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Co-creation in circular cities: A design perspective

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Abstract
The release of the European Green Deal for the circular economy has made more and more municipal authorities embed circular economy principles into their visions and strategies, fostering the transitions towards a "circular city". Collaborative practices are becoming familiar, and concepts such as co-creation are entering the policymaking vocabulary, indicating that citizens and other actors are being asked to work collaboratively towards a sustainable future. This also means re-designing systems and services in cities with the aim of tackling emerging social and environmental issues and co-creating innovation paths. However, co-creation as an approach for implementing a circular economy at the city level has not yet been thoroughly investigated. The aim of this paper is to outline a framework that can be used by cities to identify new opportunities for co-creation initiatives from a design perspective. Using a three-step research process: (i) literature review, (ii) case study analysis and (iii) results interpretation, this paper delineates nine co-creation categories for sustainable development and identifies stakeholders and tools to be adopted by seeing circular economy principles as the ultimate goal.

Keywords: Circular economy, Circular city, Co-creation framework

Introduction
After the release of the European Green Deal for the circular economy, more and more municipal authorities are embedding circular economy principles into their visions and strategies, fostering transitions towards a "circular city". The circular economy concept —popularised by the Ellen MacArthur Foundation (EMF) – is not limited to businesses but entails a wide transformation that affects all the systems in which we live and act. In this scenario, cities can play a crucial role in fostering sustainability at all levels, from policies to a single person's behaviours. Many cities, especially in Europe, are embedding circular economy principles in their visions and strategies with promotion by the EU. Increasingly, the concept of a circular city is becoming familiar. The transition from a linear to a circular connection requires various stakeholders' participation, discussion and action. The municipal authority is no longer the only body that takes the lead and needs to work with other parties to realise a sustainable urban future. Although the concepts of co-creation and co-production are well explored in the literature, particularly in the field of management and service science, co-creation at the city level has not yet been thoroughly investigated.

By examining how co-creation activities operate in the current circular city from a design perspective, this paper aims to explore the opportunity of collaborative practices in circular cities. Hinging upon qualitative analysis, this research proceeds as follows: (i) literature review, (ii) case study analysis, (iii) results interpretation in a co-creation framework. First, the literature review examines the definition of a circular city and explores the concepts and forms of co-creation. Second, by examining six European urban contexts, forms of co-creation activities in frontrunner circular cities are analysed, and remarkable co-creation activities are highlighted. In particular, the research builds upon the "co-creation design framework" proposed by Frow, Payne and Storbacka (2011) and the ReSOLVE framework (EMF, 2015). The result is an integrative co-creation design framework, proposing nine co-creation initiatives that

summarise state-of-the-art circular city operations, including the stakeholders involved and the tools adopted. The research outcomes underline the importance of embedding co-creation practices in a circular city to support strategies, plans and concrete outcomes. Also, the research reveals the lack of a widely shared approach in such a transformation process to attain a circular city.

Overview of the circular economy in cities

The concept of the circular economy is introduced by EMF (2015): "restorative and regenerative by design and aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles" (p. 19). The notion and principles of the circular economy have been around for a long time. It can be seen as an umbrella concept encompassing various principles (i.e. industrial ecology, biomimicry and cradle to cradle). The circular economy relies on three fundamental principles (EMF, 2015): (1) preserve and enhance natural capital; (2) optimise resource yields; and (3) foster system effectiveness. In addition, the circular economy contributes to the delivery of at least 12 Sustainable Development Goals (SDGs) (United Nations, 2015) at both the local and global levels. In particular, a circular city relates to Goals 11, 12 and 13, which are about making cities safe, resilient and sustainable, as well as taking urgent action to combat climate change and its impacts. For example, Helsinki is the first city in the European context to integrate its circular economy strategy into SDGs, representing their ambition to achieve a permanent positive change (City of Helsinki, 2019).

However, although the definition of a circular city is weak, the objective of the circular economy strategy is clear. "A circular city aims to generate prosperity and economic resilience for itself and its citizens while decoupling value creation from the consumption of finite resources" (EMF, 2017, p. 7). A circular city embeds the circular economy's principles across all its functions, establishing an urban system that is "regenerative and restorative by design" (EMF, 2015). Prendeville, Cherim and Bocken (2018) interpret a circular city as an element in the larger goal of developing a future-proof city that practises circular economy principles to close resource loops in partnership with the city's stakeholders. Girard and Nocca (2019) see a circular city as a metaphor for an ideal space where ecological crises and social inequalities are eliminated. The circular economy provides cities with an excellent opportunity to face tough challenges, as specified by activities that may occur at various scales. Considering this, the circular economy should be adopted into policy development and implementation at different scales (EMF, 2015; EU, 2020; OECD, 2020). The ReSOLVE framework (EMF, 2015) turns three key circular economy principles into six practical actions to generate circular strategies and initiatives. However, the ReSOLVE framework is outlined from a business perspective and is not entirely suitable when applied to the urban context. The circular city framework (CCF), which is based on the ReSOLVE framework delivered by Prendeville, Cherim and Bocken (2018), combined with bottom-up and top-down interventions (Krauz, 2016; Ghisellini et al., 2016; Lieder & Rashid, 2016), expands the ways in which the circular economy could be put into practice in an urban environment.

Inside a circular city, hybrid spaces (Panzar & Willig, 1981) are needed that connect diversity and create a bridge between different actors as they occur within the arena of public-interest services (Selloni, 2017). Usually, such hybrid spaces are enabling platforms (Jegou & Manzini, 2008), namely, virtual or physical spaces where inspiration, exploration and discussion arise. Involving a group of citizens and other actors in collaborative processes is crucial to facilitating decision-making and developing solutions. Apart from digital platforms, part virtual and part physical spaces provide social and spatial areas for learning and experimenting, which are seen as being convergent with the circular economy (Ede, 2016). Enabling platforms like Urban Living Labs and Fab Labs allow stakeholders to team up and build up a strong network that is tightly connected to the city administration. A prominent example is the industrial area in

Amsterdam, Buiksloterham, where the whole district runs as a large-scale living lab, aiming at achieving total self-sufficiency and circularity (Steen & van Bueren, 2017).

A few challenges have arisen in previous research regarding the implementation of the circular economy in cities. One of the barriers claimed by Prendeville, Cherim and Bocken (2018) is that there is an unbalanced way to involve stakeholders. Authorities place too much emphasis on leading businesses to guide the civic society. Conversely, the term "smart" frequently appears in circular cities' literature about the use of new technologies such as sensors or digital platforms (Girard & Nocca, 2019). Although digitalisation is crucial for the urban transformation of the great metropolis (i.e. economic restoration and social cohesion), the benefit is maximised only when the social context is considered. Even though the implementation of the circular economy in cities is proliferating, research shows that many municipalities identify themselves as a circular city without comprehensive knowledge about it (Prendeville et al., 2018).

Consequently, there is a need to accelerate the transition towards a sustainable urban future with a clear framework. Progress towards the future-proof city needs greater participation for sharing the responsibility. Human-centred approaches are crucial for such cultural shifts across various government and stakeholder levels. The design's nature provides positive directionality about the future and proactively contributes to what will come about next (Fuad-Luke, 2012). From design's contribution, it is important that best practices, processes and tools can be developed and spread in various contexts. In this scenario, services and systems need to be transformed to meet the main current challenges, and practical methods are required to co-create with different stakeholders.

Designing co-initiatives in circular cities

Recently, municipalities have adopted new strategies to involve people in policymaking and public services for people-centred solutions (OECD, 2019). There is an increasing need to develop collaborative knowledge that supports a whole-of-system view and transformational change at multiple scales. This reveals an emerging focus on co-creation in actor networks (Åkesson et al., 2016; Pinho et al., 2014), where the municipality has a leading role, consisting of coordinating researchers, practitioners, citizens, designers and other stakeholders in the co-creation process. Although interest in collaborative practices is gaining momentum, the specific means of co-creation in circular cities remain underexplored.

The academic discussion of co-creation is extensive. In design research, Sanders and Stappers (2008) define co-creation as "any act of collective creativity, i.e. creativity that is shared by two or more people" (p. 6). When applied to varied contexts, the concept of co-creation can underline the systematic principle for business and customers (Prahalad & Ramaswamy, 2004; Grönroos, 2012), the partnerships between public service and citizens (Voorberg, Bekkers, & Tummers, 2015), or the shared responsibility (Lelieveldt, 2019). Frow, Payne and Storbacka (2011) argue that the advantage of subdividing co-creation into precise forms is centring innovative co-creation opportunities. With this aim, they put forward 12 forms to improve firms' capabilities for co-creation. In addition, in their later research, *Managing Co-creation Design: A Strategic Approach to Innovation,* Frow, Nenonen, Payne and Storbacka (2015) propose a framework to help firms identify new co-creation possibilities. On the other hand, Oertzen et al. (2018) developed an integrative framework, and a detailed process was formulated to describe the specific forms of co-creating services, containing the five "co-" phases. Moreover, from the viewpoints of Ramaswamy and Ozcan (2018), "co-creation is the enactment of interactional creation across interactive system-environments (afforded by interactive platforms), entailing agency engagements and structuring organisations" (p. 5). The "interactional co-creation framework" developed by Ramaswamy and Ozcan (2018) stimulates thinking on both the means and the ends of interactive value creation in a broader way. Interactive platforms are

means where the potential value of participation will be generated in value co-creation, ranging from the perspective of the ends of experienced actors to empower actor networks with resourced capabilities. Above all, we witness the growing dynamics of co-creation accompanied in an increasingly interactive way.

In the private sector, co-creation influences customer satisfaction and loyalty and helps firms achieve a competitive advantage (Grissemann & Stokburger-Sauer, 2012). In this scenario, users are seen as an interesting source of product and service innovation (Prahalad & Ramaswamy, 2000; Vargo and Lusch, 2004). However, when discussing public services, these end users are citizens, namely a more comprehensive community with a wide variety of needs and characteristics. As one of the crucial actors, citizens become increasingly crucial in the public decision-making process (Voorberg, Bekkers & Tummers, 2015). More and more policymakers and decision makers are trying to adopt strategies to involve them as active players for growth and prosperity. Voorberg, Bekkers and Tummers (2015) identify three degrees of citizens' involvement in the co-creation process (which will be discussed in the upcoming section): (a) citizens as co-implementers (involvement in services, which refers to the transfer of implementing activities previously carried out by the government); (b) citizens as co-designers (involvement regarding the content and process of service delivery); and (c) citizens as initiators (citizens who take up the initiative to formulate specific services). They point out that since both efficiency and satisfaction are raised during the process, the goal of co-creation is the value produced in itself. Therefore, policymakers must enhance stakeholders' trust and acceptance. Even though the municipality, businesses and civil society have varying objectives in moving towards the circular economy, it is essential to encompass various levels of stakeholders, build synergies at the correct scale and minimise the future burden for society. For example, the Netherlands regards citizens as a major stakeholder in its revised circular economy roadmap due to the considerable contribution that they make in relation to sustainable consumption habits and behaviours (OECD, 2020).

Hence, design activities embody co-creation that are "typically carried out in groups, with roles involved in complex relationships" (Nelson & Stolterman, 2012, p. 290) for strengthening creativity, developing innovative solutions, and generating value. While there is a significant difference considering the extent of involvement and actors' role, value is created collaboratively with people (Akoglu, 2015). The adoption of co-creation activities in circular cities can bring different benefits, such as enhancing the awareness of environmental issues and encouraging new habits among a variety of stakeholders (Bačová et al., 2016; Jonker et al., 2018; Paiho et al., 2020). Based on these premises, this paper aims to explore the various forms of co-creation that can be adopted to foster circularity at the city level.

Research process and the first results

Previous research has already recognised the advantages that co-creation can bring about (Barczak, 2012; Frow et al., 2011, 2015). However, to better understand how co-creation is adopted in circular cities from a design perspective, a three-step research process has been undertaken: (i) a literature review, (ii) a case study analysis and (iii) results interpretation within the co-creation framework. First, a systematic literature review was carried out to explore the role of design in supporting the transition to a circular economy at the urban level and the increasingly active and interactive role that co-creation plays in the public sector. The objective is to understand the most noticeable co-creation forms inside circular cities and the practices used to support the transition towards circularity. Second, we carried out a case study analysis. The aim was to identify co-creation practices in circular cities and understand the explicit or potential contribution of the design in the processes of co-creation to have a wider view towards circular cities implementations. Focusing on the European context, the criteria for determining cities to be examined were: (a) defining themselves explicitly as a circular city; (b) implementing a systematised circular city strategy (circular

programmes/agendas at city/regional level instead of a single project); (c) engagement, involvement or participation are emphasised in a co-creation process with citizens; and (d) availability of information. According to the OECD (2020), four distinct levels of advancement towards the circular economy transition of cities are labelled, which are advanced, in progress, newcomers and not in place. Advanced means cities and regions establishing clear strategies or roadmaps and engaging diverse stakeholders. In progress are those cities and regions that have already applied for specific programmes and/or are starting their implementation towards the circular economy, following impromptu activities. In the cluster of newcomers, cities or regions explore options for implementation by recognising the circular economy's relevance and potential. The cluster of not in place was excluded in this research because of insufficient data and restricted documents.

To increase diversity within these three categories, we selected two cities for each group. Eventually, six cases were selected, including (alphabetical order) (1) Amsterdam (advanced), (2) Brussels (advanced), (3) Glasgow (in progress), (4) Gothenburg (newcomers), (5) Helsinki (newcomers) and (6) Ljubljana (in progress). The municipalities mentioned stress the collaborative manner of working with stakeholders to achieve the desired results. These contexts are then examined through the co-creation lenses to better understand how and in which part of the process the collaborative approach has been adopted. The third step consisted of interpreting the data collected through the literature review and case studies. The interpretation led to the development of a descriptive framework for listing co-creation initiatives in circular cities. In particular, this research built on the co-creation design framework defined by Frow, Payne and Storbacka (2011). By examining the evolving co-creation framework against existing literature-based theory and case studies, we identified nine specific co-creation practices in circular cities. Furthermore, this research outlines three additional categories that are not included in previous studies relevant to co-creation in circular cities: co-vision, co-prototyping and co-sense, mainly related to the strategic aspects of the co-creation process. Finally, the circular economy actions (i.e. regenerate, share, optimise, loop, virtualise and exchange) and the co-creation practices with actors and tools are integrated into the framework we propose.

Co-vision, co-prototyping and co-sense as co-creation activity categories: The first research result

The case study analysis was carried out first to understand how the co-creation categories that emerged from the literature review are being adopted in circular cities. Second, it contributes to understanding how co-creation supports the transition towards circularity at different stages, from the strategic level to the execution level. Based on Frow, Payne and Storbacka's framework, we initially considered the following co-creation practices: (1) co-conception of ideas, (2) co-design, (3) co-production, (4) co-promotion, (5) co-maintenance, (6) co-experience, (7) co-pricing, (8) co-distribution, (9) co-outsourcing, (10) co-disposal, (11) co-meaning creation and (12) co-consumption. By analysing the initiatives carried out in these six circular cities, some of the categories proved to be consistent with the urban level, whereas others were limited to business activities. Consequently, we streamlined the list of co-creation practices to the following: (1) co-conception of ideas, (2) co-design, (3) co-production, (4) co-promotion, (5) co-maintenance and (6) co-consumption. Also, another three practices were introduced to describe essential aspects that emerged from the research: co-vision, co-prototyping and co-sense. While they are not explicitly mentioned in the cases that we investigated, we consider them as strategic practices (see Table 1) as far as the realisation of a future-proof city is concerned.

Co-vision initiative

In the movement to achieve a future-proof city, co-creating a shared vision becomes crucial. Methods include enabling collaborative processes, creating awareness and, at the same time, raising hope amongst people. Building on previous research and case studies, it is evident that developing circular economy guidance systems and making the circular economy concepts knowable for citizens and other stakeholders is fundamental. Such practices may include showcasing the city's circular projects online, hosting awareness-boosting green events/festivals and running campaigns to encourage new habits. Likewise, creating a collaborative vision means supporting future actions and culture, e.g. reinforcing education and training for future generations to equip them with the necessary skills to act in a circular city (Jonker et al., 2018; Russell et al., 2020). With consistent goals shared by stakeholders, co-vision is the core of a city's entire transformational process. Moreover, co-vision can activate collective optimism, especially in the co-design process, and visualisation is a powerful means used by designers in this stage. As Sangiorgi (2011) points out, designers can work from the outside in, providing future visions and intervening more systematically from a higher level so they are considered essential resources. Thus, this research interprets co-vision as a shared vision among civic society and main stakeholders, which can vary from municipality to municipality, depending on the local context.

Co-prototyping initiative

Participatory prototyping is one of the main activities carried out through collective co-designing. Such a way of prototyping, no matter whether rapid or slow, can stimulate situations and create community awareness (Selloni, 2017). When applied to services, prototyping activity is about making services visible, to learn and communicate about services and identify them as a collaborative effort (Blomkvist & Holmlid, 2010). Prototyping is led by designers who possess the capability to design and develop mock-ups, physically or digitally, and can ensure a certain level of aesthetic and/or authentic quality (Selloni, 2017). These prototypes can be seen as an artistic intervention (Selloni, 2017), allowing people to experiment and communicate efficiently through physical or virtual mock-ups. Working as a team for brainstorming and taking decisions together is the typical design intervention type. As Selloni (2017) puts it, "creating service prototypes is necessary not only to test solutions but also to reinforce the idea of making services together within a community" (p. 153). Co-prototyping initiatives are mainly carried out in a real-world setting. For example, Urban Living Labs, Fab Labs, and maker spaces gather multiple stakeholders of multiple specialities, interacting as co-innovators for experimenting, creating and prototyping (Westerlund & Leminen, 2011). Building on the research of Selloni (2017), co-prototyping in this research is understood as two or more actors jointly collaborating to propose innovative solutions (products or services) and run them in a flexible and co-creative way with mock-ups or service rehearsals (Selloni, 2017).

Co-sense initiative

From the case studies, we found that co-sense activity is happening in "advanced" cities, where resources are concentrated, and economic and technology development are relatively thriving. The so-called co-sense activity, built on participatory sensing, has been promoted in recent years because of the widespread use of affordable digital equipment. Because of the advancement of information and communication technology and global social networks, participatory sensing has become popular. In the past, institutions benefited from the data collected by citizens by providing them with technological equipment. Nonetheless, nowadays, local problems are presented by grassroots initiatives in the community where civic groups actively take solutions and action. Considering this, practical skills are required to solve shared problems. These emerging challenges have led to rising interest in using design in participatory sensing technologies and cooperation programmes (Tangmunarunkit et al., 2015; Lukyanenko et al., 2016). Design, in this respect, allows the local community to participate in such a process with little top-down legislation and

informal bottom-up initiatives. In addition, knowledge exchange and co-creation are two crucial elements regarding environmental awareness enhancement and action adoption (Coulson et al., 2018), which can be done by conducting workshops and meetups to encourage participation and develop learning and knowledge in areas such as sensors, data visualisation and interpretation. As labelled by the authors, co-sense activity refers to two or more actors collaborating on using daily and readily accessible technology to detect and collect data for tackling common issues.

Co-creation initiatives in circular cities

In total, nine types of co-creation practices were identified, which can be divided into two main groups. First, regenerative co-creation (Oertzen et al., 2018) relates to new measures and co-creation forms in the early stages (i.e. in the strategic phrase) of the service development process. In this study, regenerative co-creation practices promote circular economy actions and trigger innovation within the circular city. To be specific, regenerative co-creation practices comprise co-vision, co-conception of ideas, co-design, co-prototyping, co-production and co-promotion, and they can foster new cooperation channels among different actors. Second, operative co-creation (Oertzen et al., 2018) refers to user-specific and service-related events that may occur several times, leading to incremental innovation. Operative co-creation practices encompass co-maintenance, co-consumption and co-sense. The following section describes the nine types of co-creation practices about the initiatives mapped in the six case studies mentioned above.

1. Co-vision

Depending on regional conditions, co-vision is a vision of the desired future shared by the municipality, civic society and related stakeholders. Usually, the city-level roadmap follows its national guideline. Taking a leading role in the circular economy transformation movement, the Netherlands' national goal is to be fully circular by 2050 and to cut down half of raw materials by 2030. Many community-owned circular economy initiatives in Amsterdam adhere to the national strategy. Brussels aims at resource efficiency to help stimulate the economy to boost entrepreneurship and create new employment opportunities. The city of Glasgow's vision is to become one of the world's first circular cities, creating a movement to inspire businesses of all sizes to innovate and become future-proof by adopting circular strategies (EIT, 2018). All six cities under investigation show their efforts to support co-vision activity. It is worth mentioning that Ljubljana has involved multiple stakeholders facilitating circular economy practices. For instance, open forums, green events and stakeholder engagement conferences are the main media in which municipalities can rely on communicating and sharing the same vision with other stakeholders for a sustainable lifestyle.

2. Co-conception of ideas

Co-conception of ideas refers to two or more actors collaborating on concept innovation. One large-scale crowdsourcing example is *Circular Glasgow*, launched by the Glasgow Chamber of Commerce. *Circular Glasgow* aims to engage local businesses involved in the production of major city events and conferences. This ongoing project promotes circular economy ideas related to global challenges by inviting individuals and businesses to contribute circular ideas within the events sector online. In the end, the challenge received 60 ideas from 13 countries, and these works are in progress to support the implementation of resultant ideas and solutions. Correspondingly, the call from *"Be circular—be Brussels"* launched by Brussels-Capital Region aims to support self-employed people and businesses in their creativity and develop economic activities that benefit the environment and local jobs. Innovative ideas have been collected from this call, and more than 40 companies and start-ups have been awarded financial and service support.

3. Co-design

Co-design refers to two or more actors/designers sharing their design perspectives, respectively, especially in the "fuzzy front-end" phrase. Co-design activities take place in all cities examined at various levels of involvement. Citizens explore possibilities and gain inspiration by co-design practices related particularly to collaborative workshops. Remarkably, the city of Helsinki appeared very active in co-design activities focusing on intelligent transportation. In the district of Jätkäsaari, designers engaged residents in solving local mobility challenges. Jätkäsaari offers a living lab and urban testbed for innovative mobility development in Helsinki. Numerous pilots, experiments and projects have been conducted in the lab, focusing on innovative mobility services, traffic safety, mobility data, and behaviour change. Residents are actively involved in living lab activities and a web-based survey concerning mobility challenges and people's opinions about the services. The results were elaborated on in four open workshops with the residents and traffic planners involved (Forum Virium Helsinki, 2020). A dedicated website (*jatkakokeilee*) was created to inform the ongoing process for residents and encourage their participation.

4. Co-prototyping

Building on the research of Selloni (2017), co-prototyping in this research means that two or more actors collaborate in proposing innovative solutions and running them in a flexible and co-creative way with mock-ups or service rehearsals (Selloni, 2017). For example, a model in the Smart Kalasatama district of Helsinki—the Agile Piloting Programme—has been developed to experiment with new services and technologies in a co-creative way. This programme engages companies, residents, the public sector and other stakeholders to experiment with new solutions responding to environmental issues in a real-life environment (e.g. city districts, schools, hospitals, etc.). The piloting teams prepared and co-developed their agile pilot within the urban lab. Agile pilots are fast experiments of early prototypes running for a maximum of six months. Moreover, a facilitated platform is available for collaboration with the whole ecosystem, aiming to learn as much as possible (Forum Virium Helsinki, 2020).

5. Co-production

Co-production emphasises an equal and reciprocal partnership (Boyle & Harris, 2009) between users while delivering public services. Co-production activity occurs in digital or physical spaces (e.g. Urban Living Labs, Fab Labs, maker spaces, incubators, innovation hubs, etc.), and distributed urban production systems, enabled by new technologies, are necessary to explore the potential for a new dynamic of the city. In the city of Amsterdam (the Buiksloterham district, where the Circular Neighbourhood Action Plan is implemented), a set of resources is available for local residents and developers to translate higher-level goals into everyday activities. Here, an entirely circular community called De Ceuvel is situated in the city. It is a participatory urban living lab of a self-sufficient community, where designers, enthusiastic citizens and other actors generate synergies and partnerships.

6. Co-promotion

Co-promotion is described as two or more actors collaborating on promotional activities related to a specific product, brand or entity. Examples include the municipality of the Gothenburg, which aims to strengthen its ability to push, co-operate, communicate and support the transformational work required to achieve the desired results with many stakeholders. On the other hand, Helsinki works towards finding, co-creating and demonstrating innovative, practical solutions that are climate-positive, smart with resources and improve people's wellbeing (EIT, 2018). Unlike the other five northern European cities in the case study, Ljubljana uses a different strategy to achieve a circular city. The title of European Green Capital has significantly strengthened Ljubljana's recognition worldwide and upgraded the city's brand. Twenty-four ambassadors were appointed to raise awareness among citizens, involving them in the process

of making Ljubljana more environmentally friendly (City of Ljubljana, 2016). It is clear from this case that forming and sharing ideas of the future is crucial for a successful and smooth process of co-creation.

7. Co-maintenance

In circular cities, co-maintenance is related to two or more actors sharing either the maintenance service or a core product or service. Co-maintenance stems from the concept of the repair café, operating within the framework of the Reuse Centre, which entails the involvement of experts in different professions (e.g. electricians, sewists, carpenters, etc.) and volunteers to help repair and refurbish products. Although repair café can be commonly seen in these circular cities, the large-scale Alelyckan recycling park in Gothenburg provides residents with a platform where they can sell their unwanted items and pick up some bargains amongst things that are judged to be useless or unnecessary by others.

8. Co-consumption

Co-consumption involves collaboration during usage, as actors employ their resources (physical, social or cultural) individually or collectively, when co-consumers determine and enhance their own consumption experiences. It is implemented widely in these six cities to reduce mobility demand by releasing developers from the high parking requirements currently in the area and investing in additional alternatives and shared mobility. To give an example, the city of Gothenburg consists of an exciting mix of sharing services (part of the Smart Map project) initiated by companies and civil society. Such services were created as part of an innovative civil-public partnership, which is a tool that maps the sharing economy in Gothenburg, including over 100 sharing initiatives, such as bike kitchens, co-working spaces, digital services, a toy library, mobility pools, clothes swapping days, etc.

9. Co-sense

Co-sense activity, as labelled by the authors, refers to two or more actors collaborating on using daily and readily accessible technology to detect and collect data. These types of activities are widespread in the cities of Amsterdam, Helsinki and Glasgow. Impressively, in Amsterdam, the Smart Kids Lab allows children to observe the environment (e.g. soil, liquid and air) by using small-scale tests and self-made sensors enjoyably. An online platform assists these young citizens to perform tests and helps them compare the results with downloadable materials. On the other hand, over the last few years, Glasgow—together with Innovate UK—has been developing several initiatives to demonstrate the technology potentiality offered by intelligent technology. In Glasgow, open data is utilised from various sources across the city; citizens can create or update their open dashboard from hands-on digital widgets (Glasgow City Council, 2021).

	Amsterdam	**Brussels**	**Glasgow**	**Gothenburg**	**Helsinki**	**Ljubljana**
Co-vision	x	x	x	x	x	x
Co-conception of ideas	x	x	x	x	x	x
Co-design	x	x	x	x	x	x
Co-prototyping	x	x	x		x	
Co-production	x	x	x	x	x	x
Co-promotion	x	x	x	x	x	x
Co-maintenance	x	x	x	x	x	x
Co-consumption	x	x	x	x	x	x

Co-sense	x	x	x	x

Table 1: Co-creation activities examined in circular cities.

Stakeholders and tools

As described above, all forms of co-creation initiatives rely on the active participation of two or more actors (Frow et al., 2015). It is crucial to have distinct roles, competencies and engaging platforms that make co-creation work effectively (Ramaswamy & Gouillart, 2010). Based on the literature and case studies, seven relevant actors and three leading engagement platforms were identified in the mutually beneficial co-creation practices. Seven actor groups were classified, including:

(1) Municipalities: the authorities act as promoters of integrated initiatives and interconnect resources with other actors. Following the scope of their circular economy strategy, government engages the broader society in circular economy activities. It tries to communicate with the public about its activities and environmental impacts (OECD, 2020).
(2) Business sector: businesses as enablers of new business models for implementing circular economy concepts to advance more inclusive evaluation of their supply chains (World Economic Forum, 2018); as content providers that foster sharing, reusing or recycling; and provide repair, maintenance and remanufacturing services.
(3) Knowledge institutes: academia and research centres with specialists are key partners contributing to creating circular Economic knowledge to promote educational purposes.
(4) Non-governmental organisations (NGOs): NGOs deliver on capacity-building projects and raise awareness of circular economy practices (OECD, 2020), e.g. creating an online circular observatory to share information on the circular economy and monitor citizens' level of engagement to promote reuse behaviour and raise awareness.
(5) Citizens: citizens are co-implementers involved in services that used to be carried out by the government; citizens behave as co-designers of the content and process of service delivery; citizens also act as initiators, taking up the initiative to formulate specific services (Voorberg, Bekkers & Tummers, 2015), e.g. residents provide repair, maintenance and remanufacturing services in their community.
(6) Local experts: accessible experts who are familiar with the local situation can help other actors by providing appropriate information and advice.
(7) Designers: designers contribute in several ways, from advocating cultural/organisational change to supporting specific collaborative processes, aiming at human-centred solutions. Designers' contributions are crucial for inspiring people and enhancing people's imagination and visions of a better future (Selloni, 2014).

On the other hand, the analysis of co-creation practices showed how the initiatives are supported and enabled by different engaging platforms. Effective co-creation typically requires an engagement platform (Ramaswamy & Gouillart, 2010), enabling actors to share their resources and adapt their processes. Platform is often used to refer to a complex network that enables innovation (Zahra & Nambisan, 2011). In some cases, the circular economy co-creation platforms are part of the municipal website itself. For example, the *Think Sustainably* digital service of Helsinki resembles a regular city guide but puts environmental sustainability as the primary factor (Aouf, 2019). In this study, an engagement platform is considered a tool for enabling productive co-creation, intentionally brought to the co-creation context by the leading actor. Three clusters of engagement platforms can be identified:

(1) Digital resources: refers to a digital application for interactions with diverse actors (Sawhney, Verona, & Prandelli, 2005) and coordination of strategies for promoting collaboration between different actors; sharing economy platforms, enabling a new form of co-creation for facilitating economic transaction and creating mutual benefits (e.g. car sharing software); and platforms provided by critical circular economy networks (e.g. EMF, C40, ICLEI, etc.) for co-producing and translating relevant knowledge.

(2) Physical resources: refers to spaces where collaborators can be brought together to contribute to co-design or co-prototyping activities. Physical spaces (e.g. Urban Living Labs, Fab Labs, maker spaces, incubators, innovation hubs, etc.) play an essential role in stimulating co-creation practices, including the municipality transforming iconic buildings into attractive platforms to facilitate co-creation culture in the metropolitan area.

(3) Events and festivals: green events and festivals are staged to encourage visitors to adopt more sustainable lifestyles and behaviours, usually financed and organised by local authorities (Mair & Laing, 2013). Green events are defined as a type of event characterised by the integration of sustainability guidelines into their planning, organisation and management processes (Tölkes & Butzmann, 2018).

In conclusion, leading municipalities collaborate with NGOs, knowledge institutes, local experts and designers to promote citizens' and businesses' acceptance and awareness of the circular economy through proper tools to refine the whole process and boost innovation. Additionally, designers can intervene to reduce the gap between top-down and bottom-up actions, playing the role of cultural operators (Manzini, 2015) that foster systemic and cultural changes. When involved in participatory projects, the character of designers is shifting from facilitators, translators, interpreters, guides and visualisers to provokers, triggers, change makers and actionists (Selloni, 2017). On the other hand, city stakeholders' concrete interventions need the support of engaging platforms, which are important for gaining insight and proposing ideas to make things come true eventually. Engaging platforms work as both physical/digital resources and goal-oriented events/festivals dedicated to co-creation activities and prototypying circular solutions in the cities. Based on the case studies, it is beneficial to apply co-creation to transformational practices for integrating people and resources.

A circular city co-creation design framework

This research provides insight from case studies and the literature, coming up with an actionable method to propose a shared co-creation framework for future circular cities. Municipalities have acknowledged the importance of cross-chain and cross-sector collaboration and have started to adopt co-creation processes based on regional differences (EMF, 2015). However, municipalities lack a shared approach—in terms of process and tools—to systematise the current knowledge. To fill this gap, we propose the circular city co-creation design framework (see Figure 1), which includes nine co-creation categories for sustainable development with the stakeholders involved, seeing circular economy principles as the goal. The elements constituting the framework are listed according to the emerging practices revealed from the case studies. The ReSOLVE model labelled by the Ellen MacArthur Foundation is regarded as the principle of carrying out a circular city in the circular city co-creation design framework.

The ReSOLVE framework aims to transfer the circular economy principles (preserve and enhance natural capital, optimise resource yields and foster system effectiveness) into six concrete actions, i.e. regenerate, share, optimise, loop, virtualise and exchange. The framework proposed by the authors includes seven

categories of potential actors (i.e. the municipality, businesses, knowledge institutes, NGOs, citizens, local experts and designers) that may engage in co-creation practices. Additionally, three main engagement platforms are identified and added to the framework—considered as engaging platforms—with the purpose of providing virtual resources, physical resources and green events/festivals for communication, participation, experimentation and further innovation. In the framework we propose (see Figure 1), nine practices are included and clustered into two major groups:

- Regenerative co-creation practices (i.e. co-vision, co-conception of ideas, co-design, co-prototyping, co-production and co-promotion) intensify the strategic part of innovation to facilitate the implementation of the ReSOLVE framework (EMF, 2015); and
- Operative co-creation practices (i.e. co-maintenance, co-consumption, and co-sense) provide implementation strategies, balancing top-down municipal power and bottom-up efforts from the private and public sectors within the regional area.

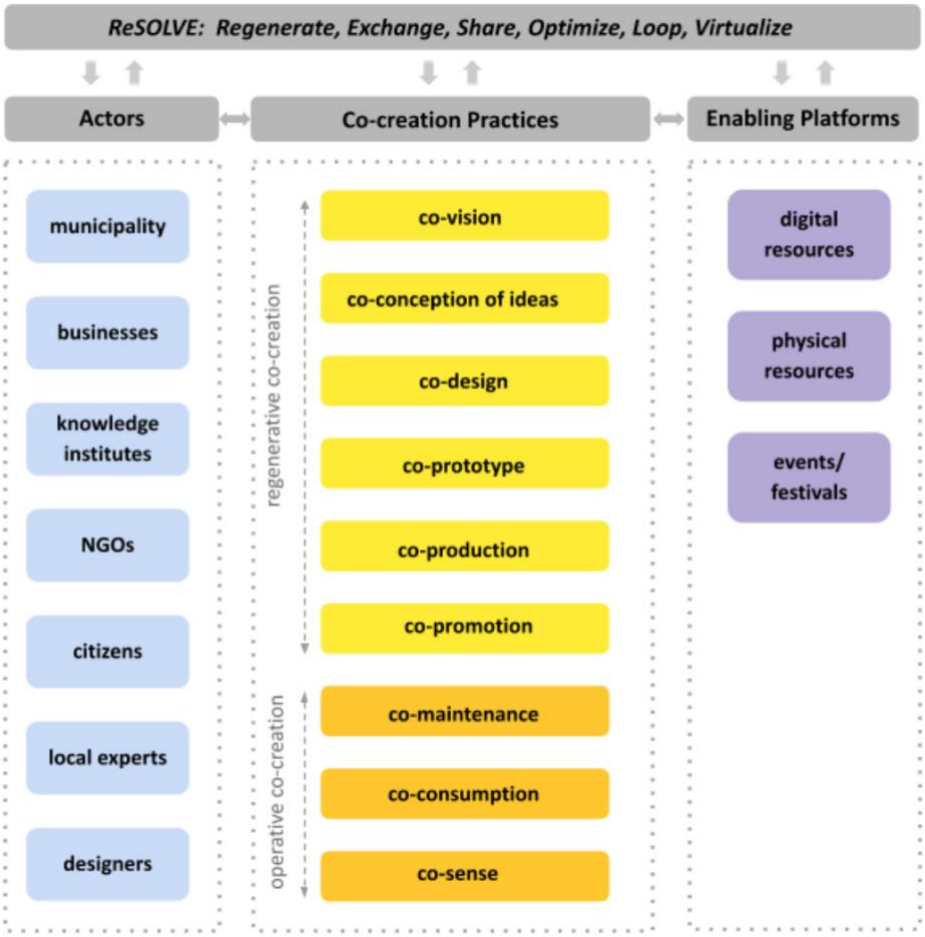

Figure 1: Circular city co-creation design framework, adapted from the ReSOLVE framework (EMF, 2015).

This framework generates potential circular economy activities, drawing co-creation design methods to inspire further innovation and boost circular economy imaginaries in cities. While previous research and municipal reports stress the importance of a collaborative manner and partnership, a feasible and thorough examination that can be adapted to different geographical scales is overlooked. Nine co-creation practices were grouped into two categories. To intensify the strategic part for further implementation, six regenerative co-creation practices were discerned. Co-vision refers to a clear vision shared by stakeholders in line with the city's comprehensive future strategy. As with Ljubljana's experience, multiple stakeholders

have been involved in realising a sustainable urban future. Co-conception of ideas refers to two or more actors collaborating on concept innovation; two typical examples can be seen from Glasgow and Brussels. Co-design is a creative process that refers to two or more actors sharing their respective design visions when co-creating solutions. An iconic example of large-scale co-design is the district of Jätkäsaari in Helsinki. Co-prototyping describes how two or more actors jointly collaborate to propose innovative solutions (services or technologies) and run in a flexible and co-creative way with physical mock-ups or service rehearsals (Selloni, 2017), such as Helsinki's Agile Piloting Programme. Co-production describes how two or more actors collaborate jointly in public service delivery. For instance, in the Buiksloterham district in Amsterdam, where the Circular Neighbourhood Action Plan is implemented, a set of resources is available for residents and developers to translate higher-level goals into everyday activities. Co-promotion is described as two or more actors collaborating on a specific product or brand's promotional activities. As a unique example, the title of European Green Capital has significantly strengthened Ljubljana's recognition worldwide and upgraded the city's brand.

Furthermore, three operative co-creation practices provide implementation strategies, balancing top-down municipal and bottom-up efforts from the private and public sector. Co-maintenance indicates two or more actors sharing either the maintenance service or a core product or service. Repair cafés and other maintenance centres are the most common examples in the cases examined. Co-consumption involves collaboration during usage, as actors employ their resources (physical, social or cultural), individually or collectively, when co-consumers determine and enhance their own consumption experiences. For instance, the city of Gothenburg consists of an inspiring mix of sharing services (part of the Smart Map project) initiated by companies and civil society. Co-sense practices, which are widespread in Amsterdam, Helsinki and Glasgow, denote two or more actors collaborating on using daily and readily accessible technology to detect and collect data. Since these three co-creation practices depend heavily on the contextual resources' characteristics, it is essential that actors who have deep knowledge and understanding of local resources are included in the discussion. Overall, grounded on tangible examples, the circular city co-creation design framework (Figure 1) provides city stakeholders (mainly the municipality) with a concrete method of performing co-creation initiatives.

Concluding remarks

This paper describes co-creation as a practical approach in circular cities, focusing on different co-creation initiatives. Case studies allow the identification of the implementation of recommended circular economy co-creation practices in urban systems and a selection of actors and tools to take into consideration. The circular city co-creation design framework provides a design approach to apply co-creation activities in circular cities. Regenerative co-creation practices (i.e. co-vision, co-conception of ideas, co-design, co-prototype, co-production and co-promotion) intensify the strategic part of generating ideas to facilitate the implementation of the ReSOLVE framework inside cities. Conversely, operative co-creation practices (i.e. co-maintenance, co-consumption and co-sense) provide implementation strategies and balance top-down municipal efforts and bottom-up trials from the private and public sectors.

A growing body of research shows the contribution of design towards the implementation of circular economy strategies. Frameworks, tools and strategies are developed from the design field to scale up these circular economy initiatives (Fleischmann, 2020; McAloone & Pigosso, 2017; Wastling et al., 2018) from the local level to regional and national ones. Part of the design nature emphasises a participatory manner, since it has widened its practice from co-design with staff and users to collective design by all actors (Vink et al., 2020). Design approaches, such as systemic design, transformation design and transition design, embed futurist qualities, including transformative capacity (Burns et al., 2006; Irwin, 2015; Jones, 2018; Sangiorgi,

2011), which are required in the transformation process to realise a future-proof city. This also means that co-creation processes that involve multiple stakeholders at various levels and with diverse competencies are part of such a transformation. In this perspective, designers can contribute to advancing such processes more than facilitating, envisioning and supporting. The framework we proposed provides detailed co-creation forms based on actual initiatives; it helps this transformation process in realising a future-proof city. Nevertheless, it could encounter practical issues when applied to various cities. Previous research has already pinpointed the difficulty and limitation of collective co-creation work, considering the time and effort devoted. Furthermore, when projects are transferred from designers to local communities, it is difficult to maintain the same quality and aesthetics of the artefacts or services. All the above issues reflect the obstacles to putting co-creation into practice.

This co-creation circular city framework has been developed to inform what variables and alternatives can be chosen and implemented when applying co-creation methods at the municipality level. However, a few restrictions were identified in this research. First, this co-creation circular city framework remains exploratory, as further validation from policymakers and participants in a broad circular economy discussion is needed. Second, the effectiveness of this framework is hard to assess, as the degree of urban sustainability cannot be evaluated. Third, the circular economy is still in the developing phase, and the ReSOLVE framework that we used as a reference model in this framework does not entirely fit the urban context. It is also unknown whether the circular cities we analysed will become genuinely circular, although they had proven outstanding achievements and grounded long-term plans. Besides, while we evenly choose samples from the clusters of advanced, in progress and newcomers cities, these municipal samples are not dynamic enough. They are limited within the European context, including relatively prosperous cities concerning educational, financial and social development.

This framework outlines an open scenario in which each of the phases and co-creation categories accompanying the transformation towards circularity needs to be further explored in practice from a design perspective. Further research may be conducted on this issue from a systemic view and at the international level. To generate systemic change globally, improved coordination across multiple levels of government is required. Innovation in the circular economy requires a systemic approach where authorities must act as key facilitators, stimulating co-creation initiatives with key actors. It is essential to promote new models and integrate alternative sources where people can actively participate in the path towards a sustainable urban future. Both capacity building and knowledge sharing are crucial for fostering systemic innovation processes. While there is much work to be done, there is also a clear need to build on existing knowledge developed from design fields.

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