deliverable 4.2 (Bakırlıoğlu, 2022d).

3. Exploring business models in distributed value creation settings

3.1. Opportunities through open design and knowledge

DF-MOD workshops explored how the openness of design knowledge can initiate and sustain flourishing distributed value creation networks when it is supported by appropriate IPR and licensing strategies. Six different business models/value creation processes were found especially important and represented the potential of DVCNs. These were mainly for electrical household appliances but for branching out to other products and services, as *enablers* of such networks through connecting value-creation-for-self and value-creation-for-others to generate economic, environmental, social, and cultural values. The below lines present these business models/value creation nodes along with the necessary capabilities of stakeholders involved and potential outputs of the distributed value creation networks, as explored during DF-MOD workshops.

3.1.1. Local parts and components manufacturer for unique needs and preferences

Local, on-demand production has long been discussed in (design for) sustainability literature as one of the most impactful strategies to reduce the CO2 emissions stemming from global distribution channels, as well as to empower local skills and capabilities, improve the accessibility of post-use services, and increase their adoption by culturally meaningful and individually relevant products and services (e.g. Diez, 2011; Doğan & Bakırlıoğlu, 2020; Dogan & Walker, 2008; Kostakis et al., 2015; Ramos, 2017). The premise of distributed production lies in the networked value creation processes that increasingly localise production, while effectively utilising the opportunities for global/mass production. These opportunities were discussed in deliverable 3.1, along with the limitations of incumbent business models and the policy landscape on IPR (Bakırlıoğlu, 2022b). With the assumption that GMPs and RPs openly share design knowledge of parts and components, participants conceptualised LPs of personalised, one-off appliances that mainly produce unique parts and components to iterate appliances to respond to the VCFS stakeholders' needs and preferences at the local scale (Figure 6). *This business model was explored in all WSs.*

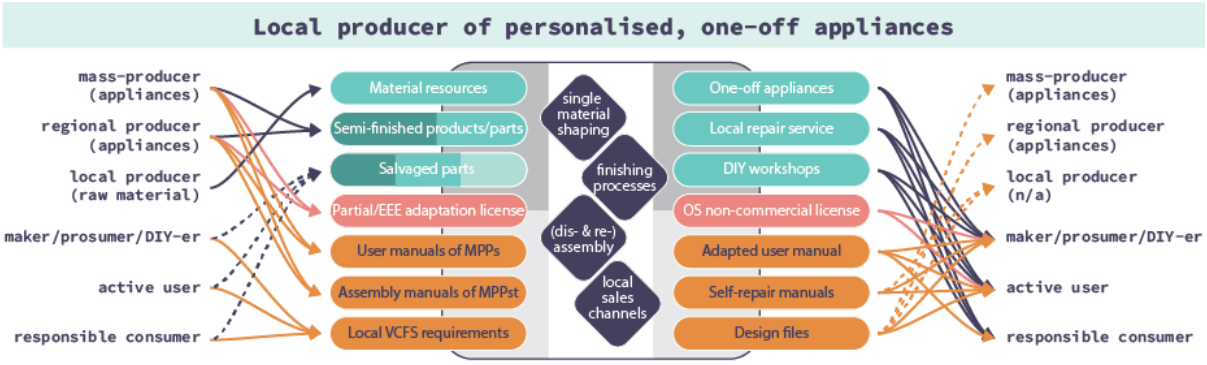

Figure 6. Local producer of personalised, one-off appliances, designing and producing parts and components and assembling them with mass- or batch-produced semi-finished products

3.1.1.1. Knowledge and resource inputs required

For this business model to operate, it would at least require semi-finished products and parts RPs and GMPs, along with a license agreement on partial EEE adaptation for commercial purposes, covering the post-sale responsibilities of both this business model and RPs/GMPs involved. This inevitably involves B2B sales channels being formulated and adopting a *layered design approach* (Bakırlıoğlu & Hasdoğan, 2022) to offer semi-finished products. This business model would also require local raw material resources (virgin and/or secondary) and can utilise salvaged parts and components.

Beyond these, this business model would require access to assembly manuals of MPPs to formulate assembly processes for semi-finished products and one-off parts and components it produces. It would also require user manuals of MPPs in order to adapt them to the unique products it will deliver. But more importantly, it will require knowledge of the local needs and preferences of VCFS stakeholders in order to prepare for addressing unique, individual needs in that locality.

3.1.1.2. Internal processes and outputs

This business model focuses on a singular material type (e.g., glass, ceramic, plastics, etc.) and has flexible and highly adaptable production and finishing processes for creating parts and components. As such, the business can improve the quality of its products and build its reputation as a specialist in certain types of iterations. As such, the business model offers one-off appliances unique to the needs and preferences of VCFS stakeholders, while at the same time, critical EE and non-EE parts and components produced by RPs and GMPs remain compliant with certain safety standards.

It also has an adaptable dis- and re-assembly procedure for the assembly of one-off appliances and their post-use (i.e., repair and upgrading). Offering repair services is a crucial part of the business model, as the products are highly unique to individuals' needs and preferences which would support emotional attachment to the products and improve the adoption of repair services. Furthermore, the products remain modular and upgradable so that the business can offer upgrading services for when VCFS stakeholders' needs and preferences change.

The above-mentioned highly flexible processes as well as proximity to VCFS stakeholders enable codesign processes and DIY workshops for PMD and AU, during which novel product and part ideas can be developed and contribute to the knowledge pool of the community. This can, in turn, improve the design, production and post-use processes of the business, or even espouse new local businesses e.g., focusing on different materials, product types, etc.

For the latter, it is important that the business openly shares the design files, drawings and other relevant design knowledge for the parts and components it produces with at least a non-commercial OS license. This enables PMD and AU uptake these designs, who intend to make their own iterations of the shared designs, and the business can offer post-use services to PMDs and AUs afterwards.

The business also prepares altered user manuals for all VCFS stakeholders that clearly explains the differences between MPPs and the unique, one-off appliances produced and how these differences alter the usage of the unique, one-off product.

Finally, the business also openly shares self-repair manuals for PMDs and AUs, which would eliminate the potential overburden on the repair service component that might hinder the production processes, yet still facilitate value capture through the provision of spare parts and components.

3.1.1.3. Value creating relations and value recapture

Local producer of personalised, one-off appliances business espouses a wide range of value creation and (re-)capture relations with VCFS and VCFO stakeholders through on-demand production of unique products, a local service to repair and upgrade parts and components, and codesign opportunities in the form of DIY workshops and open design sharing. It enacts a final VCFO stakeholder role in the value (re-)capture process of appliances, and the value capture of the business model mostly happens through its relations to VCFS stakeholders. However, its relations with other stakeholders revealed various opportunities for economic, environmental, social and cultural value creation throughout the distributed value creation network (Table 1), as explored during the DF-MOD workshops.

Table 1. Value creation and (re-)capture in distributed value creation network facilitated by local producer of personalised, one-off appliances

	Economic	**Environmental**	**Social**	**Cultural**
Responsible consumers	Sale of unique appliances, repair service, upgrading service	Post-use services for product longevity (i.e., repair and upgrading)	-	Unique parts and products responding to local cultural practices and needs, initiating a culture of product longevity through accessible post-use services

	Economic	Environmental	Social	Cultural
Active users	Sale of unique appliances, repair service, upgrading service, spare part sale, upgraded part sale	Post-use services, spare part provision, and OS self-repair manual for product longevity (i.e., repair and upgrading),	Maker community around codesign of unique appliances and their post-use processes	Unique parts and products responding to local cultural practices and needs, initiating a culture of self-repair and upgrading
Prosumer/ maker/ DIY-ers	Sale of unique appliances, spare part sale, upgraded part sale	Post-use services, spare part provision, and OS self-repair manual for product longevity (i.e., repair and upgrading),	Maker community around codesign of unique appliances and their post-use processes	Unique parts and products responding to local cultural practices and needs, initiating a culture of self-repair and upgrading
Local producers	Raw material acquisition	Reduced CO2 emissions with shorter local value chain for raw materials	Empowering LPs by raw material acquisition, espousing new business models through community involvement	Locally produced, unique products that reflect local cultural practices, needs and preferences
Regional producers	Semi-finished products and parts acquisition, commercial use licensing	Reduced CO2 emissions with semi-finished (lighter) products and parts reaching closer to the final VCFO stakeholder directly, local repair and upgrading services of MPPs by this stakeholder	RPs empowering this business model by providing semi-finished products, parts and components, along with partial EEE adaptation license, community of local and regional entrepreneurs	RPs enabling local iterations of electrical appliances that match local, cultural needs and preferences by through hardware *platformisation*
Global/mass producers	Semi-finished products and parts acquisition, commercial use licensing	Reduced CO2 emissions with semi-finished (lighter) products and parts reaching closer to the final VCFO stakeholder directly, local repair and upgrading services of MPPs by this stakeholder	GMPs empowering this business model by providing semi-finished products, parts and components, along with partial EEE adaptation license, community of local and regional entrepreneurs	GMPs enabling local iterations of electrical appliances that match local, cultural needs and preferences by through hardware *platformisation*

3.1.1.4. Revisiting existing roles and capabilities

This stakeholder is a final node in DVCN before VCFS processes start, and its value offering is the highly personalised, one-off – sometimes collaboratively designed and produced – products, as well as locally accessible post-use services (i.e., repair and upgrading). This is enabled through highly flexible production processes (e.g., crafts, digital fabrication, etc.), capabilities for facilitating codesign processes with VCFS stakeholders, accessibility to commercial use OS licensing opportunities, accessibility to dis- and re-assembly knowledge of MPPs, logistics services among LPs, RPs and GMPs.

The survey *(deliverable 4.2,* Bakırlıoğlu, 2022d) revealed that GMPs are, unsurprisingly, not keen on OS sharing of design knowledge or dis- and re-assembly knowledge, with only appx. one-third of GMPs indicated that they can/do openly share design and assembly knowledge, and this is even less (24%) for repair knowledge. Furthermore, only appx. one-

fourth of VCFO stakeholders indicated that they were willing to provide the resale of spare parts. On the other hand, it was revealed that LPs mostly did not engage with production licensing and IPR management procedures. These constitute immense barriers to the realisation of the above-mentioned business model currently in Turkey, yet there are also a small number of RPs and GMPs that might transform their processes to enable it.

For the VCFS stakeholders, there is a noticeable lack of digital fabrication skills overall, except for PMDs, which might limit the reach of DIY workshops. However, considering the purposes of such workshops (i.e., to attract PMDs and AUs, and to codesign new iterations), it may not affect the value capture processes of the business as much. The main barrier is VCFO's overall reluctance to supply spare parts and OS repair information, even though the majority of VCFO stakeholders are interested in providing repair and upgrading services. The survey revealed that VCFS stakeholders are highly interested in self-repair practices, *and* they face barriers in reaching spare parts (especially EE parts and components). Thus, this business model and collaborating RPs and/or GMPs might provide a value offering matching the market needs and differentiating itself from other VCFO stakeholders.

3.1.2. Software developer for meaningful upgrading

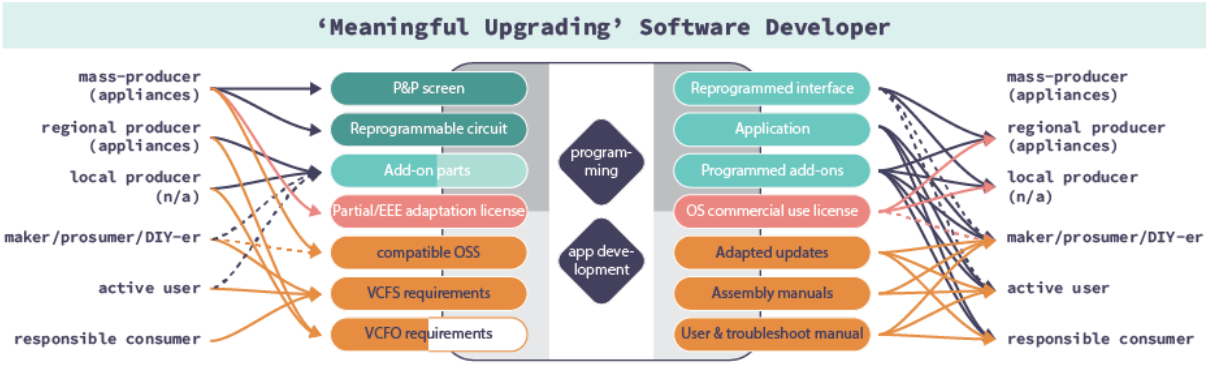

Figure 7. 'Meaningful Upgrading' software developer altering the programming of products and interface to adapt the product specifications

Software updates to digital products have long been conceptualised to elongate product lifetimes in the design for sustainability literature. Ensuring that a digital product can improve its functionality through updates can diminish the need for purchasing a newer version of a product (Bakker et al., 2019). During the DF-MOD workshops, participants regarded that upgrading could become more meaningful to value-creation-for-self stakeholders if they can alter the functionality of products to match their varying needs. A detailed and interesting example of this was upgrading the air fryer with different programmes to not only accommodate new recipes but also use it for more unique purposes like firing hobbyist ceramics that are normally done with other kitchen

appliances. Noticing that this might be beyond the capabilities of many value-creation-for-self stakeholders, a new business model was conceptualised that alters the programming of mass-produced household appliances (Figure 7). *This business model was explored in WS1, WS2, WS5, WS6, WS7 and WS8.*

3.1.2.1. Knowledge and resource inputs required

For this business model to operate, plug-and-play screen and reprogrammable circuitry should be part of the product from the beginning – i.e., they should be designed to enable software alterations. Also, mass producers should grant a license to partially adapt the electrical/electronic components in the first place for such a business to be established.

If the software alterations are required to accommodate additional parts and components designed and produced by RPs and LPs, the software developer might require access to these parts, as well as their design knowledge. However, if these add-ons are designed and produced by PMDs or AUs as one-offs, only the design knowledge might have to suffice considering logistics feasibility.

The alterations can only be done with open-source software developed by the initial mass-producer, which may be iterated and openly shared by PMDs for their own value creation processes.

Additionally, the software developer will need access to the requirements of VCFS stakeholders in order to design, develop and deploy meaningful upgrades suitable to their needs and preferences, and can utilise this knowledge to generate more generic products. On the other hand, this stakeholder would require access to LPs' and RPs' requirements which can be openly available or directly provided. For example, the software developer might utilise open access knowledge on the requirements of VCFO to design and develop more generic software that enables the establishment of LPs and RPs in the distributed value creation network. Or LPs and RPs might approach the software developer for specific projects of their own and directly provide their requirements.

3.1.2.2. Internal processes and outputs

The software developer business needs the skills and capacity for programming and application development, which involves not only coding but also user experience and interface design skills. By using these skills, this stakeholder creates (1) reprogrammed interfaces, (2) applications, and (3) programmed add-ons. These upgraded parts and components can be included in the RPs' and LPs' production processes for the development of new iterations of the initial product or their resale practices to distribute these parts and components to RCs, AUs and PMDs for mass-customisation. The business model can also take on retail practices and directly provide these parts and components to RCs, AUs and PMDs.

The reprogrammable interface is open-source, and PMDs can use and iterate programming for their value creation processes. However, the software developer should grant RPs and LPs a commercial reproduction license, so that RPs and LPs in the

distributed value creation network can initiate the production of these parts and components and resale practices.

Finally, the software developer, directly or through RPs and LPs, provides *adapted* updates to RCs, AUs, and PMDs. These are adapted in the sense that they are different, iterated versions of the initial OSS developed by the mass producer. The business also provides assembly guides for programmed add-ons to VCFS stakeholders to ensure their appropriate installations, and user & troubleshooting guides for their effective use, maintenance and repair where necessary.

3.1.2.3. Value creating relations and value recapture

'Meaningful Upgrading' software developer stakeholder espouses a wide range of value creation and (re-)capture relations with VCFS and VCFO stakeholders through offering reprogrammable parts/components, a service to reprogram these parts and components at different scales (i.e., singular, in bulk and batch) and offering pre-programmed parts/components for self-repair and upgrading. It enacts an important role in the value (re-)capture process of appliances with digital components and its relations to other stakeholders reveal opportunities for economic, environmental, social and cultural value creation presented in Table 2 throughout the distributed value creation network.

Table 2. Value creation and (re-)capture in distributed value creation network facilitated by 'Meaningful Upgrading' software developer

	Economic	**Environmental**	**Social**	**Cultural**
Responsible consumers	Profit from the sales of customised/ personalised parts and add-ons for upgrading	Upgraded products prevent the disposal of old products & providing relevant maintenance and repair knowledge	-	With adapted add-ons and parts, the products accommodate cultural practices and needs
Active users	Profit from service of programming add-ons designed by AUs and reprogramming the interface accordingly	Upgrading products to respond to unique needs and preferences of active users & providing relevant maintenance and repair knowledge	Community around codesign of unique programmed add-ons for appliances, reprogrammed interfaces and their post-use processes	With adapted add-ons and parts, the products accommodate cultural practices and needs & opportunity for new culture of repairing and upgrading appliances
Prosumer/ maker/ DIY-ers	Profit from the sales of reprogrammable interface to accommodate parts designed and produced by PMD	Making of unique appliances by PMDs & self-repair and upgrading by PMDs, enabled through reprogrammable interface	Community around unique appliances and other objects using reprogrammable interfaces and their collaborative design, production, and post-use processes	An opportunity for new culture of making, self-repairing and upgrading unique appliances & other objects
Local producers	Collaboration on design and production of unique interfaces, parts and add-ons for	Reduced CO2 emissions with shorter local value chains, local repair and upgrading services of products,	Empowering LPs by providing electronic parts and components, as well as external design, production,	Locally produced products that accommodate local cultural practices, needs and preferences

	Economic	Environmental	Social	Cultural
	novel retail products of LPs	on-demand provision of spare electronic parts	and post-use support, to diversify their product offerings	
Regional producers	Collaboration on design and production of unique interfaces, parts and add-ons for novel retail products of RPs	Reduced CO2 emissions with shorter local value chains, regional repair and upgrading services of products compatible with local repair services, on-demand provision of spare electronic parts	Empowering RPs by providing electronic parts and components, as well as external design, production, and post-use support, to diversify their product offerings	Batch production of regionally relevant appliances that respond to regional contexts and requirements
Global/mass producers	Acquisition of hardware (screen, circuit) with compatible OSS that can be reprogrammed and adapted for appliances	Localised production of iterated appliances and other products & network of repair services at the local and regional scales	Community of local and regional entrepreneurs using the same base hardware and OSS, sharing insights and experiences	-

3.1.2.4. Revisiting existing roles and capabilities

The value offering of this stakeholder in DVCN seems to coincide with the perception of especially VCFS stakeholders regarding the *necessity* of accessing electrical parts in *deliverable 4.2* (Bakırlıoğlu, 2022d). Similarly, VCFO stakeholders' responses revealed that *standards on electrical parts* highly affects the de-centralisation of production processes (ibid). Through global/mass-producers offering open design hardware and compatible software and 'meaningful upgrading' businesses, there is an opportunity to partially remedy the existing barrier of accessing electrical parts against participating into DVCN, both for VCFS and VCFO.

3.1.3. Secondary raw material producing waste management

Accessing secondary raw materials produced from local disposal practices has critical importance to establishing and sustaining localised, open circular economy loops, as has been explored in numerous research projects and initiatives (e.g., Pop-Machina H2020 project, Fab City initiative, and so on). The issue here is the utilisation of recycled content for VCFS and LP activities. The participants in different sessions explored the idea of specialised waste management businesses that produce secondary raw materials not only in the form usable by RPs and GMPs but also in the form usable for desktop digital fabrication technologies, craft practices, etc. While the processes for re-shaping different materials vary immensely, this business model can focus on the material(s) with local market demand and/or the material(s) of existing local *waste* flows (Figure 8). *This business model was explored in WS1, WS2, WS4, WS6, WS7, and WS8.*

Figure 8. Secondary raw material producing waste management, producing material resources for both ready for production for VCFO and compatible with digital fabrication and/or individual making for VCFS

3.1.3.1. Knowledge and resource inputs required

This business model utilises sorted production material and part waste of RPs and GMPs, which are presumably more consistent and standardised flows of materials. It also acquires WEEE products and parts, and discarded non-EE parts from LPs and all VCFS stakeholders through the existing waste management system (WMS). Parts or products separated either at the point of disposal by VCFS stakeholders or later at a sorting facility through WMS will enable the business to establish more consistent and reliable waste flows.

In addition to these, this business model requires information about recycling different parts (each of them) which should be openly available – along with the material limitations of recycling specific materials (e.g., number of times, amount of virgin material required, etc.). This is an important part of this business model especially if it is specialising in a single material or product type to ensure that the recycling process is streamlined, and an economically viable (auto-)sorting process can be set up.

As a business operating locally, this model should have detailed information about the demands of not only the VCFO stakeholders but also the VCFS stakeholders – especially AUs and PMDs who actively partake in the making of things. This information is not only related to material types and properties, but also to the conditions that they are offered by this business model. For example, if this business model is focusing on thermoplastics as material, the offering may need to be offered as pellets for wholesale to VCFO stakeholders, and as filaments compatible with the most popular 3D printers among the local VCFS stakeholders and/or the local makerspaces. The data to draw such information might be openly available, yet it would still require additional market research.

There is also a specific (set of) stakeholder(s) not visible in Figure 8, i.e., the existing waste management system/infrastructure where this business model is located. Specialising on a singular material type or resource (e.g., product type) is crucial for this model to process and offer secondary raw materials back to the market. This is where existing WMS should

act as an intermediary between the business model and VCFS stakeholders and, maybe even LPs who utilise the existing WMS structure. The incoming waste stream should be categorised enough to become an input to this value re-capture process and further sorted to ensure good quality outcomes, yet it should also be a large enough stream to become economically viable – which makes the existing WMS a crucial collaborator to this business model.

3.1.3.2. Internal processes and outputs

The internal processes of this business model are about finer sorting and categorisation of materials to produce secondary raw materials of certain levels of quality. There should be a certification involved with regard to the secondary raw material quality of diverse outcomes, according to the specialisation of the business model. There should also be a resale and/or marketing unit to handle sales to VCFS stakeholders.

The value offerings of this business model vary and include mass/batch production ready secondary raw materials for the VCFO stakeholders, individual *making* ready materials for AUs and PMDs, sorted and functioning parts not suitable for internal recycling processes for everyone, and local distribution/delivery service. Quality certification is especially important for material offerings, which should be compatible with the industry standards of VCFO stakeholders and accompanied by a more accessible, non-technical explanation of that certification for VCFS stakeholders.

3.1.3.3. Value creating relations and value recapture

'Secondary raw material producing waste management' business model's value offering is straightforward, in the form of a limited portfolio of secondary raw materials ready to be utilised in production and *making* practices. However, value (re-)capture relations are complex and add to the backend organising of the business model (Table 3).

Table 3. Value creation and (re-)capture in distributed value creation network facilitated by secondary raw material producing waste management

	Economic	**Environmental**	**Social**	**Cultural**
Responsible consumers	Input costs reduced thanks to waste streams	Waste from RCs as material input, categorised according to existing WMS	-	-
Active users	Input costs reduced thanks to waste streams Profit from secondary raw material sales for making practices	Waste from AUs as material input, categorised according to existing WMS. Uncontaminated material waste from making activities as material input, *AUs might undertake prior dismantling for finer sorting*	-	-
Prosumer/ maker/ DIY-ers	Input costs reduced thanks to waste streams Profit from secondary raw material sales for making practices	Waste from PMDs as material input, categorised according to existing WMS. Uncontaminated material waste from making activities as material input, *PMDs might undertake prior dismantling for finer sorting*	-	-

	Economic	Environmental	Social	Cultural
Local producers	Input costs reduced thanks to waste streams Finely categorised waste material, reducing operation costs Profit from secondary raw material sales for production practices	Finely categorised, uncontaminated waste material as material input Recycled materials used for production Reduced CO2 through local distribution to/from LPs		
Regional producers	Input costs reduced thanks to waste streams Finely categorised waste material, reducing operation costs Profit from secondary raw material sales for production practices	Finely categorised, uncontaminated waste material as material input and value recapture Recycled materials used for production Reduced CO2 through local distribution to/from LPs		
Global/mass producers	Input costs reduced thanks to waste streams Finely categorised waste material, reducing operation costs Profit from secondary raw material sales for production practices	Finely categorised, uncontaminated waste material as material input and value recapture Recycled materials used for production Reduced CO2 through local distribution to/from LPs		

3.1.3.4. Revisiting existing roles and capabilities

This business model is very well matched with the outcomes of the DF-MOD survey (see *deliverable 4.2,* Bakırlıoğlu, 2022d). 'Secondary raw materials for individual fabrication' was a prominent dimension for VCFS stakeholders since accessibility to small-scale recycling equipment (e.g. Precious Plastics) was found significantly affecting their fabrication capabilities. This business model presents potentials for externalising the production of secondary raw materials and reducing the material costs for AUs and PMDs, improving their potential to participate in DVCNs.

For VCFO stakeholders, the survey revealed that in-house recycling was found necessary, especially for GMPs (nns=51, nas=56). The higher necessity score of GMP is visible in the response distribution as %29 of GMP indicated they don't have *enough* access to in-house recycling, and %21 indicated they have no access to in-house recycling practices, but they are required. While these results suggest that this business model may not be engaging GMPs as much, who might prefer to set up recycling as an internal business component, the recycling equipment and their maintenance is highly costly and such an investment may not be economically viable. On the other hand, a core component of this business model is the certification of secondary raw materials, and this can enable externalizing the recycling process to a trusted third party such as this business model.

3.1.4. Local producer & service provider of professional use appliances

Another interesting business model explored in the workshops was the emergence of a local producer & service provider that alters consumer products to satisfy the needs and preferences of other local businesses. This business model iterates products designed for B2C business models to offer B2B services in this regard. As can be seen in Figure 9,

this business model is solely focusing on VCFO stakeholders as a result and reveals alternative considerations for the open design of electrical appliances in terms of value creation. *This business model was explored in WS1, WS6, and WS7.*

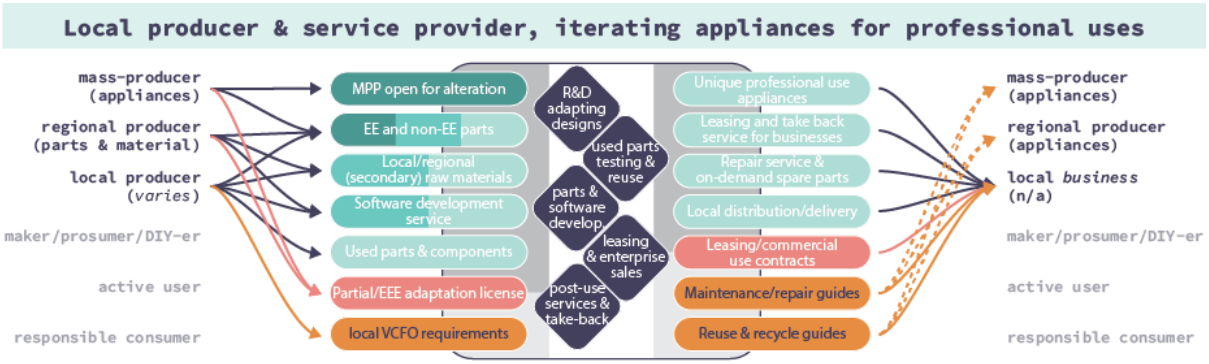

Figure 9. Local producer & service provider of professional use appliances, iterating consumer appliances for professional uses and offering enterprise-level leasing and post-use services

3.1.4.1. Knowledge and resource inputs required

This business model requires MPPs to iterate with various EE and non-EE parts that can be sourced from LPs, RPs or GMPs. It also requires raw materials to produce one-off parts/components according to the needs and preferences of its professional customers. The materials can be sourced from (secondary) raw materials provided by LPs and RPs. Similarly, it can source used parts and components from its customers to reuse them in other products and/or for maintenance and repair practices. Additionally, if the business is iterating smart products or products with digital interfaces, it might require a software development service to update the product's software to match iterated features.

The design of the iterations requires detailed input from local VCFO stakeholders that are the customers of this business model. However, it is also highly dependent on the overall sector this business model is targeting (e.g., hospitality, healthcare, education, etc.) as well as the product-service system focus (e.g., cleaning, food preparation, etc.). Furthermore, the capacity of this business model lies in the openness of design knowledge and limitations of the EEE adaptation licensing. This business model was developed with the assumption that GMPs openly share design knowledge *and* grant partial EEE adaptation and production licenses. While there is a possibility that this business model can operate without these licenses, considering the existing policies on consumer goods ownership, the lack of this licensing would make the business model vulnerable.

3.1.4.2. Internal processes and outputs

This business model requires a small R&D team to iterate MPPs' designs to undertake more professional requirements. This involves the development and production of any

new parts and compatible software updates where necessary. At this stage, reusing parts and components is important but requires testing for satisfactory performance. Considering that this is a service provider of product-service systems for e.g., professional cleaning, food preparation, etc. tools, the unique products are leased and maintained by this business model. As part of the post-use and takeback services, this business model has the capacity to properly assess if used parts can deliver satisfactory performance in an economically and environmentally efficient way.

The outputs of this business model vary; however, they are all addressed to local businesses. The main value offering of this business model is unique appliances for professional use, which are iterated to match the varying needs and requirements of local businesses in different sectors. These are supported by surrounding services that enhance the core value offering, including leasing and take-back systems for businesses, repair services, on-demand spare part sales for unique parts and components, and local distribution and delivery services. The business model offers leasing/commercial use contracts for their unique designs. For the local businesses who are willing to purchase the unique products, this business model also creates maintenance and repair guides iterated from the original MPPs' guides, as well as reuse and recycle guidelines it utilises to build trust in its part/component reuse practices. GMPs and RPs designing and producing the original MPPs can also utilise these guides as inputs for their product development.

3.1.4.3. Value creating relations and value recapture

The local producer & service provider of professional use appliances offers local B2B services and products for local businesses, that are unique to specific businesses' needs and preferences. The DVCN of this business model is reduced only to VCFO stakeholders, although the other VCFO stakeholders it is linked to are mostly creating value for VCFS stakeholders. This is a unique positioning for this business model, which iterates products designed and produced for VCFS to cater for the needs of local businesses. Table 4 summarises the value creating relations among these stakeholders and this business model.

Table 4. Value creation and (re-)capture in distributed value creation network facilitated by local producer & service provider of professional use appliances

	Economic	**Environmental**	**Social**	**Cultural**
Responsible consumers				
Active users				
Prosumer/ maker/ DIY-ers				
Local producers & businesses	Acquisition of raw materials, EE and non-EE parts, used parts, and software development.	Reduced CO2 through local distribution and delivery of products, parts and materials.	Empowering LPs and other businesses by catering their unique needs and improving their businesses.	Responding to unique cultural preferences that local businesses uphold for e.g.

	Resale of unique appliances Services and leasing	Reusing parts and components. Repair and upgrading service.	Localised community of practice utilising adapted appliances for business purposes.	cleaning, food preparation, etc.
Regional producers	Acquisition of raw materials, EE and non-EE parts, and software development. *Partial/EEE adaptation license*	Reduced CO2 through regional distribution and delivery of parts and materials.	-	-
Global/mass producers	Acquisition of raw materials, and EE and non-EE parts. *Partial/EEE adaptation license*	-	-	-

3.1.4.4. Revisiting existing roles and capabilities

Considering the high accessibility to logistics services of LPs among other stakeholders (%57), this business model seems to fit well with local value networks. However, there are multiple considerations in terms of designing unique appliances. For example, 28% of LPs indicated that they do not have enough codesign capabilities with end-users and 12% indicated that do not have such capabilities at all (see *deliverable 4.2,* Bakırlıoğlu, 2022d). This constitutes barriers to understanding and enacting upon the unique needs and preferences of local businesses.

The survey also revealed that more than half of LPs consider open-source production licensing as not required, and only 44% of LPs find meaning in participating in the horizontal management of DVCN, which might become an issue for this business model that iterates MPPs for different purposes, effectively becoming a forking node in the open design process (Bakırlıoğlu & Kohtala, 2019). In this regard, this business should be effectively participating in horizontal management of production licensing in order to ensure that all IPR rights are protected including its own iterations of MPPs.

3.1.5. Local/regional producer of alternative product ecosystems

Emerged as a more formalised and systematic 'hacking' practice, this business model is conceptualised as an alternative ecosystem of locally and/or regionally produced products that are used with mass-produced black box products (BBPs). Especially in the electrical appliances product category, the functions of products belonging to the same product category were regarded as more or less similar – even for the 'smart' products (e.g., robot vacuums) – which the participants regarded as opportunities for designing products and ecosystems that works with BBP electrical appliances and circumvents production licensing. More common features of electrical appliances are utilised with additional products to respond to VCFS stakeholders' needs and preferences. While many different ideas emerged throughout the workshops, the most comprehensive one was

around smart pet products that utilise the common 'remote camera and manual steering' function of the robot vacuums to activate and de-activate various pet accessories. The depiction of this business model in Figure 10 is developed considering all these ideas. *This business model was explored in WS1, WS2, WS4, WS5, and WS8.*

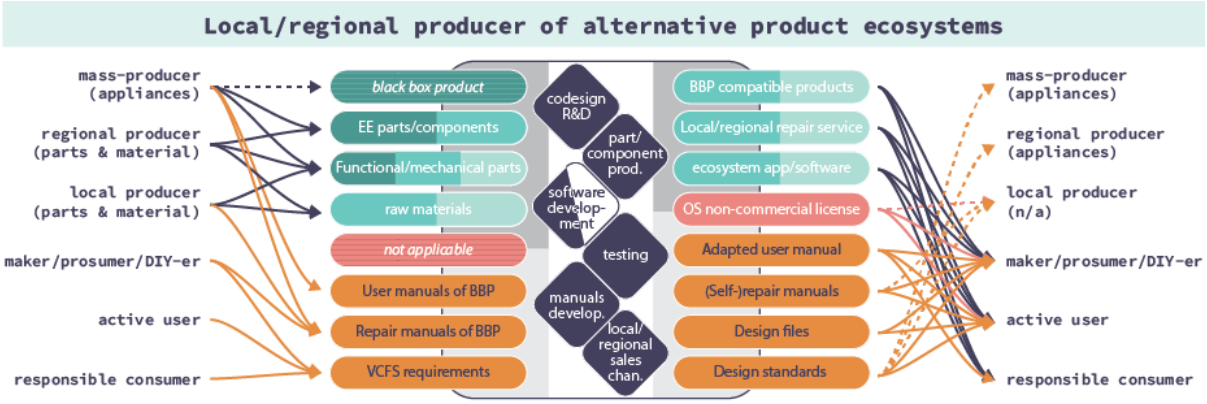

Figure 10. Local/regional producer of alternative product ecosystems, developing novel electrical products and alternative product ecosystems compatible with commercial electrical appliances

3.1.5.1. Knowledge and resource inputs required

This business model highly depends on BBPs and their standardised functions – either through standardisation bodies or through market developments – to create and offer value. Beyond the design processes, this business model does not require BBPs themselves as material input. It will need other EE parts/components, functional and mechanical parts, and/or raw materials from other VCFO stakeholders according to the production processes it sets and the level of externalising production (e.g., through MaaS). More importantly, this business requires open access to user manuals for information regarding the utilised functions as well as repair guides to ensure that there are no incompatible or damaging parts, components and behaviours that damage the BBPs or the alternative products offered by this stakeholder.

A crucial input for this stakeholder is proper recognition of VCFS stakeholders' requirements, capabilities and circumstances. The participants conceptualising such a business model brought forward that, when the complexity of the BBPs, which deliver the necessary function for this business model to build upon, increases so will their price point, affecting the audience of the BBP as well as the value offering of this business model. For example, while robot vacuum cleaners or air fryers are getting more and more popular and affordable, there is still time for them to become as commonplace as e.g., water kettles. On the other hand, different product categories are commonplace in different regions around the world, such as a toaster *versus* a toaster grill in the case of Turkey, where the latter is more commonplace than the former. This is a crucial aspect

for further detailing this business model that might operate best at local and regional scales.

3.1.5.2. Internal processes and outputs

This stakeholder operates not so differently from the previous 'local producer & service provider of professional use appliances' model, but the target audience is main VCFS stakeholders rather than business customers. This business model requires a design and R&D unit capable of facilitating codesign processes with VCFS stakeholders. It also requires production capacities for producing parts and products. If the products require software development (e.g. for circuitry or app development), it might either have an in-house team or externalise the software development processes. As a result of this, the outputs include BBP-compatible products, local/regional services for these products, as well as a digital ecosystem supporting the products.

Openly sharing designs with an OS non-commercial license is important for this business model, in order to constitute a community of practice around the new product ecosystem and continuously improve its product offerings through iterations developed by and/or feedback from the community members. To this end, this business model shares design files as well as understandable industry standards (i.e., common features and specifications). This business model also develops user manuals to show how its products are used alongside BBPs, and self-repair manuals utilised by its repair service and can be utilised by VCFS stakeholders.

3.1.5.3. Value creating relations and value recapture

This business model offers unique products that utilise existing BBPs and their common features. In that sense, its offerings are differentiated in the market; however, it is also dependent on the existing market conditions of BBPs. It forms direct and indirect value creating relations with VCFS and VCFO stakeholders (Table 5) and operates within a flexible DVCN consisting of multiple different GMPs, RPs and LPs.

Table 5. Value creation and (re-)capture in distributed value creation network facilitated by local/regional producer of alternative product ecosystems

	Economic	**Environmental**	**Social**	**Cultural**
Responsible consumers	Sale of unique products compatible with appliances, repair service	Post-use services for product longevity (i.e., repair)	-	Unique products responding to local cultural practices and needs, initiating a culture of product longevity through accessible post-use services
Active users	Sale of unique products compatible with appliances, repair service	Post-use services, spare part provision, and OS self-repair manual for product longevity (i.e., repair and upgrading), design	Maker community around codesign of hacking appliances, unique products and their post-use processes	Unique parts and products responding to local cultural practices and needs, initiating a culture of

		files and knowledge to iterate and upgrade designs		hacking, self-repair and upgrading
Prosumer/ maker/ DIY-ers	Sale of unique products compatible with appliances, repair service	Post-use services, spare part provision, and OS self-repair manual for product longevity (i.e., repair and upgrading), design files and knowledge to iterate and upgrade designs	Maker community around codesign of hacking appliances, unique products and their post-use processes	Unique parts and products responding to local cultural practices and needs, initiating a culture of hacking, self-repair and upgrading
Local producers	Raw material acquisition, Functional/mechanical parts/components acquisition	Reduced CO2 emissions with shorter local value chain for raw materials and functional/mechanical parts	Empowering LPs by raw material acquisition, espousing new business models through community involvement	Locally produced, unique products that reflect local cultural practices, needs and preferences
Regional producers	Raw material acquisition, Functional/mechanical parts/components acquisition, EE parts/components acquisition	Reduced CO2 emissions with raw materials, functional/mechanical parts and EE parts reaching closer to the final VCFO stakeholder directly	RPs empowering this business model by providing raw materials, functional/mechanical parts and EE parts, community of local and regional entrepreneurs	-
Global/mass producers	EE parts/components acquisition, *BBPs (indireclty)*	-	-	-

3.1.5.4. Revisiting existing roles and capabilities

This stakeholder is a final node in DVCN before VCFS processes start, and its value offering is an ecosystem of products that works with BBPs, and also offers repair services. Considering that LPs mostly did not engage with production licensing and IPR management procedures, as revealed in the survey *(deliverable 4.2,* Bakırlıoğlu, 2022d), this business model can be preferable for existing LPs. However, it requires proper OS non-commercial licensing to constitute and sustain a community of practice for AUs and PMDs. Regarding the latter, the VCFS stakeholders noticeably lack digital fabrication skills overall, except for PMDs, which might limit the uptake and iteration of OS designs. However, VCFS stakeholders are highly interested in self-repair practices, given that they have access to spare parts (especially EE parts and components). Thus, this business model and collaborating RPs might provide a value offering matching the market needs and differentiating itself from other VCFO stakeholders.

3.1.6. (Re-)using open-source parts and products through abstraction

As a practice for reusing parts and components, 'abstraction' as a strategy in open design iteration was introduced by the researcher in the context of his PhD study (Bakırlıoğlu, 2017; Bakırlıoğlu & Doğan, 2020). It refers to the repurposing of parts and components

according to what their shape, size, material properties and other features can afford other than what they were initially designed for. It is a risky strategy that requires a proper assessment of parts and components in terms of their capability to afford their newly assigned roles, which is harder for more complex and/or EE parts and components. While it is a strategy for the continued use of an open part and prevents disposal, it may also lead to the underutilization of that part or its material (Bakırlıoğlu & Doğan, 2020). During the workshops, this strategy was not introduced to the participants *at all*, yet it emerged as a form of value creation process and was explored for PMDs during workshops. It is not a VCFO exploration and does not depict a business model per se; however, it depicts a node of value creation and re-capture in DVCN (Figure 11). *This value creation node was explored in WS2, WS3, WS5 and WS7.*

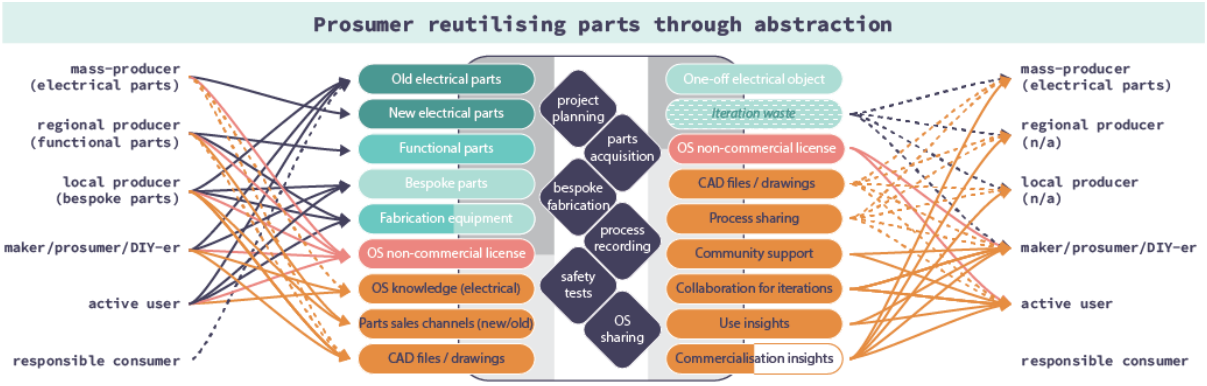

Figure 11. Prosumer reutilising parts through *abstraction,* making novel one-off electrical appliances for personal use

3.1.6.1. Knowledge and resource inputs required

As expected of PMD processes, this value creation node requires diverse input from all stakeholder types. They can acquire old electrical parts from other VCFS stakeholders and LPs, and new electrical parts from GMPs. Non-EE functional parts can be acquired from RPs, and the PMD can collaborate with LPs, other PMDs and AUs to develop and produce bespoke parts required for the project at hand. They can also utilise existing fabrication equipment of RPs, LPs, other PMDs and AUs to fabricate parts and components themselves.

An OS non-commercial license for any open designs from VCFO stakeholders and other PMDs and AUs is important, in order to build upon and protect the previous work of fellow PMDs and AUs, and to manage the IPR implications of this new iteration. Such licensing would also cover the PMDs' own IPR on the new iteration as well.

This PMD requires knowledge of electrical parts and especially about dis- and re-assembling and safety. This is a crucial aspect of this value creation node, as such knowledge is generally not shared for specific EE parts or components and PMDs dealing

with EE parts are generally knowledgeable about EE safety due to their previous experience or discipline. In this regard, a community of expert PMDs and AUs is important for knowledge exchange, and GMPs can also share more detailed and clear information about the safety, use and capabilities of mass-produced EE parts openly. Additionally, there should be sale channels of new and old parts and components known to the PMD, that are also reliable. Accessing the CAD files and drawings of parts and components is also important for this value creation node, as these streamline the whole process.

3.1.6.2. Internal processes and outputs

While the processes of PMDs vary greatly according to individual preferences and the project at hand, this value creation node involves some sort of project planning, acquiring parts from VCFO stakeholders, other PMDs and AUs, fabrication of bespoke parts, recording the process every step of the way, carrying out testing at different stages where necessary, and open-source sharing of the process and outcomes. These activities may not be as structured and the process may seem more ad hoc; however, these activities capture the internal processes of PMDs.

The tangible outcomes of these processes are the one-off electrical object designed and made by the PMD, and the material waste resulting from the iterations (i.e., fabricating one part, testing it, revising the design and fabricating again). While the one-off electrical object is for personal use, the iteration waste can be utilised by VCFO stakeholders (i.e., sent directly to them or through the existing local WMS), as well as other PMDs in shared fabrication spaces (e.g., makerspaces, fab labs, etc.).

The knowledge outcomes vary greatly and this stakeholder shares them with an OS non-commercial license to give back to the community and to protect their IPR rights for commercialisation by themselves or others. This license allows other PMDs and AUs to use, iterate and adapt the knowledge shared. Openly shared CAD files and drawings, as well as the making process, can be utilised by VCFO stakeholders and PMDs and AUs for peer-review, knowledge exchange, adoption and adaption of the open designs. This PMD also provides community support to other PMDs and AUs, collaborates with them to iterate, provides insights into the use experience of the one-off electrical object. Insights into the commercialisation of the open design can also be shared; however, that conservation can happen openly or not, depending on the level of information being shared and the intentions of this PMD.

3.1.6.3. Value creating relations and value recapture

The prosumer reutilising parts through *abstraction* partakes in the DVCNs to make a unique object for personal use, and openly shares its process and outcomes. The DVCN of this value creation node is diverse, and it especially requires diverse types of resource and knowledge inputs. While it is a VCFS stakeholder and its tangible outputs are for personal use, the knowledge outputs contribute to the value creation processes of all VCFO stakeholders and other PMDs and AUs. Table 6 summarises the value creating relations among these stakeholders and this value creation node.

Table 6. Value creation and (re-)capture in distributed value creation network facilitated by prosumer reutilising parts through *abstraction*

	Economic	**Environmental**	**Social**	**Cultural**
Responsible consumers	Acquisition of old/used parts (through sales channels)	Reusing old/used parts and components		
Active users	Acquisition of old/used parts, Sharing fabrication equipment	Reusing old/used parts and components, Sharing equipment (not owning)	Maker community around codesign of hacking appliances, unique products and their post-use processes, Sharing fabrication equipment, Collaborating on bespoke parts	Unique objects responding to individual and/or local cultural practices and needs, Maker culture of knowledge sharing and collaboration
Prosumer/ maker/ DIY-ers	Acquisition of old/used parts, Sharing fabrication equipment	Reusing old/used parts and components, Sharing equipment (not owning)	Maker community around codesign of hacking appliances, unique products and their post-use processes, Sharing fabrication equipment, Collaborating on bespoke parts	Unique objects responding to individual and/or local cultural practices and needs, Maker culture of knowledge sharing and collaboration
Local producers	Acquisition of old/used parts, Acquisition of bespoke parts, Renting fabrication equipment	Reusing old/used parts and components, Using local materials, Local parts acquisition and shorter delivery, Sharing equipment (not owning)	Empowering LPs by bespoke parts acquisition, Using local equipment rental services	Bespoke parts for unique objects responding to individual and/or local cultural practices and needs, LPs supporting a maker culture of knowledge sharing and collaboration
Regional producers	Acquisition of functional parts, Renting fabrication equipment	Using regional materials, Regional parts acquisition and short delivery, Sharing equipment (not owning)	RPs empowering PMDs and AUs by providing parts, workspaces, and relevant knowledge	RPs supporting a maker culture of knowledge sharing and collaboration
Global/mass producers	Acquisition of new EE parts	Acquiring parts and not whole products (lighter global distribution)	GMPs empowering PMDs and AUs by providing EE parts and relevant knowledge	GMPs supporting a maker culture of knowledge sharing and collaboration

3.1.6.4. Revisiting existing roles and capabilities

The survey (*deliverable 4.2,* Bakırlıoğlu, 2022d) revealed that PMDs in Turkey do not necessarily use digital fabrication technologies, and there is an overall lack of knowledge about digital fabrication and accessibility to digital fabrication equipment. This indicates that this node of value creation will probably utilise crafts and non-digital workshop equipment throughout their making processes. However, this creates barriers against OS

sharing of CAD files and drawings, since they will not be in a sharable format. This constitutes the biggest barrier against the social and cultural values conceptualised for this stakeholder.

Another barrier against carrying out making activities is the accessibility to EE parts and components since 46% of PMDs indicated that they have little or no access to electrical parts and components. This is also visible in VCFO stakeholders' responses about providing/selling spare parts, only 27% of LPs, 31% of RPs and 28% of GMPs indicated that they would sell parts. This indicates that EE and non-EE parts and components will mostly remain out of reach for many PMDs and reaching those parts will require additional effort for such projects.

In addition to the above, accommodating the participation of VCFS stakeholders in the DVCN of electrical appliances and acknowledging them as nodes of value creation in this network requires the recognition of value creation and (re-)capture possibilities by LPs, RPs and GMPs, and altering their own business models towards that direction.

4. Conclusions

4.1. Unlocking the potential of distributed value creation

The exploration of alternative open design-led business models in DVCN revealed various kinds of economic, environmental, social, and cultural value being created by the involvement of each VCFS and VCFO stakeholder. This section discusses those kinds of values in relation to existing roles, intentions and capabilities of each stakeholder in an attempt to identify areas of support and frame directions for future exploration.

4.1.1. Values created with the involvement of VCFS

The roles conceptualised in explored DVCNs involved all VCFS stakeholders; some of these roles were very much in line with the outcomes of the survey (*deliverable 4.2*, Bakırlıoğlu, 2022d), while others suggested different forms of participation enabled through increased accessibility to knowledge and resources. RCs generated economic value in the forms of monetary gains for VCFO stakeholders through sales of unique appliances, products that work with existing appliances and customised/personalised parts and add-ons for upgrading, as well as post-use services for repair and upgrading. The latter also creates economic value for RCs, if these services are reliable and economically viable (i.e., using the existing appliance rather than buying anew). Additionally, for the VCFO stakeholders utilising secondary raw materials, RCs are contributing to their input cost reduction when they appropriately dispose of their appliances. RCs' practices generate environmental value in the form of utilising post-use services for product longevity, specifically for repair and upgrading, which delays the disposal of old products. It is important that maintenance and repair knowledge is shared by VCFO stakeholders – and the products are designed to facilitate these practices. Additionally, RCs act as the final node between an old product and landfill, and they need to utilise the existing WMS to initiate recycling. The conceptualised business models were also responding to local cultural practices and needs since they were operating at the local and regional scale. These values emerged either in the form of products assembled at the local scale along with adapted designs of LPs and RPs or as add-ons and parts designed and produced by them. RCs utilising locally available post-use services of LPs also contribute to a shift towards a culture of product longevity.

Different from RCs, AUs generate economic value also through the purchase of spare and upgraded parts if they decide to carry out individual post-use practices. They also utilise additional services to adapt certain aspects of the products (e.g., software, interface, etc.) to match the add-ons they made. For any making activities, they purchase materials from

local (secondary) raw material producers. The latter generates environmental value in the form of reducing CO2 emissions for transporting raw materials. While AUs can utilise post-use services offered by LPs, they can also undertake individual repair and upgrading practices as they can purchase spare and upgraded parts, and VCFO stakeholders also openly share self-repair and upgrading manuals – which are mostly different from their current practices. Finally, AUs have the capacity to undertake dismantling prior to WMS for finer sorting, given that necessary knowledge is provided to them. Additionally, they can generate uncontaminated material waste from making activities, which can be used as material input. AUs also generate social value through community involvement around the codesign of unique appliances, hacking appliances, unique programmed add-ons, reprogrammed interfaces and their post-use processes. The survey, however, revealed that accessing AUs and PMDs for codesign activities is a challenge for VCFO stakeholders. AUs can also generate cultural value through making add-ons and similar parts that respond to local cultural practices and needs and can contribute to a culture of self-repairing and upgrading.

Different from AUs, PMDs generate economic value through the sales of (secondary) raw materials, parts and components rather than products and services. This is the main difference in the generation of economic value. This would require OS sharing of design files and knowledge by VCFO stakeholders – which is the opposite of the outcomes of the survey. They can generate social value through involvement in communities of practice, OS sharing of their designs, and partaking in community-based codesign activities. However, the survey revealed that OS sharing of designs was relatively low for AUs and PMDs, hindering this potential.

The above paragraphs summarise how VCFS stakeholders can potentially generate economic, environmental, social and cultural value for all stakeholders in DVCN. Considering the survey outcomes, the pitfalls emerging from this exploration are (1) an overall lack of accessing local post-use services, parts, components, and locally produced (secondary) raw materials, and (2) not sharing designs and knowledge in communities of practice. Addressing these can foster the conceptualised business models, and support DVCNs that generate the diversity of values summarised here.

4.1.2. Values created with the involvement of VCFO

The roles conceptualised in explored DVCNs involved all VCFO stakeholders; some of these roles were very much in line with the outcomes of the survey (*deliverable 4.2*, Bakırlıoğlu, 2022d), while others suggested different forms of participation either enabled through increased accessibility to knowledge and resources or opening up certain resources and knowledge at different stages. These played different roles in DCVN and enabled varying kinds of value to be generated.

LPs generated economic value by resale of unique appliances to AUs and RCs, renting fabrication equipment to PMDs and AUs, and offering local leasing services and post-use services for the products they design and produce. They enable other processes for

economic value, by selling secondary raw materials to other LPs and RPs and ready-to-use materials for fabrication (e.g., filaments, etc.) to PMDs and AUs. They also have the capacity to facilitate personal fabrication processes by crafting bespoke parts that PMDs and AUs cannot or will not. Also, they can reduce their input costs through increased accessibility to local, separated waste streams, and functional old/used parts and components. These are highly intertwined with the environmental value created and re-captured by LPs. As local nodes, LPs play a crucial role in reducing CO2 emissions, not only through producing things closer to VCFS stakeholders but also by using the local WMS for secondary raw materials, local parts and components production for other LPs as well as PMDs and AUs. Offering local repair and upgrading services makes it easier to access by RCs and AUs, and on-demand production of spare parts enables personal repair and upgrading practices. The ways LPs were conceptualised throughout the workshops revealed different forms of social value as well, especially through more engaged relations with other LPs and local PMDs and AUs. LPs collaborating on design and/or production was explored in different DVCN settings, not only for own processes, parts and products but also for others' processes. In some cases, such collaboration is considered to lead towards new LP business ideas or retail product ideas emerging. LPs become members of local communities of practice, and their value creation processes diverge with different collaborations done with other LPs, PMDs and AUs. This would promote a local maker culture of knowledge sharing and collaboration, although initiating and sustaining such local culture is fraught with challenges (Coskun et al., 2022). Additionally, LPs' outputs reflect and accommodate local cultural practices, needs and preferences, as well as individual ones. LP-to-LP exchanges would also be responsive to unique cultural preferences that local businesses uphold for e.g., cleaning, food preparation, etc.

Different from LPs, RPs' involvement in DVCNs mostly does not directly generate social and cultural values; rather, they help create the conditions for such value creation and recapture in different localities. For example, they were conceptualised to generate economic value for themselves through the sales of finalised products for RCs and AUs, and also the sales of semi-finished products, parts and components to LPs and PMDs. This is a hardware platformisation approach and has the potentials for establishing local clusters in DVCNs (see deliverable 3.1, Bakırlıoğlu, 2022b). Establishing and deploying a fair partial/EEE adaptation license that is also straightforward and understandable is crucial, especially for LPs who will build businesses around RPs outputs. This approach is also conceptualised to increase the capacity of RPs in offering localised post-use services through LPs, in terms of environmental value. In some cases, RPs were thought to offer design and production support to LPs and other RPs to diversify their offerings, which could also lead towards communities of local and regional entrepreneurs; however, the participation of VCFS stakeholders in such communities is not directly addressed during the workshops.

GMPs' involvement is more indirect in that regard, and they were almost always conceptualised as selling parts, components and semi-finished products in addition to

MPPs. Only one conceptualised stakeholder (see Section 3.1.5) dealt with BBPs as input, however, it was not the direct acquisition of BBPs. GMPs' contributions to DVCNs were mostly conceptualised as the provision of parts, components and semi-finished products to RPs, LPs, PMDs and AUs so that they can utilise them in design iterations and create novel value offerings. They should do so by establishing and deploying a fair partial/EEE adaptation license, similar to RPs, and only then they can contribute to DVCNs' value creation and recapture capabilities.

The above-mentioned practices for LPs, RPs and GMPs that potentially generate economic, environmental, social and cultural value for all stakeholders in DVCN are mostly contradictory to survey outcomes and pose several pitfalls in their implementation. These include an overall lack of interest in and intention for (1) providing parts and components to other VCFO and VCFS stakeholders, (2) openly sharing design, production and post-use related knowledge, and (3) horizontal management of production licensing of designs. However, this exploration peers into potentials for different forms of value being generated in DVCNs in case these practices are adopted by VCFO stakeholders.

4.1.3. Notes on value creation and (re-)capture as a networked activity

The reader might have noticed that the previous sections outline the value created and (re)captured with the involvement of VCFO and VCFS stakeholders, but do not discuss them only in terms of value created and (re-)captured by each stakeholder in itself. This is the preference of this researcher to avoid any confusion regarding the purpose of this study – which is *not* to assess the financial sustainability of each business model idea developed. The aim here was to explore alternative ways of doing business when designs are truly 'open' and enable the participation of VCFO and VCFS democratically and freely in DVCNs. The openness of design here refers not only to the open design-related knowledge but also open-to-participate processes (Bakırlıoğlu & Kohtala, 2019), and achieving both requires further facilitation and horizontal management – as will be outlined in the next section. Thus, the above exploration of different forms of value created and (re-)captured through the links among multiple stakeholders in DVCNs tries to illustrate the potential of such networks as a whole.

4.2. Designing for distributed value creation

The networked business model canvas enabled not only the exploration of alternative open design-led business models in DVCNs but also facilitated conversations about how open designs need to be so that they can operate in such networks. Considered along with previous conclusions drawn in deliverable 3.1 (Bakırlıoğlu, 2022b) and two conference papers further discussing those conclusions (Bakırlıoğlu, 2022a; Bakırlıoğlu &

Hasdoğan, 2022), these business models seem to require a different approach to designing, and horizontal management of DVCN by the openness of designs.

4.2.1. Layered design outcomes & collaboration by iteration

The networked business model canvas and the conceptualisation of DCVNs in this project suggest various dimensions for business model development. First of all, the workshop sessions explored DVCNs that are enabled through the openness of design and production knowledge, and the participants explored the VCFS and VCFO stakeholders and their different levels of partaking in DVCNs from this perspective. This was beyond the conceptualisation of a single stakeholder and its business operations. Instead, participants explored a series of stakeholders creating value atop each other's value creation processes, allowing forking and diverging within DVCNs through open-ended design and production processes. This is coined as *collaboration by iteration* (Bakırlıoğlu & Hasdoğan, 2022), which is not managed by a primary stakeholder nor towards an agreed-upon direction. The six nodes of value creation presented in *Section 3* illustrate how businesses can operate within such iterative value creation and create value offerings that either initiate that iterative process (e.g., software developer for meaningful upgrading) or continuously deploy iterative design and production/ fabrication methods as the value offering (e.g., local producer and service provider of professional use appliances).

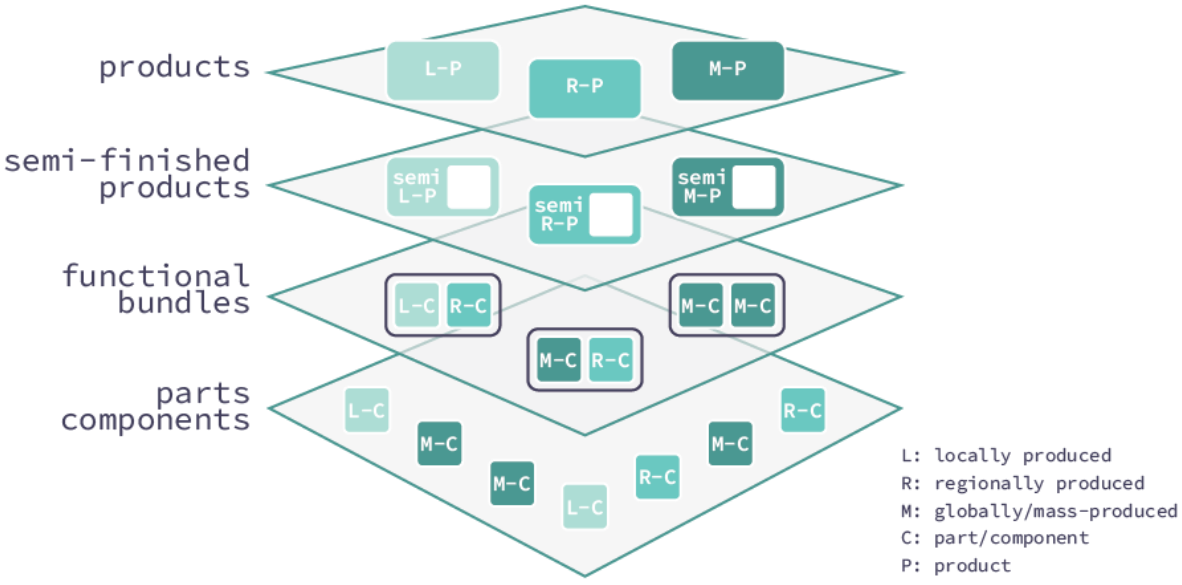

Figure 12. Open design layers to accommodate varying resources, skills and capabilities of DVCN stakeholders

Beyond the business model design in terms of its internal processes, IPR strategies and relations to other stakeholders in DVCNs, a such *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 VCFS and VCFO stakeholders that have wide-ranging resources, skills, and capabilities. For designing a product, this is beyond the modularity of parts and features and involves identifying the levels of engagement with it. This is where a *layered approach* to open design emerges (Figure 12) where open design practitioners need to reflect a layering of value offerings according to levels of engagement in their design outputs. There are four levels observed during the workshops:

- *End-user products layer* is rather straightforward and refers to fully functional products designed and produced by LPs, RPs or GMPs. These outputs are addressed to RCs and AUs, and AUs can personalise them with add-ons and other external interventions. In the case of the 'local/regional producer of alternative product ecosystems' (see section 3.1.5), 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 RPs, LPs, PMDs or AUs. For example, the local producer of personalised, one-off appliances (see section 3.1.1) operates at the local scale and requires semi-finished products from RPs and/or GMPs. As a node of value creation, its unique selling point is the production of a part or component with unique features and codesigned with VCFS stakeholders acquiring it. This LP does not have the capacity to design and produce whole appliances, and they may not need to in DVCNs enabling *collaboration by iteration*. In this case, the '*semi-finished product*' in question is a *layer* of that open design system between functional part 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 RPs, LPs and PMDs lacking a certain capability to produce/fabricate and assemble certain types of parts. 'Software developer for meaningful upgrading' stakeholder (see section 3.1.2) is one such stakeholder that produces reprogrammable interfaces and plug-and-play screens for RPs, LPs, PMDs and AUs, and offers services to reprogramme them according to the needs and preferences of these stakeholders.
- *Parts/components layer* is also rather straightforward and involves the parts and components produced by GMPs, RPs and LPs. VCFO stakeholders can provide these parts on their own and as parts of functional bundles, semi-finished products or end-user products.

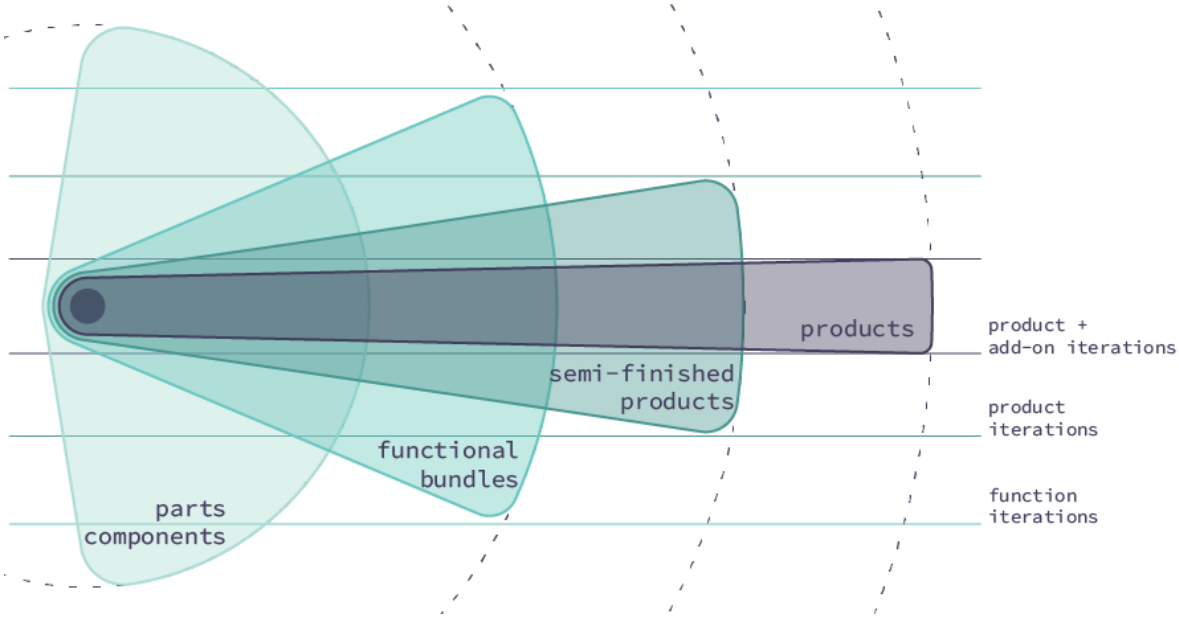

Figure 13. Reach according to required skills, resources and capabilities & potential for iteration imposed by layers of open design 'things'

Figure 13 illustrates the potential reach of DVCNs according to design layers. Horizontal lines represent 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 design semi-finished products will not allow such wide-spreading possibilities on their own; they can be used by VCFO and VCFS stakeholders with limited resources, skills and capabilities and thus can be utilised by more stakeholders in DVCNs. This figure illustrates the importance of designing for all layers in open design and offering alternatives for unconstrained iterative design processes as well as more constrained but easily adoptable value creation processes. While this may seem like a tension between the potential for innovation and the potential for inclusivity, open designs can accommodate both sides by adopting a layered approach and designing things for these layers.

4.2.2. Formalising distributed production through open design management

The suggested collaborative process indicates numerous potential stakeholders in diffuse value creation networks, that operate in parallel and iterate value offerings in different directions. N-BMC was developed with this conceptualisation in mind, where numerous value creation nodes (i.e., VCFS and VCFO stakeholders) freely operate within DVCNs and form value creating links among each other. Hence, managing distributed value creation networks may not be feasible within the confines of singular business models. The openness of design knowledge (both the processes and the outcomes) coupled with appropriate licensing strategies can serve as an effective management tool since it is transparent, accessible, and responsive to stakeholders' needs and preferences. The issue here is the complex OS licensing landscape caused by the existing IPR laws separating novel functional inventions (e.g., patent law), original creative work (e.g., copyright law, design registrations), and source (e.g., trademark law). These espoused different OS licensing types and certification schemes 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, and so on.

This fragmented landscape of IPR management is complex and hard to navigate for many stakeholders, which many LPs might prefer to simply bypass (see deliverable 4.2, Bakırlıoğlu, 2022d). 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 IPR 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. Many open design practitioners and communities struggle with documenting and sharing their work, especially open designs of physical objects (Bakırlıoğlu & Kohtala, 2019). Navigating the existing IPR landscape to protect the openness of designs and stakeholders' right to commercialisation at the same time requires additional effort from DVCN stakeholders. OSHWA certification[1] is a good example of managing the openness of various aspects of designs and such a certification can assure other VCFO and VCFS stakeholders that they aren't infringing upon the IPR of the initial open design. However, it is still an additional certification stage after properly licensing open designs and does not reduce the amount of effort required. The VCFO and VCFS stakeholders would also require going through complex licensing and certification processes if DVCNs are to geographically expand and localise production through initial open designs and their iterations.

The layered approach to open design can alleviate or aggravate this fragmented IPR landscape depending on the complexity of the product, its safety requirements, and other external factors (i.e., standardisation, policy, etc.), considering that IPR and safety

[1] For more information about the OSHWA certification, please visit: https://certification.oshwa.org/

certification processes can be intertwined for some sectors. Most of the value creation nodes presented in section 3 depend on a loosely defined ‘partial adaptation licensing’ that would grant VCFO stakeholders rights to limited commercial activity using the open designs, however, there isn’t any standardisation of these limits. The discussions about this during the workshops revolved around benefits and safety, and how such limits can ensure the open design iterations of VCFO stakeholders still satisfy the safety requirements of electrical appliances. These discussions reveal that making designs ‘open’ by itself may not be enough and managing DVCNs should involve clear limits, quality control and assigning responsibility for parts, functional bundles, and semi-finished products. How these processes can be horizontally managed and enable VCFO and VCFS stakeholders to democratically and freely participate in DVCNs requires further exploration through research *and* practice. This deliverable introduces alternative open design-led business models that can serve as models for such future exploration.

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Appendix 1 – DF-MOD workshops information

Table 7. DF-MOD workshops, number of participants, their profiles, starting points, and number of potential DVCN stakeholders explored in each workshop

	Number of participants	Participants profile	Starting points	*VCFO*			*VCFS*			Other	Total	Key business models / value creation processes					
				GMP	RP	LP	PMD	AU	RC			Section 3.1.1	Section 3.1.2	Section 3.1.3	Section 3.1.4	Section 3.1.5	Section 3.1.6
WS1	6	2 industrial/ product designers, 1 service designer, 1 Technology Transfer Office manager, 2 design students	air fryer, robot vacuum cleaner	6	5	6	1	2	2		22	X	X	X	X	X	
WS2	3	1 design director, 1 internal operations officer, 1 design researcher	Turkish tea maker/ kettle	1	2	2	1	3	2	1	12	X	X	X		X	X
WS3	3	1 architect/ researcher, 1 service designer, 1 design researcher	Energy saving/ gen.	3	3	4	2	1	1	2	16	X					X
WS4	4	1 UX designer, 1 design researcher, 1 mechanical engineer, 1 HR officer	Food prep.	2	3	2	1	2	2		12	X		X		X	
WS5	6	2 industrial/ product designers, 2 UX/UI designers, 1 electronics engineer, 1 craftsperson (ceramic)	Electric pot, air fryer	3	3	2	2	1	1	1	13	X	X			X	X
WS6	7	4 industrial/ product designers, 1 NGO representative, 1 municipality officer, 1 makerspace coordinator	Robot vacuum cleaner, Turkish tea maker/ kettle	6	5	6	1	2	2	2	24	X	X	X	X		
WS7	5	2 industrial/ product designers, 1 UX/UI designer, 1 WMS engineer, 1 craftsperson (leather)	House cleaning app.	2	2	3	2	2	1	1	13	X	X	X	X		X
WS8	4	2 product designers, 1 marketing expert, 1 communications expert/ entrepreneur	Food prep.	3	3	4	2	1	1	1	15	X	X	X		X	

DF-MOD

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