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Designerly Ways of Entrepreneuring for a Sustainable Circular Economy - Envisioning a Smartphone Firm of the Future

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Abstract

The smartphone industry is undergoing a slow transition towards sustainable design and circular business models in response to mounting social and ecological concerns. This paper discusses a smartphone concept regarding sustainable value creation over its entire lifecycle—thereby urging the creation of alternative designs and future-fit businesses. Hence, drawing inspiration from existing start-ups seeking to establish a sustainable smartphone market, a speculative business proposal is synthesised. It employs an analytical framework, with the three layers 'agent-situation', 'product system', and 'business/venture', custom-made to explore value creation in smartphone design, production, and consumption for both existing businesses and this study's case. Through the simultaneous consideration of designing and business modelling, this case exemplifies a sensible navigation between sustainability values, regardless of whether trade-offs or even synergies emerge. The resulting cross-fertilisation of the two fields contributes to stretching notions of what is possible and desirable in an advanced circular society future.

Keywords Sustainable smartphone design · Sustainable entrepreneurship · Strong sustainability business model · Effectual business logic

Introduction

In 2022, according to Statista, more than 6.6 billion people use mobile phones. The number of mobiles in circulation even reached the fifteen billion mark [1], making them one of the most short-lived digital products [2–7]. Given the sheer quantity of materials and energy that went into producing them, their insufficient recycling from disused devices piling up, and often informal recycling and disposal, it is clear why concerns about resource scarcity, environmental, and social injustice are growing [3, 8–11]. Hence, efforts are needed towards more sustainable smartphone design, fairer production, and better product and disposal regulations whilst seriously considering higher-level issues such as overconsumption,

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eternal economic growth, and social and environmental depletion. Therefore, scholars from diverse academic fields, including design, industrial ecology, waste management, and law, along with the industry, have started to explore more sustainable smartphone alternatives [5, 12–21], with which the society might 'move the needle' in the right direction towards a safer space for humanity [22]. Not least, fields such as transition and interaction design have raised attention to sustainability [10, 23, 24] through their streams such as responsible/sustainable interaction [24–28] or critical-speculative design to discuss future technologies [29–32]. Ideally, all design should take place within the planetary boundaries and social foundations or Sustainable Development Goals (SDGs) as suggested in [33–37] and strengthen particularly intergenerational justice, discussed in diverse definitions of sustainability and SDGs [33, 35, 38]. Here, intergenerational justice implies concerns that the present generation might not fulfil its obligations towards the next generations, leaving them with depleted resources and mounting challenges. It also implies care for relations, between individuals, groups, and society, and between the local and the global, that are fair and just. This motivation represents the strive towards posthuman design, where the environment is a true stakeholder in a more-than-human world with restorative character, where humanity and the planet 'flourish' together [39–41].

Given that complex challenges such as sustainability can seldom be tackled from within a single discipline, an increasingly transdisciplinary positioning is needed to address the entanglements involved [42–45]. Such positioning opens for broader, non-mutually exclusive explorations and reflections dispersed "between, across and beyond individual research disciplines, trying to understand the reality" ([44]:15). It also recognises that humans, their technologies, and the world are ontologically inseparable [43]. This study exemplifies such transdisciplinary understanding-the-reality work, as the author embraces the overlap of sustainability, product, and interaction design, combined with a strong interest in entrepreneurship. The work presented in this paper probes into sustainable smartphone design aligned with circular economy principles [46–49] and the 'firms of the future' concept, introduced by DeLuca et al. and Wahl [41, 50]. It suggests that understandings of such future-fit ventures could be more extensively used as a tool to consider the complex entanglement of innovative technologies and economic, social, and environmental factors. The firm of the future concept builds on the critical perspective on ventures today and highlights contemporary features and values such as the increased technology dependency, flexibility, and adaptability of ventures, new business, and ownership models, eco-systems of partnerships, a different interplay between the local and the global, and ambitions beyond mere profit orientation. One way to explore such future-fit ventures is to envision their design and use in detail to speculate about their potential impact. The primary research interest lies in sustainability transitions by design of sustainable digital products and ways of assessing their implications in and for entrepreneurship, which showcases the transdisciplinary nature of the work.

The methodology used in this work builds on a related study [51] that considers three start-up cases featuring existing sustainable smartphone proposals (Fairphone[1], Shiftphone[2], and Puzzlephone[3]) and analyses how they integrate sustainability dimensions, i.e., navigate their sustainability performance. These three might be considered pioneers

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[1] https://www.fairphone.com/

[2] https://www.shiftphones.com/en/

[3] https://web.archive.org/web/20190824080309/http://www.puzzlephone.com/blog-read/captain-s-log-a-status-quo-update

of (strong) sustainability business models [52] in the smartphone industry and (strong) sustainable entrepreneurship or sustainopreneurship [53–55] as perhaps the most ambitious form of Sustainability Entrepreneurship [56]. To inquire into (potentially) circular-sustainable mobile technology ventures and assess the "significant positive benefits […] for the environment and society" ([57]:44), one needs to consider both alternative smartphone design and alternative business model innovation conjointly. The study of the existing cases helped develop an assessment framework of indicators, which is introduced in the Background section and later used to discuss the nascent business (model) for the critical-speculative proposal of the smartphone named Ec(h)oFon. The lens of value creation is used to discuss how such a phone affects production and usage and vice versa. The work on the three existing start-ups to elicit implications for design of alternative smartphones represents an "entrepreneurial ways of designing" study. The present article represents the complementary "designerly ways of entrepreneuring" work—two modes in which Klenner et al. found that designer-founders typically operate in [58]. Here, it is built a critical-speculative design [29, 31, 59] of a firm of the future, named 'Ec(h)o', featuring the Ec(h)oFon as alternative to today's smartphones.

The paper contributes with (i) how the developed assessment framework might be applied to critical-speculative design(s) to explain sustainable value creation, (ii) showcasing how critical-speculative design and (strong) sustainable entrepreneurship are interlinked and may fertilise knowledge creation across and beyond individual disciplines, and (iii) suggesting more meaningful ways of navigating the sustainability performance and inevitable trade-offs therein, first by stretching notions of what is possible in circular society futures, and hence enabling assessment of what might be desirable.

The Background section that follows discusses relevant previous work from interaction design, introduces the Ec(h)oFon proto-practise, and provides relevant details from the sustainable entrepreneurship theory and the analytical framework from the related entrepreneurial study. The third section presents the methodology used in this work. The next section presents the business case based on critical case analyses along the (three layers of) indicators of the analytical framework. The findings section reports the prospective results of the strategy for the business case. The last section discusses the contributions made, the perceived limitations, and concludes the study with an outlook on future work.

Background

The following three subsections introduce firstly prior work from the emerging field of sustainable interaction design relevant to this study. The second subsection describes the author's critical-speculative design work which had brought about the Ec(h)oFon proto-practise. The third one familiarises with work within sustainable entrepreneurship and provides a summary of the three existing smartphone start-up cases, as well as the framework used to later discuss Ec(h)oFon and the shaping of its nascent business proposal (a firm of the future), hereafter named Ec(h)o.

Relevant Prior Work from Sustainable Interaction Design

More and more interaction design scholars have engaged with issues of sustainability since Blevis's [26] seminal paper, suggesting to link invention and disposal and promoting renewal and reuse. At first, they focussed on sustainable behaviours, more precisely,

individual and social practises, including everyday practises [16, 27, 60–62]. Also, the critical-speculative proposal discussed in this paper is grounded in the idea that practises leading to more sustainable behaviours can be designed, i.e., practises are considered a unit of design [63], which is to take social practise theory [64] as a starting point of research.

Two studies that discuss future technologies, electronics, and phones, respectively, use speculative and critical design (SCD) practises attempting to dream up alternative futures by posing 'what-if' questions. They have served as a source of inspiration for this work which articulates SCD as a method towards a more solution-driven, rigorous imagining, for speculative product design to make concrete the alternative design solutions of long-term sustainability today through 'designerly ways of futuring' [65]. The first inspirational piece is Pierce and Paulos' article [61] that considers the repair, sharing, customisation, and reuse of digital artefacts. They suggest to "[f]or example, consider making space for repair and maintenance of digital products at an "Electronics Co-op"—perhaps within the space of a first-hand site like the Apple Store or Best Buy (a proposition we recognise is fraught with challenges and contradictions)—where people can repair, customise, share, and re-use digital parts and products" ([61]:9). With similar intentions towards repair, customisation, sharing, and reuse as suggested with the "Electronics Co-op", the present study arrived at that the inclusion of business considerations into speculative sustainable design work is important. Second, in Blevis's article [66], photographic methods are suggested to support understanding design and concepts that matter for sustainability. For example, design fiction featuring photographic images of a 'mePhone' and a 'wePhone' explains the differences in design philosophies and implications of what is inscribed on the back of the respective phone images. The inscription on the 'mePhone' reads "Designed by Design Geniuses in California. Assembled by Displaced Migrant Labour in China. Model U-WL11-N33D-M0R3" (model: you will need more) and on the 'wePhone' "Everywhere Designed with Respect for All. Model LAS-TU-N33D-EVR" (model: last you need ever) [66]. What Blevis presents as design fiction delivers the core message through satire and photorealism. Similarly, critical-speculative design might further promote the message of "Everywhere Designed with Respect for All". These critical-speculative design efforts are here considered necessary and adequate to move beyond devices, to thus include realistic business cases.

Prior Work in Critical-Speculative Design and Sustainability Transitions—the Ec(h)oFon Proto-Practise

The Ec(h)oFon, a brainchild of design research conducted between 2017 and 2021, is a critical-speculative design proposal for an alternative smartphone that has undergone several iterations [67]. It started as an inquiry into practises around digital artefacts aiming to design proto-practises as suggested by Kuijer and as had been adopted by a few design projects/domains, e.g., concerning bathing or food practises [63, 68]. Similar to the photo-realism of the fictional 'wePhone', a proto-practise is also essentially speculative. Bearing in mind that an actual change in current practises is intended, a thorough understanding of existing, present practises and how they develop, i.e., emerge, persist, and disappear, is needed [64]. In the work on the proto-practise regarding Ec(h)oFon, an example of a particular practise that was close to circular was central and could be described as 'bringing out the circularity hidden behind single use practises', see [67]. The roots of that practise date back to the author's project work on single use cameras and lifecycle assessment of such in 2008.

Such camera presented an epitome of a reverse logistics approach and inspired 'single use' and 'reverse/circular' ideas for designing Ec(h)oFon practises, forecasting low-energy and zero waste lifestyles regarding production and consumption of this phone. The phone was named based on the metaphor of 'echo' /ˈekəʊ/, understood as repercussions, referring to the strong focus on product and component bring- and take-back incentives, and 'eco' /ˌiːkə/ standing for the desirable future sustainability. It features a production and consumption/(re)use model based on a PSS (product-service system), where hardware is borrowed-for-use only. The system of shared use also allows for (future) product generations to overlap. Together with a 'local communities' approach for professional maintenance, repair, and take-back, this long-term thinking and practise seek to 'design out' waste eventually. Both the Ec(h)oFon and the corresponding business and brand Ec(h)o (Fig. 1), which builds forth on the proto-practise by simultaneously focussing on sustainable design and business modelling, distinguish themselves from existing (unsustainable and non-circular) smartphone production and current consumption. Due to—in this critical-speculative design and business case—operating without or beyond detailing the precise inner buildings and aesthetics of the artefact, illustrations (such as Fig. 1) do not front these to not distract from the important functional and usability changes as discussed in the later analysis and findings sections.

Relevant Prior Work Within (Strong) Sustainable Entrepreneurship

For the business and, more concretely, entrepreneurial considerations made in this article, a literature corpus on (strong) sustainable entrepreneurship (SE/SSE), (strong) sustainability business models (SBM/SSBM), and effectuation and non-predictive strategy has been central [48, 52, 55–57, 69–78]. Based on this theoretical framing of BM and entrepreneurship which also guided the study of three real-world sustainable smartphone ventures (cf. [51]), an analytical framework has been created. It consists of three nested layers. Layer 3 'business/venture', in large parts, resembles the SBM framework [57]. Since said three cases and the present study—in contrast to case studies using the SBM framework across different industries and firm sizes—concentrate on the smartphone industry and small businesses, two layers were inserted to zoom into particular aspects of these firms of the future. Layers 1 'agent-situation', and 2 'product system' have thus been embedded in layer 3. That means, as illustrated with Fig. 2, it was found applicable the composite interrogation of 'who' (agents partaking in design and entrepreneurship) creates 'what' (product system), 'how' (business model), and, lastly, 'why' (towards strong sustainable ventures—as an overall context for designing and business modelling). Not least, the innermost layer 1, representing the (traits of) the designer-founders, is a natural starting point for a start-up making a product (layer 2) and corresponding business model (layer 3) embedded in the socio-economic and ecologic context. Both the outer (business model) and inner (agent-situation) layer largely refer to the discourse and non-discursive practises around production and consumption (of smartphones as complex products). Meanwhile, the middle layer addresses the product (or product-service system architecture with associated services), as the manifestations of design [79]. Whilst these are crucial to the process of integrating designing and 'entrepreneuring', the resulting nested structure of analytic indicators allowed and allows to examine design and entrepreneurship processes in the case(s) conjointly.

The agent-situation layer focuses on the who (i.e., agents, such as the designer-founders and other change actors, e.g., regulators and activists), where the literature stream around effectuation/effectual business logic is associated. Whilst Sarasvathy coined the

Fig. 1 Imagery of the Ec(h)oFon—a not-yet-existent, but desirable, future best practise (top); hypothetical brand image and store graphics for Ec(h)o—the corresponding zero-waste PSS business (bottom)
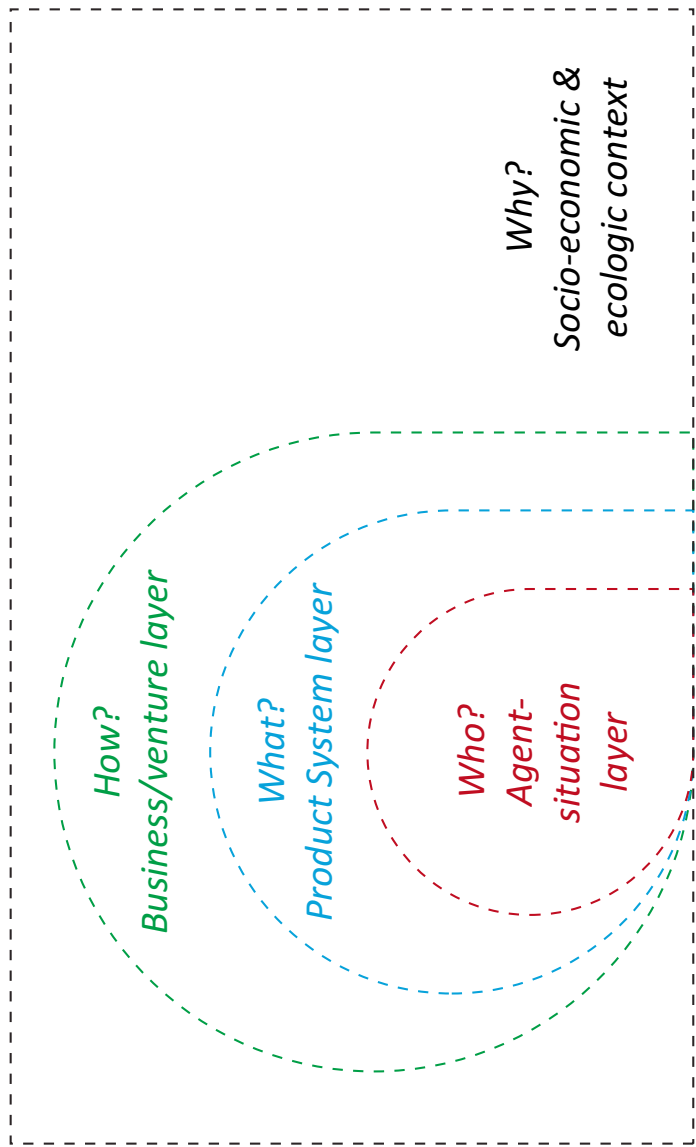
Fig. 2 The three nested layers in the analytical framework and their context layer (cf. [51])

term effectuation, it has further been complemented by concepts such as Lean Startup Approaches (LSA) and non-predictive strategies [80–84]. The effectual business logic thinking has found its way into conceptualisations of how designers become designer-founders thanks to the authors of [58]. These approaches with deliberate emphasis onto the 'traits and development of the individual' [56, 58, 83] have been considered key components of contemporary business innovation, particularly innovation for sustainability [85], because of their incentives towards addressing uncertainties and creating future(s) through the very strategies of the players and their "[s]turdy [logics] of the future […] filled with enduring human relationships that outlive failures and create successes over time" ([83]:7). Hence, introducing the agent-situation layer containing indicators interrogating and describing the agents and their situatedness in the world ('who they are, whom they know, what they know' [82]) allowed to examine existing start-up cases for their effectual business logic and having new ones like the Ec(h)oFon business case in mind. The layer's indicators in four groups, see Table 1, can thus be used to explore an actor-dependent and effectual-controlled future of the new venture as is subject of this article.

At the product system layer, indicators are to examine closer the what, the product system (products, services, product-service systems (PSS), technologies, and platforms) on which a business relies. Several scholars advocate for sustainable PSS (e.g., [86–92]). They argue that a PSS to be successfully designed "requires adopting a stronger business perspective", i.e., novel product-service bundles need to be developed to jointly "fulfil[] final customer needs whilst fostering a positive sustainability impact" ([93]:6). Hence, the product system layer allows to examine the status and success of introducing such a sustainability-promising concept for both the 'entrepreneurial ways' in existing start-ups and the 'designerly ways' in this article. The indicators in this layer, organised in four groups (Table 1), are based on indicator adoptions from [92, 94–96].

For the business/venture layer, the SBM framework [57] was adopted and infused with some novel indicators to relate the cases under study to strong sustainability concepts such as sufficiency thinking [57, 69, 70], strong sustainability business models [52, 55], and supply chain redesign for the circular economy [94], in three indicator groups, see Table 1.

The complete analytical framework features indicator groups under the described layers as illustrated in Table 1 (omitting indicators for each group for clarity). The framework was used for comparative cross-case study of the three cases featuring more sustainable smartphones, Fairphone, Shiftphone, and Puzzlephone [51], to describe and explain sustainable value creation. The analyses yielded implications for design and future business strategies ('what ought to be'). One of the insights relates to an argument that there is a certain lack of imagination in 'what could be' and, thus, 'what ought to be' at the designer/entrepreneur level. These professionals are, according to Fry, not leading but should have a more substantial role in putting "alternatives into the public domain" ([97]:172) and might suffer from the general "lack of systems thinking" ([98]:81). The three, more sustainable smartphone start-ups have been found to complement each other in their strategies, in the sense that the strongest alternative and way to put into the public domain seems to be a synthesis of all three. However, their hybridisation or coherent improvement based on their common cause has not yet been satisfactory [51]. The three start-up cases are exemplary, that means demonstrating, even leading, in specific sustainable business strategies such as: taking an open design approach; dealing with technology lock-ins; doing and strengthening technology take-back (incentives); finding sustainable (or alternative) forms of commerce; promoting organic growth/replicative scale-up; ensuring continued usage of their product (system); hindering internal cannibalisation; or changing what concerns the location of production. However, seen through a systems perspective, such an imagining and devising of a means-driven product system and business

Table 1 Three-layer indicator framework as developed in [51]

Layer 1	Who? **Agent situation**		
Indicator groups:	Background and Vision of the Agents (designer founders)	(Evolving) Situation and Maturity of the Founder(s)/Venture	Initiative, Attitude, and Perseverance	Collaborative Context and Motivation
Layer 2	What? **Product system**		
Indicator groups:	PSS Design, Supply Chain Redesign, and Communities and Platforms	Product System Complexity and Flexibility	Barriers to Users' Acceptance	Impediments on Producer Side
Layer 3	How? **Business/venture**		
Indicator groups:	Value Proposition	Value Creation and Delivery	Value Capture	

(model) that conjointly implements these strategies has unfortunately not occurred. For some of the indicators and connected strategies, alternative and feasible idea(l)s (possible and desirable future solutions) have been lacking. It is thus the task of the present study to put the prior critical-speculative design work, described in the former section, to the inquiry under sustainable entrepreneurship terms as to firstly utilise the hybridisation of existing cases, to fill eventual blank spaces, and yield an enhanced sustainable business strategy set.

Methodology: Critical-Speculative Design Meets Real-Life Comparative Case Study

The approach used in this article, 'designerly ways of entrepreneuring', is a single case study which builds on two former works. The first is described in the Background's second subsection (the critical-speculative design work—as a strand of Research through Design [99]—using Ec(h)oFon to critique the present and point to possible alternatives). Second, as described in the Background's third subsection, the multiple case study provides the 'entrepreneurial ways of designing' type of study from a sustainable entrepreneurship and small business research perspective. Its three existing sustainable smartphone business cases (Fairphone, Shiftphone, and Puzzlephone) and the derived implications for design were taken as input for this work, to again compare and find similarities and differences with the critical-speculative Ec(h)oFon proposal, see Fig. 3. The figure shows how the indicator framework (in white) and the comparative study of the three existing start-ups (in light grey) provide the input to discuss the case of Ec(h)o (in dark grey). As another 'edge case', the Ec(h)o case identifies and deliberately shapes a venture (with agents, product system, and business model adhering to the effectual, means-driven logic) in designerly ways. The intent is for the speculative design to meet real world business modelling, enabling reflection and deliberation on alternative presents and speculative futures [29]. However, those future strategies should lead beyond imaginary futures towards conveying more normative implications ('what ought to be') and to be even more daring "to stretch notions of what is possible" ([100]:80). To achieve that, speculative design needs to have technological believability, showcased for instance by Blevis's photorealism [66] or Auger's Audio Tooth Implant [29], which both are technologically believable but not yet realised designs.

The desired outcome of 'design meeting business modelling' is to further disciplinary hybridisation and inform both design of interactive artefacts and business modelling research. Hybridisation encourages pivoting, i.e., changing the conduct ongoingly whilst 'staying with' the problem of sustainability ([24]:89). This hybridisation, i.e., transdisciplinarity, has been enacted through the author taking the role of researcher, designer, and entrepreneur to explore desired futures that design combined with business modelling could materialise [101], emphasising the need and the urgency to prepare firms of the future. Such preparedness, across firms, industries, and society, might positively affect the idea of turning the circular economy into a circular society [102]. The primary outcome of this designerly single case study is to arrive at a desirable, speculative business strategy set (Fig. 3). As illustrated in the figure, it is the three-layer indicator framework and its indicator groups from Table 1 that allowed the juxtaposition of the nascent business case based on Ec(h)oFon. Ec(h)oFon as critical-speculative design input enabled to infer more about the case, as it asked back for alternatives across or beyond answers found from the study of Fairphone, Shiftphone, and Puzzlephone. To the extent possible, divergent ideation processes, inspirational literature, and critiquing techniques were used to underpin the outcomes of this speculative venture design experiment.
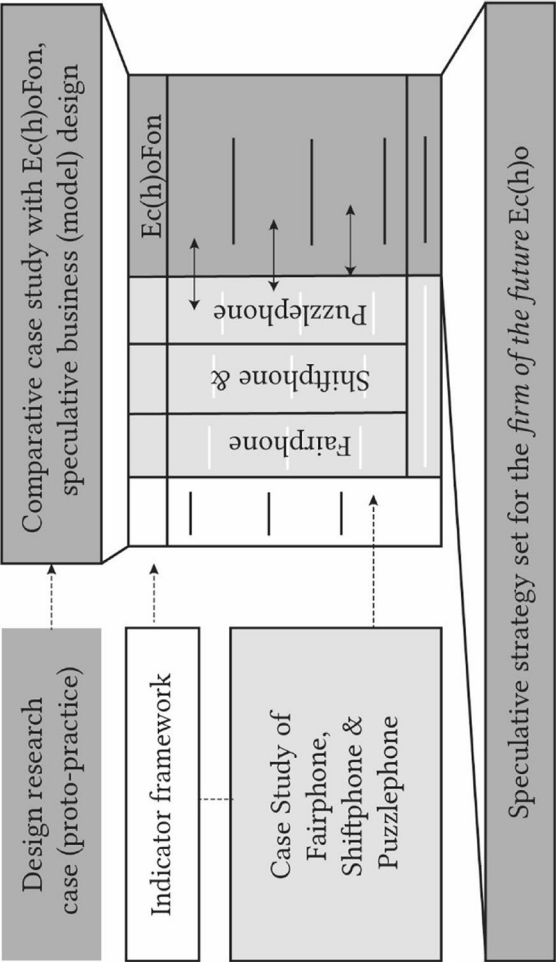
Fig. 3 Outline of the case study process with inputs on the left, analysis on the right and output at the bottom

Case Study Along the Three Layers of Indicators

This section describes analyses results following the framework of indicators outlined in Table 1, summarising the speculative business case for the agent-situation layer, the product system, and, finally, the business/venture layer. Each subsection includes a short comparison to the existing sustainable phone business cases.

Summary of the Case for the Agent-Situation Layer

Background and Vision of the Agents (Designer-Founders)

Concerning the background and vision, Ec(h)o is a cause-driven business case that considers circularity and 'designing out waste' as entry points. Its initial setting differs considerably from the existing start-ups, since it results from transdisciplinary efforts of the main protagonist. It promotes gender balance and diversity in practise (more female entrepreneurs, designers, and researchers), besides including heritages that were frugal and known for being 'keep & repair' societies [103], such as the GDR, with, e.g., electronics 'made to last'. Furthermore, this background moves the funding approach beyond crowdfunding campaigns into the crowdsourcing of materials taking advantage of waste streams, allowing for take-back initiatives for old, hibernating phones or similar, to feed into a non-virgin production (see 'return flow', Summary of the Case for the Business/Venture Layer).

(Evolving) Situation and Maturity of the Founder(s)/Venture

The speculative start-up case Ec(h)o, in terms of the evolving situation, renders immature compared to more advanced existing start-ups. Emphasising the early design phase that determines most of the later product system impact, it represents a front-end thinking project [104] that typically would not allow for any quick releases. However, as an enactive research-oriented endeavour, it seizes the potential for commercialisation of results from systemic, sustainable technology design research, thus promoting outcomes such as researcher entrepreneurship or technology transfer projects.

Initiative, Attitude, and Perseverance

With regard to initiative, attitude, and perseverance, the venture wants to build on a local community of early adopters and a dedicated Ec(h)oFon provider and maintainer persona, keeping the market entry small. Ec(h)o then replicates such 'communities of use'. It favours a 'continuity plan', employing only the number of people needed to build and support the product system and whose wages can be paid from the earnings. This attitude creates a potential for like-minded people to discover the start-up, not vice versa, to onboard them as associated maintainers, co-founders, or employees. Continuity is thus dependent on the ability to replicate 'communities of use' other places. However, uncertainties remain concerning (i) the general ambiguity between commercialising/marketing a product still subject to research; (ii) the ambiguity between collected experience and training (technology design and lean start-up), and else unacquainted ambitions in systems level change; or (iii) the hitherto unprecedented material-sourcing campaign and non-virgin production. For Ec(h)o to persevere, those insecurities would have to be resolved whilst walking the path without diluting the desire for systemic change.

Collaborative Context and Motivation

The collaborative potential for the Ec(h)o concept is already high, grounded in large, funded research projects within a design research community [105, 106] that would continue to seek synergies between strategic design and sustainable business transition studies. Ec(h)o could be the first venture to respond to the call for the co-creation of mobile electronics issued by Shiftphone. Furthermore, it would seek to establish affiliations with local and global change-making initiatives, such as (i) local refurbisher of ICT and player in the labour market OsloKollega AS [107]; (ii) urban mining projects, e.g., on platinum row metals at SINTEF (Norwegian research institute) [108]; (iii) as ambassadors of the global Precious Plastic movement [109]; and (iv) international design/business case competitions, e.g., the Samsung electronics Future Tech Challenge [110]. Though this collaborative, co-creative mind-set might allude to a non-profit open source approach, Ec(h)o would, due to low uptake rates usually connected with such projects [111, 112], not seek release pathways that force the innovation to 'take care of itself'.

Comparison

The speculative case in agent-situation terms is both similar to and distinct from the sustainable smartphone cases studied earlier. In maturity terms, it is the most similar to Puzzlephone (also not marketed but in a research/prototyping stage). On the other hand, its vision and initial approach present the most significant distinction from the existing cases. Nevertheless, it connects a sufficiency mind-set similar to Shiftphone's with the highly ambitious, systemic vision of Puzzlephone. Regarding initiative and attitude, it appears similar to Shiftphone (by globally connected localism) and Fairphone (by immersing into the industry and competing to change it). Finally, concerning the collaborative context and motivation, it is similar to Shiftphone (co-creativeness) and, somewhat, to Fairphone and Puzzlephone (research partners and mentorship/start-up ecology).

Summary of the Case for the Product System Layer

PSS Design, Supply Chain Redesign, and Communities and Platforms

Focus on access to and sharing of resources has been essential for the Ec(h)oFon; hence, the concept was labelled 'borrowed-for-use'. Whilst acknowledging and integrating the human desire to consume, the concept helps create a flexible PSS covering the whole spectrum between shortest affordable use and longest possible use that details the alignment of economic and physical lifetimes down to the subcomponent/material level. The alignment is concerned with different users and use scenarios, transferring designing such PSS from a user-centred to an adoption-centred perspective [112]. It leans towards asset usage optimisation, i.e., a maximised utilisation of mobile electronics in daily life, by approaching the least amount of electronic components necessary to fulfil the objective of 'mobile communication', see Fig. 4. Concerning the concrete PSS kind, Ec(h)o should be considered a Hardware-as-a-Service (HaaS) product system favouring both geographically dispersed 'communities of use' (cosmopolitan localism, for instance, with community building in so-called transition towns) and professional maintainers in place. These professionals each head a community and simultaneously provide, repair, take-back at end-of-use, refurbish,
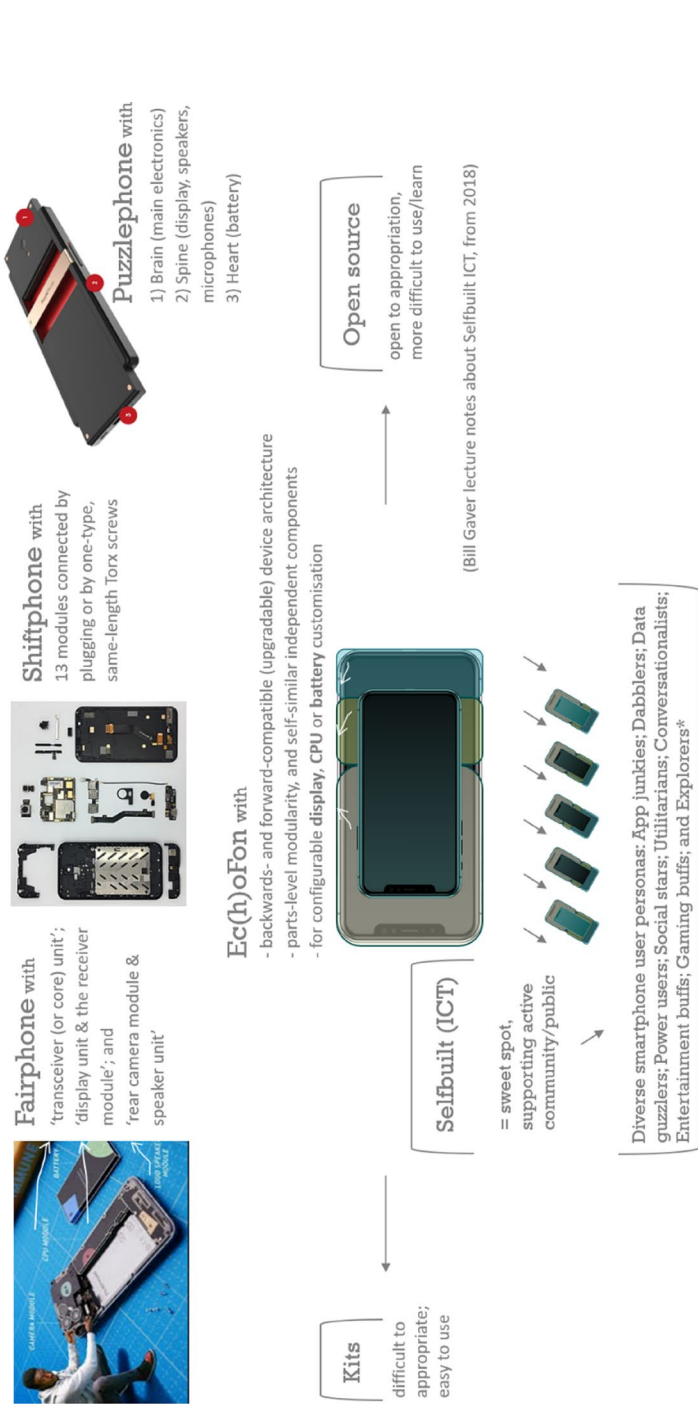
Fig. 4 Synopsis of the hardware configuration (different demarcations of modules) of Fairphone, Shiftphone, and Puzzlephone versus Ec(h)o's PSS with envisioned (re)configurability *[113]

and thus eventually (re-)produce devices for their local users, whilst being globally connected through an Ec(h)o platform. A high level of interactions between Ec(h)o maintainers as the hardware providers and the users, as well as the 'community feeling' and thinking of a sufficient 'fleet' of phones for the whole community, are consequently being held important for this business case.

Product System Complexity and Flexibility

The highly-flexible PSS to cater to both shortest affordable and longest possible use increases the system's complexity. Starting with the crowdsourcing approach, the conceptual strategy in this PSS is continued redesign and frugal innovation for sustainability, "reinvigorated particularly in the developed world" ([57]:59). Frugal innovation for sustainability is in large part 'innovation under constraints' [67, 114], where environmentally or socially unsustainable situations pose certain constraints (e.g., seen as an artificial resource scarcity), within which the PSS and its continued redesign have to operate.

With already high product complexity of phones, this PSS's complexity stays a hard-to-solve product characteristics challenge [94]. The Ec(h)oFon proto-practise was building on the existing electronics components platform (worldwide provided by mainly Chinese/Asian centres of manufacturing and suppliers), without emphasis on interface standardisation or modularisation. Instead, components/parts/materials were considered intrinsically modular [67] and sought to illustrate both a manufacturer's and user's system ([115]:140). On the user's system side, different device configurations, e.g., for young and old, tech- or not tech-savvy users and in professional or lay use situations are made available, allowing for the individual user's 'fashioning' (i.e., a customisation) of their resulting device during and beyond the process of purchase/acquisition. On the manufacturer's system side, this (re-)configurability is paralleled by cascaded component reuse, production, and redesign (see Fig. 5) and shall eventually—integrating both sides—allow consumption to refocus onto non-manipulated, true needs ([115]:147), whilst avoiding to satisfy 'wants' and psychological obsolescence [91, 116, 118].

For Ec(h)o's desired backwards compatibility, standards are relevant to the extent that developed ones that are in use may either inhibit or allow it. The task to tune materials, parts, and components to a hierarchy of resource retrieval and circling rates as established for the single use camera reverse logistics [67] is comprehensive since product complexity is so high and the ease of disassembly in the existing electronics poor. However, the described frugality and 'mass customisation' place much "confidence […] in the users' willingness and ability to participate actively and continually in the optimisation of their material surroundings" ([115]:150). First with the individual's consumption, in the use phase, the specific use values and design quality get finalised ([115]:146). This confidence in the user, reverse compatibility, and the alignment of lifetimes down to the subcomponent/material level are cornerstones not only in the Ec(h)o PSS but also in the greater sustainable consumption discourse (see later Sections Summary of the Case for the Business/Venture Layer and Prospective findings: Ec(h)o strategy set). Unfortunately, a proof-of-concept for this 'ideal, but unrealised solution' remains pending, which is also why the Ec(h)oFon devices are underdetermined (recognising that this may be remedied through future work). However, the purpose here is to enable discussion and not present a fait accompli.
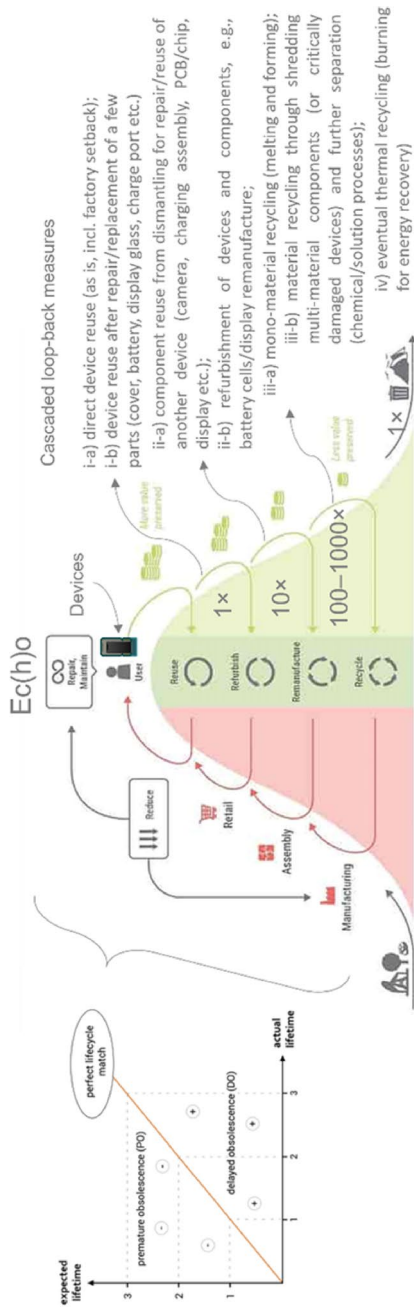
Fig. 5 Value Hill model for Ec(h)oFon explicating loop-back measures and cascaded value preservation [116, 117]

Barriers to Users' Acceptance

From the outset, Ec(h)o would focus on user acceptance of an eco-efficient PSS, which is why it tries to integrate two somewhat contradicting goals: catering to the human desire to consume and mitigating premature obsolescence. It means a significant upfront investment into R&D or knowledge creation is necessary, as hitherto, no results to bettering user acceptance can be shown. However, aspects like 'frugal innovation' and 'local communities of use' are considered expedient to user acceptance of borrowed-for-use: in this concept, care for the borrowed hardware is deliberately distributed between the user and professional maintainer, strengthening their interaction and customer relationship (see also next section). Furthermore, ownership of devices/components remains with the user as long as they are in use, lowering the sense of hardware rental, whilst extending producer responsibility at the end-of-use point to ensure the various loops back into the product system (repair, refurbish, recycle, and redesign; in order to capture the sustainability values, see Summary of the Case for the Business/Venture Layer). Replacing the commonplace versioning in technology development by thinking in long-term 'product generations' instead is expected to positively affect user acceptance. Versions usually came with some end-of-support (whereas the device could still function otherwise). With overlapping generations, Ec(h)o would considerably prolong backwards compatibility, establishing strong user bonds due to basing every redesign (a new generation) on the material and resources already in use and circulation. Ec(h)o could go as far as regularly recalling technology/components from the market. Whilst reusing latter materials in other contexts or even to restore nature, redesigned components could feature innovative, more health- and environmentally-friendly materials and eventually make for a net-positive PSS with growing acceptance.

Impediments on Producer Side

The professional maintenance and service focus of Ec(h)o introduces a new role, professional maintainers (see earlier). These peers, i.e., hardware and maintenance providers in a franchise manner, play a vital role in data privacy. As their relationship to the individual user is so close, maintenance and end-of-use treatments to the devices and components include personal data protection and data-clearing activities—as a matter of good service. The professional maintainers are also a hub for anonymised statistics over aggregated use, damage, repair, upgrade, or other. Even though this maintainer role might base on existing roles, such as current repair service providers, these considerations are more than "instrumental understandings of repair as a tool to extend product lifespans" ([119]:4). They embrace "a much richer notion of repair, one that encompasses a widespread, creative, innovative and reconstituting capability and sensibility, […] in the context of a dyadic relationship between manufacturer and user" ([119]:4). Such an understanding of repair as 'reconfiguration' [119], where repair transforms and (re-)designs, depicts a PSS of the future uniting the roles of user, repairer, and designer, and hence a PSS that allows capturing important social values (see also Summary of the Case for the Business/Venture Layer). In terms of testing the Ec(h)o PSS, testing the Ec(h)oFon device itself (which is underdeveloped) should be decoupled from finding a community diverse enough to immerse into the systemic 'borrowing', constant rearranging of finite resources and different usage over time. This service-providing side could be tested relatively independent of the hardware (say only employing a fleet of

phones capable of swopping batteries for recharge), e.g., in a transition town, as these are known as a testbed for different ways of living and the sharing economy. However, it can be assumed that filling this role of a transformative repair service provider is hard when the self-perceptions as producers dominate in broader society. Those tests as service provider may, in return, influence much what the Ec(h)oFon device should be like from a producer's point of view, presumably changing these self-perceptions.

Comparison

In product system layer terms, Ec(h)o bears similarities and differences to the existing business cases as follows (cf. [51]): most similar it is to both Fairphone, particularly their Fairphone-as-a-Service (FaaS-) trials, and the Puzzlephone in the sense of configurability. Considering product complexity and flexibility, Ec(h)o's use of both manufacturer's and user's systems is very similar to the more generic Puzzle concept. In accordance with the three compared start-ups, Ec(h)o's product system is primarily based on the confidence that users are willing and able to participate in co-creating the system whilst drawing on non-manipulated, true needs. Regarding user acceptance, the Ec(h)o product system resembles in part Shiftphone and in part Fairphone with their servitisation efforts. It has a similar understanding of ownership that largely remains at the user but incentivises bring-back at the end-of-use. Besides, Ec(h)o strives for better user acceptance by connecting innovative product system elements (bolder visions of future mobile technology like with the Puzzlephone concept), adapting to different user needs, and sustainability gains through take-back and (re-)design of the 'former generation' elements. For Ec(h)o becoming a service provider means almost the same as for Fairphone and its FaaS-trials (third-party companies as test communities), or both Shiftphone and Fairphone with their respective general user communities. Ec(h)o only introduces a different approach to larger servitisation, through its communities of use.

Summary of the Case for the Business/Venture Layer

Value Proposition

Ec(h)o's product and service, and therefor value for the consumer, rests on 'repurposable, multi-functional smartphone Hardware as-a-Service' (see Summary of the Case for the Product System Layer). Systemic focus is on (hardware and serviceability) longevity and sufficiency, which both leverage mass customised use values. Hence, a user-needs oriented, circular production-enabling hardware system is the technological innovation with which a comprehensive service and sufficient consumption can be provided. The venture's sustainability communication and identity are reflected in branding Ec(h)o as 'lovable' or 'beloved' technology that is sensitive to human needs and capabilities. Its 'For the love of circularity' branding highlights care for the environment, equality, and human rights. The venture could be marketed as 'do not buy this phone – only borrow it' just as Patagonia does in their "Don't buy this jacket!" campaign [120]. The Ec(h)oFon being referred to as "Forever yours" and "Eternally ours" reflects a circular yet flexible handling of resources towards consumers (yours) and society/environment (ours), coupling changing user needs with the needs of future generations. The Ec(h)o venture might attract both business customers (B2B) and consumers (B2C) to build strong, long-term customer relationships.

Following Bocken and Short's [57] extension of the term, the value proposition is triple-fold. The resulting unique priority mix for this speculative business is besides 'providing phones to use', 'reduced emissions and energy in production' and 'zero-waste' as environmental propositions, and 'reduced overall consumption' as societal proposition. Given its distinct entry strategy described earlier at agent-situation layer, the venture makes a step towards sustainable value creation. Ec(h)o's route through circularity tackles to 'design-out-waste' by cascading reparability, modular-upgradability, and similar. Coupling end-of-use with (re-)invention and (re-)design is the major value proposition for environment and society, which requires a step up from typical recycling, including reuse of else obsolete parts and materials, or even obsolete designs and inventions (see Fig. 5). This challenges the Ec(h)o venture to practise 'available-resources-led design' and 'frugal innovation', daring it to stretch what is or ought to be possible in the sense of the designers' imagination [100].

Value Creation and Delivery

Ec(h)o's key activities lie in the research on the Ec(h)oFon proto-practise, the epitome for reverse logistics inspired by the single use camera [67], and on incentivised bring-back of end-of-use phone technology in a PSS scenario. Activities for strengthening the connection between material science and design research could help transfer the technology and research outcome to business. Key resources in this speculative case concern end-of-use consumer electronics (e-waste) that are consciously not cross-contaminated as in conventional shredding of e-waste [94]. Ec(h)o designs this return flow into the business model as 'crowdsourcing', i.e., retrieving obsolete materials/parts/components/devices acknowledging their inherent technology and design history. That measure significantly lowers the uncertainty in return flows (supply chain management challenge [94]) by proactively increasing the chances of achieving an economic scale. Knowing the quantity, mix, quality, time, and place of incoming resources allows for resource-led design and technology development in overlapping product generations. Resources are, thus, valued higher and their proper separation and reuse prioritised mitigating cross-contamination and 'down-cycling'.

The distribution channels of Ec(h)o would be distinct from the classic mobile telephony providers. They would include online crowdsourcing campaigns, an online shop (local but distributed globally) with advantageous postal shipping, and the essential local franchises driven by professional maintainers. With local cosmopolitan attitude, distribution channels might be relatively informal locations for the purpose of quick testing, e.g., organised as a pop-up store, market stand in transition towns, or locally installed (reverse) vending machine for spare-parts sale and take-back [121].

Regarding suppliers/partners/coalitions, Ec(h)o pays special attention to a localised supply chain. That means more local sourcing, i.e., urban mining, parts harvesting, consumers becoming partially 'suppliers' of resources, and coalitions with local (continent-based) recycling companies on 'reuse over recycle' are to be brought on their way. Furthermore, as local sourcing leads to de-centralised forms of non-virgin production (i.e., reuse/refurbishment/redesign), the relationship with the upper end of the supply chain (assembly and services) becomes closer. Consequently, the demand for virgin resources, conventionally coming from African, Asian, South-American countries, and Russia [122], decreases, as well as the labour amount in electronics assembly conventionally provided by Chinese/Asian partners shifts globally to more local workforces. This considerable retraction to distributed places worldwide signals a shift to sufficient resource circling, transport/postage of these, and connected labour. Delivering on the triple-fold value proposition (to customer, society, and environment) relies on enacting this holistic retreat to sufficient levels.

Three enabling processes and features are key for Ec(h)o's value creation and delivery: focussing on (i) professional maintenance as a service that is distributed but globally connected in a peer-to-peer manner, (ii) the phone HaaS eventually providing perfectly repurposable parts and materials, and this system being (iii) of such simplicity in design that it allows continuous improvements without harming compatibility. Through continuous improvement, delivering both customer/social value (needs-oriented phone use) and societal-environmental values (responsible consumption and production) corresponds to a distinct business logic. It is the effectual, lean start-up and R&D approach (see agent-situation layer) and the confidence in user participation and the alignment of lifetimes and backwards compatibility (see product system layer) that may be lifted to the business/venture layer and thus to the greater innovation and sustainable consumption discourse. This venture's approach means to innovate with, in, and for sustainability, rendering all innovation a positive drive for sustainability. Ec(h)o designers/developers may learn to cope with imperfect applications of this sustainability drive, eventually adopting a confident 'relentless-improve' attitude. By virtue of being means-driven, 'what-is-there-from-before' is taken as starting point preventing the 'escape' into an unsustainable 'new from scratch' (designing anew) approach. The latter would reveal "destruction denialism", meaning that creators deny that they "are, and must be, […] destroyers of existing products and even whole product ecologies[, patterns, expectations, habits and systems]" ([100]:77). Forgetting about the past would not be an option in any lifecycle phase; thus, Ec(h)o business representatives essentially behave as redesigners ('all design is redesign' [100, 123]).

Value Capture

Ec(h)o's potentially high upfront costs and therefore low affordability (for users) due to implemented durability and environmental friendliness are offset by focus on the systemic borrowing. However, since borrowing-for-use implies prioritising usage/needs to ownership, pricing is more flexible. Prices are hence associated with the service and care given to (upgrading) the device rather than with the resources 'embodied' in the device. Corresponding to the product system flexibility, costs can follow dynamic pay-per-use schemes according to the specific features and capacities provided, e.g., computing, memory, and energy capacity. User needs, preferences, and behaviour can be met and possibly allow decreasing prices the longer devices/components stay in use (e.g., French/German Cooperative for Sustainable Electronics Commown features such 'commonly owned' phones and laptops and decreasing payments [124]). At end-of-use, through an 'integrated financial' take-back incentive, Ec(h)o users are encouraged/asked and rewarded for returning resources to a new product generation. Furthermore, value capture for the consumers and the venture lies in catering to consumers seeking both variety and novelty, be it for status and prestige reasons or for performance benefits. This spells out as a spectrum from low-end (minimalist, frugal, and durable) technology at low(er) prices to high-end (customised, specialist, and short-term/flexible use) technology at high(er) prices, and mass customised mixes between these extremes (see also customisation in Fig. 4). In the latter, technological innovations, such as efficiency gains, or even allowing sufficiency, can integrate an early, frequent adaptation of R&D (such as alternatives from material science or whole component alternatives from electronics/optics/sensor R&D). Along with these novelties, early adopters can regularly buy themselves into testing and co-creating new services, devices,

components, or materials for each product generation in the illustrated crowdsourcing and funding manner. Cost savings from sustainability gains benefit the user—offering a value capture opportunity for them, whilst the venture pursues their ethical strategy of compromising on margins for each sold item.

Value capture for others (environment and society) lies in the Ec(h)o venture's product system striving to achieve 'zero-waste to landfill'. By connecting one product generation (first life) to the others, the use of resources over time, places, and societies is altered. It corresponds to the three CE strategies of (i) closing, (ii) narrowing, and (iii) slowing loops [49]. Environmental value is captured as a result of that the repurposable Ec(h)oFon parts and materials are kept in the technical loop (closing the loop) through a "deposit refund scheme [that] improves the return of goods to the producer [or in general] manag[ing] the movement of goods in a network" ([49]:21). Additionally, components and materials underlie the steady efficiency gains (narrowing the loop) in electronics, through fairly common miniaturisation and thin-film technology, albeit yielding a relatively low environmental value capture. Most of the societal value lies in slowing loops, as Ec(h)o's BM and value chain support continuous reuse over time. The repurpose imperative means that consumers have something (the hibernating resources) to contribute with, to be tapped for a future generation of phone technology in a crowdsourcing manner. The distributed Ec(h)o communities of use each represent "[a] value network at a local scale", reducing resource losses common in complicated global value chains [49]. Slowing the loop should happen on the condition that the venture is not simply using extra resources in production (including for repair, maintenance, upgrades, refurbishment, and remanufacturing) of the more durable but that this (re-design) effort translates into actually longer, if not multiple, product life-spans. Maintenance is seen as central to the necessary skill-base in the CE and repair as "a critical contribution to (social and economic – not ecological) regeneration" ([119]:4). Ec(h)o regards "'repair' as something being done to the resource cycle (rather than to the product) […] which understands renewable resource regeneration as part of the challenge" ([119]:3). Given these special forms of capturing value for the customer and others, Ec(h)o would alter production and consumption cultures for phones as it shifts the paradigm from that of mass production to mass customisation instead [125].

Concerning the overall growth ethos, Ec(h)o conceptually departs from mainstream notions of economic growth exploring its preference for post-growth, degrowth, or organic growth and the effects of slowing down. Counting devices, components, and services brought or remaining in use is still essential for Ec(h)o, just in a circular fashion, being less about 'measures, metrics, indicators' to maximise linear throughput [94] and more about optimising circular sufficiency. Ec(h)o's approach favours not to issue publicly traded shares and not to end up in a buy-out of the venture, i.e., making for a capable benefit corporation (e.g., in the Economy for the Common Good, ECG network). However, the venture's leading cause with replicative growth is persistently growing its influence and replacing old, unsustainable patterns of smartphone production and consumption. This requires the venture's growth strategy not to be too self-restrictive concerning sales and user adoption, which might trigger rather rapid turnover and employment increases, or alliances with other players in a coopetition manner [58, 126]. Not least, such coopetition might allow the sustainable alternatives to overtake the competitive second-hand market share—at, for instance, the level of one company like remade refurbishing around 600.000 smartphones (iPhones) a year (in 2017) ([127]:42).

Comparison

In value for customers, similarity is mostly reflected in Fairphone's FaaS trials (their B2B segment): an Ec(h)o (community) user almost equals a FaaS consumer, who is a third-party company's employee. The former is, however, also similar to the non-FaaS Fairphone consumer (B2C segment), as Ec(h)o's franchise business may depict a B2C and B2B mixture. Ec(h)o's value proposition builds forth on all three existing propositions. However, it adds the professional maintenance, decentralised production, zero-waste, and overlapping product generations concepts. In value creation and delivery terms, many Ec(h)o aspects build on similar activities, resources, processes, and features as primarily Shiftphone and Fairphone, and secondarily Puzzlephone (try to) implement, adding some unique attributes: (i) under key activities the R&D on finding a suitable epitome for reverse logistics is unparalleled, (ii) under key resources 'designing in' the return flow for a non-virgin production is new, (iii) extending distribution channels with local (physical franchise) stores and vending machines for spare-parts and take-back is audacious yet unheard-of, (iv) with partners localising the supply chain, even promoting a holistic 'retreat' to local scales and thus sufficient levels, has only similarity to the Puzzle-technology concept, and (v) lastly, the key enabling process of creators behaving as re-designers, evincing a relentless-improve attitude whilst not harming (backwards) compatibility, is only partially paralleled by Shiftphone's open design call.

In value capture terms, Ec(h)o distinguishes itself by the integration of customisation (user-oriented design and appropriation) and early, frequent adaptations of R&D novelties (e.g., from material science) in a forward-leaning manner to simultaneously capture both value for the customer, the venture's employees, and others (environment and society at large). In similar veins as all existing cases contributing to closing, narrowing, and slowing loops in the CE, Ec(h)o particularly elevates maintenance and repair to being critical contributions to social and economic regeneration, with which regenerative work is upvalued, and wasteful behaviour banned.

Regarding the growth ethos, Ec(h)o unites three perspectives: (i) Fairphone's immersion aspirations (becoming a competitor to change the industry), (ii) Puzzlephone's systemic orientation towards electronics (Goliaths) as bigger role models and collaborators towards the common cause, and (iii) Shiftphone's benefit corporation and compromising-on-margins conviction, whilst abandoning self-restrictions on growth in favour of the desired, replicative capturing of value for others, and whilst omitting contributions in other domains of sustainable living than sustainable ICT.

Considering niches, Ec(h)o remains 'deepening the niche' similar to Puzzlephone that stays in a precompetitive/pre-market sphere, as, for all cases, niches are the context for sustainable practise experiments outside the current regime [128]. Nevertheless, Ec(h)o has illustrated a niche scale-up plan through replication, to embed the transitional experiments (which all cases represent) into new "dominant ways of thinking (culture), doing (practises) and organising (structure), at the level of a societal system" ([128]:33). Between the—thought out and dreamed of—greater delivery and capture of social and environmental values and a self-sufficient capturing of economic value, the Ec(h)o case might still lack the means for action on 'broadening the niche', which is vital for diffusing the innovation geographically, repeating it spatially or linking it to new domains [128].

Prospective Findings: Ec(h)o Strategy Set

This section presents prospective findings related to the Ec(h)o design and business model proposal, expressed as a set of business strategies. This set represents an accumulation and combination of findings, extracted, explained, and derived from the analysis presented in the previous section, which mirrors the transformation of the Ec(h)oFon proto-practise into the Ec(h)o business case. The abducted strategies in the set are either based on (same or similar to) or accompanied by (complementary or contrary to) the retrospective insights and conclusions won from the existing sustainable phone ventures, Fairphone, Shiftphone, and Puzzlephone. The findings provide a concrete idea(l) of the priorities given when navigating the Ec(h)o venture's sustainability performance, in light of sustainability placing such normative demands on business. By thus depicting the necessitated redesign and business model pivoting, the Ec(h)o strategy is exemplary for a desirable firm of the future, i.e., for strong sustainable entrepreneurship. The strategy set is presented in a thematic structure of sub-strategies, spelled out at the end of each of the eight paragraphs below, which was found suitable for the prescriptive (normative) nature of the proposal.

Ec(h)o would strategically follow the existing call announced by the Shiftphone venture. It can and would idea-historically draw upon Shiftphone's openly designed product system, Puzzlephone's platform modularity concept and an evolving standard approach, the Fairphone community's bespoke simpler, low-tech approach, and other conceptual or conventional phone designs. All these, Ec(h)o subsumes under the inspirational concept of frugal innovation "reinvigorated particularly in the developed world" ([57]:59), blurring the unreasonable Global South/Global North divide. Frugal technology means fulfilling diverse user needs at lower costs, including at lower environmental and social sustainability 'costs', whilst delivering a 'good enough', i.e., sufficient, performance, e.g., in reasonable proportion to human perception capacities. The frugal, open design mind-set upgrades the else "passive consumer […] to an active 'prosumer' who helps to define the functionality and benefits […] of an appropriately designed product" ([129]:517), which might even result in an integrated producers' and users' system [115]. We may call this the frugal innovation and open design strategy in the set.

Frugality could exactly prove helpful in case of technology lock-ins and general technology hick-ups. In one of the industry's typical issues—how many spare parts producers should stock—Ec(h)o sees a principal call and opportunity to take action against lock-ins. Turning away from any quantification, Ec(h)o stands for a qualification through on-demand production [105]. That means firstly producing in small series only, secondly keeping inventory low to take up production of supply whenever backwards compatibility demands it (a straightforward example being '3d-printing' customised spare parts). In an Ec(h)o community of use, such services can be provided one-on-one, with theoretically no end-of-support. On-demand thinking might eliminate obsolescence, i.e., no longer wasting both physical resources and conceptual knowledge. When principally components or functions are re-creatable (because openly designed), on-demand might even become possible for more complex production processes, software development, and at the front-end meeting needs for new (frugally developed) features based on the obsolete or replaced and taken-back device/component/material. The latter is tightly coupled with a rethink, redesign, and positive (frugal-innovative) change to embrace the obsolete and not to serve mass consumption. Instead, on-demand conceptualises how to question, act upon, or practically stop mass production, with which 'zero waste' and 'no hibernating resources' seriously come into reach. Large series production often yields high tooling costs (e.g., for injection

moulding) and high environmental/social costs due to undesirable, backfiring dependencies, such as technology lock-ins. In a bottom-up small-series, customised, on-demand production costs per item might be higher; however, in the systemic view, those 'real costs' of former mass production no longer occur. We may call this the avoiding technical lock-ins strategy in the set.

As a consequence of ruling out the above technology lock-ins through mass customisation and on-demand production and development, the independence of stocks and (sub-)suppliers might be reached eventually. This could be seen as the most far-reaching measure for 'vertically integrated' circular service operations of a firm [130], and it would thus rely on resources from 100% technology take-back. According to the vertical integration taxonomy, such incoming obsolete components and devices give rise to innovation within the firm, e.g., in technical, service, and organisational terms [130]. Contrary to other start-ups who embarked on the task by designing the product anew and having it produced from virgin resources, Ec(h)o exemplifies starting out with considerable amounts of (foreign) technology take-back to be followed by a redesign based on the taken-back and oriented towards its product generations overlap [67]. In contrast to the majority of known waste-to-value approaches (circular BMs), this targets up-cycling (same use scenario) instead of the else occurring down-cycling (lower quality use cases for the resources). Ec(h)o could thus enter the market differently—spinning off from (crowd-)funded design research implementing crowdsourced production from non-virgin materials, lifting concepts such as a salvaged ICT platform (in accordance with the existing standard salvaged computing platform [131] and the rich phone components platform that the Ec(h)oFon proto-practise envisioned to use [67]). Similarly, the redesign does not stop at software but follows a 'radically sustainable computing' mind-set [132], with software considered 'a material of design' [133]. We may call this the take-back or loop-back incentivising strategy in the set.

Ec(h)o distinctively seeks to establish local communities of use for its product system, with which it emphasises professional maintenance and service. Proliferating such decentralised communities opens for reimagined concepts of a store or forms of commerce. Conceptually, franchise-takers with a 'glocal' mind-set might drive distributed, hybrid stores to sell, repair, and take back the offered technology. Both sales and take-back could also be part of self-service, e.g., through vending machines [134] that provide batteries or other self-serviceable parts to renew a device. Similar spare-part vending practises have been available for bicycle parts, but returning the old material against a refund could become part of smart exchange practises at reverse vending machines. Furthermore, a franchise-style allows for lounge-like or even pop-up stores that could promote 'Join the circular culture!'. We may call this the diversity in forms of commerce strategy in the set.

The latter forms of commerce allude to a business growth strategy based on replicating the concept in diverse geographical areas. Since Ec(h)o—in comparison, rather late-to-the-market—intends to further the efforts others have made for introducing a sustainable PSS, it might be necessary and acceptable to progress as a 'hybrid' between research and commercialisation (similar to the Puzzlephone project). A potential commercial and entrepreneurial reality (as designer-founders) is known to place much strain on the agents: it would "demand a balance between producing "perfect" solutions whilst also launching these solutions to market [58]. Addressing that dilemma, the actual entry is sought to be held as small and local as one person 'building her own phone' (one customer). Upon that, means-driven measures for replicating and growing the concept follow, such as networking in the DIY (repair) scene (several users), in existing repairer/maintainers communities (repair experts as customers each responsible for some users), and only last adding a mother business for the holistic product generations development. In this process of at times "decelerating the

innovation process to produce perfect outcomes and accelerating [it] to improve time-to-market" ([58]:521), common notions of minimum viable product (MVP), "the smallest set of features that would produce paying customers" ([112]:1754), seem misplaced. In SSE, those 'perfect' solutions are not solely connected to 'paying customers' but also assessed against the sustainability performance. MVP greatly shifts meaning which might provoke notions of 'several minimum performing products, MPPs'. These mirror the continuous, means-driven, non-predictive pattern so as to gather the means to grow by seizing opportunities and by only replicating what works well towards a holistic performance. This may be called the replicative growth strategy in the set.

Ec(h)o's replicative growth ethos is an answer to the proposition that "whether [the small disruptive players] are reducing overall impacts by undermining or displacing the conventional more environmentally harmful businesses" matters if they want to "have any meaningful impact on the world" ([57]:57). It might not allow spending much time growing 'organically' [57]. To displace the unsustainable, a venture must be allowed to adopt many new customers (convert them from the dominant system) rapidly and grow big without moderating promotion efforts/sales. After this acquisition, keeping customers for as long as possible is vital. The PSS user experience's appeal is not only a decisive driver for the adoption but also continued usage [135]. In a long-term perspective [52], this continuation ensures the sustainable values are captured the longer the system is in use and joined by more users. Hence, the system has significantly lower impact than the "overall decline in demand that [it] precipitate[s] in the market" ([57]:57). For the sake of lowering overall consumption, Ec(h)o might tie two tactics, 'user adoption' and '(existing) customer satisfaction', together through its product generations overlap concept: during a product generation's (first) life (~5-10 years), the focus is on converting new users to the product system. Existing customers are served with repair and maintenance but sales to them (e.g., of parts that risk promoting 'wants' not 'needs') are moderated for this period. Then, at the overlap of product generations, focus shifts onto how to both serve existing customers' unneglectable, occasional desire for variety, novelty, and pleasure and attract unconverted consumers. A redesigned product system generation is made based on returned/recalled components and materials. New needs, which might have grown from former wants, and scientific insights that herald matured (not incremental) innovations find their way into the PSS. Developing Ec(h)o technology further in this 'responsible innovation' way might keep employees engaged in meaningful, local design, development, and customisation work. To ensure continuity, capital, profit, and management/overheads are kept at meaningfully low levels. The venture's 'organic' growth corresponds to the increase in customers and, be it big or small, is in proportion to the sustainability performance and compliant with ECG, Corp B, or similar 'organic' business rules. Attending ambitiously to establishing continued usage in and through such a comparatively harmless smartphone production and consumption system, i.e., its continued usage strategy in the set, renders Ec(h)o a firm of the future.

The described kind of innovation, responsible for sufficient and long-term use, may mean that "even after designing alternatives, designers must try to prevent re-appropriation by aspects of current systems that remain in place" ([100]:80). In the case of electronic devices, (re-)appropriation does not concern users' and designers' (repair and repurpose) activities to 'open black boxed technology'. These concerns with re-appropriation, in contrast, tackle activities that exactly re-establish black boxes that sales-oriented designers, or their allies in management, might impel. Their mind-set leaning towards making a profit from selling 'more of less', not 'less of more' [136], they either blame or downright stimulate customers to urgently demand back old patterns, expectations,

systems, or standardisation (and eventually new technology lock-ins). Re-appropriation endangers and misuses the alternative(s) principally created to counteract the inappropriate old patterns and systems. Preventing this re-appropriation needs a holistic, no longer venture-centric perspective. Like-minded ventures in the small business community providing sustainable alternatives need to distance themselves from internal cannibalisation (i.e., the prevailing competitive mind-set) in order to gain market share but from the unsustainable part of the industry, thus, for instance, opting for coopetition instead [126]. This can be named a directing cannibalisation outwards strategy in the set.

Further regarding practises or activities that are (to be) eliminated, the following describes the retract of production and resource extraction that Ec(h)o evokes. The mentioned technology take-back and salvage of ICT renders Ec(h)o retracting components manufacturing from predominantly Asian countries and sourcing from African and other countries as the mining centres of the world (i.e., from the Global South). Given that these two, sourcing and manufacturing, are problematic in the sense of being severe unsustainability hotspots, e.g., concerning conflict minerals/critical materials financing war/crime and the lack of labour (protection) laws or generally precarious work conditions [20, 137, 138], this could be seen as a welcome relocation of production to Europe or the Global North. However, here, the relocation is one to more local, decentral infrastructures and communities of urban repair/refurbishment and mining, closer to the users and the hibernating resources—worldwide! In such peer-to-peer structures, more frequent transport (of spare parts, components, semi-processed goods, and materials) must necessarily happen, e.g., by post. The resulting high amount of, but shorter-distance, postage is, nevertheless, considered sufficient, as former dominant practises with higher transportation distances, virgin resource extraction, and waste treatment levels are replaced. Non-virgin, i.e., recycled, materials lower the demand for (critical) materials, whilst the remaining virgin material demand should be covered with fair-mined supply or might even be substituted by another material that comes in recycled or fair-mined form. Additionally, the new peer-to-peer structures can benefit an eventual industrial symbiosis, through which processes are co-located in local closed resource networks [49]. So far, Ec(h)o 'localises' the use and reuse side of phones, the next step being to co-locate the communities of use with symbiotic (non-virgin) production sites. Such symbiosis could gather the production of diverse technologies that depend on the same materials (e.g., consumer electronics, batteries, and more) on the spot. This way, Ec(h)o could seize synergies, even lower the transport distances further, and feed from the shared resources. Similarly, it could feed other industries' resource demand, for instance, with what it potentially 'designs out' of its product system for each product generation. This last strategy we may summarise as localising of production concluding the whole strategy set.

Conclusion and Discussion

This final section discusses key contributions to academics and practitioners this transdisciplinary study has made. The study is concluded with the limitations and an outlook on future work, drawing attention on what might remain to be done in terms of transforming sustainability into a more manageable brief for (smartphone) design.

The Contribution to the Circular Economy and Sustainability

This study proposed a new perspective for critical-speculative design and exemplified it through a sustainable smartphone business case regarding how it creates value and how it might affect production and consumption towards the use of a meaningful alternative. With the apparent need to make the design, production, and disposal of phones more sustainable in mind and based on the design fiction idea of an everywhere-designed and respect-for-all 'wePhone' or an 'electronics co-operative', sustainability has been connected to interactive artefact design and corresponding business modelling and creation. It has been argued that using the effectual business logic in critical-speculative design has a significant benefit as it supports the vital interactions between a designer-founder and the environment in achieving strong sustainability performance. It also helps promote the scientific knowledge creation across disciplinary boundaries that more and more scholars see as central to transitioning to strong sustainability by design, here to transitioning the smartphone industry to a strongly sustainable one.

This study's main contribution lies in the application of an assessment framework onto a critical-speculative design case to explain sustainable value creation in the smartphone industry. From the comparative study of Fairphone, Shiftphone, and Puzzlephone, the earlier developed three-layer indicator framework (from agent-situation to product system to business/venture layer) and several findings and ideas from the regarded start-ups were reused, i.e., applied to earlier critical-speculative design work, the Ec(h)oFon proto-practise. Through the framework, incorporating 'PSS design and supply chain redesign' important initiative is taken for circularity/Circular Economy and Corporate Social Responsibility (CSR) to climb 'to new levels' [139]. The resulting proposal called Ec(h)o describes another way of sustainable value creation for smartphone production and consumption at the crossing of circular-sustainable design and business.

The speculative business (model) design this paper contributes to Circular Economy and Sustainability research provides both explanations and even normative prescriptions of sustainable value creation. In the context of smartphone production and consumption, the resulting Ec(h)o business strategy set delivers on possible norms and desirable ways to a holistic, meaningful navigation in terms of future firms' sustainability performance. It has been synthesised by comparative analyses against real-world conditions and showed how to deliberately shape an actor-dependent and effectual-controlled future business that can in good conscience be called a firm of the future.

Not only depicting such firm of the future, which society at large is calling for, Ec(h)o aimed to establish and strengthen environmental justice, inter-generational justice, and the balance between the local and the global. The 'product-oriented zero-waste PSS' it features, together with a 'local communities' approach for professional maintenance and repair, seeks to 'design out' waste, and therefor to not least stretch notions of what is possible or desirable, e.g., society at large becoming a fulfilling, flourishing circular society.

In sustainability transition research terms, this study has contributed with knowledge creation across individual disciplines. By untangling complex (mutually shaping) decision processes, e.g., trade-offs or synergies in and between sustainability orientation, design, business strategy, production, and consumption/use, the case renders as a pioneer of transdisciplinarity. This fertilisation of the disciplines' collaboration and co-creation (through cross-disciplinarily working individuals) invokes the desired change in fields such as sustainable interaction and product design towards incorporating SBM/SSBM and SE/SSE.

Limitations

A main limitation of the work is that it remains within the critical-speculative design research sphere, as long as Ec(h)oFon and Ec(h)o have not been verified in the field (with either designers or some experienced entrepreneurs/peers). An actual enactment with interested stakeholders—enactive research by founding and researching a venture simultaneously [140]—could yield more systemic results that for instance had dealt with occurring rebound effects. Whilst the study of real-world cases may depict "successful practises implemented in industry, which Vezzoli et al. (2015) and Tukker (2013) considered of utmost importance", the speculative venture might serve as a serious precursor of an encouraging "application of the existing body of knowledge regarding systemic transformations for industrial sustainability" [141].

Future Work

This application in the real world, e.g., through integrating designerly and entrepreneurial ways into product and service development processes on a more general basis, is our goal for further research. The study concludes with the outlook that to succeed with that—given that the encouragement by sustainable business initiatives remains growing—we might be able to make the imperative of sustainability more manageable for design. Ec(h)o, i.e., this effectual, cause-driven business logic, serves as a deliberate foundation for own future work, representing an initial, 'outlining' design brief. This outline can be filled with more elaborated, concrete details complementing the holistic picture established thus far, which then detail the 'precise inner buildings and aesthetics of the interactive artefact' not (yet) detailed through this study. The concrete pathway to extend this work was imagined as a series of workshops, where the first one has already taken place with the following extension opportunities as further four briefs: (1) fewer/mono-materials, (2) all biodegradable materials, (3) energy-plus technology, and (4) sufficient interactions (output pull approach). These new inquiries, aiming to transform the sustainability of smartphones into a more manageable design brief, are not hierarchical or mutually exclusive but are expected to yield synergies that the participating experts discover as they engage with them. This research seeks to unite towards the common goal, that is, integrated, holistic, regenerative product and service development, regardless of whether such sustainability transitions are initiated by the design of, for, or with the smartphone.

Declarations

Competing Interests The author declares no competing interests.

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