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Journal of Cleaner Production 387 (2023) 135724

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Design-led repair & reuse: An approach for an equitable, bottom-up, innovation-driven circular economy

Marco D'Urzo *, Cristian Campagnaro

Department of Architecture and Design, Politecnico di Torino, Turin, 10129, Italy

ARTICLE INFO

Handling Editor: Cecilia Maria Villas Bôas de Almeida

Keywords:
Circular economy
Social & solidarity economy
Design-driven innovation
Reuse
Repair
Appropriate technology

ABSTRACT

The circular economy is a social, technological and economic paradigm that aims to build a production and consumption model focused on waste reduction and maximization of discarded matter recovery.

Discussion of the circular economy often treats it as a technocratic and profit-driven phenomenon that can be developed by capital investment in a particular industrial sector without necessarily taking into account the needs of the surrounding geographic area. The promotion of the circular economy often emphasises recycling and other practices that may not fully use the recovered material but are highly automatable, thus creating only a limited number of jobs.

At the same time, there is another model of the circular economy, in which small and medium-sized organizations engage in transformative and low-technology activities such as reuse and repair, benefiting local development and creating job opportunities. This model is often explicitly driven by a social development mandate. Still, it risks falling short of its goals because of a lack of expertise and a less systematic approach.

This paper aims to introduce the Design-led Repair & Reuse (DLRR) framework for mitigating the shortcomings of this second model, using an approach that is both sustainable and accessible to organizations with limited resources. Inspired by the principles of "Design-driven innovation", "social & solidarity economy", and "appropriate technology", DLRR aims to generate a higher quality of processes and products from circular, low entropy and low capital-intensity production activities, resulting in a more solid, identifiable and conscious positioning in the reuse market. It complements the socially inclusive ethos of these third sector small and medium-sized organizations while contributing to the debate on integrating alternative perspectives into the mainstream circular economy discourse.

The first part of this paper discusses the theoretical principles that have inspired the DLRR framework. The second part presents research that tests the consistency of these founding principles based on a case study of a sample of organizations in Italy that are active in circular waste transformation processes.

1. Introduction

Today, the circular economy (CE) is proposed as a paradigm for addressing environmental issues by reintroducing discarded materials and products into production and use cycles, thus minimizing waste.

The literature shows no generalised consensus on the meaning and definition of circular economy (Geissdoerfer et al., 2017; Ghisellini et al., 2016; Homrich et al., 2018). However, it is possible to identify a dominant interpretation, adopted by a large number of institutions and companies, which is based on the vision of CE expressed by the Ellen McArthur Foundation think tank that considers it an "industrial system that is restorative or regenerative by intention and design" (Ellen MacArthur Foundation, 2013, p. 8). This view aligns to the "reformist" perspective concerning CE, which sees the concept as integrated "*into the current economic paradigm and a rhetoric of healthy growth, rather than using it as a vehicle for modification of the capitalist system into one where value is distributed more fairly and equally.*" (Reike et al., 2018, p. 250). In detail, two weaknesses of this vision are underlined.

Abbreviations: CE, circular economy; SSE, social & solidarity economy; DDI, design-driven innovation; C-CE, care-centered economy; CIVE, civil economy; DLRR, Design-led repair & reuse; AT, appropriate technology.

* Corresponding author.
E-mail addresses: marco.durzo@polito.it (M. D'Urzo), cristian.campagnaro@polito.it (C. Campagnaro).

https://doi.org/10.1016/j.jclepro.2022.135724
Received 29 July 2022; Received in revised form 9 December 2022; Accepted 21 December 2022
Available online 24 December 2022

- Although it refers to the concept of sustainability, which is formed by the balance between the environmental, economic and social dimensions (World Commission on Environment and Development, 1987), it does not investigate the matter in depth and concretely (Calisto Friant et al., 2020; EASAC, 2015; Hobson, 2016; Hobson and Lynch, 2016; Korhonen et al., 2018; Koumparou, 2017; Lazarevic and Valve, 2017; Moreau et al., 2017);
- The circular processes and examples it refers to most are high entropy processes, such as recycling (Blomsma and Tennant, 2020). From an environmental point of view, these do not make the most of the recovered waste, dispersing much of its embodied energy (Blomsma and Tennant, 2020). Moreover, these processes lend themselves to automation and centralization, reinforcing a conception of the circular economy that depends on industrial-scale plants and high-tech components (Llorente-González and Vence, 2020). This understanding of the nature of CE fuels a discourse that it is viable only for companies with substantial economic resources.

These weaknesses could lead to a strongly technocratic and exclusionary vision of the CE as it is only accessible to entities that already possess the capital and operating resources required to participate in the traditional industrial system (Campagnaro and D'Urzo, 2021). However, in addition to this vision of the CE and the entities that participate in it, there is a different perspective that can be defined as "transformationalist" (Reike et al., 2018, p. 250), according to which the construction of a truly circular and sustainable economy requires a "radical transformations to the economic order, including the fundamental recasting of manufacture, retail, consumption and property rights" (Gregson et al., 2015, p. 235). It is possible to identify a broad spectrum of entities that are working, not always explicitly and consciously, towards the construction of a circular economy that is also socially equitable and focused on the characteristics and needs of local territories (Campagnaro and D'Urzo, 2021). These include entities such as social cooperatives, associations, social enterprises and, generally speaking, all those associated with the "third sector" (Newcastle University, n.d.). It should also be specified that between these two poles, there is an equally broad spectrum of entities that do not strictly belong to either one or the other vision; for example, small, but for-profit entities in which the social remit is either explicitly or implicitly sought after (e.g., family-run businesses developing circular production and transformation processes, or small and medium-sized enterprises active in the environmental sector). However, the interest of the authors of this article focuses on promoting activities with an explicit social purpose.

In this regard, as emerging from the authors' direct experiences with third sector entities, which was further confirmed by a previous survey work involving social cooperatives (Campagnaro and D'Urzo, 2021) and partially by the case study research carried out for this paper, these entities often exhibit fragilities that hinder the full development of their potential.

- Research, development and innovation processes are often absent or, when present, they lack an expert, solid and effective methodological component;
- The small size, geographic distribution, and heterogeneity of these organizations make it complex to systematize their commonalities, hindering the formation of a critical mass that can influence policy and debate;
- Their economic and operational resources are often severely limited, limiting the possibility for experimentation and innovation.

As shown in the authors' previous work, these organizations could benefit from having a clear template for circular activities that are economically and operationally viable. Given their social remit, strengthening these organizations would help their local areas to achieve a more equitable and sustainable model of development (Campagnaro and D'Urzo, 2021).

The objective of this paper is, therefore to outline a framework for an approach to the circular economy that fosters low entropy and low capital Design-driven innovation processes, focused on meanings rather than technology and on social, equitable development rather than merely profit-centred economic development. Drawing on the concept of Design-driven innovation as intended by Verganti (Verganti, 2008, 2009, 2010), processes with these characteristics can foster the development of high-value products while avoiding expensive and complex technology-focused research and development. Creating a common approach for low entropy, high added-value circular processes can strengthen the argument for adopting this kind of practice as complementary to the more technocratic CE models. Thus, starting from a review of the literature, a theoretical elaboration and analysis of case studies from a pre-existing database of CE projects, the "Design-led Repair & Reuse" framework aims to help to create such a common approach. This framework can be helpful.

- to academics as a basis upon which to define and strengthen alternatives to the mainstream discourse on CE;
- to design practitioners and professionals as a cue for circular design practices downstream of production processes;
- to third sector organizations interested in innovating in circular practices.

The rest of this paper is organized as follows: in Section 2, the data collection methods upon which the research is based are outlined, together with the specifics of the database used for the analysis; in Section 3, the references and theoretical elaborations that led to the synthesis of the Design-led Repair & Reuse framework are developed; Section 4 shows and visualizes the results that emerged from the database; Section 5 discusses and elaborates on the results and highlights the research findings; Section 6 is dedicated to a summary of the work and conclusions, including some possible options for design action.

2. Material and methods

This paper has been developed from three fundamental elements.

- A non-systematic literature review focusing on four main topics:
  - o Circular economy: definitions, meanings, principles, design approaches and criticisms;
  - o Economic models of equitable and sustainable development, with a focus on the "social & solidarity economy" (SSE), "Care-centred economy" (C-CE) and "civil economy" (CIVE) paradigms;
  - o The "appropriate technology" paradigm: definitions, meanings, principles;
  - o Design-led/Design-driven innovation: definitions, meanings, principles.
- The purpose of the literature review is to explore the state of the CE debate and position this paper within it. The literature review consolidates and develops the authors' previous work on these topics. In this paper, only the topic of Design-led/Design-driven innovation will therefore be dealt with extensively. Reflections and conclusions on the critical aspects and the principles of circular economy and definitions of SSE and Appropriate Technology can be found in a previous publication by the authors (Campagnaro and D'Urzo, 2021). Nevertheless, in Fig. 1 the literature review criteria are outlined, so as to give an overview of the used parameters.

- o Name, place of activity, year of creation;
- o Productive sector;
- o Destination of the activities provided: business-to-business and/or business-to-consumer;
- o Type of organization: enterprise, association, social cooperative, social enterprise;
- o Indicative number of employees.

Aside from basic data, four additional parameters resulting from the development of literature review and theoretical reflection activities were then added, being relevant to the specific aim of this research.

- Design domain (Jones and van Patter, 2009; Jones, 2014). This parameter has been defined so as to organize the analysed cases according to their design level (artefacts, services, organizations, communities), thus avoiding simplifications and trivialisation of design processes;

Non-systematic literature review criteria

Topic	Quantity and Typology	Keywords	Source database	Type of articles	Publication date
Circular Economy	30 Scientific Papers 10 Position Papers by institutions/NGOs 2 Books	Circular Economy; Circular Economy definition; Circular Economy concepts; Social Circular Economy; Circular Economy critics; Circular Economy criticalities; Circular Economy critique; Circular Economy case studies; Circular Economy examples	Database aggregator (semanticscholar.org/) Scopus	**Academic literature:** • Systematic reviews • Concept reflections • Critical reflections • Definitions • Case studies *To obtain systematic reflections on concepts, case studies and critical elements* **Grey literature:** (think tanks, institutions, NGOs): • Position papers • Definitions • Proposals • Case studies *To obtain non-academic, common and diffused points of view about the topics*	10-years span *Literature-rich topic, 10 years span to follow debate development* 50-years span *Less debated topics, 50 years span to include as much references as possible*
Economic models of equitable and sustainable development	12 Scientific Papers 7 Position Papers by institutions/NGOs 4 Books	Social economy; Solidarity economy; social sustainability; Social and solidarity economy; SSE; SSE definition; Care economy; Civil economy; Social justice; Economic equity; Equity+economy; Local development; Local economy			
Appropriate technology paradigm	9 Scientific Papers 4 Position Papers by institutions/NGOs 3 Books	Appropriate technology; Appropriate technology definition; Intermediate technology; Appropriate technology case studies; Appropriate technology examples			
Design-led/ design-driven innovation	7 Scientific Papers 1 Books	Design driven innovation; design led innovation; Design driven innovation definition; Design driven innovation concept; design led innovation definition; design led innovation concept; design led innovation case studies; design led innovation examples; Design driven innovation case studies; Design driven innovation examples			

Fig. 1. Literature review parameters.

- Field experience the authors have been developing since 2014 on projects focused on design for social inclusion and low-entropy circular processes using appropriate technologies. This also allowed the gathering of experience and knowledge about third sector organizations of various kinds, and their specific weaknesses and strengths. Field experience is a fundamental element of the paper as it provides insights and preliminary data on which the research was based; it also provides opportunities for practical testing of some of the hypotheses outlined.
- A desk analysis of case studies (Baxter and Jack, 2008) obtained from a database that collects projects active in the circular economy in Italy, namely the *Atlante dell'economia circolare* ("Circular Economy Atlas") (EconomiaCircolare.com, 2021). The Circular Economy Atlas is "*an interactive web platform that censuses and recounts the experiences of economic realities and associations committed to applying the principles of the circular economy in Italy.*" (EconomiaCircolare.com, 2021, author's translation). The Atlas aims to raise awareness about circular economy and create networking opportunities both for citizens and organizations. Database entries are self-entered by organizations by answering a survey ("Atlante Italiano dell'Economia Circolare," n. d.) realised by the scientific committee of the platform, which will then examine and review entries before their publication. As of October 2022, the Atlas counts 257 entries of projects and organizations active on the Italian soil on the topics of CE. Of these, cases dealing with low-entropy processes (such as reuse and repair) to transform waste products into new or semi-finished goods were selected. Using the case database entry page as a starting point, additional informations about the case were collected through the case official website or web reference, if present. This allowed to collect more details about the single cases, thus leading to a more solid analysis. Then, using Microsoft Access, a second database of the selected entities was created (available in the "Research Data" section at the end of the article). This database categorizes the entities according to some basic data:

Table resume of the parameters defined for the literature review and their specifications.

- o Type of design knowledge and practices: "expert" or "diffuse" (Manzini, 2015). Projects were considered "experts" if they included experts with professional training in design (designers, architects, etc.) or who appeared to have assimilated a deep design culture through experience. This parameter was defined so as to make a distinction between entities that have an explicit and professional design approach, and those that have an implicit design approach instead, without personnel with professional design training. This allows to relate the design quality of products to the entities' level of design professionalism;
- o Presence of an explicit commitment to and interest in social sustainability. Given the specific focus of this paper on third sector entities and more generally on those which are active in promoting social sustainability, this parameter allows to identify which and how many entities are explicitly active in achieving social objectives;
- o Presence of a Design-led approach and its categories of belonging. These categories were defined by cross-referencing the reflections arising from the literature review and an initial batch of 30 cases, so as to have an initial verification of the theoretical framework.

It should be emphasised that, since this is a qualitative analysis of the projects examined, although the process is reproducible, some categorizations may be susceptible to subjective variation. So as to minimize the occurrence of this option, thresholds were defined for each parameter. These are summarised in Fig. 2 together with the other foundational elements of the case study approach.

The objective of the case study research is to verify the consistency of theoretical hypotheses and to verify and build upon what has been observed through direct experience in the field.

Especially in the definition of certain parameters, such as the type of "expert" or "diffuse" design component, in some cases it is impossible to make an absolute and objective assessment. Nevertheless the number of cases vary in terms of production sectors, design knowledge, geographical contexts and organization typologies and -in the authors' opinion-represent a dataset relevant enough to preliminarily verify the outlined framework (Figs. 1 and 2).

3. Theory

3.1. Positioning of the framework

The proposed framework is positioned to fulfil the need for a local, non-industrial and equitable conception of the circular economy.

As previously discussed by the authors, the CE is normally perceived via one of two lenses: either it depends on high entropy processes such as recycling, to be developed through large investments and high, complex and expensive technology plants; or it consists of generic instructions focused on individual behaviour and consumption.

What emerges, therefore, is the absence in this discourse of an intermediate conception of the CE: one that goes beyond individual choices and involves organizations, but does not depend on industrial and extra-regional scales that risk neglecting the specific needs of particular locales.

The entities that are active at this intermediate level, attentive to local development processes and all three dimensions of sustainability, may be profit-making enterprises, social cooperatives or associations. However, such entities are not systematically organized, and there is currently no consistent framework promoting a CE approach that is suitable for and accessible to this kind of organization. The aim of this contribution is precisely to outline an approach to the circular economy that addresses aspects that are less dealt with in the literature:

- From a design perspective, the literature focuses on upstream approaches to production processes (Ellen MacArthur Foundation, n. d.; Moreno et al., 2016 are some examples); systematic reflections on downstream processes, on which this contribution intends to focus, are less explored;
- Regarding the characterization of circular practices, as anticipated, the literature and mainstream discourse focus on high entropy, high technology, capital and energy-intensive practices, while a systematic conception of low entropy practices is absent (Llorente-González and Vence, 2020). At the opposite extreme, a large number of individual low-tech circular practices can be traced, often referring to the term "upcycling". This contribution aims to focus on technology-appropriate approaches that enable complex and scalable outputs while remaining operationally and economically accessible;
- Given the absence of a concrete and systematic conception of the social component of sustainability in the mainstream discourse on CE, this contribution intends to focus mainly on entities characterized by non-profit or profit-for-society missions;
- Concerning geographical development, given the absence of systematic reflections on the local development dimension of CE in the mainstream discourse, this paper intends to focus on the regional level and below. Its aim is to outline development proposals which would be accessible to small and medium entities, while fostering local development in a simpler and faster way to experiment and implement than complex, large scale extra-regional and national processes.

The positioning of the article is visualised in detail through a flowchart (Fig. 3) based on 7 pillars designed as follows:

- **Product life position:** being in a linear economy context, each product has a life cycle that goes from conception/design, to distribution, purchase, use and finally disposal. This pillar was therefore chosen to define a clear position of research interest with respect to this process and the products' life cycle (McDonough and Braungart, 2002; Moreno et al., 2016).
- **Circular practices:** having defined the position of interest in the products' life cycle of the products, a broad spectrum of possible circular approaches to the recovery of these products and their value emerges from the literature. Blomsma and Tennant offer a particularly interesting categorisation of circular processes that allows to go beyond the individual process and focus more on the desired outcome: the recovery of entire products or recovery of the material they are made of. This pillar defines the positioning of the contribution with respect to these two perspectives (Blomsma and Tennant, 2020).
- **Technological level:** both high entropy and low entropy circular processes can be implemented through different levels of technological complexity. Following the analysis of a past research work on circular case studies carried out by the research team (available in the Research Data section at the end of the paper), three levels of technological complexity were defined.
- **Organization's mission: c**ircular processes can be implemented by entities characterized by different organizational models and missions. Based on the authors' field experience and the types of entities emerging from the case studies extracted from the Circular Economy Atlas database, three general types of entities were defined, that allow for a positioning based on mission rather than on specific name.
- **Development scale:** each entity, regardless of its organizational model, may have different scales of development. In order to define positioning according to geographical dimension, the authors started from the institutional division of the reference context (Italy) so as to have consistency across the actions of the entities analysed and the territory in which they operate (Clemente di San Luca, 2015) (Fig. 3).

In order to concisely integrate these characteristics and positions, the Design-led repair & reuse (DLRR) framework is introduced. The

Case study analisys qualitative parameters

Parameter	Description and references	Aim	Possible Values	Thresholds
Design domain	Position projects and entities in the appropriate level of design complexity. (Jones and van Patter, 2009; Jones, 2014)	Avoid banalization of project outputs: for example, a project can simply produce artifacts to be sold, while another project can produce artifacts instrumentally as tools for producing social change.	• 1.0: Artifacts and communications: design as making, or traditional design practice; • 2.0: Products and services: design for value creation (including service design, product innovation, multichannel, and user experience), design as integrating; • 3.0: Organizational transformation (complex, bounded by business or strategy): change-oriented, design of work practices, strategies, and organizational structures; • 4.0: Social transformation (complex, unbounded): design for complex societal situations, social systems, policy-making and community design.	Given the complexity, this parameter lacks a threshold and is defined on a per-case basis.
Type of design knowledge and practices	Characterisation of the level of design knowledge involved in the entity's activities. (Manzini, 2015).	Differentiate entities based on their design knowledge; this allows to relate design knowledge level to entities' output quality, abilitating possible RIFLESSIONI on this relationship.	• Expert: "design action carried out by people trained to operate professionally as designers, and who put themselves forward as design professionals." (Manzini, 2015, p. 37). • Diffuse: "design action [...] put into play by "nonexperts," with their natural designing capacity " (Manzini, 2015, p. 37).	"Expert" if the entity/project includes experts with professional training in design (designers, architects, etc.) or who appeared to have assimilated a deep design culture (use of tools, design methods and languages) through experience. "Diffuse" otherwise.
Presence of an explicit commitment to and interest in social sustainability	Presence of explicit goals and will towards social sustainability.	Define quantity and tipology of entities with explicit social aims among the ones present in the database to obtain an overview of the socially-engaged entities active in this field.	• Yes (presence of social committment) • No	"Yes" if the entity/project includes explicitly shows in its communication material a committment about social topics; also, if the entity is a social cooperative or social enterprise (these two tipologies have intrinsic social goals). "No" otherwise.
Presence of a design-led approach and its categories of belonging	Presence of a design-led approach as defined in the paper (see sections 3.3 and 4 for a detailed elaboration on the design-led approach and framework).	Define quantity and tipology of entities that shows a design-led approach, and how is this characterized based on the design-led categories identified in the paper (see section 4.1 for a detailed elaboration on the categories). This allows to verify, expand and detail the design-led hypotesis developed in the paper.	• Yes (presence of a design led approach) If yes, the entry will also have at least one of these 3 categories selected: ○ Explicit and asserted design component; ○ Attention to design as a system and a multilevel concept that exists beyond the individual product and touches on contexts, cultures and communication; ○ Research activities related to supply chains, technologies, languages and activities with a systematic, formal, organized character. • No	"Yes" if the entity/project shows elements that belongs to at least one of the 3 defined design-led categories. "No" otherwise.

Fig. 2. Case study analysis parameters.
Table resume of the parameters defined for the case study analysis and their specifications.

objective of DLRR is to promote a bottom-up, local development of the circular economy that is viable for entities with limited capital and operating resources, that promotes labour-intensive practices favouring job creation and reduced energy and capital expenditure, and that aims to spur production of products and services with high added value. The DLRR framework is rooted in a number of approaches to innovation, technological development and social and environmental sustainability that have been selected following the results of the literature review and reflection processes developed for this contribution and in the author's previous work (Campagnaro and D'Urzo, 2021), upon which this paper builds up. The theoretical references will now be discussed in more detail.

3.2. DLRR theoretical references

3.2.1. Circularity: low entropy circular approaches

Circular Economy was chosen as a reference as it is currently widespread both in academic professional and citizens communities as a concept for the economic-social-productive restructuring of society in the face of climate change. This allows the contribution to be positioned in an expanding field, with growing possibilities of dissemination and discussion of the proposed contents and practices.

The literature on the circular economy presents a variety of approaches to dealing with waste material, which are referred to as 'R's because of the emphasis on the prefix "Re" that precedes each action. These approaches to treating waste resources are organized hierarchically according to their energy use. In particular, the authors refer to a framework composed of 9 R's and synthesized by cross-referencing different sources (Potting et al., 2017; Reike et al., 2018) and including the following Rs: Refuse, Reduce, Resell/Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover energy, Remine.

As developed by Blomsma & Tennant (Blomsma and Tennant, 2020), within the spectrum of R's, circular approaches can be further ordered according to the entropy they generate. High entropy approaches to value the material for its chemical and physical characteristics, ignoring

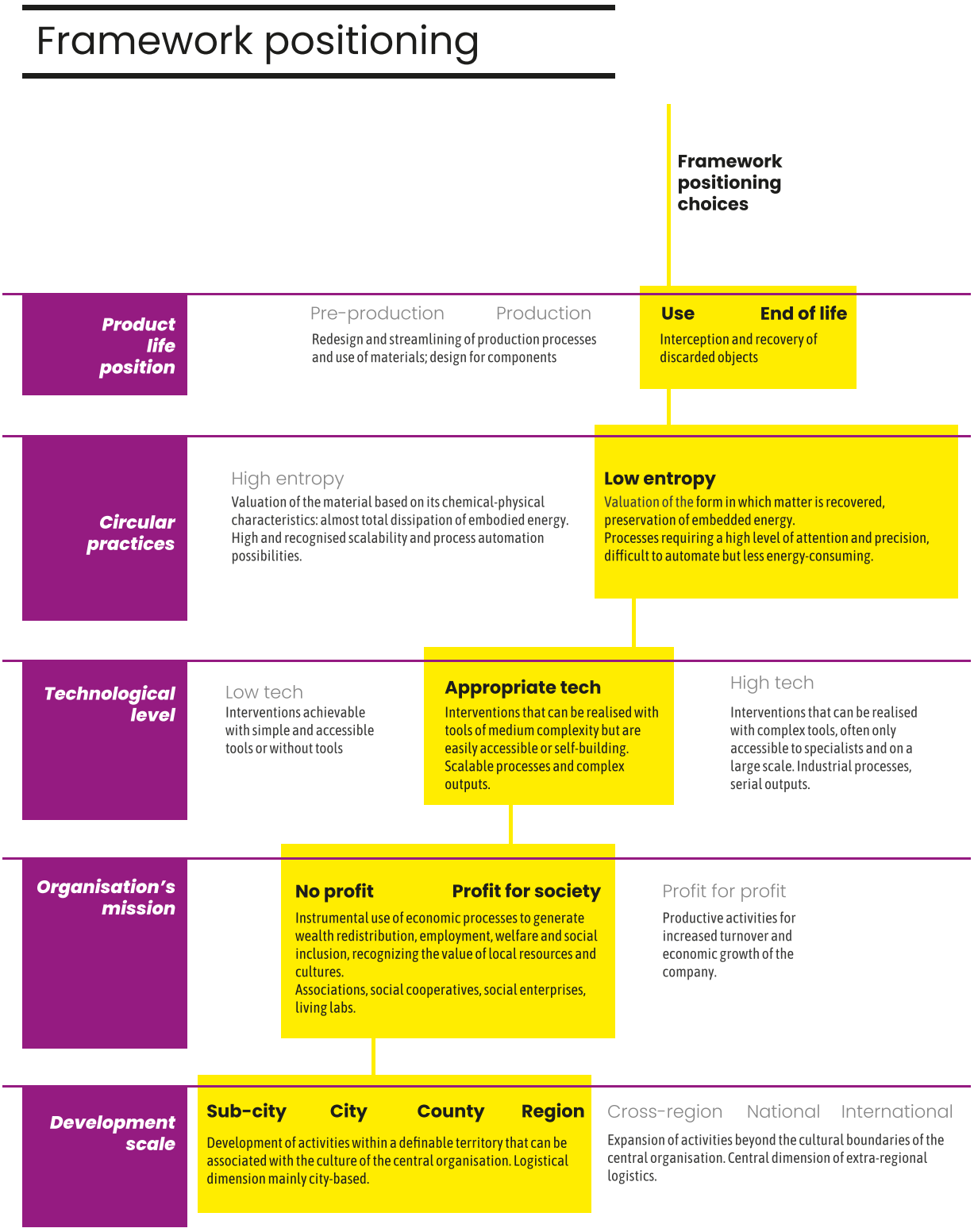

Fig. 3. Flowchart of framework positioning.
Visual representation of the positioning of the framework within the spectrum of the CE debate.

the form in which it is recovered and dissipating much of the energy embedded in it. These processes require limited attention and precision and for this reason, are more easily automated. Low entropy approaches value objects not only for their physical characteristics but also for their formal characteristics and meaning, preserving the objects' form and, consequently their inherent energy. Given the variety and complexity of the forms in which objects are recovered, these processes require careful and conscious selection and processing. Thus, low entropy processes are hardly automatable: being so, they are characterized by higher possibilities to generate employment opportunities than high entropy processes (RREUSE, 2015). Moreover, low entropy processes are also less impactful than high entropy ones at environmental level, being labour a "renewable resource", according to Stahel's principle of "substitute manpower for energy" (Stahel et al., 1981): "*By extending the service life of goods through reuse, repair, remanufacture and technological and fashion upgrading, the circular industrial economy employs labour-intensive activities of a nature similar to producing goods, to the detriment of energy and material intensive ones of producing basic materials. The circular industrial economy, replacing the production of new goods, thus substitutes manpower for energy, and local workshops for centralised factories, enabling local job creation and the reindustrialisation of regions.*" (Stahel, 2019, p. 13).

Low entropy circular processes can be represented by several of the R's previously listed. For the proposed DLRR framework however, only two Rs were chosen, namely "Repair" and "Reuse". This is partly to give the framework a succinct and easily understandable name and partly because they are sufficiently broad in meaning to include other low entropy approaches since it is possible – with an acceptable degree of approximation – for "Repair" to encompass "Reconditioning" and "Remanufacture", and for "Reuse" to also refer to "Repurpose" and "Resell".

3.2.2. Technological approach: appropriate technology

Regarding technological approaches, the objective was to identify a conceptual framework focused on environmental and social sustainability, and accessibility (economical and operational), as well as centred on a local dimension of development, promoting the potential of territories and attempting at responding to the critical elements emerging from them. With this goal, the concept of 'Appropriate Technology' was selected as the founding one of the framework, being consistent with these objectives and having a consolidated literature, diffusion and history.

The concept of "appropriate technology" (AT) was originally developed by the economist Ernst Friedrick Schumacher under the name "intermediate technology" (Schumacher, 1973). This concept refers to the use of technologies that enable the development of local-scale, energy efficient projects that use locally-sourced materials and are viable both economically and operationally for the populations directly involved[1] (Wicklein and Council on Technology Teacher Education (U. S.), 2001). It is important to underline there are no absolute "appropriate" technologies: in fact, technologies are appropriate in relation to the context in which they develop; the needs that emerge from said context; the materials offered by said context; and the characteristic cultural elements (Hazeltine and Bull, 1999). Considering these criteria, the AT framework appears to be consistent with the goal of creating socially inclusive, environmentally sustainable and bottom-up production chains based on the use of waste material. . Moreover, as emerged from the interviews with some social cooperatives operating in the waste management sector in Italy, which were carried out in the author's previous work (Campagnaro and D'Urzo, 2021), waste is very often freely or cheaply available, and can be locally sourced, avoiding complex and environmentally impactful logistics.

3.2.3. Social equity and sustainability: the social & solidarity economy and the care-centred economy

As discussed in the introduction, the aim of this paper is to contribute to the construction of a CE sub-paradigm that promotes equitable social development, rooted on the objectives of environmental and economic sustainability. From the literature review on economic models of equitable and sustainable development, the concept of Social & Solidarity economy emerged as particularly interesting given: its diffusion; the amount of material and reflections on it; its open, adaptable and inclusive character. It was also chosen to associate SSE to the concept of "Care-centred economy", which besides having many points of contact with the SSE places the accent on "care", which is particularly consistent with the low entropy circular activities (reuse and repair) on which the paper focuses, which precisely involve a high level of care and attention to recovered materials and products.

The concept of social & solidarity economy (SSE) has no universally accepted definition. It is variously interpreted as *"an alternative to capitalism and other authoritarian, state-dominated economic systems"* (RIPESS, 2015) and a "*concept designating enterprises and organizations, in particular cooperatives, mutual benefit societies, associations, foundations and social enterprises, which have the specific feature of producing goods, services and knowledge while pursuing both economic and social aims and fostering solidarity*" (ILO Regional Conference on Social Economy, Africa's Response to the Global Crisis, 2009). As anticipated below, another useful concept in that context is the "care-centred economy" (CCE): an economy that does not exclude monetized and marketized exchange, but in which these are *"no longer forms the core of economic activity. It is linked back to the subordinate function of distributing surpluses which was rightly ascribed to it in the Aristotelian construction of the world; now, they must be measured by the standard of whether they actually achieve what they purport to achieve."* (Praetorius, 2015, p. 84). This could translate into the goal of "civilizing" the market economy, introducing the concept of public and mutual benefit rather than individual enrichment, and putting people and environment at the centre (Bruni, 2010).

3.2.4. Design and innovation: the design-driven innovation approach

We envisage DLRR as a design approach rooted in the principles of Design-driven innovation, as understood by Verganti (Verganti, 2008, 2009, 2010). However, our first conceptualization of the transition toward a low-tech circular economy originates from the term "Design-led repair", for which we are indebted to the research group Repair Design (Repair Design, 2021). A quantitative analysis of the literature on these topics[2] showed that the terms "Design-led" and "Design-driven" are effectively synonyms and can be defined as *"[…] the tools and approaches which enable Design Thinking to be embedded as a cultural transformation within a business."* (Bucolo and Matthews, 2011 in Wrigley, 2017). "Design thinking" is defined as *"the way designers' think and work to solve problems, typically from multiple perspectives, iteratively improving possible solutions"* (Wrigley, 2017).

"Design-driven innovation" (DDI) is defined by Verganti as *"an innovation in which the novelty of a message and of a design language prevails over the novelty of functionality and technology"* (Verganti, 2008). DDI processes move away from user-centred and market-pull design, as well as solely technology-push design, favouring instead a Design-driven model that aims to radically reinterpret the meanings of the products and services developed, going beyond incremental innovation processes. The result is products and services that are not configured as answers to emerging market demands, but rather as proposals, new visions and interpretations of contexts and cultures, often at the limit of what could be acceptable and comprehensible to users: sufficiently innovative to represent a radical and anticipatory change, yet sufficiently familiar to

[1] A recent review of AT projects and how AT concepts are translated into reality can be observed in the proceedings of the 9th International Conference on Appropriate Technology (Trimble et al., 2020).

[2] Results of a research query on terms "design led" and "design driven" through Scopus database can be obtained at this link: https://cloud.disroot.org/s/w5kR6TjMtyj6o7i.

be accepted and understood by users (Verganti, 2009).

DDI processes therefore focus on the observation and interpretation of sociocultural contexts and the languages that develop within them. This requires a continuous process of observation and interpretation of the social culture of the contexts of interest, a constant presence within the evolutionary processes of meaning and language. A presence that is achieved through a continuous relationship between companies and those that Verganti defines as "interpreters", i.e. individual and collective figures who observe, read, anticipate and direct the sociocultural development of society: artists, universities and other bodies and figures who are enmeshed in social and cultural processes (Verganti, 2009). DDI processes therefore require a constant investment in establishing and maintaining relationships with different interpreters, rather than capital investments in technological R&D.

In detail, Verganti lists the following features of DDI (Verganti, 2008):

- It is a networked research process.
- It spans widely outside the boundaries of the firm, including users, but also and mainly several other interpreters.
- It is based on sharing of knowledge (about sociocultural models, meanings, and product languages).
- It includes an action of influencing and modifying (through the interpreters themselves and their influencing and seductive power) the sociocultural regime.

These characteristics are synthesized, by its author, in an approach aimed at generating products and services with high longevity (Verganti, 2009, chap. Escaping the Innovation Race: Product Longevity). The DDI approach appears particularly interesting if transferred into the sphere of circularity, due to its capacity for creating value and its suitability for entities with limited economic capital but high potential for innovation. The authors consider this as a key concept: aiming to maximize the value of waste objects and materials through meaning and language-focused innovation rather than technology-focused and market processes. This approach allows the development of breakthrough innovations even where economic and technical resources are limited. (Verganti, 2009, chaps. 5; Investments).

3.2.5. DLRR and which design?

In the framework proposed here, the design component is a fundamental element. Particular attention is given to two variables of the design action: the scale of the work that can be achieved and the differing expert approaches that can be applied. Taken together, these enshrine the complexity of the design by offering a schematic reference for evaluating projects level of action and assessing the outputs produced for the role they could play in a larger, more complex system and not only for their intrinsic qualities. This prevents a trivialisation of projects. Moreover, assessing the type of expertise of the project processes allows to evaluate the long-term sustainability and adaptability of the analysed projects.

Regarding the first variable, the main reference is the "design domain", codified by Jones & Van Patter (Jones and van Patter, 2009). As taken up by Jones (2014), "*Recognizing that contemporary designers are now involved in more complex problems and require further guidance than the doctrine of placements, van Patter* (Jones and van Patter, 2011) *advocates four distinct design domains. The four domains advance from simple to complex, with a series of learning and skill stages necessary for negotiating increasing complexity*". The design domains are marked by a progression of ambition and scope, with increasing emphasis on the creation of meaning and context and a simultaneous loosening of disciplinary and commodity confinements. They are defined by Jones as follows (Jones, 2014):

- 1.0: Artefacts and communications: design as making, or traditional design practice;
- 2.0: Products and services: design for value creation (including service design, product innovation, multichannel, and user experience), design as integrating;
- 3.0: Organizational transformation (complex, bounded by business or strategy): change-oriented, design of work practices, strategies, and organizational structures;
- 4.0: Social transformation (complex, unbounded): design for complex societal situations, social systems, policy-making and community design.

This reference thus makes it possible to clearly distinguish design action plans, facilitating the identification and organization of design objectives according to the level at which they are to be acted upon.

The second fundamental reference in the DLRR framework relates to the "diffuse" and "expert" characterization of design, codified by Manzini (Manzini, 2015, p. 37). In detail, the author defines diffuse design as a design action "[…] put into play by "nonexperts," with their natural designing capacity […]", in contrast to an expert design action carried out by people "trained to operate professionally as designers, and who put themselves forward as design professionals." (Manzini, 2015, p. 37).

This distinction is therefore useful for defining the genesis of the design action and identifying possible weaknesses. A diffuse design action, even if successful (e.g. reaching large audiences, producing economical value and profit …), could be at least partially the result of a fortuitous and random intersection between intuition and the context in which the project develops. These are elements that the promoters may not have full awareness and control of. This could make projects of a "diffuse" nature fragile in the face of changes in the social, economic and environmental contexts in which they operate. In contrast, professional designers are trained to build in advance a holistic and complex understanding of the context of action and a critical mass of the values that characterize it (Germak and De Giorgi, 2008). These elements make it possible to foreshadow possible directions of change, and to develop research, development and innovation processes consistent with these.

3.3. The design-led Repair & Reuse framework: synthesis of a theoretical framework

As stated above, the DLRR framework is shaped from a synthesis of these theoretical fundamentals.

The DLRR framework is articulated along two intersecting axes. The first axis relates to the design dimension. At one endpoint is Design as a discipline in its own right, including the methodological, transformative, adaptive and innovative dimensions that belong to it regardless of its specific field of application.

At one end is design intended as a discipline, including the methodological, transformative, adaptive and innovative dimensions that belong to it. At the opposite end is the specific scope of the design discipline on which this contribution focuses on, called " (re)production & maintenance", representing production and repair practices that require little in terms of capital and energy but are labour-intensive and can consistently add value to recovered objects by applying expert design knowledge. Following the principle of DDI, that expert design knowledge can go beyond restoration and repair. These practices aim to reproduce the previous meaning, function and use experience of the broken/recovered object. However, is possible that during the attempted repair process this aim is not completely fulfilled, leading to imperfect and incomplete results. This could be due to the original status of the recovered item, lack availability of knowledge and capabilities to correctly repair it and general repair processes difficulty. These imperfections could lead to objects that are diminished versions of their brand-new equivalents, thus making them less appealing. Instead, DLRR processes, informed with expert design knowledge and following DDI concepts, can valorise the broken/recovered status of objects and use it as a basis for a design aiming at an augmentation or transformation that imbues the objects with new meanings, languages and functions (Fig. 4).

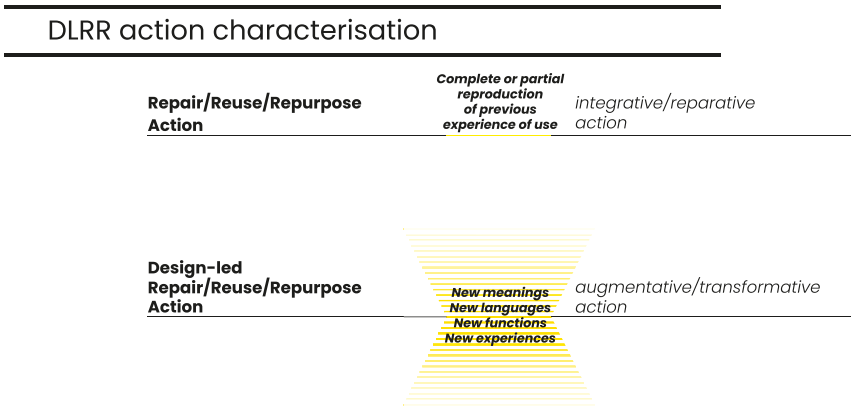

Fig. 4. The Design-led action characterization in repair and reuse practices.
Visual representation of the augmentative action of Design-led practices.

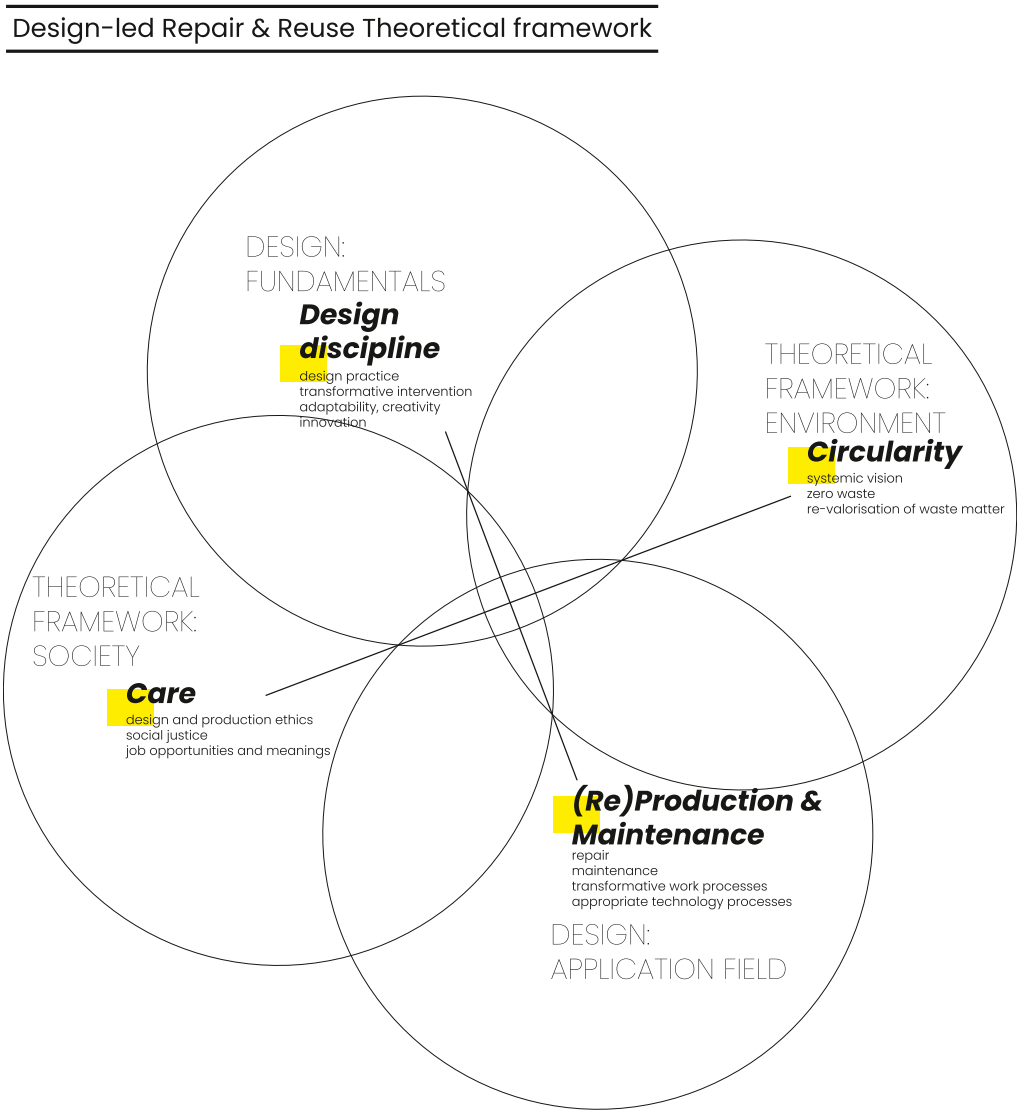

Fig. 5. The Design-led Repair & Reuse framework.
Visual representation of the two axes of the DLRR framework proposed, each with its key characteristics.

The second axis, transversal to the first, is that of socio-environmental reference frameworks. At one end is "care", the social component that relates to the principles of the SSE, the care-centred economy and the civil economy discussed in Section 3.4. This dimension highlights the ethical and moral implications of design and production processes, the search for equity and social justice, and a vision of work not only as a means of generating and accumulating capital but as an instrument of self-realization and contribution to the community (Zamagni, 2012). At the opposite end is the environmental component, "circularity", which relates to the main principles of the circular economy: a systemic vision that does not recognize waste, seeing only resources that can be put back into circulation by imbuing them with value.

The two axes and the scheme derived from them were built so to visualise the theoretical framework proposed in this paper and its objectives: the establishment of a design vision focused on low-entropy circular processes, to be realised by building a balance between positive social and environmental impact resulting from such processes (Fig. 5).

3.4. Design-led Repair & Reuse framework: design and practical directions

Having defined the theoretical structure of the framework, we define three possible areas of intervention. These areas revolve around the discipline of design and the designer as a figure capable of generating innovation scenarios, with mediating and organizing skills, who can suggest and apply methods to research and the development of products and services.

The three areas are organized according to the domains of design as defined by Jones and Van Patter (Jones and van Patter, 2009; Jones, 2014) (Fig. 6). The first two areas fall within the spectrum of domains 1.0 and 2.0, ranging from the creation of products at the craft level to the development of complex products and product-services, characterized by overlapping semantic levels.

The first area relates to technologies and processes, in which design can act on the level of technological appropriateness, the possibilities of scalability and the ways to make transformation processes and technologies accessible and sustainable both operationally and economically to the entities covered by this research. This entails investigating modes of adaptation and technology transfer, and the designer's roles in developing and/or accompanying them.

The second relates to semantics and thus has to do with languages, forms, meanings and anticipation of the perceptions that a product or service might generate in its users. It therefore means investigating and developing the languages and meanings inherent in reuse and repair practices and in the products derived from them, and on how to communicate them to their potential audience.

The last area falls within the spectrum of domains 3.0 and 4.0, which include complex changes related to a specific context, from a single organization to the whole of society.

The area within this zone is that of strategies and visions/perspectives, and concerns the role of design in defining complex elements such as the mission and organization of an entity on various levels, from the desired social-environmental-economic impact to logistics and supply chains, and the desired scale of development. It therefore means defining and organizing possible supply chains and material flows, business models and logistics (Fig. 6).

4. Results

4.1. Design-led categories definition

After the definition of the DLRR characteristics, the construction and

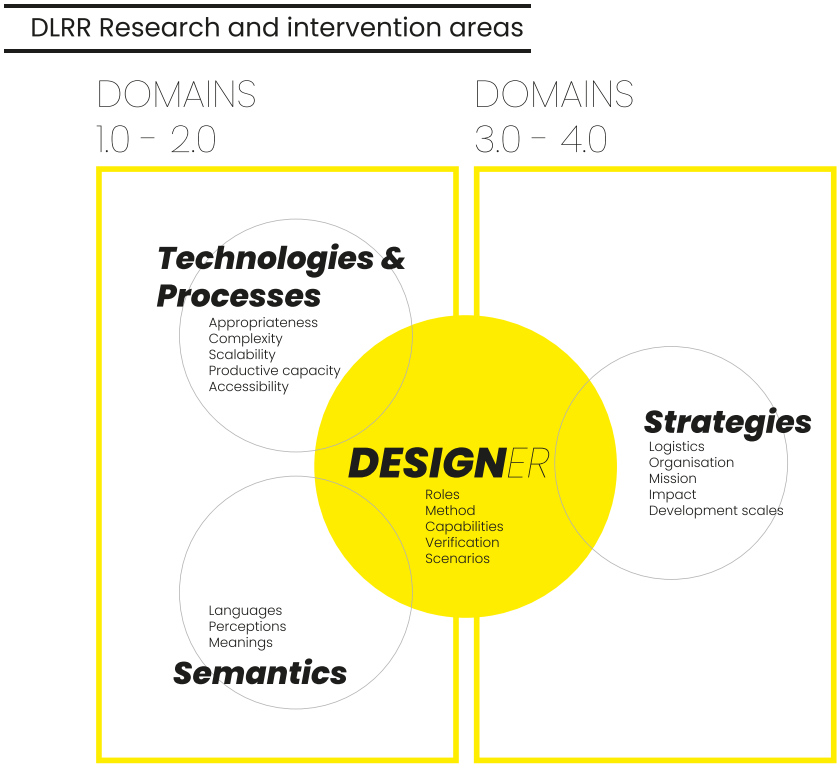

Fig. 6. DLRR framework design domains and intervention areas.
Visual representation of three possible intervention areas of the DLRR framework and their belonging to Jones and Van Patter's Design Domains.

analysis of the complete database of case studies was carried out. The theoretical framework developed in the previous section was cross-referenced with an initial batch of 30 cases, in order to have a first concrete verification of the outlined principles against actual entities and highlight recurrent elements among the different cases. It was decided to limit the first run of analysis to 30 cases out of the total 78 in order to streamline the process and check if any recurrent elements in a limited number of cases remained consistent and valid even when compared with the entire sample of selected cases. This process led to the definition of three characteristics of an applied DLRR approach:

- Explicit and asserted design component: projects and entities that make explicit reference to the field of design as a practice and discipline capable of multiplying added value in product development, and/or that have present within them figures professionally trained as designers;
- Attention to design as a system and a multilevel concept that exists beyond the individual product and touches on contexts, cultures and communication. This category includes projects that show a holistic consideration of design, relate to the local culture, and care for communication as a design aspect of equal importance to production;
- Research activities related to supply chains, technologies, languages and activities with a systematic, formal, organized character; projects that show a systematic and organized interest in research and in-depth study activities concerning formal languages, technological solutions and possible new flows of materials and supply chains, including experiences of collaborations with external bodies (universities, research centres, etc.) for research and development purposes.

Cases were considered as having a DLRR approach if they had at least one of these three characteristics. The choice is due to the fact that each of these characteristics originates a conscious, methodical, precisely directed design approach, that can potentially be extended to other fields of action of the considered entities. The presence of even just one of these characteristics thus identifies a conscious design approach as an element that can potentially make the entity more sensitive to external and internal feedbacks, more adaptable to the context and more capable of activating innovation processes.

4.1.1. Case studies examples

With the aim of facilitating the understanding of the logic of the case study analysis, in this subsection a summary analysis of two indicative cases is proposed: one considered markedly non-DLRR and another considered markedly DLRR. Each was analysed by relating it to the three characteristics identified in section 4.1.

- **Non-DLRR case study example**: "La Cartonera" ("La Cartonera | Atlante," n. d.)'La Cartonera' is a project active since 2013 in the production of jewellery made from recovered paper and cardboard.

  - o **Explicit and asserted design component:** the project doesn't include neither professional figures trained in design practice, nor explicit references to design practice, culture and methodology.
  - o **Attention to design as a system and a multilevel concept:** the production of "La Cartonera" doesn't appear to be emerging from an in-depth design research process on cultural, semantic and functional elements, but rather to be driven by the personal flair of the authors. The communication aspects emerge as clearly secondary to the production aspects of the artefacts: a coherent brand communication project is absent and the only available reference is a social page.
  - o **Research activities related to supply chains, technologies, languages and activities with a systematic, formal, organized character:** no systematic and formal reflections on languages and production chains emerge. The project appears based on an initial intuition (the use of waste paper) of which no further insights are described in terms of possible scalability, meanings, supplies and supply chains.

- **DLRR case study example:** "Laboratorio Linfa" ("Laboratorio Linfa, " n. d.)'Laboratorio Linfa' is a design studio that makes and repairs furniture from reclaimed wood.

  - o **Explicit and asserted design component:** within the studio there are several figures professionally trained in the practice and culture of design. There are also explicit references to a mature design culture driven by research and gathering of design context-related knowledge.
  - o **Attention to design as a system and a multilevel concept**: the entity demonstrates an explicit focus on the needs, potentials and culture of the area in which it is. In addition, direct references to contemporary currents of thought and socio-cultural trends also emerge, demonstrating a conscious cultural positioning of the project. The communication aspects are taken care of in the same way as the production aspects, with the presence of a clear and coherent coordinated identity project.
  - o **Research activities related to supply chains, technologies, languages and activities with a systematic, formal, organized character:** the various projects realised by the entity demonstrate a conscious, multilevel and explicit attention to the characteristics, potentials and criticalities of the individual project sites: from the possibility for activation of local supply chains for building materials to research about formal languages consistent with the final use of the products.

4.2. Analysis of design-related data emerging from the database

The selection led to the inclusion in the database of 78 cases, consisting of entities active in circular processes with low entropy and appropriate technology. Of these, 78, 43 included an explicit social mandate in their activities. This fact is reflected in the type of organization: in fact, more than half were entities with deep interests in the social development of local areas and mandates that are not solely focused on generating profit (associations, social enterprises, social co-operatives). The number of social co-operatives active in this field also confirmed the authors' previous research in which the central role of social co-operation in waste management in Italy emerged (Campagnaro and D'Urzo, 2021) (Fig. 7).

Regarding their distribution among the four design domains, most projects were concentrated in domain 2.0: complex products and

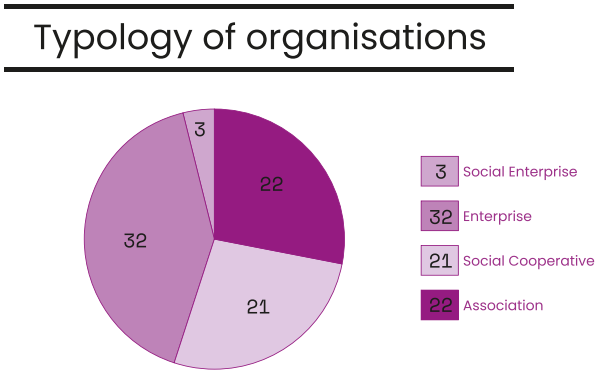

Fig. 7. Organizational typology data.
Visual representation of the proportion of each type of organization in the database.

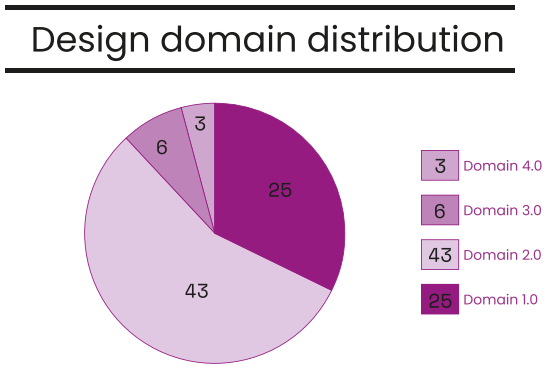

Fig. 8. Organizations' distribution among design domains.
Visual representation of numbers of organizations in each design domain.

services. This was followed by domain 1.0, simple products and craftsmanship. Domains 3.0 and 4.0 showed a limited number of entities, which is understandable considering the inherent complexity of these domains (Fig. 8).

Of the 78 projects, 55 were considered Design-led. Of these, 35 showed an expert design component, and 20 had a diffuse design component. Of the categories belonging to a Design-led approach, the most common was that relating to research activity on supply chains, technologies and languages, with 41 records. This was followed by the focus on design as a multi-level system with 35 records. Only 20 of the 55 projects considered Design-led explicitly claimed to have a design component (Fig. 9).

5. Discussion

Most entities cross-referenced with DLRR present approaches that fit into the framework. This fact highlights how the DLRR approach, as defined in Section 3, presents an effective lens for examining entities that already exist in this field. The existence and persistence of the activities analysed that can be defined as Design-led, some of which have been continuously active for more than ten years, shows how this approach can really be considered a lever for an alternative and complementary development to the more technocratic models emerging from the debate on CE. Furthermore, a comparison of entities that can be defined as Design-led with those that do not show how such an approach can constitute a crucial and substantial element in an organization's ability to act effectively in the market, positioning and enhancing the value of its products. On the whole, the Design-led entities largely confirm the characteristics used to define and structure the database (Section 4.1), showing:

- A higher formal quality of products compared to other entities. These products appear to be developed by expert knowledge and the result of research, and are not the result of an impromptu or unconscious design action;

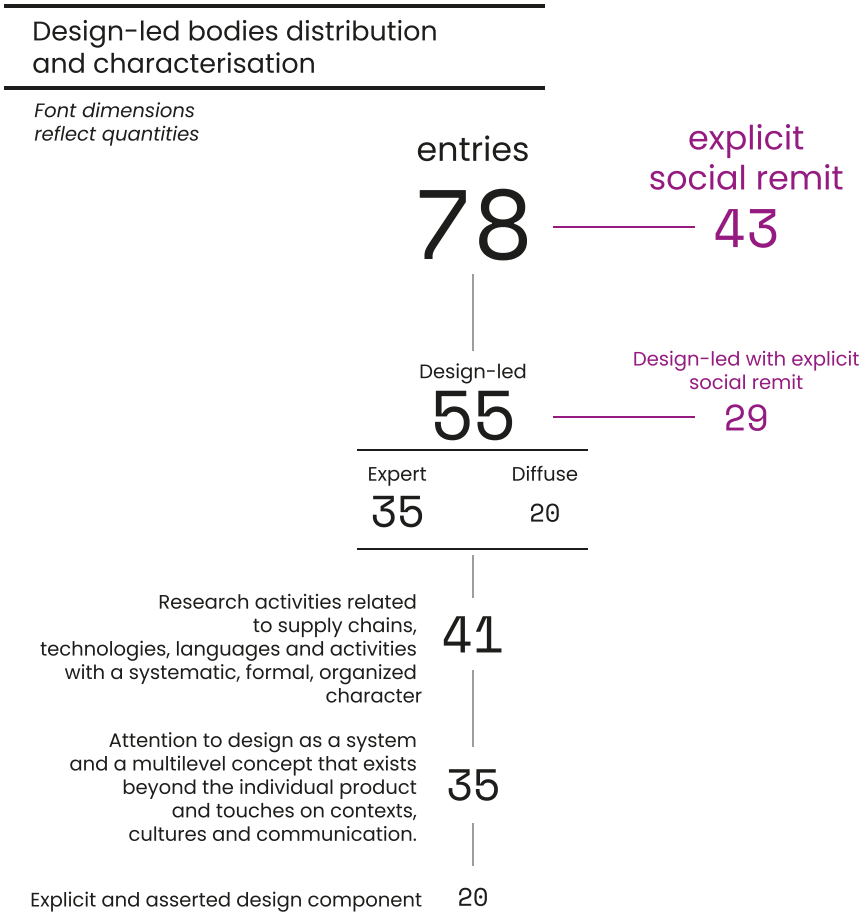

Fig. 9. Design-led organizations' characteristics.
Visual representation of the characteristics of the Design-led bodies in from the database. Font dimensions reflect quantities.

- A high degree of coherence and depth in the choice of formal languages and meanings associated with the products, which demonstrates a synthesis between technical and sociocultural elements;
- Continuous and systematic research on a technical and organizational level, expressed in innovative solutions and collaborations with local research bodies and related entities; these reinforce networking activities and the identification of new opportunities for social and commercial activities;
- A profound and continuous attention to the communication plan, represented both by a web presence and its formal and communicative quality, as well as the characterization of packaging, branding and other product marketing actions.

In today's extremely competitive market, these characteristics seem to allow a more effective and incisive commercial action, increasing the possibilities of development and market adaptability of the entities that present them, especially in product sectors currently subject to saturation (e.g. clothing and furniture, two of the most populated sectors by the cases analysed).

Nevertheless, among the entities considered to be Design-led, those that explicitly refer to a design culture and discipline are a decidedly small number (20 out of 55), even considering the predominance of design components that can be defined as experts among Design-led cases. This may indicate that although the approach exists in practice, it is not explicitly and consciously recognized and codified. This element could represent a fragility both at the level of communication, promotion and valuation of its activities, and at the level of organizational and economic sustainability.

Concerning the communication aspects, explicitly linking a Design-led component to the developed products allows them to be associated to the imagery and language commonly conjured up by the word "design". Although these references are often the result of stereotypes and superficial observations, they nonetheless make it possible to broaden one's target audience and imbue the product with higher perceived quality, especially in sectors historically associated with design (such as furniture and clothing).

Regarding the aspects of organizational and economic sustainability, the absence of an explicit Design-led approach may mean the absence of a structured methodical attention to the evaluation, analysis and development of design scenarios that can be adapted to social, environmental and market evolutions. This can lead to a loss of innovative drive in the event of changes in the target market or the emergence of competitors. This element was previously found by the authors to apply in particular to social co-operatives, which, having exhausted their innovative drive and not introducing a critical and systematic design component, entered a severe crisis due to tough competition to which they struggled to respond.

It also emerges that more than half of the cases examined, and 29 of the 55 Design-led cases, presented an explicit social mandate. This highlights the compatibility between an approach such as the one proposed by the framework and organizations belonging to the third sector, which often have limited economic and operational resources but compensate for these weaknesses through a high capacity for adaptation and a propensity to innovation. The DLRR approach can therefore contribute to consolidating, strengthening and expanding the presence of such organizations in the circular economy.

6. Conclusions

The objective of this paper was to outline a framework for an approach that is complementary to the mainstream approach in the debate on circular economy. This approach fosters a bottom-up local development of circular economy processes that are viable for organizations with limited capital and operating resources. By promoting low entropy and labour-intensive circular practices, this approach favours the creation of jobs and the reduction of energy and capital expenditure, and it aims to create innovative products and services with high longevity (Verganti, 2009, chap. Escaping the Innovation Race: Product Longevity). Such outputs are the result of a Design-driven approach, which promotes creativity, innovation and adaptability and optimizes the relationship between resources used and value produced. The characteristics of this approach emerge as particularly important in relation to the variability of forms and materials that can be addressed in low-entropy circular processes, in which "form follows availability" (Brütting et al., 2019; Josefsson and Thuvander, 2020).

Therefore, the concept of DLRR was introduced as a theoretical framework, drawing on concepts and practices such as Design-driven innovation, social & solidarity economy, appropriate technology, and low entropy circular practices. Moreover, the framework relies on the concepts of design domains (Jones and van Patter, 2009; Jones, 2014) and expert/diffuse design (Manzini, 2015) to contextualize and orient design action.

A desk analysis of case studies focused on Italy substantiated the theoretical framework. It showed how the principles expressed were effectively reflected in the daily practice of multiple organizations within the circular economy. However, no theoretical reference framework can identify and consolidate such circular approaches.

The coding of such a framework can therefore be useful to:

- Consolidate a complementary circular approach in the CE debate, in order to foster more equitable and sustainable alternatives to those more technocratic emerging from the debate on CE;
- Promote the dissemination of this circular approach among entities that have a potential interest in circular processes;
- Strengthen the actions of entities that are already engaged in design-led repair and reuse by deepening and making explicit the Design-led component, so as to strengthen its capacity for innovation and adaptation;
- Strengthen the action of non-DLRR entities by introducing a methodical and expert design approach that systematizes and enhances their transformative processes and the outputs generated by them.

Design Driven Innovation processes can be an effective tool to create products with a strong identity and market positioning potential, without costly investments in technological research and development processes that could potentially be accessible only to entities with substantial capital. The DLRR framework put these DDI processes within the context of low-entropy circular practices such as reuse and repair, combining the qualitative innovation potential of DDI processes both with the environmental impact reduction and job generation potential of these practices.

Some points about the designer's role can also be elaborated:

- Collaboration, continuous accompaniment or the "embedded" presence of the designer can strengthen the entity from within and potentially also redesign its organizational structure according to the new supply chains and experiments;
- Where project collaboration is impromptu and relates to only a single supply chain/product, a designer can create a Design-led supply chain that can be managed autonomously by entities without an in-house designer.

With this paper, the authors aim to contribute to the debate and promote reflections, both on the circular economy – by systematizing approaches that can foster this paradigm in a more plural, inclusive, fair and eco-friendly sense; and on the theory and practice of design – by shaping a perspective that encourages the involvement of designers in the CE beyond the product development phase, and by promoting their capabilities to "revalue, reshape, strengthen and extend what exists" (Crocker, 2018, pt. Reuse and the co-creation of value).

In doing so, we note some limitations of the present work:

- The geographical area of reference was limited to Italy for reasons of practicality, as the primary database from which the data was extracted was for Italy alone. However, it would be interesting to expand the research at least across the European continent, since this is in the common framework of the European Union's circular economy policies;
- Since this is a semi-quantitative analysis aiming to highlight or refute the existence of a theoretical approach in reality, the research did not go into the details of individual cases. This exploration might prove useful in a separate forum to enrich the approach theorized here with details, practices and reflections;
- The database used is populated on a voluntary basis and may be susceptible to errors or inaccuracies. However, for the purpose of the contribution, it is deemed sufficiently reliable.

Building on the reflections and data presented in this contribution, the authors look forward to continuing and deepening the investigation of the DLRR framework, especially referring to the possible applications and the sustainability of DLRR projects and production chains.

Research Data

- The database on which this contribution is based can be retrieved at this link, in Microsoft Access formathttps://cloud.disroot.org/s/faM3HM9qgDCb4fi
- Circular case study research referenced in section 3.1 can be retrieved at this link, in PDF formathttps://cloud.disroot.org/s/nnkDbpXfxyB8AmA

Credit author statement

Marco D'Urzo: Conceptualization, Methodology, Software, Validation, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization. **Cristian Campagnaro:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing - Original Draft, Writing - Review & Editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

We shared data as attachment and as a link at the bottom of the manuscript.

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