Master's Thesis Internship – master Sustainable Business and Innovation

Towards a city-level perspective on the stimulating and hindering factors for a successful circular economy transition: Two cases of Dutch frontrunner cities

Jorinde Guldenaar | student number: 5543193 | j.guldenaar@students.uu.nl
Faculty of Geosciences | Utrecht University
Date: 20-12-2020
Word count: 26,918

University supervisor: Dr. I. Wanzenböck
Supervisor PBL: Dr. M. J. Kishna | Maikel.kishna@pbl.nl

PBL Netherlands Environmental Assessment Agency

Utrecht University

Abstract

The circular economy (CE) concept is gaining momentum in both academic and policy circles. In particular, the vital role of cities in CE transitions has recently received attention. The aim of this thesis is to contribute to the field of CE transition theory by analysing evidence regarding local factors that drive or hinder CE transitions at the city-level. Additionally, we take a geographical perspective on urban CE transitions by using key concepts of economic geography and evolutionary economic geography (EEG) theory. We compare two empirical cases of Dutch frontrunner cities, Rotterdam and Amsterdam, by means of an abductive reasoning approach. Both qualitative and quantitative data is linked to theory in systematic way with the aim to gradually develop the cases. As a result, we find that the local factors knowledge, economic factors, geography, engagement, regulation and urban management have influence on CE transitions in cities. Geography and engagement are considered to be main drivers, whereas regulation and urban management serve as main barriers by civil servants and circular firms. This thesis provides empirical evidence that a geographical perspective is meaningful in exploring CE barriers and drivers for cities, as findings show that urban CE transitions unfold differently across cities due to differences in spatial contexts. The findings imply that building on the regional knowledge base result in high absolute numbers of circular firms in cities. However, it is important for cities to stay focussed on a diversity of circular innovations to achieve a successful CE transition. Ultimately, this thesis contributes to the development of well-founded policy guidelines for local governments and emphasizes that changes in national regulations are crucial for both the success of local and the wider CE transition.

Keywords: Circular Economy, transition studies, cities, economic geography, evolutionary economic geography, innovation

Executive summary

The current linear economy is based on the use of raw materials for the production of goods and the disposal of post-consumer waste. This increasingly impacts the environment, especially since the world population is growing and per-capita consumption is rising (Brown et al., 2014; IPCC, 2018; Rockström et al., 2009). Additionally, the linear economy jeopardises the supply of materials, because of fluctuating material prices, scarce materials and volatility in the market (Ellen MacArthur Foundation, 2015). In a circular economy (CE) the aim is to close the cycles of the raw materials, energy and waste flows, which increases resource efficiency (Geng & Doberstein, 2008) and provides many economic opportunities (Social and Economic Council, 2016).

In particular, cities may play a vital role in CE transitions. Cities are found to facilitate a high number of innovative circular initiatives (PBL, 2019) that are crucial for the take-off of transitions (Geels, 2019). However, the field of research on CE transitions at the city-level is scarce. In order to gain a better understanding on urban CE transitions, this thesis aims to investigate how local factors influence the implementation of innovative circular initiatives in cities. We found that geographical factors are currently overlooked in existing research on urban CE transitions, but are already widely recognized to play an important role in transition literature (e.g. Coenen & Truffer, 2012; Loorbach & Rotmans, 2010; Smith et al., 2010). We use key concepts from economic geography and evolutionary economic geography (EEG) literature that stress the importance of the spatial context of urban environments in innovation processes (e.g. Asheim & Gertler, 2009; Audretsch & Feldman, 1996; Boschma & Martin, 2010). Consequently, this thesis contributed to the field of research on CE barriers and drivers at the city-level and particularly to CE transition theory as we took, contrastingly to existing literature, the spatial context of urban CE transitions into account.

As an empirical case, this thesis investigated and compared the Dutch CE frontrunner cities of Amsterdam and Rotterdam. Influential local factors identified in literature were re-organized and re-defined into a conceptual framework covering a broad range of categories that was used to explore CE barriers and drivers for both cases. By implementing abductive reasoning we discovered new insights and the framework of local factors that can act as either a barrier or driver in urban CE transitions was expanded. Both quantitative (i.e. a secondary database) and qualitative data (i.e. semi-structured interviews and desk research) were linked and interpreted to increase understanding on how CE transitions unfold differently across urban areas.

After analysing the data, we found that of all studied local factors geography, engagement, regulations and urban management are more influential in urban CE transitions compared to the local factors knowledge and economic factors (Table 9). The framework on local factors influencing urban CE transitions was expanded with the categories geography and knowledge. The two cases completely

overlap in categories that were identified to be more or less influential in the urban CE transition. Per local factor, the type of influence (i.e. driving or hindering) on the urban CE transition was almost completely similar in both cities. We identified the following interesting insights based on the cross-case analysis:

1) The *geographical* factors location and spatial proximity function as main drivers in both cities, since they provide an attractive environment for circular initiatives to establish in the urban area. Both local governments embed their innovative circular initiatives within their local strengths, what is perceived by civil servants to work fast and successful in stimulating the CE transition. The city's strongest local industries seem to influence the prevalent type of circular initiatives and influence their CE transition pathway. This argument is strengthened by both the explorative spatial analysis and desk research. We identified that Rotterdam focusses on the circular manufacturing industry, while Amsterdam has a relatively high share of circular tech solutions.
2) In both cases we identified *engagement* to be a main driver mainly due to the positive impacts of collaboration and convening on circular initiatives, what increases innovation in the city. Matching of circular firms to other organisations within the city boundaries by the local government reinforces collaboration and convening.
3) In both cases, *urban management* was both a main driver and a main barrier. Co-location of circular firms through sufficient urban planning was identified to reinforce collaboration and convening. The local governments of the two cities differ in their approach of convening circular entrepreneurs at particular sites in the city. This may be related to their differences in CE transition pathways, as the circular initiatives in Rotterdam seem to be more place-dependent than the circular initiatives in Amsterdam. Both approaches, either co-locating circular entrepreneurs at circular hotspots or by means of a strong innovation system were found to stimulate the urban CE transition. In contrast, public procurement was identified to be a large obstruction for circular initiatives in both cities.
4) In both cases we found that many circular firms are far more obstructed by national *regulations* over municipal regulations. A discrepancy between subsidized circular initiatives at the city-level and an insufficient regulatory environment at higher scale levels (e.g. openness to interpretation of regulations) is hindering the implementation of local radical circular innovations and obstructs circular firms to completely close their waste loops. Changes in the wider institutional environment are required to take full advantage of local subsidized projects. Local governments could give guidance to circular initiatives in the wider regulatory environment.
5) In both cases we found that a lack of *knowledge* is obstructing urban CE transitions. In particular, this lack of knowledge is found to affect circular firms working with secondary materials or second hand products. Furthermore, local government seems ignorant of the influence of relocation of

circular tech-based activities on the urban CE transition. It is important to improve knowledge on all types of circular initiatives in the city.

The study provided important empirical evidence that a spatial perspective on urban CE transitions is meaningful, as we found that CE transitions unfold differently across different urban areas (see findings 1 and 3). Besides, cities that embed circular initiatives in their local strengths seems to work successfully in absolute terms, but we put into discussion whether it will truly result in a transition. It remains important for cities to stay focussed on a variety of different types of innovative circular initiatives, both in radicality of circular innovations and in sector specialisms, to realise a successful urban CE transition (e.g. Martin & Sunley, 2006).

Table of content

List of abbreviations

CE	Circular economy
EEG	Evolutionary Economic Geography
MLP	Multi-Level Perspective
MMR	Mixed Methods Research
R&D	Research and Development
SNM	Strategic Niche Management

1. Introduction

Our current dominant linear 'take, make, dispose' economic model refers to the unidirectional model of production: raw materials provide our factory inputs, which are used for mass-production of goods to be purchased and, typically, disposed after single use (Ellen MacArthur Foundation, 2015). Consequently, the global use of resources increased eightfold in the past century and this trend is expected to intensify in the future due to population growth and increase in per-capita consumption (Brown et al., 2014; Krausmann et al., 2009). Especially in cities, where more than 50% of world's population is living nowadays, the demand for natural resources will heavily increase from 40 billion tons per year in 2010 to 90 billion tons per year in 2050 (IRP, 2018). This acceleration of the use of resources is causing resource depletion, higher price levels and more volatility in many markets (EMF, 2015). If continuing business as usual, the rise of human activities may have catastrophic consequences for both the environment and humanity (IPCC, 2018; Rockström et al., 2009).

For this reason, the Circular Economy (CE) concept received increasing attention among scholars, policy-makers and businesses in recent years (Kirchherr et al., 2018). CE is seen as a route to increased resource efficiency through realising a closed-loop of materials, energy and waste flows, resulting in a more restorative economic system (Geng & Doberstein, 2008). Based on transition literature (e.g. Geels, 2019), it is argued that the transition towards CE requires socio-technical innovations. This implies that a successful CE transition cannot solely be achieved by technological innovations, but is dependent on all-encompassing systemic changes involving multiple actors and social groups (e.g. firms, policy makers, social movements, consumers) who engage in multiple activities (e.g. learning, power struggle, goal-setting) in the context of rules and institutions. The CE transitions requires for instance fundamental changes in consumer practices, cultural meanings, public policies, markets or business models (Geels, 2019).

Cities may play a crucial role in fostering the transition towards CE as they hold critical concentrations of business activity, human capital and regulatory capacity (Jonker et al., 2018). This sparks innovation and collaboration, and makes cities the ideal ecosystem for implementation of circular innovations (Holland Circular Hotspot & Circle Economy, 2019). However, existing research into barriers and drivers in CE transitions is mainly focused at global, European and national levels (e.g. Kirchherr et al., 2018; Mont et al., 2017; Preston, 2012; Rizos et al., 2015; Shahbazi et al., 2016; Vanner et al., 2014). The city-level remains rather unexplored. This calls for further investigation of CE transitions in urban areas.

1.1 Towards a city-level perspective

Cities have increasingly been identified as particularly important places where sustainability transitions emerge and unfold (e.g. Bulkeley et al., 2016; Frantzeskaki et al., 2017). Sustainability transitions are

recognized to be closely related to CE transitions, as circularity is seen as an absolute necessity for sustaining economic output (Ellen MacArthur Foundation, 2015). As urban spaces act as 'agents of transformative change' in sustainability transitions (Fuenfschilling et al., 2019), the investigation of cities may similarly be relevant in the emergence of CE transitions. However, only a handful of studies have examined drivers and barriers in CE transitions at the city-level (EMF, 2019; Jonker et al., 2018; Prendeville et al., 2018). Furthermore, the importance of geography in transitions is extensively discussed in literature (e.g. Coenen & Truffer, 2012; Loorbach & Rotmans, 2010; Smith et al., 2010), but none of the studies engage with the spatial context in urban CE transitions.

This thesis aims to make a contribution to the field of CE transition theory by taking a geographical perspective on urban CE transitions. The gap of the geographical perspective will be addressed by using key concepts of the 'geography of innovation' and evolutionary economic geography (EEG) literature within the conceptual framework in order to study the influence of the spatial context on urban CE transitions. These strands of literature provide explanations on how innovative activity becomes spatially clustered (e.g. Asheim & Gertler, 2009; Audretsch & Feldman, 1996) and show how geography matters in determining the nature and trajectory of how economic systems evolve (Boschma & Martin, 2010). Spatial proximity and co-location of firms are pivotal in understanding the dynamics of the innovation process. In particular dense urban areas are therefore places where high successful innovation is concentrated (Feldman & Kogler, 2010). The innovative local projects and urban experimentation (e.g. innovative circular initiatives) that emerge in cities, play an important role in the take-off of transitions (Geels, 2019). Innovative circular initiatives aim to reduce the primary production of virgin materials by replacing the end-of-life concept by a circular strategy and involve innovative or new applications to existing product designs, technologies or business models (PBL, 2019). Consequently, by including a geographical perspective this study may provide well-founded explanations on how *circular* innovations are stimulated in cities. Additionally, it can shed insights on how CE transitions unfold differently across space.

Accordingly, by investigating urban CE transitions we are interested in how local factors influence the implementation of innovative circular initiatives in cities. We consider local factors here as the main aspects that hinder or drive innovative circular initiatives, of which its influence is restricted to the urban environment. Consequently, the following research question is formulated for this master thesis:

How do local factors stimulate or hinder the implementation of innovative circular initiatives in cities?

To answer this research question, we will compare two Dutch frontrunner cities, Amsterdam and Rotterdam, as empirical cases. The Netherlands is considered a suitable study area, since it is known as the circular hotspot of Europe and as a centre for knowledge and innovation (Gladek et al., 2018). Besides, the Dutch Cabinet is highly committed in the transition towards CE and developed a

government-wide programme for CE (Government of the Netherlands, 2016). While the cities are frontrunners in the CE transition, we need to emphasize that both city regions are still far away from achieving 'full-circularity'. We identify them as *success* cases due to their outstanding number of circular initiatives and pro-active CE policies (PBL, 2019). Frontrunner cities have made past developments in their CE transitions, by both local governments and businesses, and facilitate numerous circular initiatives what allows us to examine the evolution of the economic transformation as opposed to laggard cities. The investigation of success cases provides a sufficient foundation to reveal the role of cities in CE transitions, the influence of different actors as well as the influence of the spatial context on urban CE transitions. Accordingly, influential local factors identified in existing CE literature will be re-organized and redefined into a conceptual framework covering a broad range of categories that will be used to explore CE barriers and drivers for both cases. The use of abductive reasoning in this study may result in discovering new insights, thereby expanding the conceptual framework of barriers and drivers in urban CE transitions.

This study will provide a novel focus by expanding the framework of local factors that influence CE transitions at the city-level, especially by gaining understanding on how CE transitions unfold differently across cities. This thesis may therefore inspire other researchers to discover the processes behind 'the geography of circular innovation' in more detail. Besides, we will present novel policy recommendations that can be used by other local governments in their CE strategies to transform the urban area into circular regions successfully. Additionally, governmental organisations in cities require supporting regulations at the national level to realise CE transition locally. Therefore, the results of this study may serve as an important input for policy makers at higher governmental levels who endeavour to achieve a nation-wide CE transition.

This introductory section is followed by Chapter 2, where the theoretical foundation of this research is explained and where the conceptual framework is presented. Chapter 3 covers the research methods employed in this study and Chapter 4 presents the analysis and findings of the case study. Lastly, Chapter 5 provides conclusions, which are put into discussion in Chapter 6. We will provide final remarks on the contributions of this research, its limitations and interesting fields for further research.

2. Theoretical framework

2.1 The CE concept

The core concepts of CE already emerged in the 1960s (e.g. Boulding, 1966). Boulding (1966) drew attention on the physical limitations of the planets' natural resources by describing a possible alternative approach of a closed economy, called the 'spaceman' economy theory. The CE concept has been further discussed since then (e.g. Stahel, 1981) and unfolded gradually towards an economic strategy rather than purely an environmental strategy. Contrastingly, the sustainability concept originated already in the early 18th century (von Carlowitz, 1713) and its modern definition takes a more holistic view on the environment, the economy and society at large (Geissdoerfer et al., 2017). The most commonly used definition of sustainability is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland et al., 1987, p. 37).

It is widely recognized that the concepts of sustainability and CE are interlinked, since CE is seen as a necessary condition for maintaining economic growth in a sustainable way (EMF, 2013; Kirchherr et al., 2017; Webster, 2017). Besides, the interlinkages between sustainability and CE transitions come to light in debates of 'zero-waste cities' (Zaman & Lehmann, 2013), 'smart cities' as enablers of digitalisation (Neirotti et al., 2014) and 'wise management of natural resources' (McLaren & Agyeman, 2015). Literature on CE is emerging from distinct fields, such as economy, biology and ecology, and is forming a conceptual umbrella encompassing different frameworks (Homrich et al., 2018). To sharpen the understanding of CE in our study, we will adopt the currently most comprehensive CE definition (e.g. Kirchherr et al., 2017). Accordingly, Kirchherr et al. (2017, p. 229) constituted a meta-definition of CE from an analysis of 114 definitions in literature:

> '[CE is] an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers.'

This definition reflects sufficiently upon the interlinkages between CE and the sustainability concept, makes a well distinction between the micro and macro level of our study (i.e. the city-level and circular initiatives) and acknowledges that CE goes beyond recycling initiatives alone. The latter aspect plays an important role within this study, as will be further discussed in Chapter 6 of this thesis.

The implementation of CE leads to reduced environmental impact and creates economic opportunities, such as the strengthening of competitiveness, generation of employment and reduced dependency on the import of scarce materials (Ranta et al., 2018; Social and Economic Council, 2016).

Consequently, several governments have embraced CE with dedicated initiatives (Kirchherr et al., 2017). Also businesses are increasingly adopting CE strategies in their business models to address the challenges of economic and physical resource constraints (Mont et al., 2017). However, CE is far from being implemented on a large scale (Kirchher et al., 2017).

2.2 The position of CE transitions in the multi-level perspective

The shift towards CE is seen as an economic transformation as this new economic model seeks to ultimately decouple global economic development from finite resource consumption (EMF, 2015). A transition requires all-encompassing systemic changes involving multiple actors and social groups, not solely firms, consumers or markets, who engage in multiple activities. A transition entails not only new technologies, but requires also changes in regulations, governing institutions, markets, user practices, infrastructures and cultural discourses (Geels, 2011b).

To understand how CE transitions take place, this study draws on the Multi-Level Perspective (MLP) that uses system thinking in order to approach the complex issues of socio-technical transitions in a comprehensive way (Geels, 2019). MLP combines ideas from evolutionary economics[1], science and technology studies[2] and neo-institutional theory[3], in that it suggests that transitions come about through the interplay between processes at the niche, system and landscape levels. The process of socio-technical transitions describes that a) niche-innovations gradually build up internal momentum, b) niche-innovations and landscape changes create pressure on the system and regime, and c) destabilization of the regime creates windows of opportunities for niche-innovations, which then diffuse and disrupt the existing system (Figure 1) (Geels, 2019).

[1] Key concepts of evolutionary economics are trajectories, regimes, niches, speciation, path dependence, routines (Geels, 2011a)
[2] Concepts include sense-making, social networks, innovation as a social process shaped by social contexts (Geels, 2011a)
[3] Concepts of neo-institutional theory include the rules and institutions that are the 'deep structures' on which knowledgeable actors draw in their actions and the duality of this structure (i.e. the 'rules of the game' that structure actions) (Geels, 2011a)

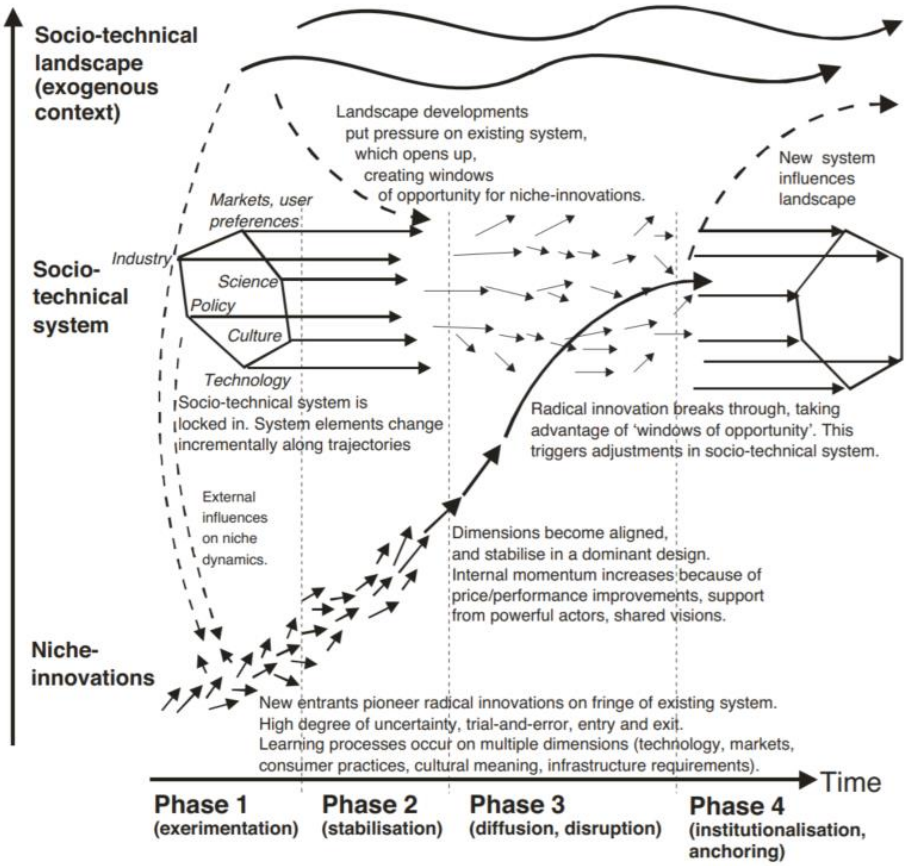


Figure 1. Multi-level perspective on transitions (Geels, 2019)

The MLP assumes that radical innovations emerge in small niches at the micro-level. *Niche-innovations* involve pioneering activities of for instance entrepreneurs, start-ups or activists. The niches function as 'incubation rooms' that protect radical innovations from mainstream market selection and create a learning environment where processes can be developed. The *socio-technical system* (i.e. regime) is the outcome of human actors embedded in social groups. The regime is the semi-coherent set of rules (i.e. institutions) that coordinate and reorient the activities of social groups. Regime rules are for instance regulations, cognitive routines, shared believes or user practices. The interactions between the niche-innovations and the existing socio-technical system are influenced by the slowly developing *socio-technical landscape*. This includes external context (e.g. cultural discourses, societal concerns, macro-economic trends) that cannot be influenced by the actors in the short run. In contrast to the socio-technical system, the *socio-technical landscape* functions autonomously (Geels, 2011a).

As we are concerned with influential local factors at the city-level, we are particularly interested in the niche-innovation level of MLP. The niche-innovation level is characterized by experimentation with radical innovations by means of local projects, urban experiments and living laboratories in the first phase (Geels, 2019). This phase takes place predominantly in cities, as cities provide experimentation spaces to design, test and learn from social-technical innovations (Fuenfschilling et al., 2019). Urban transition literature demonstrates that due to these experimentation spaces many new

social and technical initiatives that counteract unsustainable behaviour and practices emerge in cities (Fuenfschilling et al., 2019). Accordingly, cities may similarly play a vital role in CE transitions as they provide certain conditions that are favourable for niche-innovations, such as circular innovations, to emerge. Due to the interplay between the circular innovations in cities and the higher socio-technical landscape and socio-technical system level, the MLP framework may provide explanations on how the emergence of circular innovations at the city-level may be influenced.

To gain understanding of how urban circular innovations are influenced by other levels of the MLP framework, we first need to point out that MLP theory argues that particularly the implementation of *radical* circular innovations in cities may, next to incremental innovations, transform cities towards CE successfully. According to the MLP framework the degree of radicality of niche-innovations depends on how much they differ from the existing systems on technical, social, business model or infrastructural dimensions (Geels, 2011a). To put this differently, incremental innovations are adaptions to existing technologies, while radical innovations emerge from a fundamentally new knowledge base and lead to a substantially different product (Potting et al., 2017). Radical innovations at the niche-innovation level (e.g. innovative circular initiatives in cities) are crucial for the transition, since they provide the seeds for systematic change (Geels, 2019).

The extent to which (circular) radical innovations are adopted in the socio-technical system is highly dependent on the policies that are part of the institutional structures of the socio-technical system. From a transition perspective, the importance of policy is extensively discussed in literature (Alkemade et al., 2011; Jacobsson & Bergek, 2011; Lindberg et al., 2019). To succeed in transitions, policies are seen as crucial elements in that they have to support processes of regime destabilization. For instance, policies can support and protect niche innovations (e.g. R&D programs, subsidies) or constrain incumbent technologies (e.g. taxes or standards) (Lindberg et al., 2019). Transitions can follow different pathways as they are shaped by policies and by strategies of the actors involved (Lindberg et al., 2019). A transition pathway can be viewed as 'a semi-coherent pattern of major changes in the configuration of a socio-technical system subject to continual processes of political contestation' (Rosenbloom, 2017). Due to the overlap between sustainability and CE transitions, discussed in section 2.1, the socio-technical system (e.g. policies or regulations) may also serve as an important barrier or driver in the implementation of (radical) innovative circular initiatives in urban areas.

2.3 Circularity ladder

The circularity ladder will be used in this study to determine the radicality of the innovative circular initiatives. In our study it is important to determine the radicality of the circular initiatives in order to get an impression of what types of circular initiatives take part in, and how this influences, the city's CE transition. Based on MLP theory explained in section 2.2, we might expect that cities implementing circular radical innovations may successfully transform towards CE in contrast to cities focussing

predominantly on circular innovations that are only small improvements to existing technologies, services or processes.

In this study we distinguish several types of innovative circular initiatives, involving six circular strategies (with different levels of radicality) that can be identified along the circularity ladder (Figure 2). This ladder, developed by PBL (2019), is based on distinct ladders discussed in literature (e.g. EMF, 2015; Reike et al., 2018). As a rule of thumb, it is argued that circularity strategies higher up the ladder require less natural resources to produce new materials. While all circular strategies along the ladder are considered as a means to accomplish a transition towards CE, 'higher' R-strategies lead to higher savings of natural resources and result in a minimised impact on the environment (PBL, 2019). Furthermore, higher R-strategies require more socio-institutional changes throughout the product chain (Potting et al., 2017). This implies that circular innovations with higher R-strategies deviate more from the existing system and its dominant structures, and can therefore be considered more radical than circular strategies lower on the ladder.

By linking the circularity ladder to MLP theory, particularly the implementation of innovative circular initiatives involving higher R-strategies may be important in stimulating the transition towards CE in cities as they are more radical than the lower R-strategies. Similarly, PBL (2019) stress the need to focus on the uptake of higher R-strategies for the success of the CE transition. They demonstrated that currently more than 70 percent of the circular initiatives in the Netherlands involve recycling activities (i.e. low R-strategy initiatives).

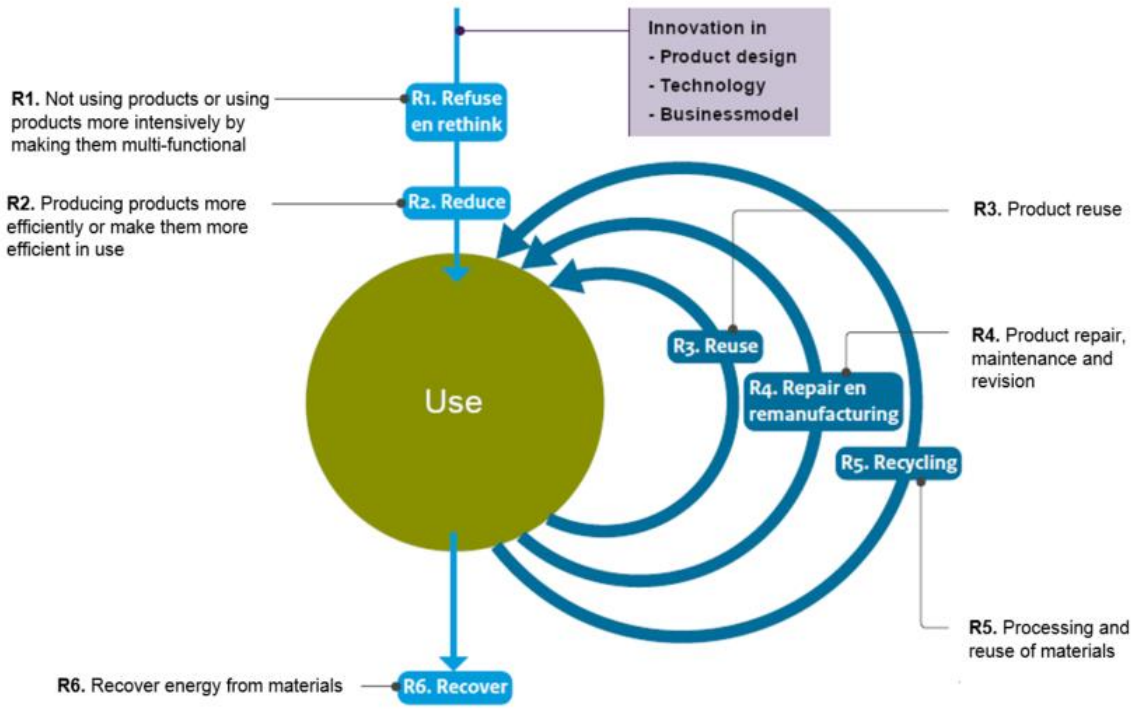


Figure 2. The circularity ladder (adapted figure from PBL, 2019).

2.4 Barriers and drivers in CE transitions at the city-level

There are various studies on drivers and barriers in CE transitions at the national, European and international level (e.g. De Jesus & Mendonça, 2018; Kirchherr et al., 2017; Rizos et al., 2015; Shahbazi et al., 2016; Van Eijk, 2015). However, very few studies can be found that aim at understanding *local* CE transitions. Local CE transitions are influenced by multiple actors, including local governments as well as firms. Accordingly, Hannequart & Naudet (2015) set out the potential role of local authorities in developing guidelines that help them to integrate efficient CE plans. Besides, Prendeville et al. (2018) studied different governance strategies for local governments that can be implemented in order to foster CE in cities. Additionally, the study mentions several impediments in the transition towards CE for city managers. Also Jonker et al. (2018) investigated CE transitions in European cities and identified current barriers and best governance practices.

Very recently, EMF (2019) presented a framework of factors that may influence urban CE transitions. This framework is relevant for our study, as we are particularly interested in what local factors, and how the local factors are influencing urban CE transitions. They emphasize the importance of embedding CE practices in urban policy by local governments and point out five main categories that stimulate urban CE transitions. However, through poorly managing these different categories they may transform into barriers for city CE transitions. Additionally, no single measure can complete the transition due to the interlinkages between the categories. Strong enabling conditions will be created within the city if local governments succeed in embedding CE principles into all five policy categories. The relations between the categories will be further described in section 2.6.

Table 1 presents descriptions of the policy categories of the EMF (2019) framework and includes supporting arguments from the other studies on urban CE barriers and drivers (e.g. Jonker et al., 2018; Prendeville et al., 2018) per category. The table shows how the categories of the EMF (2019) are embedded in other literature on urban CE transitions, what indicates that the categories may be significant in explaining how innovative circular initiatives can be stimulated or hindered at the city level.

Table 1

Descriptions of categories of the framework of EMF (2019) and supporting arguments from existing literature on urban CE barriers and drivers.

Category	Description	Good governance practice or barrier
Vision	Setting strategic goals, city roadmaps and strategies set a direction for a city and inform the development of other policy levers.	• 'Develop and communicate a long-term, holistic vision about the circular ambitions of the city' (Jonker et al. 2018). • Building adaptable future visions (Prendeville et al. 2018)
Engagement	Engaging with multiple stakeholders from across sectors and catalyse action. This requires understanding, collaboration and action within and between sectors.	• 'Identify, address and include non-municipal stakeholders early in transition process' (Jonker et al. 2018) • 'Engaging with diverse stakeholders' (Prendeville et al. 2018)
Economic incentives	City governments can use financial support to help stimulating innovation and new markets, whilst fiscal measures such as taxes, penalties, and charges, can help incentivise or discourage behaviours.	• 'Lack of financial support' (Jonker et al. 2018; Prendeville, 2018) • 'The current tax system obstructs circular development' (Jonker et al., 2018)
Urban management	The influence of city governments over the physical development in a city, the management of its assets, and the procurement of public goods and services.	• 'Use circular public procurement to create demand for circular innovations' (Jonker et al., 2018) • 'Facilitate appropriate spaces and funding for experimentation' (Jonker et al., 2018) • 'Analyse the urban metabolism (material flows)' (Jonker et al., 2018)
Regulation	Legislation and regulation can play an important role in shaping markets, influencing behaviour, and removing barriers that inhibit progress. Regulation can reinforce other policy levers.	• 'Current waste legislation hinders innovative reuse and recycling of products and materials' (Jonker et al., 2018)

Note. Good governance practices are policy actions taken by city governments stimulating urban CE transitions. Supportive arguments found in other studies on CE barriers and drivers at the city-level are linked to the categories of the EMF (2019) framework by the researcher to stress the embeddedness of the categories in literature.

2.5 CE transitions at the city-level: a geographical perspective

What is lacking in the existing studies on drivers and barriers in urban CE transitions is the inclusion of geographical factors. In contrast, literature on sustainability transitions in general shows an increased interest in geographical aspects for explaining uneven transition pathways across space (e.g. Coenen & Truffer, 2012; Loorbach & Rotmans, 2010; Smith et al., 2010). Due to the interlinkages between sustainability and CE transitions, discussed in section 2.1, the inclusion of the spatial context may also be relevant in exploring drivers and barriers in CE transitions at the city-level. Therefore, geographical

aspects should be considered in this study. This section will discuss key notions of economic geography and evolutionary economic geography (EEG) with the objective to emphasize why it is relevant to look into the geographical context of CE transitions at the local level. Similar to sustainability transitions, CE transitions could be influenced by their spatial contexts in that they shape the transition process and the transition pathways.

2.5.1 Geography of innovation: location and spatial proximity

By drawing on 'geography of innovation' we will explain the tendency for innovative activity to cluster spatially. The location is determined to be important in innovation processes, as of all economic activity, innovation benefits most from location (Feldman & Kogler, 2010). Many empirical studies of success stories of profitable and competitive regions for firms draw on the rationale of spatial clustering[4], localised learning processes and 'sticky' knowledge grounded in social interaction (Asheim & Coenen, 2005). Therefore, we draw on these concepts to illustrate the attractiveness of cities for (circular) firms.

Localised learning means that innovative activities are becoming more complex over time as well as the social interactions between firms, research organisations and public agencies. Therefore, innovation becomes increasingly based on interactions and knowledge spillovers between the agents. Knowledge spillovers are the direct or indirect transfer of valued knowledge (e.g. novel technologies or processes) from one party to another typically generated by firms that are engaging in innovative activities. Knowledge spillovers empower the receiving company regarding their competitiveness. Consequentially, in areas subjected to localised learning processes knowledge exchange becomes 'sticky', meaning that increased sharing efforts and complex social processes are required due to its context-laden tacit knowledge (Asheim & Gertler, 2009; Malmberg & Maskell, 2010).

Furthermore, innovation cannot be properly understood if one does not appreciate the central role of spatial proximity and concentration in this process. Spatial proximity plays an important role in innovation processes as tacit knowledge 'travels' not easily. Knowledge exchange requires face-to-face interaction between actors who share some basic commonalities. Examples of commonalities include the same language, institutional environment, successful collaboration in the past or informal interaction (Asheim & Gertler, 2009). High spatial proximity between firms in cities increases the frequency and impact of interactions (Porter, 2000), which results in intra-industry knowledge spillovers between firms due to specialization (i.e. MAR-externalities), inter-industry knowledge spillovers (i.e. Jacobs externalities) and productivity advantages (i.e. Porter externalities). Productivity advantages include cheaper and better access to business services, supportive labour markets, information, knowledge, institutions and public goods (Porter, 2000). The above externalities are taking increasingly place in cities due to their size, density and compactness (Doloreux & Shearmur, 2012). Accordingly, the

[4] A spatial cluster is defined as 'a geographically proximate group of interconnected companies and associated institutes in a particular field, linked by commonalities and complementarities (Porter, 2000, p.16)

increased benefits for firms by clustering in cities further stimulates firm concentrations (Ferras-Hernandez & Nylund, 2019).

To conclude, advantages of clustering in cities may also apply to the localization of innovative circular initiatives. Clusters can provide circular initiatives with abundant resources, such as a highly specialized workforce that can handle particular waste streams, and increase knowledge spillovers between circular firms and other organisations through well-developed networks. Increased knowledge spillovers may stimulate the emergence of circular innovations and improve innovation performance of established circular firms within the urban environment. By using these theoretical concepts, we may increase understanding on how innovative circular initiatives are stimulated or hindered in cities.

2.5.2 Relatedness and urban growth

The principle of relatedness is an important concept of EEG literature that is relevant for our study. Two activities, industries or research areas are related when they require the same knowledge (Hidalgo et al., 2018). Accordingly, the principle of relatedness is thought to influence the nature and scope of knowledge spillovers. Regions tend to diversify rather into related industries instead of unrelated activities, because one can benefit more from increased mutual spillovers in related activities than in unrelated activities. Related technologies are more easily recombined in regions with a higher diversity of related industries. The creation of new variety of related activities in a region is called regional branching (Boschma & Frenken, 2012). Accordingly, it is argued that future industry evolution is dependent on the historical industrial profile within the region (Neffke, 2009).

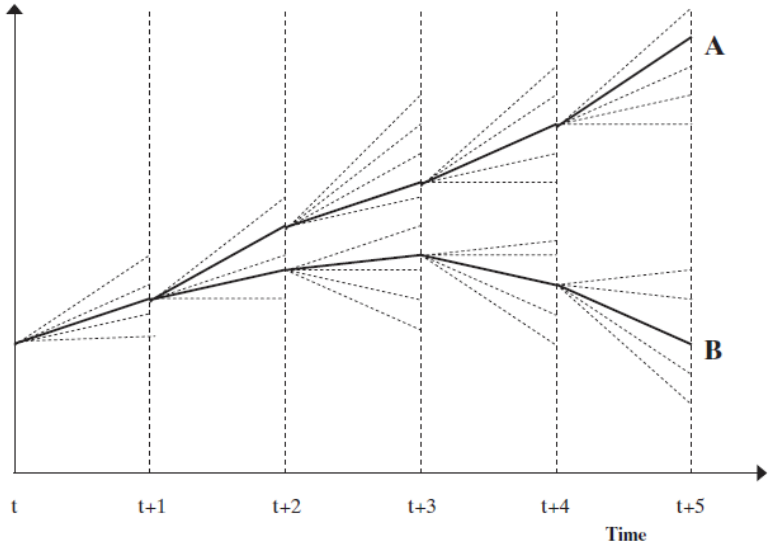
In the context of our study, the future industry can be interpreted as the emergence of a group of innovative circular initiatives that all produce a particular type of goods or services that is related to the existing industrial profile of a city. Cities diversifying into related circular initiatives may benefit from increased knowledge spillovers what stimulates innovation in the region. As cities are dependent on their knowledge base, we might expect that cities with different knowledge bases diversify into different innovative circular initiatives. Therefore, concepts of relatedness may provide explanations on how CE transitions across urban areas can be influenced.

2.5.3 Positive and negative lock-in effects

Transitioning to CE and shifting the currently embedded socio-technical systems is a difficult and slow process, because regimes that currently exist are characterised by lock-in and path dependency (Geels, 2011a). A phase of positive ‘lock-in’ can be followed up by a phase of negative ‘lock-in’. In the positive ‘lock-in’ the region benefits of increasing returns and positive externalities. The main focus is on conserving existing processes, structures and configurations (specialization), that are the result of the positive externalities. Eventually this could become a source of increasing rigidity and inflexibility (Martin & Sunley, 2006). The city may shift towards negative ‘lock-in’, which is indicated by a lack of

local investments and growth opportunities in other sectors, limited adoption of novel routines and limited sharing of knowledge (Asheim et al., 2017). This will undermine the city's productivity, adaptability, competitiveness and causing decreasing returns. The 'strong ties' that were once a source of cumulative economic success becomes a source of weakness, because the region becomes stuck in established practices, ideas and networks of embeddedness (Martin & Sunley, 2006).

Consequentially, different cities do also have different vulnerabilities to processes of negative 'lock-in'. Some seem to persistently experience negative 'lock-in', and thus pronounced relative decline, and other are able to adapt and avoid the processes of negative 'lock-in'. The latter regions are experiencing continuous regional development (Figure 3).



A – Development path with sequential phases of 'positive 'lock-in''
B - Development path in which 'positive 'lock-in'' becomes 'negative 'lock-in''
Dashed lines represent fields of possible contingent paths, while solid lines are the realised actual paths. Development path here might be measured by innovation rate, or relative economic growth, for example.

Figure 3. Development path of regional system (Martin & Sunley, 2006).

By linking this back to section 2.5.2, recombination of knowledge of closely related technologies is argued to lead to more incremental innovations (Castaldi et al., 2014). Radical innovations, that are necessary for a transition (section 2.2), may often stem from the combination of previously unrelated technologies. If successful, very different types of knowledge become related in the form of a new invention that paves the way for future technological developments and further innovation (Castaldi et al., 2014). Accordingly, Martin & Sunley (2006) found that highly successful local economies often have many specializations. These specialized clusters of activity can benefit from rapid learning and thereby escaping 'lock-in'. Nonetheless, the region can be subjected to more processes of new path

creation. For instance, through high heterogeneity and diversity of local industries[5], indigenous creation[6], transplantation from elsewhere[7] and upgrading of existing industries[8] (Martin & Sunley, 2006).

This concept of 'lock-in' and escaping 'lock-in' may provide explanations on how different cities follow a certain path towards CE transitions. Cities that are able to escape 'lock-in', for instance by the creation of new paths through the establishment of circular initiatives based on a different type of knowledge, can continuously innovate themselves towards circularity. This may be an important stimulating factor for innovative circular initiatives due to the benefits from increasing returns and positive externalities, while city's following a path of negative 'lock-in' may impose inflexibility and diminishing returns for innovative circular initiatives.

2.6 Conceptual framework

Based sections 2.2 to 2.5, we developed a conceptual framework aimed at combining local factors that are considered important for driving or hindering innovative circular initiatives in cities. The conceptual framework is presented in Table 2. The main categories in the table refer to local factors that are assumed to hinder or drive innovative circular initiatives in urban areas. The local factors are divided into sub-categories that show how innovative circular initiatives are influenced in cities at a more detailed level compared to the main categories.

The framework of EMF (2019) serves as the foundation for the development of the conceptual framework, because this is the only existing study providing a framework with a wide variety of local factors influencing urban CE transitions. Additionally, we discussed in section 2.4 that the categories of local factors are supported by findings of other studies on urban CE transitions (e.g. Jonker et al., 2018; Prendeville et al., 2018), what creates sufficient ground for using these categories in our study. Consequently, our conceptual framework includes the main categories 'engagement', 'regulation', 'urban management', and 'economic factors' of the EMF (2019) framework. The reason for not including the category 'vision' in the conceptual framework will be further explained in Chapter 3.

In contrast to the categories of the EMF (2019) framework, which are completely based on local policies, our conceptual framework will examine CE barriers and drivers perceived by both local governments and circular firms for all categories. In section 2.5 we identified the lack of geographical factors in existing CE transition literature that may be relevant for circular firms. Therefore, the framework is extended with the category 'geography'. Furthermore, we want to stress that policy has

[5] Involves constant innovation and economic reconfiguration, therefore avoiding a fixed structure
[6] Emergence of new technologies and innovations from within the region that have no immediate predecessors at all to the location
[7] Importation of new industry from elsewhere forming the foundation of the new path
[8] Enhancement of the region's industrial base by implementing new technologies, products and services

still an important position in our framework, since we substantiated in section 2.2 that policies induce regime destabilization and lead to successful implementation of radical circular innovations.

Moreover, we want to point out that MLP theory is not used within the conceptual framework, but solely improves our understanding on how the influence of local factors on the city's innovative circular initiatives are embedded in the broader system of the CE transition. The interaction and dynamics between the regime level and the niche level are important to understand the wider CE transition. Some local factors could be linked to the different levels of MLP in the end to improve understanding on how they are influencing innovative circular initiatives at the niche-innovation level.

Table 2

The categories of the conceptual framework with their definitions

Category	Sub-category	Definition
Geography	Spatial proximity	The closeness in distance within the urban area
	Location	A particular place in geographical space that comes with particular resources available
Engagement	Awareness	Knowledge sharing on CE amongst different stakeholders
	Convening and partnering	Bringing together organisations in the city (e.g. firms and local governments) that can lead to the establishment of partnerships
Regulation	Regulation and legislation	Setting motion bylaws, standards, requirements, and bans that promote CE practices
Urban management	Urban planning	The physical shaping and development of a city and management of city-owned physical assets
	Public procurement	The purchase of goods and services by the public sector
Economic factors	Financial measures	Public and private investments of parties within the city boundaries
	Fiscal measures	Fiscal tools in the form of taxes, charges, fees or fines that can be used to incentivise or discourage behaviours or market developments

Geography

The MLP framework and urban transition literature showed us that especially cities may play an important role in the CE transition as experimentation with circular innovations (i.e. niche-innovations) is taking mainly place in the urban environment (section 2.2). Consequentially, section 2.5 demonstrated that the spatial context of cities may provide explanations on how innovative circular initiatives become

unevenly distributed across space, and how urban CE transition pathways can be influenced by their spatial context. As we are concerned with different cities, and given that cities differ in their spatial context, geography may play an important role in stimulating or hindering the implementation of innovative circular initiatives in a city. Accordingly, we included the sub-categories 'spatial proximity' and 'location' in order to get a grasp on how 'sticky' knowledge grounded in social interactions and the externalities that come with spatial clustering in cities influence innovative circular initiatives. Furthermore, this enabled us to explore the concepts of relatedness and lock-in effects. Geography is related to all other categories, as local factors are bounded to the spatial context.

Engagement

For this study, the overaching category engagement includes awareness and convening and partnering. According to EMF (2019) local governments have the ability to convene public, private and civic leaders. Besides, awareness of CE can be increased by knowledge sharing and communication campaigns. It involves the awareness of consumers as well as employees within an organisation. In addition to the category engagement of EMF (2019), our conceptual framework captures also experiences of convening and partnering between (circular) firms and experiences of firms regarding their collaboration with governmental organisations.

Regulation

Whereas local regulation is determined to develop together with EU or national legislation and regulation (e.g. Kirchherr et al., 2017), local governments can set by-laws, standards, rules, bans and requirements. According to EMF (2019) regulations could support other categories in the framework. For example, it is closely related to awareness, as it may influence behaviour, or public procurement, since local governments could include circular principles in their tender policies.

Urban management

Urban management refers to the physical development of a city, the management of its assets and the procurement of public goods and services (EMF, 2019). Urban planning includes the allocation, development and usage of urban structures, such as buildings and infrastructure. It is therefore closely related to geography, as it might influence the localization of certain physical assets. This may link to spatial proximity or may influence the positioning of social networks in the urban area. Besides, urban management is highly related to regulations. This is for the reason that policies have to be implemented in order to put public procurement into practice. Public procurement ranges from the purchase of goods and services for everyday office furniture to large-scale urban infrastructure projects.

Economic factors

Economic factors include financial measures as well as fiscal measures. Financial support from local governments can be crucial for circular firms in an early-stage or for high-risk projects (EMF, 2019). According to EMF (2019), public financial support includes direct provision, public procurement, co-finance, investment funds and municipality owned corporations. However, in our conceptual framework we also included private funds, such as personal savings, bank loans, crowdfunding, private equity through angel investors and venture capitalists. Contrastingly, fiscal measures can only be implemented by governmental organisations. This includes for instance tax benefits for circular economy products or businesses, tax reductions on the use of recycled materials or tax increases on undesirable waste streams. In this study this category does not include public procurement, as public procurement is already considered to be part of urban management.

3. Methodology

This chapter will elaborate on the methods employed within this thesis. The cases are developed based on a proper and comprehensive methodology, what ensures the ability to acquire data of high quality. We will extensively discuss the research design, case selection and explain the precise steps of the research process.

3.1 Research design and case selection

Case study research lends itself well for exploring and understanding new topics (Eisenhardt, 1989). Accordingly, our study aims to fill a gap in research on the question of how local factors drive or hinder the implementation of circular initiatives at the city-level. In order to explore this new topic, this study adopted a *multiple exploratory case study* design. Case study research is acknowledged to be a good approach for studies that aim to answer 'how' questions (Yin, 2009). A multiple case study design was chosen over a single-case design, since the use of multiple case study design allowed for investigation of different trajectories of cities regarding their CE transition. Besides, it is considered more compelling and overall more robust (Yin, 2009). This research explored two cases over time through detailed, in-depth data collection using multiple sources of information (Creswell, 2007; Yin, 2009). The multiple sources in this study included a secondary database, online databases, websites and interviews, involving either qualitative or quantitative data. The data sources will be further discussed in the section on data collection.

The Netherlands was considered to be an excellent study area, since the Netherlands is known as a 'circular hotspot' where knowledge and innovation are high on the agenda (Gladek et al., 2018). In this study 'cities' are used as the basic unit of analysis. The study explores circular initiatives found within the municipal boundaries. Nonetheless, the influence of some local factors on the implementation of circular initiatives in the city goes beyond the boundaries of the municipal level alone. Therefore, the geographical boundary is set on the wider metropolitan area of the cities.

Two criteria were set for the case selection for this study. First, the city requires a sufficient number and variety of circular innovative initiatives in order to collect data on how the initiatives were stimulated or hindered. Second, the city must have made past developments towards CE in order to study the evolution of this economic transformation and the influence of local factors on this transition. In contrast to laggard cities, frontrunner cities allowed us to study their developments in the CE transition and would provide rich data on how CE was stimulated. Also CE barriers can sufficiently be studied in frontrunner cities as most frontrunner cities are currently in the initial stage of the CE transition (PBL, 2019) and still encounter barriers in their transition towards circularity. In a laggard city, the few circular initiatives would not provide a sufficient sample size to answer the research

question. For instance, stimulating factors could less sufficiently be identified in laggard cities as transitions have not come off the ground. This insufficiency could threaten validity of the study's results.

The Dutch cities of Amsterdam and Rotterdam meet the case requirements, since they pro-actively adopted CE policies in recent years and facilitate the highest numbers of circular activities in the Netherlands (PBL, 2019). Accordingly, these two cities were selected to identify and compare how local factors drive and hindered the implementation of circular activities.

3.1.1 Abductive reasoning and systematic combining

This research used an abductive reasoning approach. Abductive reasoning is a mixture of inductive and deductive approaches, but has a stronger reliance on theory than inductive reasoning alone (Dubois & Gadde, 2002). It was crucial for this study to review literature a priori, because this allowed the identification of potential relevant factors (e.g. geography, engagement, urban management, regulation and economic factors) that could be used as a guideline during the study in order to give answer to the research question in the end. Yin (2009), one of today's most prominent case study methodologists, supports the argument that reviewing relevant literature a priori is significant in case study research. Besides, Dubois & Gadde (2002) recognize that investigation of theory may improve the explanatory power of case studies.

In order to link the abductive approach of this research to case study research, systematic combining was implemented in this study. Systematic combining is an approach that links obtained data from reality to theory in a systematic way (Dubois & Gadde, 2002), which is crucial for a sufficient development of the cases. It was applied in this study as a dynamic approach of matching and (re)directing the analytical framework, the available relevant theory (e.g. CE transition theory, economic geography and EEG theory), the empirical world (e.g. what is going on in reality regarding CE transitions at the city-level), and the case that gradually evolved (Figure 4). In this thesis, the empirical world consists mainly out of initiators of circular initiatives, the policy makers and civil servants concerned with circular economy, as well as the geographical configurations in which they operate. As this study implemented abductive reasoning, an analytical framework was created covering the main categories found in existing literature regarding barriers and drivers in urban CE transitions. The analytical framework was further developed during and after the research process. Therefore, the research followed an iterative process of constantly moving back and forth between the framework, the data sources and the analysis in order to match theory and reality.

The systematic combining approach is closer to an inductive approach than a deductive approach (Dubois & Gadde, 2002), which fits very well in our study. This is because our main concern is to discover new concepts rather than confirming existing theory. Consequentially, a new framework of local factors influencing innovative circular initiatives at the city was developed through discovering new concepts from the data obtained from the empirical world.

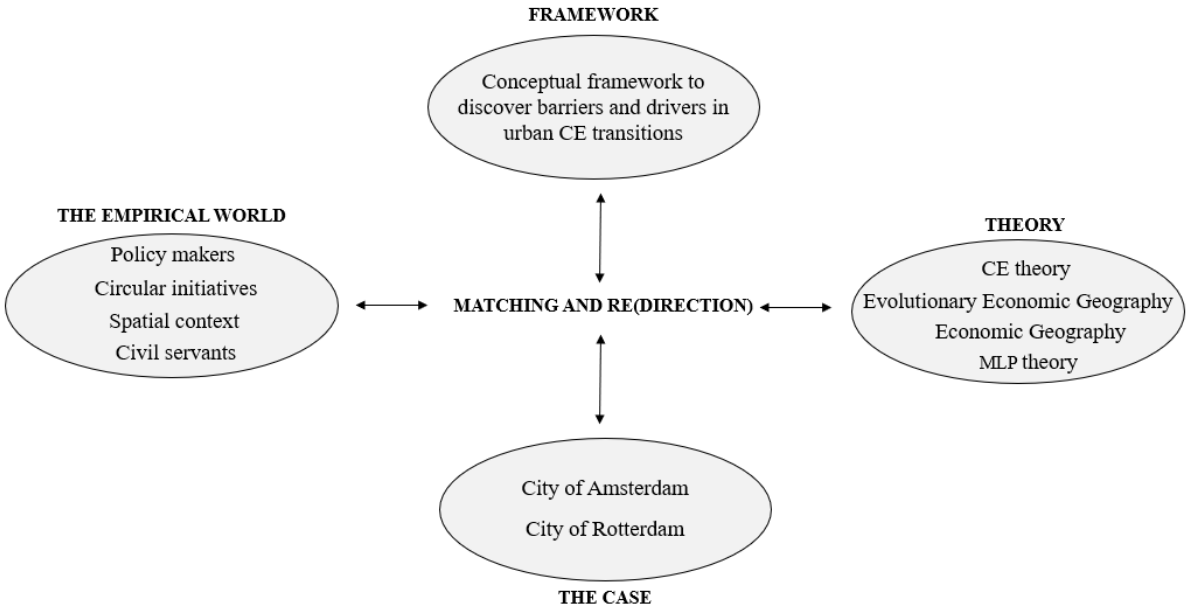


Figure 4. Systematic combining (adapted figure from Dubois & Gadde, 2002)

3.1.2 Mixed methods research

This research incorporated both qualitative and quantitative methods, also known as mixed method research (MMR) (van Griensven et al., 2014). Creswell (1999) and Yin (2009) argue that the combination of qualitative and quantitative data allows for collecting a richer and stronger array of evidence than could be accomplished by any single method alone. The use of MMR was crucial for answering the main research question, since quantitative data on the number, distribution and type of circular activities is required to interpretate the qualitative findings in a sufficient way. Qualitative data based on both secondary data collection (desk research) and primary data collection (semi-structured interviews) contributed to a better understanding of the social context and personal experiences of people with a position in a circular firm or in the city government. Therefore, the analysis of qualitative data provided explanations of how local factors are hindering or driving the city's CE. Besides, the analysis of a secondary database comprising quantitative data on all circular initiatives in the Netherlands contributed to an overview of the types and numbers of CE initiatives facilitated by the cities (i.e. the state of CE).

Consequently, interpretating and linking both quantitative and qualitative findings resulted in an better understanding of how different local factors influenced the trajectory of the city and how the city transformed towards their current CE state. Therefore, results from the quantitative data analysis were used to enhance and clarify the results derived from qualitative data. This approach also allowed us to make comparisons between the trajectories of cities. To conclude, an overview of the research

process is visualized in Figure 5. The grey arrows indicate its iterative nature. All elements of the research process will be explained in sections 3.2 and 3.3.

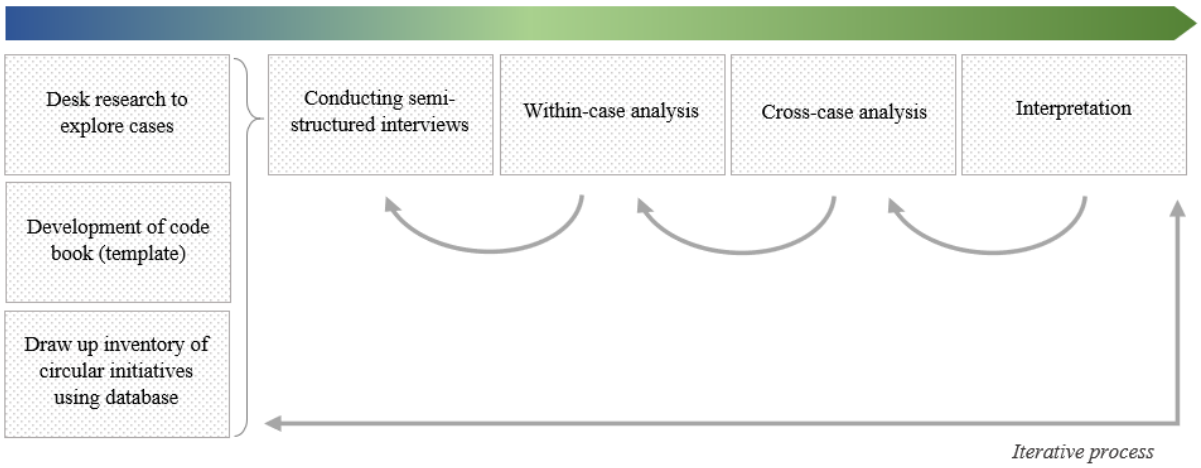


Figure 5. Research flow chart

3.2 Data collection

Circular initiative database and explorative spatial analysis

A secondary database involving 85,000 circular initiatives in the Netherlands, obtained in the period from December 2017 to May 2018, was used in this study to develop an inventory of circular initiatives for both cases. The database was developed by PBL and Royal Haskoning DHV and access to the database was granted by PBL. They define circular initiatives as activities in which one of the strategies of the circularity ladder is put into practice by an organisation (PBL, 2019). Therefore, the database consists of both 'traditional' circular activities (e.g. repair shops) and innovative or new applications to existing product designs, technologies or business models. The initiatives were divided into five themes (biomass and food, construction, consumption goods, plastics and manufacturing industry) and according to their position on the circularity ladder.

For this thesis, we used a subset of the database. This included all *innovative* circular initiatives, accounting for approximately 1500 out of 85,000 circular initiatives. Table 3 shows an overview of the shares of all innovative circular initiatives types in the Netherlands (before cleaning).

Table 3

Innovative circular initiatives in the Netherlands

		Type of industry					
		Consumption goods	Construction	Manufacturing industry	Plastics	Biomass and food	**Total**
Type of R-strategy	R1 Refuse & Rethink	50	20	0	0	50	**120**
	R2 Reduce	4	21	3	0	19	**47**
	R3 Re-use	40	1	2	0	0	**43**
	R4 Repair	108	53	13	3	0	**177**
	R5 Recycle	484	309	122	53	140	**1108**
	R6 Recover	0	0	0	0	0	**0**
Total		**686**	**404**	**140**	**56**	**209**	**1495**

The reason for the inclusion of only innovative circular initiatives in this study is based on arguments of transition theory (sections 2.2 to 2.4), where it is widely recognized that (radical) innovative activities are of high importance for the take-off of the transition (e.g. Geels, 2019; Kemp et al., 1998). This stresses the need to study CE barriers and drivers for particularly *innovative* circular initiatives, as innovative circular initiatives are essential for city's CE transitions in comparison to 'traditional' circular initiatives. 'Traditional' circular initiatives are based on similar processes, structures and configurations of the dominant socio-technical system and are less likely trigger a transition (Geels, 2019). From this point on, the terms 'circular initiative' or 'initiative' could be interchangeably used to refer to 'innovative circular initiatives'.

Furthermore, the database included aggregated data on the municipal level. Consequentially, all innovative circular initiatives in both the municipalities of Amsterdam and Rotterdam were extracted and cleaned in order to investigate the current state of CE in both cities. Inaccurate data was corrected and further investigation of an initiative was done online for missing data. For each city an inventory was developed providing an overview of all innovative circular initiatives including information about the type of industry and the type of R-strategy.

For an explorative spatial analysis off the innovative circular initiatives, this inventory was complemented with the addresses and coordinates (i.e. longitude and latitude) through an online search. Some initiatives do not exist physically and could not be linked to an address. For example, it involved initiatives where only a first implementation step, such as an investment, is realised. Other initiatives simply do not have addresses, for instance a pilot of the municipality in which they collect and re-use

excess paint. In the end the sample size included 85 initiatives for Rotterdam and 115 initiatives for Amsterdam.

For both cities the circular initiatives that could be connected to an address were mapped with the use of the software QGIS 3.12 (QGIS.org, 2020). The coordinates of the different addresses, expressed in accordance with the national triangulation system (RD), were transformed into point data and depicted on the map. Circular initiatives could be distinguished according to their different R-strategies or theme by giving them different colours. Shapefiles of city districts and neighbourhoods, derived from governmental databases (Appendix A), were added to the map in order to extract data on the circular initiatives per city district or neighbourhood and export it to excel files. This allowed us to calculate statistics, including the shares of types of industries and R-strategies of circular initiatives per district or neighbourhood.

Desk research

20 reports and documents on CE initiatives, sustainability agenda's and CE programmes for both Rotterdam and Amsterdam were investigated to improve understanding of the city's CE strategies and ambitions (Appendix B). The documents, all not older than five years, were primarily collected from municipal online databases and websites. The main CE programs of the municipalities and metropolitan governmental organisations were examined in-depth to identify their focus points. The EMF (2019) framework included the category 'vision' for exploring governmental strategies and ambitions. In our study this category is replaced by desk research what results in an even deeper understanding of the CE programmes of both cities by the researcher, what is considered important to sufficiently interpretate how the city's CE transition is influenced. Besides, the investigation of the documents provided more context and information before conducting the semi-structured interviews.

Semi-structured interviews

Semi-structured interviews were conducted with a) civil servants who have a leading position in CE departments (N=6) and b) directors and managers of circular firms (N=12) to investigate how they experienced the identified factors in literature influencing city CE transitions (Table C1). The inclusion of two different types of interviewees allowed us to gain a better understanding of the driving and hindering factors of urban CE transition than by limiting this research to the perspective of local governments alone. Consequently, it might show both sides of the coin, i.e. reveal contrasting perspectives on how factors influence CE transitions. For instance, a local factor might be a driver for one, while it functions as a barrier for the other.

Besides, purposeful sampling was applied to select individuals that are knowledgeable with the topic of CE transitions in cities or with the negative or positive influences on doing circular business in the city. We considered that these persons could best answer the interview questions, which is critical

for obtaining information-rich data for answering the main research question. With regard to the research period, this technique is also considered very cost- and time efficient. We aimed at selecting interviewees of firms with the largest variety as possible, regarding their locations, industries and R-strategies (Table C2). Besides, the interviews were held in Dutch as this was for all interviewees their native language. We believe that this allowed them to convey detailed information more easily, which may reduce the observer bias of the interviewer. Some statements of the interviewees were translated during the reporting phase.

Furthermore, themes (categories) were identified in the form of a codebook before commencing in-depth analysis of the data. In this study, the categories in the codebook were similar to the categories identified in the conceptual framework (geography, regulation, engagement, urban management and economic factors). The categories in the codebook were integrated in the interview guide to structure the interviews. Every category was operationalized in the form of a question that would obtain an information-rich answer from the interviewee. The operationalisation table can be found in Appendix D. Two interview guides (Appendix E) were designed for the different types of interviewees in order to match their expertise. The primary focus of the interviews with circular firms was on the reasoning behind their localization in Amsterdam or Rotterdam. Civil servants were asked in-depth about the local barriers and drivers they faced in the transition towards CE at the city-level.

Although the interview guide was used, the open-ended questions allowed for sufficient flexibility. Besides, during the research some questions from the interview guide were slightly adapted to gain a better understanding of interesting insights or unclear issues mentioned in earlier interviews. Most of the interviews were conducted virtually using Microsoft Teams, because of the Covid-19 outbreak. Some interviews were conducted face-to-face and one over the phone. Additionally, oral consent for recording was given before the interviews, and at the end of the interviews, participants were asked whether they preferred to review my transcripts to prevent potential biases or incorrect interpretations. Throughout the research some participants were called by phone to further clarify some of their statements.

3.3 Data analysis

Both the cases of Amsterdam and Rotterdam were treated as a separate study. The data analysis for this case study involved i) the within-case analysis, which presents a detailed description of each case and themes within each case, and ii) the cross-case analysis, in which the themes across cases were identified (Creswell, 2007).

3.3.1 The within-case analysis

The objective of the within-case analysis was to build a deeper understanding of each city with its most important aspects and experiences of the interviewees. First, all recorded interviews were manually

transcribed in Microsoft Word. Second, all transcripts were imported and analysed in the software Atlas.ti. Interviews were coded according to the hybrid approach of Fereday & Muir-Cochrane (2006), in which a coding framework was developed iteratively. This approach was considered to fit well in this study, as both the hybrid approach as well as the approach of systematic combining are based on abductive reasoning. The hybrid approach is especially designed as a procedure to abductively code the data, whereas systematic combining is a more general methodology for doing abductive case studies. Following the hybrid coding approach, we applied codes to meaningful units of text, which were based upon our initial theoretical knowledge. Moreover, the hybrid approach allowed us to assign segments of data to a new code inductively and thereby expanding the code list. In other words, the data was not forced to fit pre-existent categories, but could also be developed from the data. Consequently, we inductively created the sub-categories culture, market developments and knowledge during the empirical study. Besides, we made a distinction between national and municipal regulation in the data.

This procedure resulted in over 100 codes. The codes were grouped according to overlap in their content, leading to a reduced amount of 44 codes for Rotterdam and 43 for Amsterdam. Furthermore, an explorative spatial analysis was done for the different maps visualizing the spatial pattern of circular initiatives per case. Hereby, the number of circular initiatives was counted within each neighbourhood to demonstrate where high concentrations of circular initiatives cluster can be found in the city. Accordingly, the data was visualized into five classes using the natural breaks (Jenks) method (Jenks, 1967). The Jenks method serves to minimize the standard deviation of values within a class, while maximizing the standard deviation from the means of other classes. This classification method is considered to be best suited for this study, since it is developed to divide spatial data into relatively few classes (less than seven).

For analysing the within-cases, the statements of interviewees linked to the codes were read several times in order to become familiar with the information. Accordingly, crucial aspects of the data were analysed and interpretated by the researcher to identify CE barriers and drivers per case. In the written case description the sub-headings refer to the local factors that were found to hinder or drive CE in the city. The results of the desk research were linked to the findings of the explorative spatial analysis and were further analysed and related to interview data with the aim to determine how CE is obstructed or stimulated in both cities.

3.3.2 The cross-case analysis

The codes of both cases were compared in order to find common ground as well as to identify differences between cases. The next step was to further cluster the codes into theoretical sub-categories, building on previous empirical work discussed in Chapter 2. It involved an iterative process of continuously moving back and forth between the data and the theory. Sub-categories were revised and refined,

resulting in the final sub-categories that can be found in Table 4. Consequently, the sub-categories were clustered into six main categories, also presented in Table 4.

For the cross-case analysis, tables were created in order to identify similarities and differences between cities regarding the shares of R-strategies or industries of circular initiatives. Besides, patterns and relations in qualitative data were identified through the analysis of repetition of particular aspects across cases. We created a table to show an overview of the differences and commonalities across cases. To get an impression whether and how a local factor influences the city's CE, we assigned green colours to local factors that overall stimulated the city's CE and red colours to obstructing local factors. Lastly, local factors were identified more or less influential for urban CE transitions per case, based on the expert judgements of the researcher. The researcher weighted up the opinions of interviewees on the severity of barriers and the extent to which drivers were experienced to be stimulating with an critical eye. Besides, the expert judgement also included the counting of arguments per sub-category in interview data. Frequently mentioned sub-categories, were identified to have a higher influence than sub-categories that were mentioned to a lesser extent.

Table 4

Code list.

Categories	Sub-categories	First-order codes	Example
Geography	Spatial proximity	Proximity to transport hub	We benefit from being closely to central station
		Proximity to university	One of our reasons for localization was proximity to the university
		Proximity to other firms	Our closeness to other firms results in cross-pollination taking place
		Proximity to customer	We benefit from the many proximate potential customers in the city
		Proximity to skilled workers	The closeness to blockchain experts benefits technological initiatives
	Location	Relatedness	We located here due to the presence of a particular resource stream
		Spin-offs	Other firms in the district are nearby spin-offs of our company
		Presence large industries	Circular firms benefit due to our well-founded and large logistical sector
		Presence large sales market	We needed a large sales market for the success of our initiative
		Presence public services	We located in the city due to the incubator program of the municipality
		Presence co-working space	We benefit from the services of our co-working space
		Presence accelerator	We located in the city due to our participation in the accelerator program
		Digital infrastructure	The presence of large data centres attracts tech solutions
		Industrial space	Industrial zones can facilitate circular industrial initiatives in the city
		Place identity	A strong place identify strengthens our firm identity
		Fixed location	We are obstructed as we are obliged to relocate
		Housing prices	We located in this city district due to the low rent
		Spatial densification	Initiatives are obstructed due to a lack of space, as circular hotspots have to relocate
Engagement	Convening & Cooperation	Cooperation	We experience cooperation with other parties in this building to result in mutual benefits
		Convening	We experience the matching role of the local government to be stimulating our business
		Public-private partnerships	StartupAmsterdam connects circular firms with other organisations, driving the city's CE
		Social relationships	We prefer mutual long-term relationships as this results in return of loyal customers and increased re-use of materials
		Cross-pollination	Cross-pollination generates circular innovations
	Awareness	Publicity for firms	We benefit from media attention of circular hotspots
		Consumer awareness	Our strong communication program raises consumer awareness
	Culture	Circular values within organisation	Inter-organisational cultural differences obstruct collaboration regarding CE
		Socio-cultural values	Hands-on mentality of the citizens in the city stimulate the implementation of initiatives
		Diversity in people	Collaboration between diverse firms may result in cross-pollination and efficient knowledge exchange
		Feeling connected with the city	We located here due to our emotional connection with the city
Regulation	National regulation	Dependency on national regulations	We are heavily obstructed by national waste regulations
		Regulatory process	The regulatory process is clumsy, untransparent and unclear, which slows down our business activities
	Municipal regulation	By-laws	We benefit from sufficient household waste separation regulations pursued by municipalities
		Interpretation of regulations	Limited openness in interpretation is obstructing the speed of permitting circular innovations

		Lobby activities	Together with other sharing platforms we influence local policy developments
		Pro-active CE policy	The port is known for its pro-active CE policy, which attracts circular initiatives
		Governmental guidance	No municipal service is in place that guides us during our regulatory process at higher scale levels
Urban management	Urban planning	Circular and innovation hubs	Circular initiatives benefit from the development of circular hotspots or living labs
		Gentrification	Gentrification is obstructing us, as relocation costs us a lot and prohibits professionalization
		Pressure on house construction	Due to increased demand of residential areas, hotspot areas have to relocate
	Public procurement	Development circular tenders	We are obstructed as circular criteria are not sufficiently embedded in tenders
		Include local firms in tenders	Municipalities are not recognizing our strategic know-how
Economic factors	Financial measures	One-off investments	We benefit from subsidies, such as CityLab010
		Structural financial support	Municipal subsidies conceal the problem of structural financial support by national government
	Market developments	Supply of materials on market	We experience a discontinuous supply of secondary materials as obstructing
Knowledge	Knowledge	Improving knowledge on resource streams	We are obstructed by limited knowledge on the impact of the second hand market
		Research and pilots	Research our target group improves CE communication programs

4. Results

In this section, the results of the case-based empirical analysis will be presented. To do this, we first describe each single case and then cross-compare them with the aim to systematically review how local factors influence the implementation of circular initiatives in the cities of Amsterdam and Rotterdam.

4.1 General introduction to the cases

Both the cities of Rotterdam and Amsterdam are located in the Randstad in the west of the Netherlands. The Randstad is an industrial and metropolitan conurbation consisting of several major Dutch cities (Lambooy, 1998), being the most densely populated area in the Netherlands (MRDH, 2016). The city regions of Rotterdam and Amsterdam are the leading regions of the two 'wings' of the Randstad, namely the southern and northern part respectively. By narrowing down to the local level, within these 'wings' the two cities are surrounded by larger metropolitan areas. For both cities, an economically, socially and ecologically well-functioning metropolis is of crucial importance with regard to the (circular) economy (Lambooy, 1998). The city's locations and different districts are showed in Figure 6.

The Metropolitan area Rotterdam Den Haag (MRDH) consists out of 23 municipalities with a population of 2,3 million inhabitants and a surface area of 1,256 km^2 (MRDH, 2020). The municipality of Rotterdam makes up a substantial part of the MRDH, as they account for 641,200 of its inhabitants (Manshanden et al., 2019) and 324.2 km^2 (CBS, 2019). Furthermore, Rotterdam is predominantly known as a city of innovation and a city of no-nonsense mentality of hard work and entrepreneurship (Gladek et al., 2018). This working mentality is ingrained within the city due to their deep rooted industrial profile. This is because Rotterdam facilitated for a very long time the largest port in the world, and is nowadays still the largest port of Europe. Consequently, they perform very well regarding maritime innovations. Besides, innovations related to the mobility sector, food, climate, built environment, health care and the circular economy are high up on the agenda (Rotterdam Innovation City, 2020).

On the contrary, the city of Amsterdam is mainly known as a major hub for businesses, tourism, commerce and culture. The city is situated within the Metropolitan Region Amsterdam (MRA), comprised of 32 municipalities. Around 2,5 million people live within this region (MRA, 2020). The city of Amsterdam is home to approximately 870,833 inhabitants (CBS, 2020) and has a surface area of 219.5 km^2 (CBS, 2019). In comparison with Rotterdam, they facilitate a rather small port focused on niche markets. However, Amsterdam is especially known for its world-leading airport Schiphol. It is one of the four main European airports, supported by a wide transport network (City of Amsterdam, 2020).

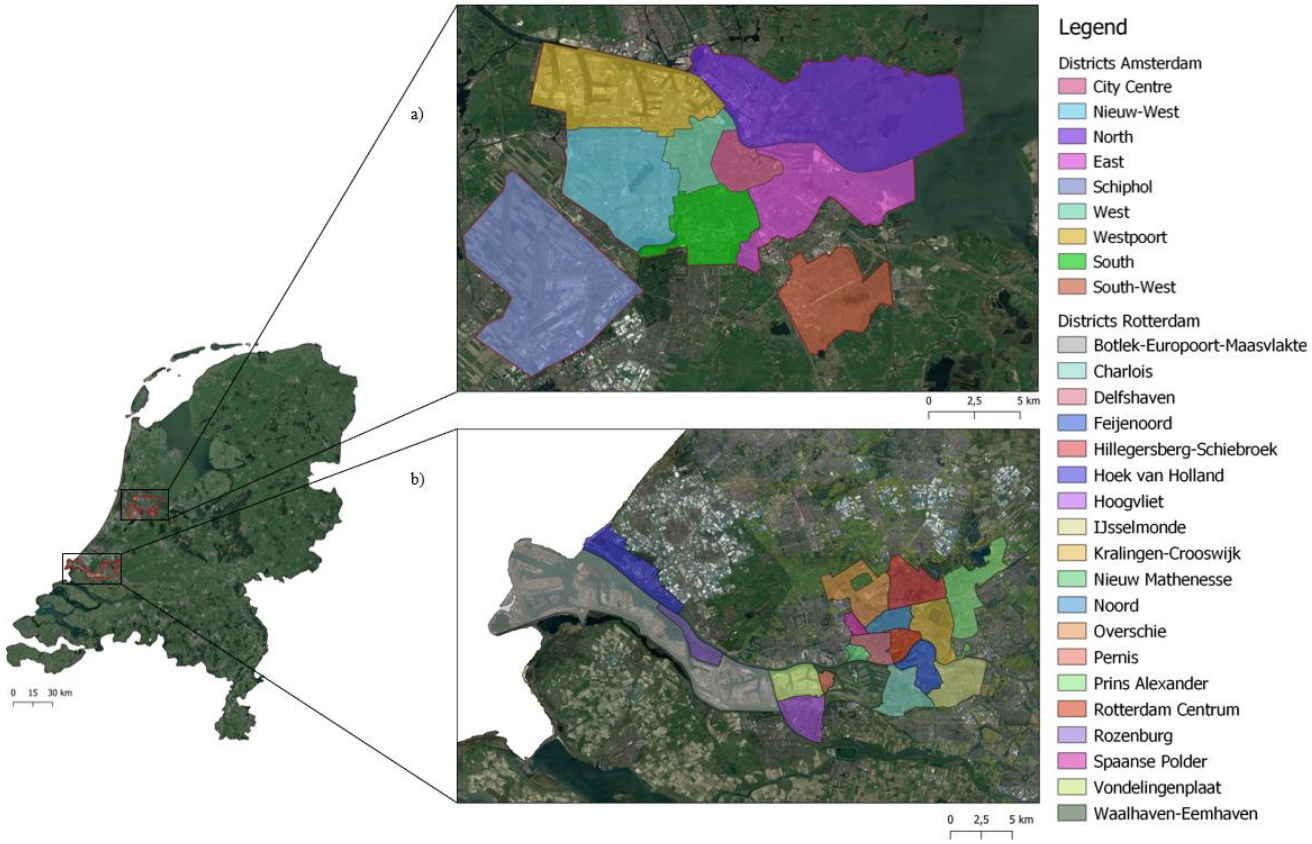


Figure 6. Locations of Amsterdam and Rotterdam and district names. Figure a) shows the city districts of Amsterdam, while b) indicates the names of the neighbourhoods in Rotterdam.

4.2 Case 1: Rotterdam

4.2.1 CE Programs and policies at the metropolitan and municipal level: a general overview

Based on the desk research, we found that CE is incorporated at the metropolitan level as one of the focus points in the Roadmap New Economy (RNE). This is the transition program of the MRDH that aims to transform the Rotterdam metropolitan area into a circular hub in the coming decades (MRDH, 2016). The municipality of Rotterdam has the ambition to reduce the use of the raw materials by 50 percent in 2030, which is in line with the national goals (Municipality of Rotterdam, 2019). In their circularity program 2019 – 2023 they concentrate on four sectors, including agri-food and green flows, construction, consumption goods and health care. Construction is considered the most important, as this sector accounts for more than 60% of the city's waste (Municipality of Rotterdam, 2019).

Furthermore, the MRDH stresses the major opportunities for the local manufacturing and local food security with regard to CE (MRDH, 2016). The manufacturing industry received increased attention in the region of Rotterdam in the past few years due to its important role for the city's innovation performance and employment (Bal & Bulterman, 2018). The high share of manufacturing business activities is mainly the result of the large chemistry complex in the port of Rotterdam and its

huge transport and food industries (Bal & Bulterman, 2018). Accordingly, the circular strategy of the Municipality of Rotterdam (2019) points out the establishment of the Rotterdam Innovation District (RID). This joint initiative between the city and the port serves as a breeding ground for circular innovative start-ups by the means of flexible regulation. What stands out is its focus on innovative circular *manufacturing* companies in the Merwe Vierhaven (M4H) Makersdistrict and Rotterdamsche Droogdok Maatschappij (RDM), where circular firms have the unique opportunities to use technical facilitates and equipment already available. Additionally, the circular hotspot PlantOne, located in the port area, offers facilities and test sites for companies in order to validate sustainable process technologies. Their focus is mainly on bio-based materials and chemical and waste recycling processes. Lastly, BlueCity can be found in the city centre. BlueCity functions as an incubator for more than 30 innovative circular companies that aim to connect their different waste streams (Barneveld et al., 2019) and is mainly focused at biobased innovations. In the RID the circular hotspot policy is actively pursued by the municipality (Municipality of Rotterdam, 2019).

Moreover, the port accounts for an substantial part of Rotterdam, both in surface area and in economic value for the city (15,5 billion) (Gladek et al., 2018). The port is an enormous source of, and sink for, waste generated by industrial clusters within the ports and the surrounding municipalities. Accordingly, we found that circularity fits within the broad ambition of the Port Authority to meet the goals of the Paris Climate Agreement (Barneveld et al., 2019). The port sets out CE as an opportunity for their activities to become future-proof in a decarbonized world and has the ambition to obtain an international position as Waste-to-Value port. They argue that this will attract innovation and new entrepreneurship, increasing economic and social value within the industrial area (Barneveld et al., 2019).

In sum, several ambitious CE programs are in place in the Rotterdam area to streamline and coordinate current policy paths at multiple scale levels. Notwithstanding that the local governments acknowledge that CE is currently still in an early phase, the programs and policies point out their commitment to transform Rotterdam into a region leading the way in the circular economy (MRDH, 2016; Municipality of Rotterdam, 2019). Besides, opportunities lie across many different industries, but in particular innovative circular *manufacturing* companies receive major attention in the municipality of Rotterdam.

4.2.2 Explorative spatial analysis of CE initiatives in Rotterdam

In order to put the above actions into perspective and to explore the types of circular initiatives in Rotterdam, we will present here our findings of the inquiry of the secondary database. It was found that in the year 2017 Rotterdam facilitated a total number of 2527 circular initiatives. After cleaning the data, the *innovative* circular initiatives accounted for 104 activities in total, distributed among different industries and R strategies as presented in Table 5. A general overview of all circular activities in the

municipality of Rotterdam can be found in Table F1. Figure 7 and Figure 8 show the distribution of 85 initiatives with an address in Rotterdam, involving different types of industries and R-strategies. Figure 9 shows the number of circular initiatives per neighbourhood.

Table 5

Innovative circular initiatives in Rotterdam

		Type of industry					
		Consumption goods	Construction	Manufacturing industry	Plastics	Biomass and food	**Total**
Type of R-strategy	R1 Refuse & Rethink	4	3	0	0	5	**12**
	R2 Reduce	0	3	3	0	4	**10**
	R3 Re-use	6	0	0	0	n/a	**6**
	R4 Repair	5	6	1	1	n/a	**13**
	R5 Recycle	22	17	11	10	3	**63**
	R6 Recover	0	0	0	0	0	**0**
Total		**37**	**29**	**15**	**11**	**12**	**104**

The neighbourhoods showing the highest numbers of circular initiatives are mainly neighbourhoods where clusters of circular initiatives can be found. Most circular initiatives are located in the city district Kralingen (28.2%), followed by the city centre (16.5%), Nieuw-Mathenesse (11.8%) and the Botlek-Maasvlakte-Europoort area (9.4%). Clusters seem to be located in Blue City in Kralingen, around the port area in Nieuw-Mathensse, and at PlantOne in the Botlek-Maasvlakte-Europoort district. Furthermore, many initiatives can be found around the central station. Clusters therefore overlap mainly with locations of circular hotspots.

Additionally, we identified a relatively high number of circular manufacturing initiatives in Rotterdam compared to other Dutch municipalities (10%). Except for Utrecht, facilitating 4% of the circular manufacturing activities, all other Dutch municipalities facilitate less than 4% of circular manufacturing activities. In Rotterdam, the highest percentage of circular initiatives in the manufacturing industry are found to be facilitated by the Botlek-Maasvlakte-Europoort district and in the City Centre (both 23.1%). Of all circular initiatives in Rotterdam, manufacturing comes third with 15.3%, after consumption goods (38%) and construction (23.5%).

Remarkably, 60% of all circular initiatives in Rotterdam involve recycling strategies. Repair (10.6%), Re-use (7.1%), Reduce (10.6%) and Refuse & Rethink strategies (11.8%) represent lower

shares of the total number or circular initiatives. It was found that all city districts have a higher share of recycling initiatives within their own district compared to initiatives with other R-strategies. Kralingen facilitates the most Repair and Reduce activities (both about 44% of the total initiatives). Nieuw-Mathenesse, the City Centre and Kralingen all have the highest percentage of Refuse & Rethink initiatives compared to all city initiatives (20%). In other words, these districts show the highest shares of radical innovative circular initiatives.

In conclusion, the explorative spatial analysis generated two important insights. First, the municipality's hotspot policy, which involves commitment on process and manufacturing initiatives at circular hotspots, seems to pay off. The highest number of circular initiatives are found at locations of circular hotspots and the results reveal that Rotterdam facilitates relatively high numbers of manufacturing initiatives. Second, Rotterdam facilitates a high share of recycling initiatives. This may be the result of years of heavy investment in recycling policies by the Dutch government (PBL, 2019).

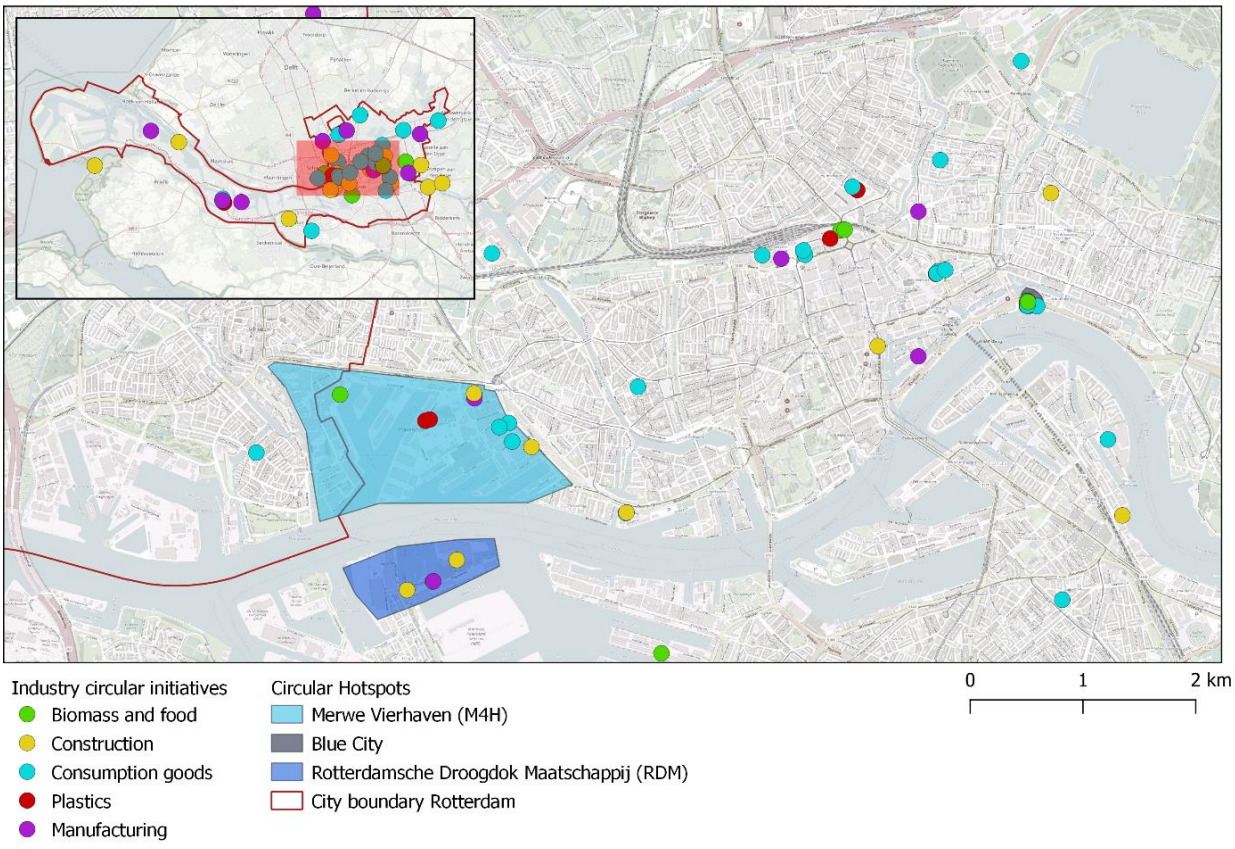


Figure 7. Distribution of industries of innovative circular initiatives in Rotterdam.

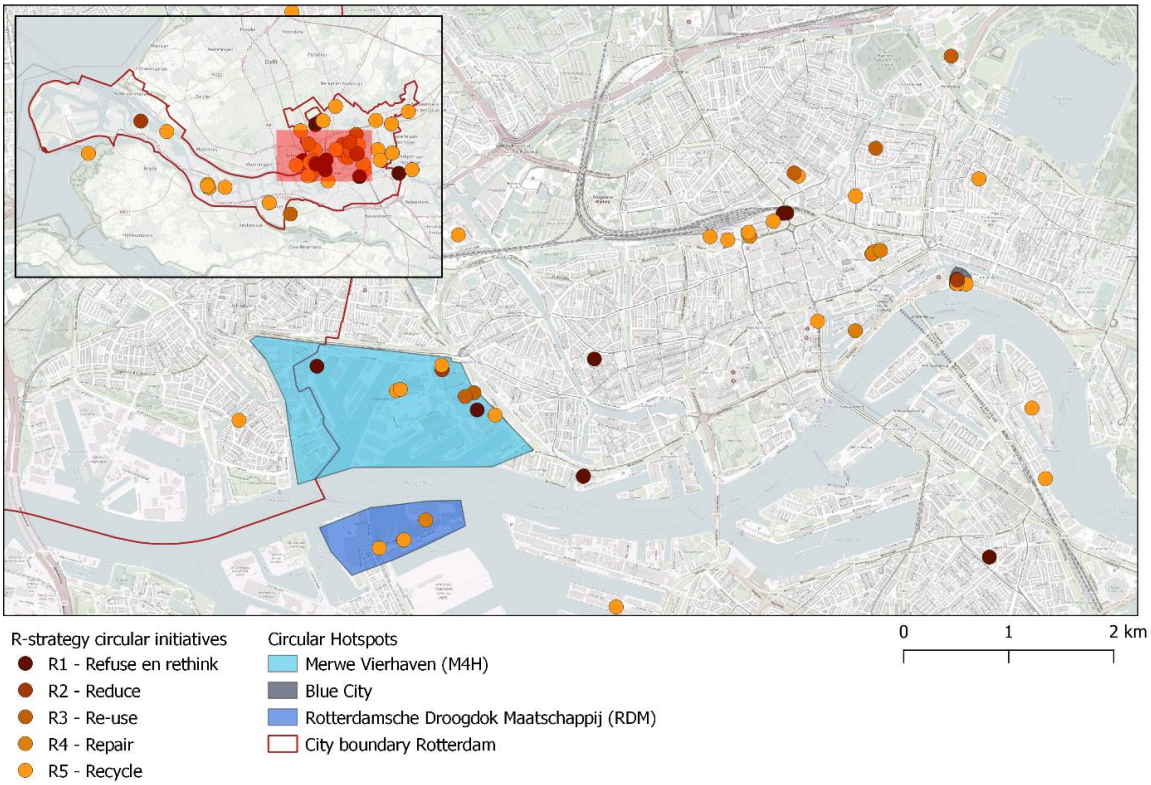


Figure 8. Distribution of R-strategies of innovative circular initiatives in Rotterdam.

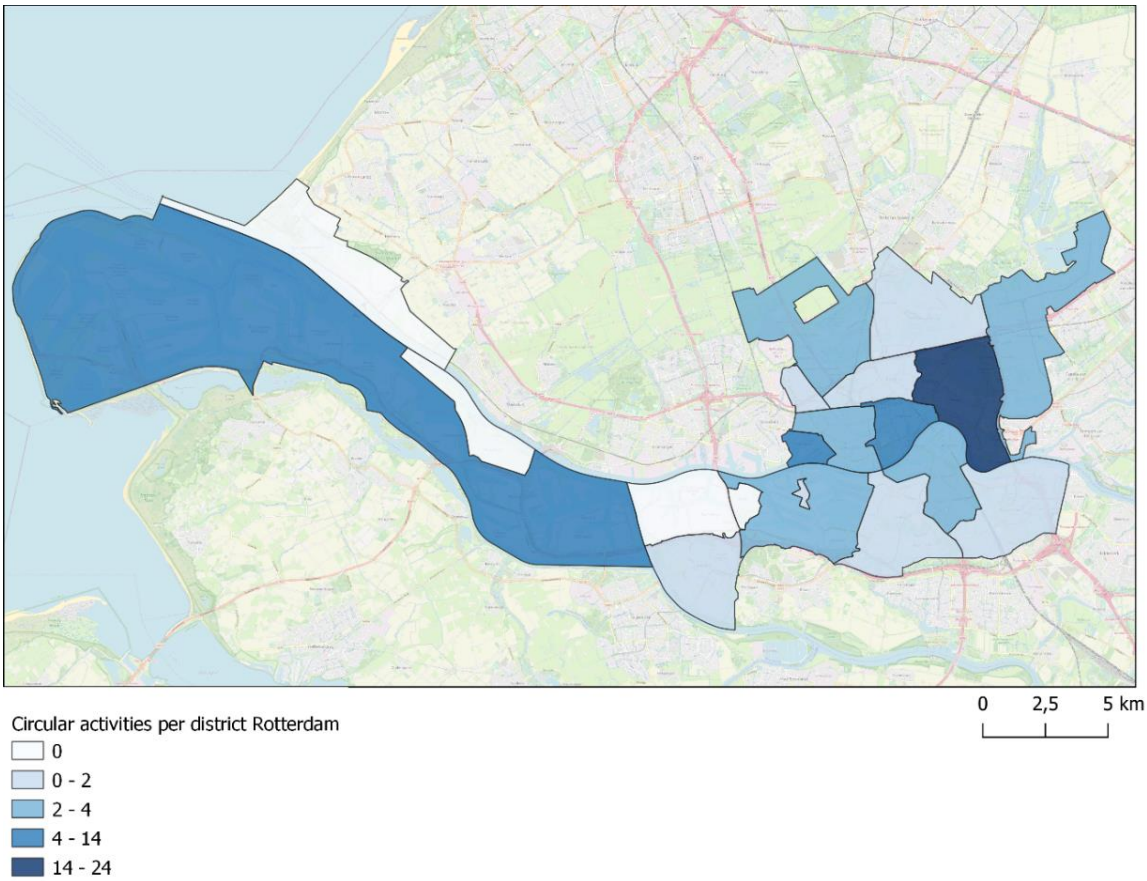


Figure 9. Number of circular initiatives per city district in Rotterdam

4.2.3 A deeper understanding of the case

This sub-chapter aims to provide explanations of how local factors fostered the establishment of the circular initiatives in Rotterdam, or did hinder the establishment of new circular initiatives. We will discuss each factor by reasoning how it is important regarding implementation of circular initiatives in the urban environment. Besides, we will provide statements from interview data that will demonstrate how the particular factor is experienced to be influencing the city's CE through the eyes of both civil servants and firms.

Location: using the strengths of the local economy

Location is identified to be a driver that influences the implementation of circular initiatives in cities. Important aspects that attract circular initiatives are the existing knowledge base, traditional market advantages and the presence of industrial zones. Location also involves the identity of the location in a specific neighbourhood or building. Apart from a few obstructions subjected to locational factors, such as a lack of space and high housing prices, we found that many (traditional) favourable locational aspects are driving circular initiatives. The following paragraphs will sum up important locational aspects.

First, the presence of strong and large industries is found important in the region of Rotterdam. The municipality of Rotterdam seems to make good use of the regional strengths in their transition towards the circular economy due to its strategic position at the centre point of the port and the hinterland (Interview_MUN_R1). Additionally, the municipality aims to embed circular activities within their local economy. Building upon earlier findings of policies and the spatial analysis, the importance of the manufacturing and process industry was further substantiated by interviewees. Civil servants currently experience many circular firms operating in the these kind of industries settling down in Rotterdam (Interview_MUN_R1; Interview_MUN_R4). A similar process takes place in the port area, in that their strong chemistry cluster attracts circular firms working in the chemistry industry that built on the knowledge of the chemistry cluster (Interview_POR_R3). In addition, other large industries do also function as a stepping-stone for localization of companies in Rotterdam. An interviewee clarifies this with the following comment:

> 'Circular companies that want to locate close to waste streams, nearby the process industry, close to the international market… you will not locate at an industrial terrain in Groningen, you will locate here, because those factors are significant for you. If those factors are not important to you, than you will not settle down in Rotterdam, because it is too expensive. Rotterdam is not cheap, but we have a lot to offer. That is how you have to think of it. That is why I do not see certain types of companies around here. For the production of circular bricks, I would definitely not choose Rotterdam, because it is very expensive with regard to its housing prices. By the development of our own circular industry we take into account our strengths. For

> instance, I would not start a circular fashion line here, while Eindhoven or Amsterdam outperforms us in this industry. You try to embed everything in your local economy, because in practice this works much faster'. (Interview_MUN_R1)

The comment illustrates how the municipality is embedding their circular industry in their local economy. The interviewee argues that it was crucial for the CE of Rotterdam that they identified how Rotterdam differentiates compared to other cities, whereafter they tried to create added value for their circular economy by means of the circular hotspots (Interview_MUN_R1). This may indicate that the local industrial base influences the most prominent type of circular innovation activities in the city.

Furthermore, the strong place identity of circular hotspots and creative districts plays an important role for circular firms regarding strengthening their own firm identity. The interviewees argue that the stronger the identity of their location, the stronger becomes the identity of their circular firm. This is experienced to attract more customers (Interview_CO_R5; Interview_CO_R8; Interview_CO_R10).

Additionally, the importance of traditional market advantages is argued by many interviewees as the reason for, or partly explaining their localization. They needed a certain volume of citizens to succeed (Interview_CO_R5), or needed a certain mass of resources provided by urban areas (Interview_CO_R6). Another interviewee stated that the initiative is located in Rotterdam, partly because it is known for its strong logistical sector, and its huge potential as an enormous hub for international and local resource streams (Interview_CO_R8).

Besides, the presence of industrial zones in the Port of Rotterdam is deemed important for certain circular firms. An interviewee argued that industrial zones are a very suitable location for circular firms that involve higher risks, such as for companies working with industrial waste substances. Without the presence of such industrial zones, certain industrial types of circular firms could not settle down in Rotterdam (Interview_POR_R3). These zones are mainly located in the port area.

Spatial proximity: stimulating the implementation of circular initiatives

Spatial proximity involves the closeness to a geographical feature or to particular people in space. A smaller distance to certain resources may provide numerous of opportunities for circular initiatives. In this study, we identified spatial proximity to a transport hub, the university, customers, skilled workers or to other firms to be drivers for circular initiatives in the city. In particular proximity to other firms is found to be crucial in Rotterdam's CE in order to strengthen the social network, creates benefits for circular firms. No hindering aspects were mentioned. Subsequently, in the following paragraphs we will discuss several important findings that relate to the influence of spatial proximity on the city's CE.

First, we found that many firms position themselves to be in close proximity to other firms in the city. Interviewees argue that the distance between other (circular) firms in Rotterdam is relatively

small (Interview_CO_R11; Interview_CO_R9) and have no difficulty with traveling the distance from their office to other (circular) firms (Interview_CO_R11; Interview_CO_R10). The city's spatial density and compactness is believed to result in a close social network of circular firms within Rotterdam, which involves a high density of social links between the actors in the city's CE. This finding was based on our impressions of links between our interviewees. Amongst our interviewees alone, the interviewees of the circular initiatives know each another very well and some have established partnerships. For instance, one of our interviewees has mutual contact with other interviewees located in Blue City and M4H (Interview_CO_R10). This collaboration is illustrated by the following quote:

> 'I pick up materials of Buurman (i.e. interviewee R5) located at M4H, and I transport excess materials to BlueCity. Here, SuperUse (i.e. interviewee R8) often uses my materials. When I have something interesting… We have for example a sort of profile for over a tube that can be attached to the ceiling of office buildings. The material is fire resistant, fire retardant and artistic. When I have a lot of excess material, I will show it to my colleagues of SuperUse, those are architects, and they will re-use that material in interior designs' (Interview_CO_R10).

Interestingly, this strong urban social network seems to stimulate the establishment of other circular firms in the city. For instance, a circular firm argued to have good contact with other circular entrepreneurs in Rotterdam that come to pick up their materials. This resulted in the establishment of for example a creative web shop or the production of craft packages by other circular entrepreneurs (Interview_CO_R10). In sum, the close social network in the city is considered to stimulate the city's CE transitions, as it fosters cooperation and leads to the establishment of new circular initiatives.

Proximity to firms at circular hotspots is experienced differently amongst interviewees. All three interviewees located at circular hotspots experience that this fosters cooperation (Interview_CO_R5; Interview_CO_R8; Interview_CO_R6). However, two out of three interviewees located at circular hotspots experience proximity to other firms as a driver for their business activities. They argue that it fosters cooperation and attracts visitors for the area (Interview_CO_R5; Interview_CO_R8). One of these interviewees argues that the many visitors create opportunities for building social relations with potential future customers (Interview_CO_R8). The following comment shows how relations are established in Blue City and how they generate shared ideas by means of their close proximity (i.e. cross-pollination) takes place in close proximity:

> 'We have done some projects in which we involved one, two or three other firms that are located here. For instance, the Polder roof is one of those things, or the transformation of a building of the Government Real Estate Agency. We also have our link with China, where we are invited here. We therefore approach firms from Blue City, that can come with us on international exchange.' … 'We are also working on a project with biobased materials that can be used in

> architecture. We work together with a firm located here, in the lab of Blue City. They do experiments with isolation materials made from mycelium, that sort of things. I think it is very nice that the knowledge present here, can be used in the development of our company.' (Interview_CO_R8)

However, one circular firm in BlueCity argues that their proximity to other firms led to collaborations within BlueCity, but that these collaborations did not contribute to their own growth. They argue that this benefits mainly the other entrepreneurs that just started their businesses. According to this interviewee it is far more important to cooperate with organisations within the city boundaries or even in the wider metropolitan area (Interview_CO_R6). From the above findings, we state that circular firms experience the importance of spatial proximity in terms of different scale levels (i.e. neighbourhoods, city-level or metropolitan level).

Lastly, other aspects related to spatial proximity involve more traditional advantages for firms. Both the firm and the municipality of Rotterdam highlight the importance of proximity to universities (Interview_MUN_R1; Interview_CO_R11; Interview_CO_R9). Especially young technologists of the TU Delft are much sought after in Rotterdam's manufacturing and process industries (Interview_MUN_R1). Additionally, for circular firms it is important to locate near a main transport hub to be better accessible for customers (Interview_CO_R5; Interview_CO_R10) and employees (Interview_CO_R9; Interview_CO_R11) or to scale-up in case large waste streams in the port could be utilized in the future (Interview_CO_R8). The latter applies specifically to circular firms, since the presence of certain resource streams is highly valued in CE.

Convening & Cooperation: the matching role of local governments

Convening & cooperation was already interwoven in the previous section regarding strong social ties between circular firms in Rotterdam. This section will further discuss the factor convening & cooperation from the perspective of the local government. The municipality and the port are found to play a major role in matching different firms in the circular economy. Matching in this context means to bring people and knowledge together on the right location. We found that this is perceived to stimulate circular initiatives.

The municipality is stimulating cooperation between circular firms by constantly trying to connect local waste streams and by pro-actively bringing circular firms into contact with each other. It may result in public-private partnerships or collaborations with other organisations. For instance, a chemical recycling company was found by the government to be able to process municipal waste created during sweeping the streets. The establishment of a partnership created mutual benefits for both parties (Interview_MUN_R1). Additionally, the municipality stressed that convening a diversity of firms is

important for circular initiatives to increase social interactions and to foster cross-pollination (Interview_MUN_R4). This is illustrated by the following comment:

> 'There is a lot of potential in exchange between sectors, so it does not need to remain in the same sector to maintain the same value. Hence, it can be of more value in a different sector. So orange peels that become perfume, or phosphate from urine that becomes manure pellets. This is just exchange of resource flows with some use of chemistry, where more value is created' … 'so the more diversity in sectors and types of products, the higher the potential for cross-pollination, which can be very valuable. The most important is that they find each other'. (Interview_MUN_R4)

Although the main focus of the municipality lies on the manufacturing industry, this comment highlights that the municipality does acknowledges that a diversity in sectors is important for the development of new ideas.

Quite similar to the approach of the municipality, the Port Authority connects new circular firms to other industrial firms located in the port with the objective to stimulate resource exchange (Interview_POR_R3). Besides the great efforts of matching waste streams and companies in the deep port area, we find it also important to stress some concerns:

> 'I can hardly imagine that they will become circular. I am very sceptic about this… I see no of the actions undertaken by the Port Authority leading towards this development. For example, we have never had contact before on materials. They are not accessible, and are not willing to help things through, while it is an enormous organisation' … 'We mailed them with the question where materials come free that can be re-used… no response.' (Interview_CO_R5)

The interviewee is owner of a circular manufacturing firm located at M4H and works with second hand materials. We believe that the focus of the Port Authority lies on the larger, industrial and technological firms deeper into the port area. Therefore, creative firms at M4H may feel somewhat overlooked. In contrast, the matching practices of the Port Authority seem to play out very well for circular industrial chemistry companies in the hotspot PlantOne. Besides, the port is combining forces with the municipality to improve matching practices between the port area and the city.

The inclusion of circular entrepreneurs in public procurement and consortia

The majority of interviewees argue that local circular firms are often excluded from tenders in favour of linear businesses due to inadequate circular criteria of the local government's public procurement. Therefore, public procurement is currently perceived predominantly as a barrier for circular initiatives

in Rotterdam. Besides, circular initiatives call for the need to include more local circular entrepreneurs in consortia instead of using knowledge from outside the city region. This would stimulate circular initiatives as they will be given structural financial support. In the following paragraph we will explain the criticism on public procurement and consortia in more detail.

Only one circular firm stated that they are currently doing a pilot project together with the municipality. They collect municipal coffee grounds in order to farm oyster mushrooms (Interview_CO_R6). Despite their contentment with this project, they would prefer structural collaboration. The same circular firm argues the need for improving the tender criteria in order to exclude big corporations from tenders that are intrinsically not sustainable (Interview_CO_R6; Interview_CO_R7). Another interviewee argues that circular local entrepreneurs do not stand a chance against large corporations as they cannot provide the required supply (Interview_CO_R5). Furthermore, an interviewee advocates for a municipal policy that would provide a share of their budget to the firm that generates the most social value locally (Interview_CO_R8). In turn, the municipality argues that they are currently working on a strategy regarding circular tenders and acknowledge that there is room for improvement (Interview_MUN_R1; Interview_MUN_R2). Moreover, an interviewee argues that the municipality can make progress with respect to the inclusion of local entrepreneurs in consortia and that they should acknowledge the strategic know-how of local entrepreneurs more often (Interview_CO_R5). For instance, despite the hard work of this circular firm on a so called 'milieupark' to collect materials sustainably and efficiently in the past five years, the municipality of Rotterdam has chosen a consultancy bureau from Amsterdam to research and advice the environmental parks (Interview_CO_R5). Similar to circular tenders, the inclusion of local entrepreneurs in consortia would benefit them financially and would give local entrepreneurs the feeling that they are valued by the local government.

Urban planning: concerns of circular firms regarding gentrification

We found that urban planning is perceived to be an important driver in the city's circular economy with respect to circular hotspots. In the previous sections, it was shown that circular hotspots are used in the CE strategy of the municipality for their matching practices and in order to make good use of the local strengths. Additionally, firms benefit from circular hotspots through flexible regulation, available technical equipment, the establishment of cooperation and publicity. However, urban planning is simultaneously found to obstruct some types of circular initiatives due to gentrification processes. We will address here two interviewees that perceive gentrification affecting their business, involving both smaller re-use companies working with second hand materials.

An interviewee states that the deterioration of M4H and its vacancy was beneficial for the circular firm at first, because they could rent their working place for a very low price (Interview_CO_R5). The district became slowly a vibrant centre for the creative manufacturing industry, while simultaneously the price of the land increased. Consequentially, their working place will be

demolished any time soon and will be replaced by residential towers. This was however already known in 2015, when they signed their two-year contract. Nonetheless, the interviewee argues that it involved a lot of uncertainty, and lack of transparency from the municipality about their gentrification strategy (Interview_CO_R5). Another circular firm also needs to relocate due to gentrification processes in their neighbourhood. Both companies experience relocation as a barrier, because they have to rebuilt their place over and over again what imposes high costs (Interview_CO_R10).

The municipality argues that it is a complex issue, as there is a high pressure on the housing sector. With the development of M4H they want to maintain circular initiatives in the district at fixed locations (Interview_MUN_R1; Interview_MUN_R2). Furthermore, they state that whenever M4H will be transformed into a mixed area for working and residential activities, also circular firms with chemical processes have to relocate. These companies need certain industrial zones in order to operate. They argue that it is a good sign that these circular hotspots are subjected to change in the interest of a growing city (Interview_MUN_R4).

Municipal and national regulations

While only a few municipal regulations (i.e. by-laws) were mentioned to be stimulating or obstructing, openness to *interpretation* of regulations plays an more important role at the local level. Openness to interpretation means the ability of licensing authorities to think along with circular companies in the permitting process. For instance, by advising circular firms to include particular resource streams in their licensing documents as a by-product instead of waste streams. Whereas some improvements have been made regarding openness of interpretation by Environmental Agencies, it is still perceived to obstruct circular firms. Nevertheless, we found that national regulations are obstructing circular initiatives in the city to a higher extent than municipal regulations. The authorisation of the municipality is highly dependent on the development of national regulations, and therefore also its possibilities to support circular initiatives. The different aspects related to regulation are discussed more in-depth in the following paragraphs by means of insightful examples.

First, some by-laws are found to obstruct the circular economy, such as the integration of different functions in a zoning plan for the development of a Upcycle Mall (Interview_MUN_R4) or regulations of the aesthetics committee prohibiting the use of certain sustainable architectural materials (Interview_CO_R11). Whereas local by-laws at industrial zones outside the city, regarding noise space or other nuisance, facilitate room for certain circular firms (Interview_POR_R3).

With regard to interpretation of regulation, both the municipality and the Port Authority find it valuable to further examine what is doable within the existing regulations in cooperation with the Environmental Agency, which is the DCMR in Rotterdam (Interview_MUN_R4; Interview_POR_R3). Besides, the following quote illustrates how the DCMR thinks along with a circular firm:

> '… It is called Blue City, because we want to realise living here, construction activities, catering industry etcetera. The DCMR is very favourable in order to make it happen. As is the municipality by the way. It is very good to do experiments, what will result in knowledge that can be used at other locations.' (Interview_CO_R8)

The comment shows how openness to interpretation could function as a driver locally. However, not all environmental agencies are as open for interpretation as the DCMR. Consequentially, the Port Auhtority gets signals from companies that they experience difficulties in regulation as other environmental agencies persistently indicate their product as a waste stream (Interview_POR_R3).

Nevertheless, many circular firms are far more dependent on national regulation and the openness of interpretation at higher scale levels over municipal regulations, as is identified to be an obstruction for the municipality itself. An interviewee points out that they frequently brainstorm with the municipality in order to tackle issues on national regulation (Interview_CO_R7). Circular firms experience great difficulty with national waste regulation (Interview_CO_R6; Interview_CO_R7), with national tax regulations on labour (Interview_CO_R8), and an interviewee stresses that they have difficulties with national safety regulations with respect to new technologies (Interview_CO_R9). These interviewees are also obstructed due to limited openness of interpretation at national governmental organisations. An interviewee asks for a strong lobby at the municipality to counteract this barrier (Interview_CO_R6).

Although it is not always regulation that forms a barrier, but all administrative obligations that come with the regulations. This is supported by many interviewees of circular firms. For instance, an interviewee explains that it is not very attractive for circular firms to start a new experiment or pilot, because they have to meet additional environmental regulations and registrations (Interview_CO_R8). The interviewee illustrates this with the following comment:

> 'And the enormous amount of administration that comes with your business activities, the tax reports, the environmental agencies, and remittances that have to be done. All types of administrative burdens where we are responsible for. Therefore, many entrepreneurs are not inclined to start an experiment or to do an investment. Besides, you are part of a production chain and you cannot be certain whether you have return on your investment. This is however crucial for the circular economy. This makes it hard to cooperate throughout a production chain.'

Need for improving knowledge on resource streams

In this study, knowledge refers to contextual knowledge[9] on the circular economy. The factor 'knowledge' currently functions as a barrier in Rotterdam. The municipality acknowledges that they are in the starting phase of measuring and the monitoring of the city's waste streams. Especially, circular re-use firms working with secondary materials or products seem to be somewhat overlooked by local governments. The municipality agrees that they have not enough knowledge on the second hand market (Interview_MUN_R1). Increasing theoretical and practical understanding of CE and its markets will help the municipality in better streamlining their CE policies and will lend a helping hand to new circular firms willing to establish in the Rotterdam region. In the port area the knowledge on industrial resource streams functions already as a location decision factor for circular firms, but in the city the lack of contextual knowledge on the different types, flows and impact of waste streams is hindering some firms to localize in Rotterdam (Interview_MUN_R1).

Remaining factors: culture, awareness and financial measures

The local factors culture, awareness and financial measures were identified to be valued less important by the interviewees in explaining how circular initiatives in cities are influenced. Some aspects of these factors are somewhat interwoven in the above sections. Therefore, we will discuss here briefly some remaining aspects that stood out in the analysis.

First, the municipality pursues a strong communication program, in which they expose circular events that are already in place, and by starting dialogues with different stakeholders in order to raise awareness on circular economy (Interview_MUN_R4). This builds further on the matching role of the municipality as it fosters social relationships. Besides, according to an interviewee it was found advantageous to be mentioned in the municipal magazines and websites. This raised familiarity of the firm amongst civil servants, including urban planners, which resulted in more projects for the firm (Interview_CO_R11). Besides, the hands-on mentality of the citizens in Rotterdam is found to stimulate the implementation of circular initiatives (Interview_CO_R5; Interview).

Lastly, what stood out for financial measures in Rotterdam is the CityLab010 subsidy. It allows for the market to come up with innovations and ideas, instead of the government spelling out the solution. This is highly appreciated by circular firms according to the municipality (Interview_MUN_R1) and is confirmed by an interviewee (Interview_CO_R9). However, an interviewee mentioned that subsidies granted by the municipality have a disruptive effect on the city's CE. Subsidies conceal the wider major political and regulatory issues at the national level that obstruct structural financial support for circular initiatives (Interview_CO_R8).

[9] Contextual knowledge can be defined as all the knowledge that is relevant and can be mobilized to understand a given situated decision problem (Pomerol & Brezillon, 1999)

4.2.4 Summary of the case: main barriers and drivers in Rotterdam

First, we found that *locational factors* are mainly a driver for the city's CE. Governmental organisations in the Rotterdam region set out ambitious CE programs and policies that aim to transform Rotterdam into a city leading the way in CE. What stood out was their focus on manufacturing companies within the circular hotspots and their relation with the Port Authority to bring these circular hotspots to a success. The more in-depth our case was studied, the more it became clear that the manufacturing industry and circular hotspots play an significant role in the city's CE. As a consequence, the spatial analysis showed us that indeed high concentrations of circular activities are found at these circular hotspots and that Rotterdam facilitates a relatively high number of circular manufacturing activities. This focus on the manufacturing industry is further supported by interview data of civil servants, who argued that the municipality aims to embed their circular activities in their local strengths (i.e. the manufacturing industry). Furthermore, we found that many aspects come together in the urban area, providing a fertile ground for the establishment of circular initiatives.

Second, *urban planning* functions mainly as a driver in Rotterdam. This local factor builds upon the previous paragraph, where it was discussed that the municipality's circular hotspot policy seems to pay off. Urban planning practices (e.g. circular hotspots) are focused on bringing people and knowledge together in the urban environment and increases spatial proximity between circular firms. *Spatial proximity* seems to benefit circular firms at circular hotspots and within the city boundaries, since it stimulates social interactions with other firms and external parties. This increases the possibility for establishing collaborations and may result in cross-pollination given that a diverse set of firms and people cooperate. Both urban management and spatial proximity may therefore enhance innovation performance of all actors involved.

Third, the strong social network of circular firms in Rotterdam provides many opportunities for collaboration and convening resulting in the attachment of circular firms to the city. Therefore, *convening and cooperation* are driving the city's CE. This driver is very close related to spatial proximity and urban management, since these factors may reinforce collaboration. With regard to convening and cooperation it was found that in particular the matchmaker role of both the municipality and the Port Authority is an important driver for the city's CE. Matching helps firms in finding other organisations with whom they can establish collaborations to exchange knowledge.

Fourth, circular criteria are considered to be poorly embedded in *public procurement* by the majority of circular firms and is therefore identified to be a main barrier. Besides, there are some concerns of interviewees about gentrification and the level of knowledge on CE at the city level. Whereas it was indicated that urban planning functions mainly as a driver, the municipality has to be aware of gentrification processes negatively influencing some circular re-use firms. This relates to the lack of contextual *knowledge* on a variety of circular initiatives and waste streams of the local government of Rotterdam. Lastly, we identified that many circular firms are far more dependent on

national regulation over municipal regulations and that interpretation of regulation is frequently obstructing circular firms in Rotterdam. *National regulation* is therefore indicated as a main barrier in the city's CE.

4.3 Case 2: Amsterdam

4.3.1 CE Programs and policies at the metropolitan and municipal level: a general overview

From the year 2016 the MRA has implemented their CE program, in which their mission is to be one of Europe's most circular metropolitan areas in 2025. In their Development Plan Circular Economy they focus on three tracks that are influencing and reinforcing each other: circular tenders, resource streams and interventions. Their main focus is on circular tenders, as this is believed to stimulate a chain reaction pushing the circular economy in the right direction (MRA, 2018). The MRA has proposed a reformed policy regarding public procurement regulations. Consequentially, a statement of intent was signed by all municipalities across the MRA in 2018. The policy implies that in 2022 at least 10% and in 2025 half of all tenders will be circular. Their aim is that in the year 2030 all tenders will be completely circular. The changes in procurement requirements form an important signal for the market that CE is emerging (Vos et al., 2019). Furthermore, they organised working groups to stimulate cooperation between different parties with the objective to recycle resource streams at high-quality. Lastly, with the implementation of interventions they aim to remove regulatory barriers for companies that currently hinder the circular economy (MRA, 2018).

The municipality of Amsterdam enrolled already a variety of programmes concerning circularity since 2015. In 2017 they won the World Smart City Award for circular economy due to their pioneering programs for CE at the urban level (Amsterdam Smart City, 2017). In 2019 the program 'Building Blocks Towards a new Strategy Amsterdam Circular 2020 – 2025' was implemented, which formed the foundation upon which their strategy stands. It constitutes seventeen development paths for the three resource streams construction, biomass & food and consumption goods on which they will lie their focus (Municipality of Amsterdam et al., 2019). Furthermore, the City of Amsterdam has joined the Thriving Cities Initiatives (TCI), a collaboration between C40, Circle Economy and the Doughnut Economics Action Lab (DEAL). They developed the 'city doughnut', in which the global concept of the Doughnut (e.g. Raworth, 2017) was downscaled and turned into an instrument for CE transitions in cities, embracing both social and ecological perspectives. As a result, Amsterdam placed the city doughnut at the heart of its policymaking (DEAL, 2020). Consequently, the municipality of Amsterdam has implemented its 'Amsterdam Circular 2020 – 2025 Strategy' (Municipality of Amsterdam, 2020), which forms a unity together with the document on the Amsterdam City Doughnut (DEAL, 2020), 'the innovation and implementation program 2020 – 2021' and 'the Amsterdam Circular Monitor' (Municipality of Amsterdam, 2020).

In ‘the innovation and implementation program 2020 – 2021’ they elaborate on the projects and steps that have to be implemented in order to make the transformation towards CE. The municipality argues that Amsterdam has a strong ICT and business services making it a thriving tech hub (Municipality of Amsterdam, 2020). This led to the development of important circular innovations, such as a digital material passport in which materials can be exchanged, many sharing platforms, and the first data-based circular monitor to measure the city’s waste streams. The latter is set out in ‘the Amsterdam Circular Monitor’ report, which aims to express the state of the CE in numbers by calculating the input, throughput and output of materials in the city. A circular monitor is crucial for the city, as they can measure their progress towards CE.

In sum, we found that the Amsterdam area has several ambitious CE programs already in place to streamline and coordinate current policy paths at multiple scale levels. Within their policies they pay a lot of attention to the embeddedness of circular principles within public procurement. Besides, the many different programs of the municipality of Amsterdam indicate that they have a very rich knowledge base and well-founded approach in order to transform Amsterdam into a region leading the way towards CE. We identified that Amsterdam is a serious player in the tech industry, resulting in many supportive tech-based innovations for the city’s CE.

4.3.2 Explorative spatial analysis of CE initiatives in Amsterdam

This paragraph will demonstrate the number and types of circular initiatives established in the municipality of Amsterdam. By analysing the secondary database, it was found that in the year 2017 Amsterdam facilitated a total number of 4175 circular initiatives. After cleaning the data, the *innovative* circular initiatives accounted for 136 activities. A general overview of all circular activities in the municipality of Amsterdam can be found in Table F2. The findings for the innovative circular initiatives for Amsterdam are presented in Table 6, indicating the number of type of industry and R-strategies of these initiatives. The distribution of the 136 initiatives with an address is visualized in Figure 10 for the different industries, and in Figure 11 for the different R-strategies. Figure 12 shows the number of circular initiatives per neighbourhood. The list of names that belong to these neighbourhoods can be found in Appendix G.

Table 6

Innovative circular initiatives in Amsterdam

		Type of industry					
		Consumption goods	Construction	Manufacturing industry	Plastics	Biomass and food	**Total**
Type of R-strategy	R1 Refuse & Rethink	20	4	0	0	4	**28**
	R2 Reduce	1	2	1	0	1	**5**
	R3 Re-use	4	2	1	0	n/a	**7**
	R4 Repair	7	5	0	1	n/a	**13**
	R5 Recycle	45	20	3	5	10	**83**
	R6 Recover	0	0	0	0	0	**0**
Total		**77**	**33**	**5**	**6**	**15**	**136**

Based on the explorative spatial analysis we found that at the district level the highest numbers of circular initiatives are located within East (20%), North (18%) and West-Poort (17%). At the neighbourhood level, Westelijk havengebied, located in the district Westpoort, and both the neighbourhoods Noordelijke IJ-oevers Oost and Noordelijke IJ-oevers West, located in the district North, facilitate the highest share of circular initiatives (all approximately 10%). Within these neighbourhoods there is place for larger warehouses, what may explain the high numbers of circular initiatives.

Besides, we found clustering of circular initiatives at places where also 'traditional' business activities usually locate. Clustering of circular initiatives can be found at the neighbourhood Zuid-as, located around the main train station Amsterdam Zuid. Moreover, the neighbourhoods Overamstel and Amstel III Bullewijk show high numbers of circular initiatives, mainly nearby large transport hubs. Circular initiatives were also found to be concentrated at Bedrijventerrein Sloterdijk in the district West.

Next to a high share of recycling strategies (60%), we found that Amsterdam facilitates a relatively high share of Refuse & Rethink initiatives (22%). Repair (9%), Re-use (5%) and Reduce (4%) initiatives show relatively lower shares. The high share of recycling initiatives is probably the result of the large investments on recycling policies by the national government. Up to 23% of Refuse & Rethink initiatives in the Netherlands can be found in Amsterdam. This relatively high number may relate to the strong tech industry of Amsterdam, what was already pointed out in section 4.3.1, as the majority of Refuse & Rethink initiatives in Amsterdam involves sharing platforms.

Furthermore, of all circular initiatives in Amsterdam consumption goods scores highest (59%), followed by construction (20%), and biomass and food (11%). The manufacturing industry and plastics

scores low with 4% of the total number of circular initiatives. The districts City Centre (83%), East (70%) and Westpoort (42%) show high shares of circular consumption goods initiatives. In particular, all seven circular firms in the district South-East are found to produce consumption goods. In contrast, at Schiphol there are no circular consumption goods produced. Up to 60% of the initiatives here include initiatives operating in the construction sector. Nonetheless, the district Westpoort does facilitate the largest number of construction initiatives (25%) and Biomass and Food (23%) compared to all initiatives located in Amsterdam.

To conclude, the explorative spatial analysis shows us three important insights. First, clustering of circular initiatives in Amsterdam takes place mainly at locations where 'traditional' firms also tend to settle down, for instance at business parks and around transport hubs. Second, the relatively high number Refuse and Rethink initiatives, involving many tech-based sharing platforms, may indicate that the tech industry in Amsterdam plays an important role in CE locally. This is also supported by the CE programs and policies, discussed in section 4.3.1, which emphasized the role of tech solutions (e.g. sharing platforms, online market places, CE monitor). Third, we found that more than half of the circular initiatives in Amsterdam are producing consumption goods.

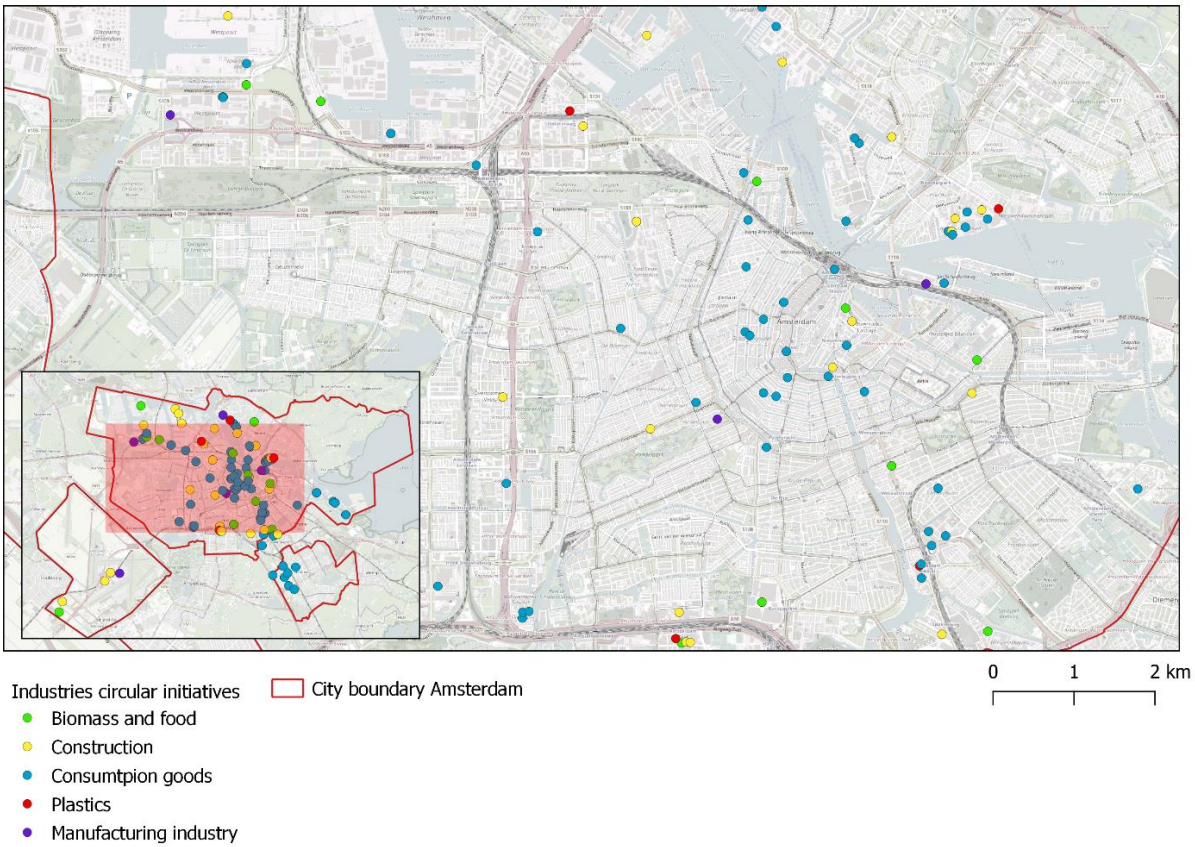


Figure 10. Distribution of industries of the innovative circular initiatives in Amsterdam

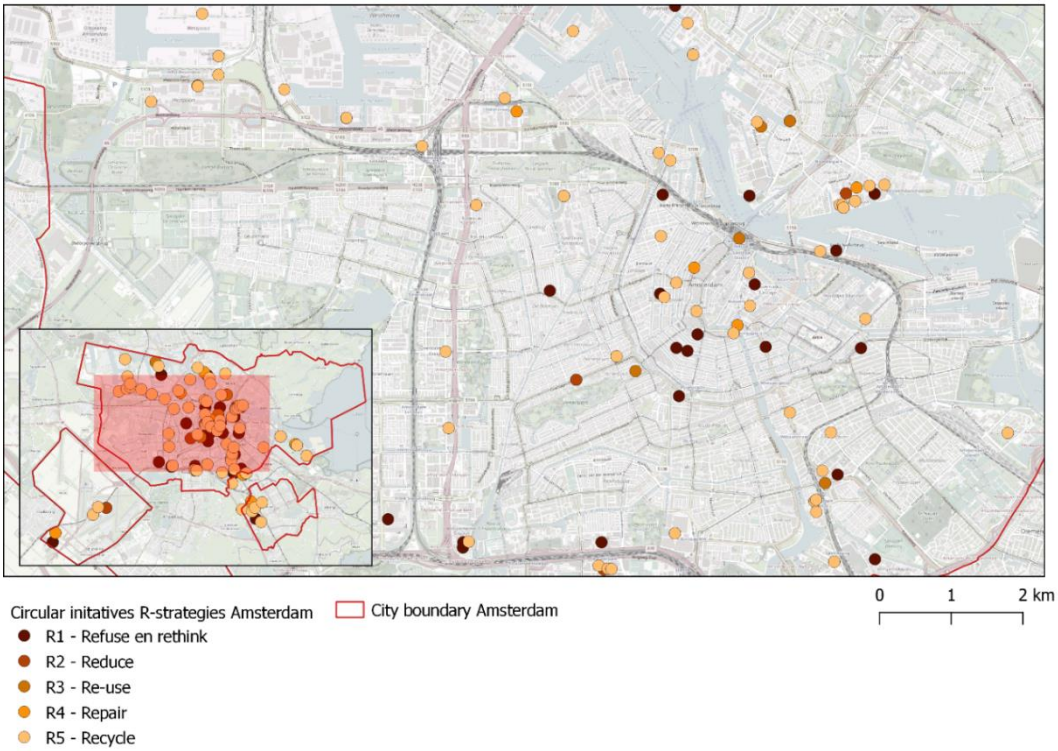


Figure 11. Distribution of R-strategies of the innovative circular initiatives in Amsterdam

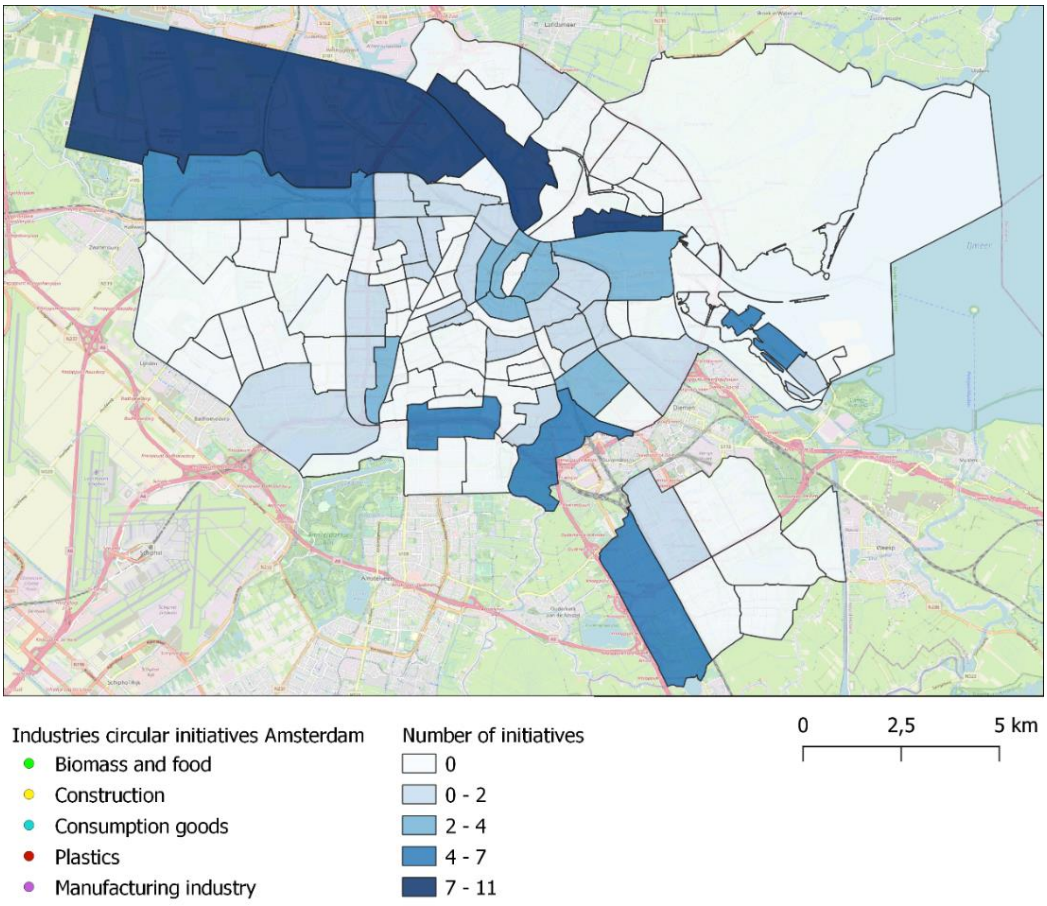


Figure 12. Number of circular initiatives per city district in Amsterdam

4.3.3 A deeper understanding of the case

This sub-chapter aims to provide explanations of how local factors fostered the establishment of the circular initiatives in the city, or did hinder the establishment of new circular initiatives. Each factor is discussed by showing how it influences the implementation of circular initiatives in the urban environment. Interview data is analysed and builds upon the findings of the main policies and the explorative spatial analysis.

Location: using the strengths of the local economy

Based on the analysis of interview data we found that locational factors in the urban area of Amsterdam are driving circular initiatives. Our findings build mainly upon earlier findings of desk research and the spatial analysis that circular tech-based innovations seem to be prominent in the city. It seems that the local industrial base influences the most prevalent type of circular activities in the city and drives innovation. Besides, other locational factors such as the presence of a strong innovation ecosystem and the city's international character are stimulating circular initiatives. The following paragraphs will discuss these findings in more detail.

A strong tech and AI sector and a good (digital) infrastructure was perceived by the municipality to be beneficial for the attraction of circular initiatives in the city. The municipality states that in the light of the Smart City Agenda they focus on the theme circular economy (Interview_MUN_A12). The interviewee illustrates the importance of technology solutions in Amsterdam by the following comment:

> 'I think that it is important to take a look at your local economy and take this as a basis for your activities. Amsterdam would be a good place for data and technology solutions, so more the deep tech solutions. We perceive this to develop naturally within the city: you see here Excess Material Exchange and the material passport Madaster, a company from Amsterdam. We started as the first city ever a circular sharing platform. You see a lot of sharing platforms in Amsterdam, such as Peerby and Marktplaats. I think this is Amsterdam's distinctiveness.' (Interview_MUN_A12)

The municipality did also explain that the presence of blockchain experts in Amsterdam was an important criteria to be able to develop CE into the direction of technology solutions (Interview_MUN_A12). Interestingly, two well-founded Amsterdam sharing platforms argued that despite their emotional attachment to Amsterdam, they have very few local collaborations (Interview_CO_A15; Interview_CO_A19). One interviewee states that a sharing platform has many non-physical components, making the location less important, since they can locate in any big western city (Interview_CO_A15). The sharing platforms even expect to continue to work from home after the

Covid-19 pandemic is over due to the many opportunities of the digital world nowadays. This implies the location independence of circular tech companies.

Similarly, the Port of Amsterdam aims to use their local strengths in the development of CE. They argue that their strong recycling base was important for the establishment of circular activity within the port area. Consequentially, chemical recycling is identified to have huge potential (Interview_POR_A14). Besides, the interviewee states that they are historically a strong blending port, meaning that they are focussing on fuels such as benzine, diesel and kerosine. Consequentially, an interviewee argues that with respect to CE the port of Amsterdam will engage in the biofuels and the biochemistry industry in their future CE trajectory. Lastly, the port is controlling the large European hinterland, functioning as a huge sales market. The interviewee argues that this is very attractive for circular firms. (Interview_POR_A14).

Additionally, the presence of a strong innovation ecosystem, the international character and the 'cosmopolitan allure' of Amsterdam are seen by the municipality as important elements that function as a good foundation for circular start-ups, as they provide diverse environments for (circular) entrepreneurs. The presence of for instance co-working places, accelerators and innovation hubs are driving elements of the innovation ecosystem that stood out in our analysis. Diversity in people and organisations fosters creativity, new ventures and new insights and is argued to eventually stimulate the implementation of circular innovations in Amsterdam (Interview_MUN_A12).

Spatial proximity: stimulating the implementation of circular initiatives

Based on the analysis of interview data of both civil servants and circular firms, spatial proximity is found to be a driving factor for circular initiatives as it makes firms closely located to a variety of resources and services. Besides, circular firms experience spatial closeness to other organisations as beneficial because it increases knowledge exchange, it may increase publicity and connections or partnerships can be established easier. In the following paragraphs we will more extensively explain important aspects of spatial proximity for the CE of Amsterdam.

The municipality stresses the importance of physical proximity in the circular economy, as waste streams coming free at one place in the city can be re-used more easily provided that companies are in each other's proximity (Interview_MUN_A12). Besides, spatial proximity improves accessibility and the working climate of Amsterdam, which stimulates circular firms mainly with respect to the attraction of skilled workers (e.g. Interview_MUN_A12; Interview_CO_A18; Interview_CO_A15; Interview_CO_A19). The following comment illustrates how a circular firm benefits from spatial proximity:

> 'By looking back I acknowledge that more can be achieved in Amsterdam in comparison to starting a company in Nijmegen. You are closer to the media, closer to other start-ups, you make

> connections more easily, you get attention more easily, and you can participate more easily in programs than in the east of the Netherlands. You also meet more people that have knowledge on start-ups.' (Interview_CO_A15)

This comment on spatial proximity is highly related to the presence of the different elements of the innovation system in Amsterdam, but indicates that the *proximity* to these elements makes it increasingly beneficial. Accordingly, an interviewee states that they located very centrally to be proximate to financial parties and investors, as well as to be close by their partners, such as architects, suppliers and contractors to establish connections. They specifically located at the heart of the 'old economy' (i.e. the linear-based real estate companies at the Zuid-as) in order to make the largest impact in the real estate business (Interview_CO_A16).

Moreover, it was argued that the proximity to a city port is beneficial for circular initiatives as materials can more easily be processed locally. For instance, a circular firm collects hardware components in the city, separates and refurbished them in the port, and transports them back towards the city (Interview_POR_A14). Also within the port area the proximity to particular resource streams is driving circular initiatives. Circular firms within the port area tend to cluster in the proximity of large corporations, such as near waste and energy companies or waste separation plants. This provides opportunities for circular firms to connect to energy and heat streams or to process mono-streams more easily (Interview_POR_A14). For instance, a circular firm argues that they localized in Westelijk Havengebied due to the reason that this location was in the proximity of a biodiesel plant and a plant that processes food waste. Besides, they located near a soda plant in order to be able to re-use transported water (Interview_CO_A20).

Convening and cooperation: the matching role of the municipality

The establishment of both formal and informal cooperation between circular firms and other organisations in the urban area is found to drive the implementation of circular initiatives. Convening and cooperation facilitated through elements of the innovation ecosystem seems to stimulate circular firms as this increases knowledge exchange by sharing learning, ideas and experiences. By analysing the data, we found that the elements of the innovation ecosystem are interlinked with some crucial locational aspects (e.g. co-working spaces, accelerators, incubators). These locational aspects as well as aspects of urban management (e.g. circular and innovation hubs) foster convening and cooperation.

The municipality argues that the circular economy is stimulated by the use of their strong innovation ecosystem (Interview_MUN_A12). Within this innovation ecosystem, the municipality fulfils an important role as matchmaker between circular companies and other parties. The municipality has created a huge department, called StartupAmsterdam, that aims to strengthen the start-up innovation ecosystem in Amsterdam and connects companies to start-ups. From their perspective, personal contact

is highly appreciated by companies. This public-private partnership contributes to the establishment of strong ties between a variety of stakeholders in the start-up ecosystem. StartupAmsterdam believes that some organisations would not have found each other without the help of StartupAmsterdam. Performance indicators show that the efforts of the overall department are paying off (Interview_MUN_A13).

The strong innovation ecosystem is partly the result of the establishment of a variety of prominent accelerators and incubators in the city. Two interviewees mentioned that they participated in either an accelerator or incubator program. Both circular firms became attached to Amsterdam due to the expansion of their social network and the establishment of strong ties with different parties in Amsterdam during the period of their participation (Interview_CO_A15; Interview_CO_A18). Additionally, we found circular firms were stimulated due to their location at a co-working space (Interview_CO_A15) or innovation hub (Interview_MUN_A12). These organisations have very close contact with a large network of many actors, organise events and workshops and facilitate collaborative working or experimentation spaces what may increase knowledge exchange. Besides, Buiksloterham is a living lab in order to experiment with circular principles where knowledge exchange between municipality, firms and citizens is high up on the agenda (Interview_MUN_A12).

Similarly to the municipality, the Port of Amsterdam matches circular firms with other parties and exchanges knowledge with circular firms on newcomers, permits and the implementation of new regulations. A circular firm confirms that the Port of Amsterdam is doing very well in matching organisations. They are frequently approached by the Port Authority with information on potential new customers that will establish in the port area. The circular firm finds it crucial that this link is being established through the help of the Port Authority (Interview_CO_A20). Furthermore, the Port Authority plans to create a diverse ecosystem, what will stimulate circular initiatives. They plan to develop a bio park and the 'circular shell', where they aim to establish collaborations between circular firms to increase knowledge exchange and exchange of waste or energetic streams (Interview_POR_A14).

Market developments: difficulties of working in circular product chains

While collaboration is highly interwoven in the above paragraphs, we will elaborate here further on the relation between collaboration and market developments. Subsequently, we will emphasize an typical example of a market barrier in CE regarding the supply of materials for circular product chains.

A circular firm that prolongs the lifetime of furniture by refurbishing materials of large offices in Amsterdam has many collaborations with large corporations. The interviewee argues that they have the advantage of locating in an urban area with high concentrations of office buildings in order to attract many projects (Interview_CO_A17). However, collaborations with organisations that focus on producing second hand office furniture for these large corporations are very scarce locally. One example of a rather small initiative includes their partnership with a bowling firm. The circular firms uses the

bowling alleys for the design of office conference tables. With regard to such initiatives, they experience difficulties of operating in a circular production chain. Especially since the Covid-19 outbreak, in that offices are hardly used and the supply of certain types of components are hampering. They experience their dependence on material flows to be highly obstructing their business activities, as they 'do not have any guarantee on what the market will and can offer'. In the example of the collaboration with the bowling firm, the circular firm is able to produce merely one to five tables. This limited amount of supply of second hand materials prohibits them to grow progressively compared to other 'linear' national furniture businesses, what obstructs them in improving the optimization of their circular business process (Interview_CO_A17). To summarize, it was found that circular firms struggle with the continuous provision of materials, making it harder to produce large quantities and to manage their business processes in the most efficient way.

Mixed reactions on public procurement

The interviewees reacted differently regarding the public procurement of the municipality. Based on analysis of interview data we identified that public procurement functions as a driver in one sector, while for circular initiatives operating in other sectors public procurement currently functions as a barrier. Ambitious policies on circular public procurement do however raise expectations that circular tenders will improve in Amsterdam in the coming years.

According to an interviewee the municipality is doing very well in circular tenders concerning their office furniture (Interview_CO_A17). They have sufficiently defined their criteria with respect to the selection of sustainable and circular local partners. One of those criteria includes whether a firm can contribute to the local sustainable or social agenda. As a consequence, this type of criteria is experienced by the interviewee to highly increase opportunities for local circular entrepreneurs to win the tender and to make good use of regional strengths by the municipality (Interview_CO_A17).

In contrast, other firms do have negative experiences regarding circular tenders. An interviewee argues that his firm and the municipality do not share the same vision in the design of buildings (Interview_CO_A16). Another circular firm stresses that their cooperation got stuck, because not all departments of the municipality were at the same page (Interview_CO_A18). Additionally, it is argued by an interviewee that they find it unfortunate that most tenders are already spelled out for the market (Interview_CO_A15). In their opinion, it obstructs CE as it results in the implementation of incremental instead of radical innovations. They prefer a new approach in which companies will compete to make the most impact locally. By grating firms a share of the budget based on their created local impact, incentive to truly maintain the impact is raised. An interviewee from the municipality responded by the acknowledgement that a lot can be improved regarding circular tenders and referred to their policy ambitions that implies that in 2022 at least 10% and in 2025 half of all tenders will be circular. In 2022 this will account for 2 billion euros (Interview_MUN_A12).

Municipal and national regulation

A few municipal regulations were mentioned to be stimulating or hindering, but the majority of circular firms seem far more dependent on national regulation for their business activities. Therefore, municipal regulation is not the deciding factor for urban circular initiatives. In the following paragraphs we will explain important aspects of regulation that are influencing the CE transition in Amsterdam.

At the municipal level, several by-laws are mentioned that obstruct or drive CE in Amsterdam. The municipality decides on what waste streams are collected. This influences circular firms differently. For instance, one interviewee is content with the plans of the municipality to improve the separation of household waste, as this provides more opportunities for them to process food waste at their plant (Interview_CO_A20). In contrast, another interviewee is very disappointed that the municipality will stop collecting plastic waste from 2021, as this plastic is required in their production process (Interview_CO_A18). Furthermore, an circular architectural firm is obstructed by the mono-functional zoning plans set in place by the municipality. The interviewee would prefer a regulation in which the market decides on what function the building is granted, taking into account functions that are strictly forbidden in an certain urban area (Interview_CO_A16). This will provide more space in the cities where circular buildings can be designed. In terms of municipal regulation at the industrial zones at the outskirts of the city, an interviewee is very pleased with the possibilities for his industrial company regarding noise space and other nuisance regulations (Interview_CO_A20). Another interesting insight at the municipal level shows us that a variety of car sharing platforms are working together to lobby for policy adjustments at the municipality (Interview_CO_A19). Besides, at the municipality they are currently investigating their fiscal and legal instruments that they can implement to drive circular economy in the city and in order to overcome regulatory barriers (Interview_MUN_A12).

Nonetheless, many circular firms are far more dependent on national regulations. In particular, tax regulations on labour are mentioned by many interviewees (Interview_CO_A20; Interview_CO_A15, Interview_CO_A16). Although it is not always the regulation that forms a barrier, but all administrative obligations that come with the regulations or the interpretation of regulations. Besides, the duration of granting a permit is experienced to be long. An interviewee perceives that at the management level of environmental agencies the circular economy is recognized to be important, but at lower levels they always end up in the regular trajectory (Interview_CO_A20).

Knowledge: commitment on city's CE monitoring

The lack of contextual knowledge is identified to be barrier in the urban CE transition of Amsterdam. It limits their understanding of the city's CE, even when it was observed that they are far ahead of other Dutch cities regarding their monitoring practices. As already described in section 4.3.1, the municipality of Amsterdam has already made huge efforts in the development of the Amsterdam Circular Monitor. However, more detailed data is still lacking. For obtaining input data for the monitor, closer

collaborations with strategic partners are required. For instance, the municipality of Amsterdam is currently busy with establishing data partnerships in order to bring the monitor to a higher level of accuracy (Interview_MUN_A12). The largest lack of data is identified to be in the city's material throughput. Research on the use and re-use of different materials streams by consumers is needed. In the coming years, the municipality aims to build a data platform to provide an overview of all relevant information on CE in Amsterdam. Improving the monitor would benefit the matching of resource streams between circular firms in Amsterdam.

Remaining factors: culture, awareness and financial measures

Culture, awareness and financial measurements were rather underexposed by the interviewees as factors that may explain how circular initiatives in cities are influenced. Some aspects of these factors are already interwoven in the above sections. Therefore, we will discuss them very briefly here.

Consumer awareness was experienced to be slightly improved amongst consumers in recent years, which stimulated a circular initiative (Interview_CO_A17). Furthermore, giving publicity to firms is perceived by interviewees to benefit circular firms (Interview_CO_A15; Interview_MUN_A13). Besides, intra-organisational and inter-organisational cultural differences are perceived by interviewees to obstruct public-private collaboration (Interview_CO_A18) and obstruct processes within the municipality that have the objective to implement circular principles (Interview_MUN_A12).

The financial barrier that stood out in the analysis regarding CE in particular is that it is extra difficult for circular initiatives to attract funding. New circular technological innovations are considered economically less reliable for investors (Interview_POR_A14). Furthermore, circular firms in Amsterdam benefit from business angels and venture capital (Interview_CO_A15) facilitated by its strong innovation ecosystem.

4.3.4 Summary of the case: main barriers and drivers in Amsterdam

First, we found that in the Amsterdam region a variety of CE programs and policies are implemented both at the municipal and metropolitan level. Especially circular initiatives in the tech-industry were identified to be most prominent in Amsterdam. In addition, findings of the explorative spatial analysis and interview data further substantiate this statement. It was demonstrated by both quantitative data and by interviewees that Amsterdam facilitates many Refuse & Rethink activities, mainly including tech-based sharing and data platforms. Accordingly, this in-depth analysis showed that *locational factors* are driving the city's CE. The findings demonstrate how local governmental organisations embed circular activities in their local industrial strengths. Consequentially, it was found that the local industrial and knowledge base influences the most prevalent type of circular initiatives in the city. The same applies for the Port of Amsterdam, where specialization of circular activities is based upon their existing knowledge base. They focus largely on the recycling and the biofuel and biochemistry industry.

Second, *spatial proximity* was defined to be a driver for circular firms in Amsterdam. The factor itself is even for some companies the reason to settle down in Amsterdam instead of other world cities, since closeness to city resources and services is experienced to be improve effectiveness and fosters collaboration and knowledge exchange. This resulted in a city where cooperation is preferred over competition, what in turn benefits the working environment. Especially with regard to the location independence of sharing platforms, we assume that a favourable work-life balance and strong social-cultural ties of circular firms with the city are becoming increasingly important in order to keep tech-based companies within the Amsterdam boundaries.

Third, *convening and cooperation* is a stimulating factor and crucial for the implementation of circular initiatives in the city. This is acknowledged by the local government. The local government gives guidance by connecting organisations of the innovation ecosystem with circular firms (i.e. matching) and makes them aware of potential new customers or resources in the Amsterdam region. Matching practices by the local government seems to reinforce knowledge exchange since dots are connected that would not be established without an overarching matching organisation. Besides, *urban planning* is identified as a driver. For instance, at living labs (e.g. Buiksloterham) and at urban planning projects in the port area (e.g. biopark and the circular shell) increase social interactions or resource exchange between circular firms. Consequentially this is highly related to convening and cooperation.

Fourth, we found that *market developments* are obstructing circular firms in Amsterdam. A discontinuous supply of secondary materials on the market is generates big differences between circular firms and other 'linear' companies. As 'linear' companies have a consistent flow of raw materials available at any time, they are often one step ahead of circular firms. Besides, *public procurement* is not managed well for almost all product groups by the municipality regarding circular criteria. Therefore, it functions as a barrier for the majority of the circular firms in Amsterdam. Additionally, we found that circular firms are far more dependent on national regulations over municipal regulation. *National regulations* are therefore identified to be a main barrier in the city's CE. Lastly, *knowledge* barriers are obstructing the matching of circular firms in Amsterdam.

4.4 Cross-case analysis

In this paragraph we will point out the empirical similarities and differences across cases. Besides, tables showing the shares of different R-strategies and industries of circular initiatives per case are presented in order to cross-compare cases.

4.4.1 Geographical factors and the type of circular activities in a city

In both cases, geographical factors are driving CE initiatives. With regard to localization factors, we found that both municipalities aim to embed their circular initiatives in the strengths of the local economy. In Rotterdam we observed a well-founded manufacturing and process industry, whereas

Amsterdam did already stand out in deep tech solutions. Consequentially, the study demonstrated that the dominant local industry determines the prevalent type of circular activity in the city. This was confirmed by quantitative data. Table 7 shows that Rotterdam facilitates three times as much circular manufacturing initiatives compared to Amsterdam.

Table 7

Industries of innovative circular initiatives per case

		Nr. of initiatives Amsterdam	Initiatives in Amsterdam [%]	Nr. of initiatives Rotterdam	Initiatives in Rotterdam [%]
Type industry	Consumption goods	77	56.6	37	35.6
	Construction	33	24.3	29	27.9
	Manufacturing	5	3.7	15	14.4
	Plastics	6	4.4	11	10.6
	Biomass & Food	15	11.0	12	11.5
Total		**136**	**100**	**104**	**100**

On the contrary, Table 8 identifies a higher share of Rethink & Refuse companies in Amsterdam compared to Rotterdam, respectively 20.6% and 11.5%. These companies involve mainly sharing platforms and companies with a product as a service. Interestingly, other Dutch tech cities, such as Eindhoven or Delft, facilitate just one Refuse & Rethink initiative.

In both cities, also the Port Authorities use their local strengths in the development of their circular economy. The port of Amsterdam will aim at biofuels and biochemistry, but also chemical recycling is identified to have huge potential. Besides, the port of Rotterdam has the ambition to become a chemical recycling cluster in the coming years. Both the port of Amsterdam and Rotterdam are thus mainly focused on recycling activities. In both port areas recycling activities account for over 80% of the total initiatives found in this district. Accordingly, chemical recycling is found to play an important role in both the Rotterdam port area, by means of consortia and coalitions based on chemical recycling (Interview_POR_R3), and in the port of Amsterdam through major urban planning projects focused on the recycling of resource streams (Interview_POR_A14).

Additionally, spatial proximity is identified in both cities to function as a main driver. Traditional market advantages that come with spatial proximity in urban areas remains very important for circular firms. This includes the proximity to a transport hub, the university, customers and skilled workers. We substantiated that proximity to other firms is more likely to play an important role in the

city's CE. Proximity to other firms is experienced by interviewees to establish social relationships and collaborations more easily. Collaboration between companies is even more important in CE, because actors are heavily dependent on each other in a closed value chain and benefit more from streamlined collaboration.

Table 8

R-strategies of innovative circular initiatives per case

		Nr. of initiatives Amsterdam	Initiatives in Amsterdam [%]	Nr. of initiatives Rotterdam	Initiatives in Rotterdam [%]
Type of R-strategy	R1 Refuse & Rethink	28	20.6	12	11.5
	R2 Reduce	5	3.7	10	9.6
	R3 Re-use	7	5.1	6	5.8
	R4 Repair	13	9.6	13	12.5
	R5 Recycle	83	61.0	63	60.6
	R6 Recover	0	0.0	0	0.0
Total		**136**	**100**	**104**	**100**

4.4.2 The relevance of circular hotspots and districts in cities

In both cities, civil servants and firms argue that the development of districts or facilities developed for circular entrepreneurs is crucial for stimulating the implementation of circular firms in cities. This can take different forms. Rotterdam pursues a circular hotspot policy to facilitate circular entrepreneurs at certain districts. The municipality of Rotterdam defines a circular hotspot as a place 'where not only knowledge is brought together, but also business activities are physically clustered' (Interview_MUN_R1). In contrast to Rotterdam, the municipality of Amsterdam does not conduct a circular hotspot policy. They are not facilitating areas especially designed for circular entrepreneurs, but provide some areas where experimentation with circular principles is encouraged (e.g. Buiksloterham). The municipality of Amsterdam makes good use of their strong innovation ecosystem, consisting out of many innovation hubs, incubators and accelerators. The different elements function as physical places where circular entrepreneurs are welcomed. As indicated by interviewees in the within-cases, all different elements increase knowledge exchange between circular firms.

The municipality of Amsterdam did not get signals from the market that they urge for the development of circular areas (Interview_MUN_A12). The municipality of Amsterdam assumes that

their choice for not developing circular hubs has to do with the difference between the city's characters (Interview_MUN_A12). Physical places may fit well in the economy of Rotterdam, as they focus largely on manufacturing and process industrial activities. Therefore, the activities in Rotterdam may involve more physical aspects that are suited for the 'circular hotspot approach'. In contrast to the more location-dependent industrial activities in Rotterdam, the many circular technology solutions that are popping up in Amsterdam involve less physical aspects. Therefore, we consider the use of the strong innovation ecosystem in Amsterdam a suitable approach. The interviews confirmed that both approaches did stimulate the implementation of circular firms in both cities.

Consequently, the different approaches of the cities result in different spatial distributions of circular initiative clusters across the city. In Rotterdam clustering takes mainly place at circular hotspots. On the contrary, circular initiatives in Amsterdam are predominantly concentrated at places where also high concentrations of 'traditional' business activities can be found (e.g. business parks). Nonetheless, when the circular initiatives become more physical and are in need of warehouses in Amsterdam, they tend to cluster in districts where there are relatively many circular firms compared to traditional businesses activities. Furthermore, the spatial analysis showed that one cluster of circular initiatives in Amsterdam is driven by the development of spin-offs from a circular parent company (Interview_CO_A17), that is a large circular furniture business. In Rotterdam no spin-offs were established in close geographical proximity.

4.4.3 The local government as a matchmaker

We pointed out that the local governments fulfill their role as matchmaker what stimulates circular initiatives in both Amsterdam and Rotterdam. In Rotterdam we did even found that matching practices of the Port Authority and the municipality complement and reinforce each other. Besides, we found some differences in matchmaker roles between cases that we want to emphasize here.

One the one hand, the municipality of Rotterdam talks more about the matchmaker role in a way of 'bringing people and knowledge on the right place'. This emphasizes the importance of the place-dependency of the circular activities in Rotterdam, explained in section 4.4.2. Accordingly, we found a group of highly connected circular firms at circular hotspots. This resulted in the establishment of collaborations, strengthening of firm identity and increased publicity for circular firms. Contrastingly, the municipality of Amsterdam emphasizes the strengths of the startup ecosystem in their matchmaker role. While both municipalities have departments that are strengthening the innovation ecosystem by matching practices, Amsterdam has an innovation ecosystem of another order of magnitude. Comparatively, Amsterdam facilitates over 20 accelerators and incubators and over 50 co-working spaces (Iamsterdam, 2020) and Rotterdam merely two accelerator programs, one incubator and approximately ten co-working spaces (WeTechRotterdam, 2020). The differences in the matchmaker

roles of the municipalities can in turn be linked to the cities' different trajectories, as the activities in Rotterdam are more likely to be place-dependent compared to Amsterdam.

4.4.4 Discrepancies between local subsidies and the regulatory environment at higher levels

In both cases it became clear that many circular firms, as well as the municipalities themselves, are far more obstructed by national regulations over municipal regulations. This was mentioned so frequently in both cases, that it was worthwhile to extent the conceptual framework by adding the sub-category 'national regulation'. Besides, subsidies granted to circular firms by municipalities for the implementation of circular innovations are slowed down heavily through the insufficient regulatory environment at higher scale levels (Interview_CO_R6; Interview_CO_R7; Interview_CO_R9). We find it therefore important to stress this discrepancy in more detail as this is argued to refrain many entrepreneurs from starting a circular initiative (Interview_CO_R6; Interview_CO_R7).

One circular firm received a CityLab010 subsidy from the municipality of Rotterdam for a pilot in order to develop a water taxi fuelled by hydrogen. Later on they received an additional incentive scheme from the national government for the implementation of their circular innovation (Interview_CO_R9). This indicates that both the municipality and the national government attach importance to these developments. However, due to the non-existence of local, national and international regulations for hydrogen-driven maritime transportation technologies the subsidized project is now highly obstructed at higher scale-levels. Similarly, another interviewee states that they received a municipal subsidy for a pilot project in order to become fully circular, but got stuck due to regulatory barriers at provincial and national level (Interview_CO_R6).

In both cases we found that the core obstruction is the limited openness to interpretation by licensing organisations at the local and national level. Employees working at licensing authorities do not have any guidance to grant permits for such innovative technologies. An interviewee experienced the permit trajectory at higher levels as clumsy, untransparent and unclear, resulting in years of work and a lot of administrative burden to receive the permit (Interview_CO_R6; Interview_CO_R7). Likewise, a circular firm has to put a lot of effort in proving the safety of their technology by working around existing regulation, costing a lot of time (Interview_CO_R9).

4.4.5 A lack of knowledge on the city's resource streams

In contrast to local factors discussed in paragraphs 4.4.1 to 4.4.4, knowledge is not indicated as a main barrier. Knowledge is explained here due to its novelty in that it is an addition to the conceptual framework. Accordingly, we identified that the local governments have both a lack of contextual knowledge on the circular initiatives and waste streams of the city's circular economy.

For instance, the municipality of Rotterdam acknowledges that they have a lack of knowledge on the impact of circular initiatives working with secondary materials and products within their city.

This may affect the decision-making process of the local government and may result in, unintentional, expulsion of circular firms working with secondary products from places that are especially designed for circular or creative entrepreneurs. In the Rotterdam case, we identified that gentrification processes of the local government have negative influence on some circular firms.

Furthermore, both municipalities experience barriers regarding contextual knowledge on material flows within the city boundaries. The municipality of Rotterdam has just started the development of a CE monitor. The municipality of Amsterdam has implemented a CE monitor, but is currently obstructed by a lack of throughput data. The establishment of data partnerships with other organisations in order to obtain information about resource streams is crucial to bring the monitor to a higher level. Therefore, improvement of 'convening and cooperation' may improve knowledge on city's resource streams. Vice-versa, improvement in contextual knowledge on resource streams may increase cooperation as this benefits matching practices of the local government. This means that a good overview of the city's resource streams would limit the 'leakage' of resource streams, since excess materials can be matched more easily to parties that are in need of that particular waste stream. Besides, a lack of knowledge by the municipalities makes them less capable of supporting newcomers sufficiently and keeping track of progress regarding CE. By increasing knowledge on CE, local governments can better streamline their policies, which is crucial in steering the CE transition in the right direction.

To summarize all findings, Table 9 shows our framework of how the local factors drive or hinder the implementation of circular initiatives in cities. The larger dots indicate local factors that can be identified to be main barriers or drivers, since the analysis of the data revealed that these local factors are more influential in urban CE transitions than others. Besides, red colours indicate an obstructing barrier and green colours identify local factors that are driving circular initiatives at the city-level. We included a brief summary per local factor to describe how it influences urban CE transitions. Lastly, we want to stress that most sub-categories across the cases overlap in the extent to which they are driving or hindering the CE transition, as well as the in how they influence (i.e. hinder or drive) the CE transition.

Table 9

Summary of the results: indentification of CE barriers and drivers in Rotterdam and Amsterdam.

Category	Sub-category	Rotterdam	Amsterdam	How does the factor drive or hinder CE in cities?
Geography	Spatial proximity			Spatial proximity benefits firms as it generates traditional market advantages and increases knowledge exchange for circular firms in both cities (see convening and cooperation). Social interactions with a proximate diverse set of actors may even result in cross-pollination. Spatial proximity is highly related to convening and cooperation as it fosters collaborations and is strengthening social ties in the city.
	Location			Locational factors are identified to be important drivers in both cities. Many aspects come together in urban areas, such as a large sales market, well-founded industries, a strong innovation ecosystem and industrial spaces. While the cities provide many advantageous resources, the housing prices are high and there is lack of space. Place identity is strengthening circular firms in Rotterdam. Additionally, both municipalities embed their circular activities in their local strengths, what seems to pay off in absolute numbers of circular initiatives facilitated by the cities. The dominant local industrial base determines the prevalent type of circular activity in both cities.
Engagement	Convening and cooperation			Convening and cooperation are highly related to urban management and spatial proximity. Collaborations contribute to the strong social network of (circular) firms in the cities and results in increased knowledge exchange. Circular firms become increasingly attached to the city whenever they establish strong social ties in the city region. The matching role of the municipality is found important in both cities. Matching can take place at circular hotspots (Rotterdam) and via elements of the strong innovation ecosystem (Amsterdam). Public-private cooperation does sometimes fail or is unsatisfactory, which obstructs circular firms (see public procurement and culture).
	Awareness			Low awareness of consumers is obstructing, but strong communication programs drive the city's CE. Dialogues with different stakeholders and publicity for CE drives circular firms. It is related to urban management as circular hotspots and living labs may raise awareness by consumers. Raised awareness amongst civil servants or traditional firms in the city also benefit circular firms as it may result in collaborations and successful circular tenders.
	Culture			Rotterdam is known for hands-on mentality of its citizens, which benefits circular firms. Intra-organisational and inter-organisational cultural differences obstruct public-private collaboration and improvement of embedding circular principles in municipalities in both cities. Diversity in both cities drives CE.
Regulation	National regulation			National regulation is a main barrier for circular initiatives in cities (e.g. waste regulation and tax on labour). Regulatory barriers at the national level are found to be obstructing circular firms in cities to a much higher extent than municipal regulation.

	Municipal regulation			Interpretation of regulations and all administrative burdens that come with experiments and pilots obstruct circular initiatives in both cities. Some by-laws are obstructing or stimulating circular firms, but these are subordinate to major regulatory barriers at the national level. Entrepreneurs will more easily start a 'linear' business due to all regulatory difficulties.
Urban management	Urban planning			Well-managed urban planning is found to drive CE, because it may for example facilitate districts developed for circular firms (e.g. the circular hotspots in Rotterdam or bioparks in Amsterdam) where entrepreneurs benefit from flexible regulation, technical equipment and publicity. Besides, the proximity to other circular firms increases knowledge exchange through increased social interaction, collaboration and cross-pollination. Urban planning is therefore related to spatial proximity and convening and cooperation. Rotterdam must be aware of gentrification processes hindering particular circular initiatives.
	Public procurement			Whereas some product groups are properly managed regarding circular criteria in Amsterdam, the majority of circular industries is obstructed by existing criteria that are in favour of 'linear' firms.
Economic factors	Financial measures			Municipal subsidies are driving CE, but subsidies may also have a disruptive effect on the city CE as they obstruct structural financial support at the national level (see national regulation). The cities provide many business angels and venture capital due to their strong innovation ecosystems. The main financial barrier is that it is difficult to attract funding for new circular technologies as it is an economically less reliable investment.
	Market developments	n/a		A discontinuous supply of secondary materials on the market is obstructing circular firms competing 'linear' firms.
Knowledge	Knowledge			Whereas Amsterdam is one step ahead of Rotterdam, in both cities a lack of knowledge is obstructing the city's CE. Increased understanding in theoretical and practical knowledge of CE improves streamlining CE policies, will improve matching practices and will help newcomers. Circular firms in Rotterdam using second hand materials are obstructed by a lack of knowledge on different types of circular activities. In both port areas knowledge on waste streams functions already as a driver for circular firms in order do sufficiently exchanging their resource streams.

* Large sized dots indicate factors that are highly valued by the interviewees to influence the city's CE.

- Driving factor, no barrier identified
- Driving factor, some barriers identified
- Barrier, some drivers identified
- Barrier, no drivers identified

5. Conclusion

This multiple case study has presented a detailed investigation of how local factors are hindering and stimulating the implementation of circular initiatives in cities. Consequentially, this thesis builds upon the very scarce amount of literature on CE barriers and drivers at the city-level. To recap, this study aimed to provide an answer to the following research (sub)questions:

How do local factors stimulate or hinder the implementation of innovative circular initiatives in cities?

Based on desk research, an explorative spatial analysis and the analysis of semi-structured interviews, we used an abductive approach to develop a framework of local factors that can act as a barrier or driver in urban CE transitions. The included local factors are geography, engagement, regulation, urban management, economic factors and knowledge. In particular the local factors geography and knowledge were added to the existing literature on urban CE transitions in that these categories were not identified before. Based on our analysis, we found that of all the studied local factors geography, engagement, regulation and urban management are more influential in urban CE transitions compared to the local factors knowledge and economic factors. This was similar for both cases.

First, the local factor geography stood out as an important driving factor in cities, as both spatial proximity and locational aspects in urban areas induce favourable conditions for localization of circular firms. Furthermore, we found that embedding circular initiatives in the strengths of the local economy seems to drive the city's CE and that distinct local knowledge bases result in different prevalent types of circular activity in the city.

Second, regulation was found to be a main barrier at the local level. Particularly national regulation is a main barrier for the implementation of radical circular innovations that are financially supported by the local government. All difficulties that come with regulations regarding circular innovations are even refraining entrepreneurs from starting a circular business locally.

Third, urban management was found to function as both a main driver and main barrier. Urban planning stimulates the implementation of circular initiatives, whereas public procurement is identified to be a main barrier in urban CE transitions in that the criteria favour linear businesses over circular firms. Urban planning is highly related to geographical factors, in that it is found crucial for CE to properly manage the urban environment in a way that places are being developed where circular entrepreneurs (i.e. knowledge) can physically be brought together. This can take different forms.

Fourth, engagement was identified to be a main driver primarily due to the sub-category convening and cooperation. Collaboration drives urban CE transitions since it increases knowledge exchange and circular firms become increasingly attached to the city region due to the strengthening of their social ties locally. Collaborations between companies are even more important in CE, because actors are heavily dependent on each other in closed value chains. Matching practices of local governments were found to play an important role in the establishment of collaborations. Above all,

spatial proximity and urban management seem to reinforce convening and cooperation, as both factors were found to increase social interaction.

To conclude, this thesis makes a first step in exploring all relevant local factors that hinder or drive urban CE transitions in cities. As we found that geographical factors played an important role in stimulating innovative circular initiatives in cities, the study provided important empirical evidence that a spatial perspective on urban CE transitions is meaningful. In the next chapter we will connect the results to theory with the objective to critically substantiate the novelty of this study in comparison with existing literature and aim to discuss our policy recommendations.

6. Discussion

6.1 Theoretical and policy implications for urban CE transitions

This thesis has presented a detailed investigation of local factors hindering and stimulating the implementation of circular initiatives in cities. The different local factors in our previously developed conceptual framework will now be matched against the empirical findings provided by the case studies. The aim of this chapter is to explore the broader theoretical implications.

Overall, this study analysed hindering and stimulating factors in urban CE transitions in more detail than existing literature. The local factor 'geography' is given special attention within the discussion, as this was identified to be the main gap in literature on urban CE transitions. Consequently, we will shed insights on whether and how CE transitions unfold differently across different urban areas. Furthermore, we will extensively explain some interesting nuances compared to previous literature on drivers and barriers in CE transitions at the city-level, including the role of national regulation and knowledge factors. Additionally, by using MLP theory we can reveal the bigger picture of how circular niche-innovations in cities are hindered or stimulated by the socio-technical landscape and the regime rules.

6.1.1 The importance of taking a geographical perspective on CE transitions

This thesis conceptualized the influence of the spatial context in urban CE transitions. The rationale of EEG theory (Boschma & Martin, 2010) and theory of 'geography of innovation' (Feldman & Kogler, 2010) align with the findings of this research. Therefore, this study extends the field of CE transition literature, in that geographical factors are found crucial in explaining the different shapes of CE transition processes and transition pathways. We revealed that, similar to 'traditional' innovative activity, location and spatial proximity are also driving local factors for spatially clustering of innovative *circular* activity.

The importance of relatedness in urban CE transitions

By linking the results to previous studies on EEG and transition literature we find some interesting insights. It was explained in the theoretical framework (section 2.5) that knowledge is place dependent, as it builds upon existing knowledge and it provides opportunities for further knowledge development. Besides, literature incorporates the main understanding that regions can better specialise by diversifying their knowledge base into a new field through building on related local capabilities (Boschma & Frenken, 2012). Accordingly, we identified that both the municipalities and Port Authorities are embedding their circular activities within the strengths of their local economy. This was found to determine the path dependency of the city regarding circular economy. As showed by our case study,

Rotterdam diversifies more easily into the manufacturing industry and Amsterdam is perceived to easily branch into the deep tech industry based on their economic history. This overlaps with research of Neffke (2009), who stated that due to the principle of relatedness the future industry evolution is dependent on the historical industrial profile. Overall, regional branching (Boschma & Frenken, 2012) is observed by civil servants to work fast and successful for the implementation of circular initiatives. The explorative spatial analyses support the statement that regional branching stimulates urban CE transitions, because a vast number of related circular activities were identified in Dutch frontrunner cities. The findings of our study therefore provide support for the path dependency of both cities regarding circular economy.

Another argument for path dependency lies in the different spatial patterns of circular initiatives found across cities. This is probably the result of the difference in approaches and distinct trajectories of the cities. Whereas in Rotterdam it was found that co-location of the more place-dependent circular firms mainly takes place at circular hotspots, Amsterdam facilitates co-location by their strong start-up ecosystem with its many co-workings places, incubators and accelerators. To conclude, this study showed that the formation of different trajectories of CE transitions across cities is the result of the uneven spatial contexts found in the urban environments.

The danger of negative 'lock-in' for urban CE transitions

The results of the Dutch frontrunner cities may imply that cities are bounded by their knowledge base characteristics in becoming successful in the implementation of circular initiatives. However, when building solely on their existing knowledge base it may result in the development of merely incremental innovations. In absolute terms it may seem a successful strategy, but at the end it is questionable whether it will truly result in a transition.

Accordingly, Martin & Sunley (2006) stated that the economy is an irreversible historical process in which future outcomes depend on past events and outcomes. A phase of positive 'lock-in', in which the region benefits of increasing returns and positive externalities, can be followed up by a phase of negative 'lock-in'. By linking back on the relation between the circularity ladder and MLP, we indicated that radical innovations are required for a successful socio-technical transition. Radical innovations are circular initiatives that address high R-strategies. Low R-strategies, such as recycling, build mainly upon the dominant processes, structures and configurations. The specialization in recycling activities or in just one type of industry may eventually result in a negative 'lock-in'. The phase of a negative 'lock-in' is accompanied with diminished productivity, adaptability and competitiveness of the region (Martin & Sunley, 2006).

This could become a serious problem for the Dutch frontrunner cities in this study, since they facilitate high numbers of circular initiatives that involve rather low R-strategies. Accordingly, the results showed that in Amsterdam and Rotterdam over 60 percent of innovative circular initiatives involve recycling strategies. Besides, the cities seem to specialize into a particular industry. Therefore,

cities need to be aware of possible negative lock-in scenario's, as a transition requires more than the implementation of a multitude of recycling initiatives.

The importance of clustering in urban CE transitions

We found that advantages of clustering in cities also apply for the localization of innovative circular initiatives. Similar to Doloreux & Shearmur (2012) we observed that the city is attractive for localization due to its high density and compactness. Spatial proximity and location are found important for the attraction of circular initiatives, what overlaps with literature of Audretsch & Feldman (1996) focused on 'traditional' innovative activity. Similar to literature on productivity advantages (Porter, 2000), circular firms seem to cluster at certain places as this provides better access to for instance a transport hub, universities, customers and skilled workers. Clustering of circular initiatives was also found to result in MAR-externalities, such as in Amsterdam where spatial proximity to highly skilled specialised labour force (e.g. block chain experts) was beneficial for circular firms. Moreover, Jacobs-externalities arise at particular sites in for example Rotterdam, where cross-pollination at circular hotspots was observed. Here, the solutions in one industry, were adopted in another industry. The findings of this study confirm the theory of 'geography of innovation' as it seems that clustering of circular firms in cities further stimulates firm concentrations due to its increased benefits, thereby causing uneven spatial clustering of circular activity.

The location-independence of sharing platforms

We want to put the instability of some trajectories of cities into discussion. For example, we found in our study that sharing platforms acknowledge that they are less dependent with regard to their physical location. They can easily relocate their headquarters to another major city, as they are not as dependent on local resources compared to other circular activities. Especially since the Covid-19 outbreak, sharing platforms in Amsterdam argued that they work from home very efficiently. Peerby is even pleased with the absence of a physical office in Amsterdam and argues to possibly continue this way of working in the future. In this highly connected digital world, sharing platforms experienced that they can easily communicate and cooperate with other organisations virtually. This can be a driver from the perspective of sharing platforms, but may function as a barrier for local governments.

For instance, in the case of Amsterdam external shocks can result in a sudden relocation of sharing platforms. Simultaneously, knowledge bases will also relocate and can no longer be utilized in local learning practices by local firms. Boschma et al. (2015) argues that the entry and exit of new technologies depends on other technologies to which they are related in the city. In the context of CE, this may indicate that the more sharing platforms exit the city, the lower the entry probability of related technologies (e.g. sharing platforms or other data-based circular technologies). With the exit of sharing platforms, the technological landscape of the city will change. This increases the probability that other

companies of the sharing platform industry, or other related circular tech-based industries, will exit the region as there are no, or poorly, related industries already present in the region (e.g. Boschma et al., 2015). As a consequence, this may obstruct or maybe even disrupt the city's CE transition.

6.1.2 Considering the influence of national regulation on urban CE transitions

This thesis contributed to urban CE transition literature in that the framework of local factors influencing urban CE transition was extended with the insight that national regulation has to be taken into account. By reflecting on MLP theory (Geels, 2011a), we confirm the importance of putting pressure on the system level for the succession of urban CE transitions and eventually the wider CE transition, as the implementation of radical innovations is largely dependent on the wider institutional environment.

Based on our study, we found that radical innovations developed by circular firms are subjected to lock-in mechanisms at higher scale levels. The subsidized projects of the hydrogen-driven water taxi and the pilot on the circular oyster mushroom production are examples of radical innovations, both involving high R-strategies, that are hindered by national regulation. Using MLP theory we stress that the subsidies that are granted at the local level, which are supposed to create a safe space for circular firms, are not paying off due to a mismatch with the national regulations that are part of the wider institutional environment. By creating protected spaces, Geels (2019) argues that radical innovations may become stabilized and trigger adjustments in the socio-technical system. In our study we found barriers obstructing the implementation of these radical circular innovations, including waste regulations, tax on labour regulations, regulations regarding technological innovations and in particular the openness to interpretation of environmental agencies and other governmental organisations at the national level. Limited openness to interpretation is obstructing permitting of circular innovations at the local level and result in more entrepreneurs starting linear businesses locally. Therefore, the regime rules (e.g. regulations, shared believes and user practices) are hindering the adoption of circular niche-innovations in cities. Hence, positive externalities are even reinforcing the regime rules that obstruct circular niche-innovations as the physical and informational networks increase in size and interconnectedness. The region becomes stuck in established practices, ideas and networks of embeddedness which may cause negative 'lock-in' (Martin & Sunley, 2006).

We extend the field of urban CE transition literature by showing that the creation of protected spaces for circular initiatives in cities by means of subsidizing projects is not sufficient enough for realising urban CE transitions. We recognize that changes at the socio-technical system of the MLP (e.g. change national regulation) are crucial to take full advantage of subsidized local radical innovative circular initiatives. It is therefore important to put pressure on the regime in order to accelerate the implementation of radical circular innovations in cities. For instance, Strategic Niche Management (SNM) is an approach giving guidance for policy makers in stimulating radical innovations and for putting pressure on the dominant regime (Kemp et al., 1998). However, the precise steps of SNM or

governmental actions that have to be taken by the national government in order to realise a social-technical transition goes beyond the scope of this research.

Nevertheless, at the city-level municipalities can play a major role in giving guidance to circular firms. We have seen that frontrunner municipalities are doing very well by matching circular firms to other organisations. This matchmaker role can also be applied in order to support circular firms in the wider regulatory environment. Additionally, the municipality can put more pressure on the national government by increasing lobby activities to succeed in the wider implementation of supporting policies to protect circular niche innovations or constrain linear incumbent technologies. Besides, we observed that local governmental organisations can have influence by taking an exemplary role. For example, improving public procurement policies regarding their circular criteria may create a chain reaction in destabilization of the regime (e.g. regulations, cognitive routines, shared believes). Increasing circular criteria in public procurement impose changes in markets, organisations and culture that are important for the regional transition towards CE (Vos et al., 2019).

6.1.3 Knowledge as an additional local influence factor

Our study extended previous urban CE barrier and driver literature by extending the framework of influential local factors with the category knowledge. It refers to the contextual knowledge of local governments on all different types of circular initiatives and the city's waste streams. Some notions of our knowledge category were noticed by Prendeville et al. (2018) and Jonker et al. (2018), such as 'developing contextual knowledge about resource use' (Prendeville et al., 2018) and 'analyse the urban metabolism' (Jonker et al, 2018). Our findings of the category 'knowledge' overlap with the these studies, but we contributed by adding the perspective of innovative circular initiatives to this category and thereby showing both sides of the coin.

In our study 'knowledge' does not only refer to a lack of contextual knowledge on resource streams by the local government, but also incorporates the ignorance of local governments in their knowledge on the different innovative circular initiatives that are established in urban environment. The latter applies especially to small circular firms working with secondary materials or products, that may feel sometimes overlooked in strategic know-how or gentrification processes by local governments. From the point of view of the municipality, gentrification is rather positively perceived as this indicates economic growth. Additionally, a lack of contextual knowledge also applies for other types of innovative circular initiatives. By linking 'knowledge' to section 6.1.1, the local government seems to be unaware of the location-independence of particular circular tech-based initiatives. This may indicate the ignorance of municipalities regarding the consequences of relocation of sharing platforms for the city's circular economy. In sum, this research showed that next to a lack of contextual knowledge on resource streams, local governments may also have limited understanding on particular types of circular initiatives within their city.

6.1.4 Policy implications

In the theoretical framework (section 2.2), we described the importance of policy for the adoption of radical innovations in the socio-technical system in that policy can support niches and processes of regime destabilization (Lindberg et al., 2019). Therefore, we aim to present concrete policy implications that will steer urban CE transitions in the right direction. In sections 6.1.1 to 6.1.3, we discussed our theoretical implications and extensively described important aspects that need attention in urban CE transitions. This resulted in the development of the policy recommendations for stimulating urban CE transitions (Table 10). We present only novel policy recommendations that add to previous findings of the policy-based studies of Jonker et al. (2018) and Prendeville et al. (2018).

We want to emphasize that our policy recommendations are based on a study of CE frontrunner cities. Nonetheless, city powers are heterogeneous across urban areas. This should be taken into account by bringing the recommendations into practice. For cities without strong industry bases, a first step may be to investigate the strengths of the regional economy at a higher scale level than the city boundaries alone. Besides, insights into the type of industries of 'traditional' circular activities present in the city could be a good foundation to diversify into related capabilities regarding radical circular innovations.

In sum, with the development of our policy recommendations we made valuable contributions to other local governments that face difficulties in their transition towards CE. The policy recommendations will give guidance to cities in constituting well-founded CE programs and strategies, in that they reinforce stimulating factors for urban CE transitions and help them in overcoming CE barriers. Particularly cities provide fertile ground for the emergence of radical circular innovations, what makes the implementation of our policy recommendations across a multitude of cities crucial for catalysing wider CE transformation. This is not to say that a successful CE transition is completely in the hands of local governments, as this study demonstrated that changes in national regulation are vital for cities to play their part.

Table 10

Policy recommendations for urban CE transitions

#	Policy recommendation	Description
1.	Embed circular initiatives in local strengths	By identifying local strengths (i.e. strong industries or clusters), cities are able to stimulate the number of circular initiatives.
2.	Be aware of negative 'lock-in' pathways	This recommendation builds upon recommendation 1. Cities should focus on radical circular innovations over incremental innovations, and should acquire multiple specialisms to prevent a negative 'lock-in' scenario.
3.	Choose an urban management policy that fits the city's industrial knowledge base	Cities should co-locate firms through an efficient urban management policy. This can be through 1) the development of circular hotspots that are based on local strengths, and 2) a strong innovation ecosystem. Option 1 fits regional economies that are more industrial-based, whereas option 2 can be better applied to city's that facilitate many location-independent initiatives.
4.	Extend the matching role of the municipality	Local governments should match circular firms to other organisations within the city region. Matching stimulates the exchange of resource streams, collaboration and may give guidance to circular firms in the wider regulatory environment.
5.	Provide governmental guidance to circular firms in the wider regulatory environment	Circular firms need support in the national regulatory environment in order to take full advantage of subsidized circular innovations at the city-level. Local governments could give this guidance to the circular initiative.
6.	Increase understanding on all types of circular initiatives within the city	Municipalities should not lose sight of circular initiatives working with second hand products or secondary materials, as these initiatives may also involve radical circular innovations that are crucial to succeed in the CE transition. Besides, municipalities should also increase understanding of the consequences in the event of relocation of sharing platforms.

6.2 Limitations of the research

Firstly, we want to stress the limitations of case studies with regard to external validity (i.e. generalizability). All conclusions should be treated with care, because the conclusions drawn from the two Dutch cities do not fully represent all other cities nationally and globally. By looking into previous literature, we might indicate that certain local factors are more generalizable than others. For the theoretical implications, literature already presented overlapping arguments on the factors knowledge, culture and national regulation in urban areas influencing CE transitions in cities (e.g. Jonker et al., 2018; Prendeville et al., 2018). However, influence of geographical factors is not explored by other case studies in existing literature and is therefore identified to be less generalizable.

Additionally, we specifically included geographical factors in our conceptual framework what resulted in pointed questions on the influence of geographical factors in the city's CE transition for the interviewees. As the interviewees were rather 'forced' to describe the influence of geographical factors, this raises the question whether the factor geography would also be identified as a main driver by conducting the research inductively.

Ideally, we should include more cases and do more interviews per case to increase generalizability. However, this was not feasible in this study due to limited time and resources. Increasing the number and variation of cases allows for the analysis of multiple urban CE transitions and will exemplify the complexity of reality, which will improve quality of results. For instance, it would increase generalizability of findings on path dependency of CE transitions at the city-level or provide more evidence on the uneven clustering processes of circular innovative activity across space.

Besides, we want to emphasize that this exploratory research is not able to identify causal relationships, but involves the identification of concepts that appear to be related. Furthermore, internal validity was increased due to constant comparisons between reality and theory during the case study by means of applying systematic combining. Replication further increased internal validity, as the cases were treated as two separate studies.

Moreover, studies with a qualitative component entail the risk of a participant or observer bias. We tackled this issue as much as possible by developing an interview guide, recording the interviews and by transcribing all interviews. Besides, the implementation of the MMR method allowed us to use quantitative data as a way to strengthen the findings of qualitative data to a certain extent. Nonetheless, the quantitative data also had its limitations. The database was created in 2017, which could be slightly outdated by the time this study was conducted. However, at the time the research was conducted no newer database was available. Therefore, this research demonstrates the most relevant insights to CE transitions in cities. Besides, by including initiatives without an address in the spatial analysis we could improve the research quality.

Lastly, the research was conducted in the period of the Covid-19 pandemic. This influenced the availability and accessibility of interviewees. Except for four interviews, all interviews were done

virtually. This could influence the interpretation of qualitative data. For interpretation of geographical aspects it may be beneficial to visit the company in order to get a grasp of the atmosphere of their working places. For instance, this may be crucial for circular hubs and other buildings facilitating co-working spaces. Besides, non-verbal expression is very significant in interpreting the participants feelings and emotions. However, the interpretation of body language was often limited for the interviewer due to the virtual interviews.

6.3 Recommendations for future research

This research serves as a foundation for future inquiries on urban CE transitions, which could enrich the findings that were elaborated on in this thesis. Some first suggestions for future research are based on the limitations of this research, in that they could increase generalizability of the findings of this study or could build upon this study by investigating urban CE transitions on a more detailed level. Overall, future research will contribute to an even deeper understanding of urban CE transitions and the role of the spatial context in CE transitions at the city-level.

First, the framework of barriers and drivers that influence urban CE transitions could be investigated into more detail. This could be done by studying the barriers and drivers for the different types of circular initiatives separately, varying in R-strategy and industry. This is for the reason that they may experience particular local factors as more or less obstructing than the framework presented in this thesis. In contrast, this study took into account a wide variety of circular initiatives.

Second, city powers are not uniform across urban areas. This key notion relates to the spatial context studied in this thesis, as not all city governments have access to the same resources across space. For instance, some local governments do not have the capability to establish a department completely focused on the matching of organisations. By performing a comparative research to a laggard city and a frontrunner city differences in drivers and barriers may come to light.

Lastly, cities with other industrial knowledge bases could be studied for their CE barriers and drivers and their specific pathways towards CE. Additionally, cities with similar knowledge bases could be compared to investigate if they followed a similar CE trajectory. Increasing understanding on the relations between the knowledge base and the urban CE trajectory may increase generalizability of the outcomes of this study. Moreover, the location-independence of sharing platforms may be researched more in-depth to discover how this may influence frontrunner CE cities specialised in this sector. We hope that possible topics for future research and current limitations will spur further research to provide a stronger theoretical and empirical basis for both the framework of CE barriers and drivers in urban transitions and for the path dependency of cities regarding their CE trajectories.

7. Acknowledgements

I want to express my gratitude to my supervisors Dr. Iris Wänzenbock, of the University of Utrecht, and Dr. Maikel Kishna, of my internship organisation PBL, who helped me through the entire thesis process. During my thesis they succeeded in giving me sharp and fair feedback that brought my thesis to a substantially higher level. Furthermore, I am thankful to all interviewees who participated in my master's thesis project and gave me very valuable and interesting insights about their experiences in urban CE transitions.

8. Reference list

Alkemade, F., Hekkert, M. P., & Negro, S. O. (2011). Transition policy and innovation policy: Friends or foes? *Environmental Innovation and Societal Transitions*, *1*(1), 125–129. https://doi.org/10.1016/j.eist.2011.04.009

Amsterdam Smart City. (2017). *Amsterdam wins prestigious award for circular economy*. Retrieved from https://amsterdamsmartcity.com/posts/amsterdam-wins-prestigious-award-for-circular-econ

Asheim, B. T., & Coenen, L. (2005). Knowledge bases and regional innovation systems: Comparing Nordic clusters. *34*(8), 1173–1190. https://doi.org/10.1016/j.respol.2005.03.013

Asheim, B. T., & Gertler, M. S. (2006). The Geography of Innovation: Regional Innovation Systems. In *The Oxford Handbook of Innovation*. https://doi.org/10.1093/oxfordhb/9780199286805.003.0011

Asheim, B. T., Isaksen, A., Martin, R., & Trippl, M. (2017). The role of clusters and public policy in new regional economic path development. In *The life cycle of clusters*. Edward Elgar Publishing.

Audretsch, D. B., & Feldman, M. P. (1996). R&D Spillovers and the Geography of Innovation. *American Economic Review*, *86*(3), 630–640.

Bal, G., & Bulterman, S. (2018). *Wonen en ondernemen kan schuren: spanning tussen wonen en maakindustrie*. Retrieved from https://evr010.nl/wpcontent/uploads/2019/02/Spanning_tussen_wonen_en_maakindustrie_essay.pdf

Barneveld, J. van, Veldboer, T., & Daniels, C. van. (2019). *Rotterdam Towards a Circular Port: a deep dive into Waste-to-Value opportunities*. Retrieved from https://www.portofrotterdam.com/en/news-and-press-releases/port-of-rotterdam-in-strong-position-as-a-future-circular-hub

Boschma, R., Balland, P. A., & Kogler, D. F. (2015). Relatedness and technological change in cities: the rise and fall of technological knowledge in US metropolitan areas from 1981 to 2010. *Industrial and Corporate Change*, *24*(1), 223–250. https://doi.org/10.1093/icc/dtu012

Boschma, R., & Frenken, K., Bahelt, H., Feldman, M., & Kogler, D. (2012). Technological relatedness and regional branching. In *Beyond territory. Dynamic Geographies of Innovation and Knowledge Creation* (pp. 64–68).

Boschma, R., & Martin, R. (2010). The aims and scope of evolutionary economic geography. Utrecht University, Department of Human Geography and Spatial Planning; Group Economy, 3–42. https://doi.org/10.4337/9781849806497.00007

Boulding, K. E. (1966). The economics of the coming spaceship earth. *New York.* https://doi.org/10.4324/9781315064147

Brown, J. H., Burger, J. R., Burnside, W. R., Chang, M., Davidson, A. D., Fristoe, T. S., Hamilton, M. J., Hammond, S. T., Kodric-Brown, A., Mercado-Silva, N., Nekola, J. C., & Okie, J. G. (2014). Macroecology meets macroeconomics: Resource scarcity and global sustainability. *Ecological Engineering*, *65*, 24–32. https://doi.org/10.1016/j.ecoleng.2013.07.071

Brundtland, G. H., Khalid, M., Agnelli, S., Al-Athel, S., & Chidzero, B. J. N. Y. (1987). Our common future. *New York*, *8*.

Bulkeley, H., Coenen, L., Frantzeskaki, N. Hartmann, C., Kronsell, A., Mai, L., & Palgan, Y. V. (2016). Urban living labs: governing urban sustainability transitions. *Current Opinion in Environmental Sustainability*, *22*, 13–17.

Castaldi, C., Frenken, K., & Los, B. (2014). Related Variety, Unrelated Variety and Technological Breakthroughs: An analysis of US State-Level Patenting. *Regional Studies*, *49*(5), 767–781. https://doi.org/10.1080/00343404.2014.940305

CBS. (2019). *Kerncijfers Wijken en buurten 2019*. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/84583NED/table?ts=1602660505437

CBS. (2020). *Bevolkingsontwikkeling: regio per maand*. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37230ned/table?fromstatweb

City of Amsterdam. (2020). *Business in Amsterdam: city of enterprise*. Retrieved from https://www.amsterdam.nl/en/business/business-locations/

Coenen, L., & Truffer, B. (2012). Places and Spaces of Sustainability Transitions: Geographical Contributions to an Emerging Research and Policy Field. *European Planning Studies*, *20*(3), 367–374. https://doi.org/10.1080/09654313.2012.651802

Creswell, J. W. (1999). Mixed-Method Research: Introduction and Application. In *Handbook of Educational Policy* (pp. 455–560).

Creswell, J. W. (2007). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (2nd ed.), London, UK: SAGE publications

De Jesus, A., & Mendonça, S. (2018). Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. *Ecological Economics*, *145*, 75–89. https://doi.org/10.1016/j.ecolecon.2017.08.001

DEAL. (2020). *De stadsdonut voor Amsterdam: een instrument voor verandering*. Retrieved from https://groenebuurten.nl/wp-content/uploads/2020/04/amsterdamcirculair2020-2025_stradsdonut_wcag-1.pdf
Doloreux, D., & Shearmur, R. (2012). Collaboration, information and the geography of innovation in knowledge intensive business services. *Journal of Economic Geography*, *12*(1), 79–105. https://doi.org/10.1093/jeg/lbr003
Dubois, A., & Gadde, L. E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research*, *55*(7), 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8
Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550. https://doi.org/10.5465/AMR.1989.4308385
Ellen MacArthur Foundation (EMF). (2015). Towards the Circular Economy. *Journal of Industrial Ecology*, *2*, 23–44.
Ellen MacArthur Foundation (EMF). (2019). *City Governments and Their Role in Enabling a Circular Economy Transition*. Retrieved from https://www.ellenmacarthurfoundation.org/our-work/activities/circular-economy-in-cities/policy-levers
Feldman, M. P., & Kogler, D. F. (2010). Stylized facts in the geography of innovation. *Handbook of the Economics of Innovation* (1st ed.), *1*, 381-410. https://doi.org/10.1016/S0169-7218(10)01008-7
Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods*, *5*(1), 80–92. https://doi.org/10.1177/160940690600500107
Ferras-Hernandez, X., & Nylund, P. A. (2019). Clusters as Innovation Engines: The Accelerating Strengths of Proximity. *European Management Review*, *16*(1), 37–53. https://doi.org/10.1111/emre.12330
Frantzeskaki, N., Broto, V. C., Coenen, L., & Loorbach, D. (2017). *Urban sustainability transitions*. Taylor & Francis.
Fuenfschilling, L., Frantzeskaki, N., & Coenen, L. (2019). Urban experimentation & sustainability transitions. *European Planning Studies*, *27*(2), 219–228. https://doi.org/10.1080/09654313.2018.1532977
Geels, F. W. (2011a). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002
Geels, F. W. (2011b). The Role of Cities in Technological Transitions. In *Cities and Low Carbon Transitions* (pp. 13–29).
Geels, F. W. (2019). Socio-technical transitions to sustainability: a review of criticisms and elaborations of the Multi-Level Perspective. *Current Opinion in Environmental Sustainability*, *39*, 187–201. https://doi.org/10.1016/j.cosust.2019.06.009
Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757-768. https://doi.org/10.1016/j.jclepro.2016.12.048
Geng, Y., & Doberstein, B. (2008). Developing the circular economy in China: Challenges and opportunities for achieving 'leapfrog development.' *The International Journal of Sustainable Development & World Ecology*, *15*(3), 231–239. https://doi.org/10.3843/SusDev.15.3
Gladek, E., Exter, P. van, Roemers, G., Schlueter, L., Winter, J. de, Galle, N., & Dufourmont, J. (2018). *Circular Rotterdam: opportunities for new jobs in a zero waste economy*. Retrieved from https://www.metabolic.nl/publications/circular-rotterdam/
Government of the Netherlands. (2016). *A circular economy in the Netherlands by 2050*. Retrieved from https://www.government.nl/documents/policy-notes/2016/09/14/a-circular-economy-in-the-netherlands-by-2050
Hannequart, J., & Naudet, P. M. (2015). *CEN Guidelines for integrated circular economy strategies at local and regional level*. Retrieved from https://circulareconomy.europa.eu/platform/en/knowledge/cen-guidelines-integrated-circular-economy-strategies-local-and-regional-level
Hidalgo, C. A., Balland, P. A., Boschma, R., Delgado, M., Feldman, M., Frenken, K., Glaeser, E., He, C., Kogler, D. F., Morrison, A., Neffke, F., Rigby, D., Stern, S., Zheng, S., & Zhu, S. (2018). The Principle of Relatedness. *Springer Nature Switzerland*, *1*, 451–457. https://doi.org/10.1007/978-3-319-96661-8_52
Holland Circular Hotspot & Circle Economy. (2019). *Circular Cities: Accelerating the transition towards Circular Cities*. Retrieved from https://hollandcircularhotspot.nl/wp-content/uploads/2019/04/HCH-Brochure-20190410-web_DEF.pdf
Homrich, A. S., Galvão, G., Abadia, L. G., & Carvalho, M. M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. *Journal of Cleaner Production*, *175*, 525–543. https://doi.org/10.1016/j.jclepro.2017.11.064
Iamsterdam. (2020). *Accelerators and Incubators*. Retrieved from https://www.iamsterdam.com/en/business/startupamsterdam/hubs/accelerators-and-incubators
IPCC. (2018). Global warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C

above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change. In *Press*, *85*(17).
IRP. (2018). *The Weight of Cities: Resource Requirement of Future Urbanization*. Retrieved from https://www.resourcepanel.org/reports/weight-cities
Jacobsson, S., & Bergek, A. (2011). Innovation system analyses and sustainability transitions: Contributions and suggestions for research. *Environmental Innovation and Societal Transitions*, *1*(1), 41–57. https://doi.org/10.1016/j.eist.2011.04.006
Jenks, G. F. (1967). The data model concept in statistical mapping. *International Yearbook of Cartography*, *7*, 186–190.
Jonker, J., Montenegro Navarro, N., Ludwig, D., Zoon, H., Voet, J., Van Stralen, N., van Ooijen, R., & Lammes, R. (2018). *Circular City Governance: An explorative research study into current barriers and governance practices in circular city transitions across Europe*. Retrieved from https://circulareconomy.europa.eu/platform/sites/default/files/circular-city-governance-an-explorative-research-study-into-current-barriers-and-governance-practices-in-circular-city-transitions-across-europe-2018.pdf
Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis and Strategic Management*, *10*(2), 175–198. https://doi.org/10.1080/09537329808524310
Kirchherr, J., Hekkert, M., Bour, R., Huibrechtse-Truijens, A., Kostense-Smit, E., & Muller, J. (2017). *Breaking the Barriers to the Circular Economy*. https://doi.org/10.1007/s00442-006-0364-9
Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the Circular Economy: Evidence From the European Union (EU). *Ecological Economics*, *150*, 264–272. https://doi.org/10.1016/j.ecolecon.2018.04.028
Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005
Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K. H., Haberl, H., & Fischer-Kowalski, M. (2009). Growth in global materials use, GDP and population during the 20th century. *Ecological Economics*, *68*(10), 2696–2705. https://doi.org/10.1016/j.ecolecon.2009.05.007
Lambooy, J. G. (1998). Polynucleation and economic development: the Randstad. *European Planning Studies*, *6*(4), 457–466. https://doi.org/10.1080/09654319808720474
Lindberg, M. B., Markard, J., & Andersen, A. D. (2019). Policies, actors and sustainability transition pathways: A study of the EU's energy policy mix. *Research Policy*, *48*(10), 103668. https://doi.org/10.1016/j.respol.2018.09.003
Loorbach, D., & Rotmans, J. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures*, *42*(3), 237–246. https://doi.org/10.1016/j.futures.2009.11.009
Malmberg, A., & Maskell, P. (2010). An evolutionary approach to localized learning and spatial clustering. In *The Handbook of Evolutionary Economic Geography*.
Manshanden, W. J. J., Oort, F. van, Koops, O., & Haaren, J. van. (2019). *Tijd voor de Toekomst: Regioverkenning 2019 - factsheets Metropoolregio Rotterdam Den Haag*. Retrieved from https://mrdh.nl/nieuws/mrdh-regioverkenning-2019
Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. *Journal of Economic Geography*, *6*(4), 395–437. https://doi.org/10.1093/jeg/lbl012
McLaren, D., & Agyeman, J. (2015). *Sharing cities: a case for truly smart and sustainable cities*. Mit Press.
Mont, O., Lepys, A., Whalen, K., & Nußholz, J. L. K. (2017). *Business model innovation for a Circular Economy: Drivers and barriers for the Swedish industry – the voice of REES companies*. Mistra REES.
MRA. (2018). *Ontwikkelplan Circulaire Economie Metropoolregio Amsterdam*. Retrieved from https://www.amsterdameconomicboard.com/app/uploads/2018/04/Ontwikkelplan-Circulaire-Economie-MRA.pdf
MRA. (2020). *About the Metropolitan Region Amsterdam*. Retrieved from https://www.metropoolregioamsterdam.nl/about-mra/
MRDH. (2016). *Roadmap Next Economy*. Retrieved from https://www.roadmapnexteconomy.com/
MRDH. (2020). *Gemeenten*. Retrieved from https://mrdh.nl/wie-zijn/gemeenten
Municipality of Amsterdam. (2020). *Amsterdam Circulair 2020 - 2025*. Retrieved from https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/coalitieakkoord-uitvoeringsagenda/gezonde-duurzame-stad/amsterdam-circulair-2020-2025/
Municipality of Amsterdam, Circle Economy, & Raworth, K. (2019). *Bouwstenen voor de Nieuwe Strategie Amsterdam Circulair 2020 - 2025*. Retrieved from https://openresearch.amsterdam/nl/page/45605/bouwstenen-voor-de-nieuwe-strategie-amsterdam-circulair-2020-2025

Municipality of Rotterdam. (2019). *Van Zooi naar Mooi: Programma Rotterdam Circulair 2019 - 2023*. Retrieved from https://rotterdamcirculair.nl/wp-content/uploads/2019/02/27403-41-Programma_RdamCirculair_2019-2023_v11-def-lr-losse_paginas.pdf
Neffke, F. M. H. (2009). *Productive Places. The influence of technological change and relatedness on agglomeration externalities* (pp. 135–162). Utrecht University.
Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in smart city initiatives: Some stylised facts. *Cities*, *38*, 25–36. https://doi.org/10.1016/j.cities.2013.12.010
PBL. (2019). *Circulaire economie in kaart*. Retrieved from https://www.pbl.nl/publicaties/circulaire-economie-in-kaart
Pomerol, J. C., & Brezillon, P. (1999). Dynamics between contextual knowledge and proceduralized context. In *International and Interdisciplinary Conference on Modeling and Using Context (pp.* 284–295). Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-48315-2_22
Porter, M. E. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic Development Quarterly*, *14*(1), 15–34. https://doi.org/10.1177/089124240001400105
Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer, A. (2017). C*ircular Economy: Measuring innovation in the product chain: Policy report* (No. 2544). PBL Publishers.
Prendeville, S., Cherim, E., & Bocken, N. (2018). Circular Cities: Mapping Six Cities in Transition. *Environmental Innovation and Societal Transitions*, *26*, 171–194. https://doi.org/10.1016/j.eist.2017.03.002
Preston, F. (2012). A Global Redesign? Shaping the Circular Economy. In *Energy, Environment and Resource Governance*. https://doi.org/10.1080/0034676042000253936
QGIS.org. (2020). *QGIS Geographic Information System* (3.12). QGIS Association. https://www.qgis.org/nl/site/
Ranta, V., Aarikka-Stenroos, L., Ritala, P., & Mäkinen, S. J. (2018). Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. *Resources, Conservation and Recycling*, *135*, 70–82. https://doi.org/10.1016/j.resconrec.2017.08.017
Raworth, K. (2017). *Doughnut economics: seven ways to think like a 21st-century economist.* Chelsea Green Publishing.
Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? - Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*, *135*, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027
Rizos, V., Behrens, A., Kafyeke, T., Hirschnitz-Garbers, M., & Ioannou, A. (2015). The Circular Economy: Barriers and Opportunities for SMEs. *CEPS Working Documents*.
Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., … Foley, J. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Nature*, *461*(24). https://doi.org/10.5751/ES-03180-140232
Rosenbloom, D. (2017). Pathways: An emerging concept for the theory and governance of low-carbon transitions. *Global Environmental Change*, *43*, 37–50. https://doi.org/10.1016/j.gloenvcha.2016.12.011
Rotterdam Innovation City. (2020). *Innovate*. Retrieved from https://www.rotterdaminnovationcity.com/Themes/
Shahbazi, S., Wiktorsson, M., Kurdve, M., Jönsson, C., & Bjelkemyr, M. (2016). Material efficiency in manufacturing: swedish evidence on potential, barriers and strategies. *Journal of Cleaner Production*, *127*, 438–450. https://doi.org/10.1016/j.jclepro.2016.03.143
Smith, A., Voß, J. P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy*, *39*(4), 435–448. https://doi.org/10.1016/j.respol.2010.01.023
Social and Economic Council. (2016). *Werken aan een circulaire economie: geen tijd te verliezen*. Retrieved from https://www.ser.nl/nl/publicaties/werken-aan-een-circulaire-economie
Stahel, W. R. (1981). *Jobs for tomorrow: the potential for substituting manpower for energy.* Vantage Press.
Van Eijk, F. (2015). *Barriers & Drivers towards a Circular Economy - Literature Review*. Retrieved from https://www.circulairondernemen.nl/uploads/e00e8643951aef8adde612123e824493.pdf
van Griensven, H., Moore, A. P., & Hall, V. (2014). Mixed methods research - The best of both worlds? *Manual Therapy*, *19*(5), 367–371. https://doi.org/10.1016/j.math.2014.05.005
Vanner, R., Bicket, M., Withana, S., Brink, P. Ten, Razzini, P., Dijl, E. Van, Watkins, E., Hestin, M., Tan, A., Guilche, S., & Hudson, C. (2014). *Scoping study to identify potential circular economy actions, priority sectors, material flows and value chains*. https://doi.org/10.2779/29525
von Carlowitz, H. C. (1713). *Sylvicultura Oeconomica: Hausswirthliche Nachricht und Naturmsaßige Anweisung zur Wilden Baum-Zucht.*
Vos, M., Geenevasen, F., Sluis, E., Waal, J. van der, Heering, N., Vries, R. de, Nederhorst, J., Smid, T., Achterberg, J., & Rongen, J. van. (2019). *Roadmap Circulair Inkopen & Opdrachtgeverschap: Op weg*

naar 100%. Retrieved from https://mraduurzaam.nl/wp-content/uploads/2019/06/MRA-Roadmap-Circulair-Inkopen-DEF.pdf
Webster, K. (2017). *The circular economy: A wealth of flows.* Ellen MacArthur Foundation Publishing.
WeTechRotterdam. (2020). *A complete guide to Rotterdam's ecosystem*. Retrieved from https://www.wetechrotterdam.com/news/rotterdam-startup-ecosystem-guide
Yin, R. K. (2009). Case study Research: Design and Methods (2nd ed.) In *Applied Social Research Methods Series, 5.* SAGE publications.
Zaman, A. U., & Lehmann, S. (2013). The zero waste index: A performance measurement tool for waste management systems in a "zero waste city". *Journal of Cleaner Production, 50,* 123–132. https://doi.org/10.1016/j.jclepro.2012.11.041

Appendix A. Data sources spatial analysis

Table A1

Data sources for the input of the spatial analysis

	Name	Data type	Publication date	Source
Rotterdam/Amsterdam neighbourhoods	Wijk- en buurtkaart 2019	Shapefile	2019	CBS & Kadaster
Amsterdam districts	Gebiedsindeling	Shapefile	2020	Gemeente Amsterdam

Appendix B. Documents desk research

Table B1

Information on the documents of the desk research

City government	Name of document	Organisation	Publication year
Rotterdam	Program Rotterdam Circular 2019 - 2023	Municipality of Rotterdam	2019
	Roadmap circular economy Rotterdam	Municipality of Rotterdam	2016
	Up!Rotterdam 2019-2023	Municipality of Rotterdam	2019
	Rotterdam Makers District: Vision and strategy	Rotterdam Makers District	2017
	Position paper Port of Rotterdam Green Deal	Port of Rotterdam	2020
	Rotterdam towards a circular port: A deep dive into Waste-to-Value opportunities	Port of Rotterdam	2019
	Roadmap Next Economy	Metropool Regio Rotterdam-Den Haag (MRDH)	2016
	Circular Rotterdam: opportunities for new jobs in a zero waste economy	Metabolic & Circle Economy	2018
	CE Approach: Zuid-Holland	Minister of Infrastructure and Water Management	2019
Amsterdam	Amsterdam Circular 2020 – 2025: Strategy	Municipality of Amsterdam	2020
	Amsterdam Circular 2020 – 2025: Innovation and implementation program 2020 - 2021	Municipality of Amsterdam	2020
	Amsterdam Circular Monitor	Municipality of Amsterdam	2020
	The City Doughnut for Amsterdam: an instrument of change	Doughnut Economics Action Lab, Biomimicry 3.8, Circle Economy &C40	2020
	Building Blocks Towards a New Strategy Amsterdam Circular 2020 - 2025	Municipality of Amsterdam	2019
	Space for the Economy of Tomorrow	Municipality of Amsterdam	2017
	Startup Amsterdam 2019-2022	Municipality of Amsterdam	2019
	Monitoring for a Circular Metropolitan Area	Metabolic	2018
	Development plan Circular Economy Metropolitan Area Amsterdam	Metropool Regio Amsterdam (MRA)	2018
	Roadmap Circular Tenders and Commissioning	Metropool Regio Amsterdam (MRA)	2019
	CE Approach: Regions Noord-Holland, Flevoland and Utrecht	Minister of Infrastructure and Water Management	2019

Appendix C. Interview list

Table C1

Interview list

City	#	Organisation	Name interviewee	Position	Code in text
Rotterdam	1	Municipality of Rotterdam	P. Verschoor	Project manager city development	Interview_MUN_R1
		Municipality of Rotterdam	J. J. van Maastrigt	Advisor sustainability and circular economy	Interview_MUN_R2
	2	Port of Rotterdam	J. Pors	Sr. advisor circular economy	Interview_POR_R3
	3	Municipality of Rotterdam	H. H. van der Heijden	Strategic advisor	Interview_MUN_R4
	4	Buurman	L. R. Jacobson	Director & Founder	Interview_CO_R5
	5	Rotterzwam	S. Cox	Director & Founder	Interview_CO_R6
			J. de Vries	Project manager	Interview_CO_R7
	6	SuperUse Studios/Pulseup	J. Jongert	Director & Founder	Interview_CO_R8
	7	Enviu	T. van Vrijaldenhoven	Head of THRUST program	Interview_CO_R9
	8	ScrapXL	M. Eilertsen	Director	Interview_CO_R10
	9	ArchitectuurMAKEN	F. in ‘t Veld	Founder & Director	Interview_CO_R11
Amsterdam	10	Municipality of Amsterdam/CTO Innovation team	A. Hassing	Circular ecosystem & partnerships manager	Interview_MUN_A12
	11	Municipality of Amsterdam/Start-up Amsterdam	J. Dori	Liaison officer	Interview_MUN_A13
	12	Port of Amsterdam	J. Hallworth	Commercial manager Circular & Renewable Industry	Interview_POR_A14
	13	Peerby	D. Weddepohl	Director & Founder	Interview_CO_A15
	14	Re-born BV	N. Slob	Director	Interview_CO_A16
	15	Desko	G. van Casteren	Director	Interview_CO_A17
	16	VanPlestik	N. Kooij	Co-founder	Interview_CO_A18
	17	MyWheels	K. Tiekstra	Director	Interview_CO_A19
	18	Orgaworld	K. van den Berg	Director	Interview_CO_A20

Note. All interviews were conducted in the period from July ’20 – September ’20.

Table C2

The different types of interviewed circular firms and their locations

City	#	Organisation	Industry	R-strategy	Neighbourhood
Rotterdam	1	Buurman	Consumption goods	R3	Nieuw-Mathenesse
	2	Rotterzwam	Biomass and Food	R1	Kralingen
	3	SuperUse Studios/Pulseup	Consumption goods and construction	R5/R2	Kralingen
	4	Enviu	Plastics and manufacturing	R5	City Centre
	5	ScrapXL	Consumption goods	R3	North
	6	ArchitectuurMAKEN	Construction	R5	City Centre
Amsterdam	7	Peerby	Consumption goods	R1	n/a
	8	Re-born BV	Construction	R1	Zuid-as
	9	Desko	Consumption goods	R4	Bedrijventerrein Sloterdijk
	10	VanPlestik	Consumption goods	R5	Noordelijke IJ-oevers Oost
	11	MyWheels	Consumption goods	R1	Jordaan
	12	Orgaworld	Biomass and Food	R5	Westelijk havengebied

Appendix D. Operationalisation table

Table D1

Operationalisation table

Category	Sub-category	Example question
Geography	Spatial proximity	To what extent is spatial proximity to other circular initiatives in the city experienced to be a driving factor for your business activities?
	Location	Why is the circular firm located in this particular city?
Engagement	Awareness	To what extent is customer awareness perceived as a hindering factor in urban CE transitions?
	Convening and partnering	To what extent would the collaboration between different stakeholders in the urban area contribute to the acceleration of the CE transition?
Regulation	Regulation and legislation	What municipal regulations are hindering your circular firm?
Urban management	Urban planning	How are urban planning practices in the city influencing your circular firm?
	Public procurement	To what extent is public procurement currently perceived as an obstructing or stimulating factor in the CE transition?
Economic factors	Financial measures	How is your circular firm financially supported by the municipality?
	Fiscal measures	How are fiscal measures supporting the urban CE transition?

Appendix E. Interview guides

Interview guide: circular initiatives

A. Introduction

This research is studying the stimulating and hindering local factors that influence the implementation of circular initiatives at the city-level. We will compare the two cities of Amsterdam and Rotterdam. They are selected, because both cities facilitate many circular initiatives and have implemented CE policies pro-actively. The aim of this interview is to gain a deeper understanding of what factors and processes were important for your localization in this city and how local factors are influencing your business activities. The interview will take about one hour.

B. Confidentiality

To increase the accuracy of my transcripts I would like to record the interview. The records will be handled strictly confidential.

- Do you agree with this interview being recorded for transcribing purposes?
- Am I allowed to use your name in my thesis?

C. Stimulating and hindering factors

Theme	Main question	Possible follow-up questions
Geographical factors	Why is the company located in this city?	• Why did you choose for this location in the city? • What geographic factors did influence your localization?
Urban management	How does public procurement influences your company?	• Are you influenced by particular urban planning projects in the city?
Engagement	How does cooperation with other local parties influences your company?	• Where are your partners mainly located? • How do you think citizens perceive your circular business?
Economic factors	What financial support did you receive from the local government?	• What other parties did financially support your circular business?

Regulation	Do you experience local regulation as a driver or a barrier for your business? Why?	
Remaining questions	What other factors do you find important for the localization of circular initiatives in this city?	

D. Conclusion

Thank you very much for participating in my research. Can I contact you if I need further clarification on any issue?

Interview guide: civil servants

A. Introduction

This research is studying the stimulating and hindering local factors that influence the implementation of circular initiatives at the city-level. We will compare the two cities of Amsterdam and Rotterdam. They are selected, because both cities facilitate many circular initiatives and have implemented CE policies pro-actively. The aim of this interview is to gain a deeper understanding of what factors and processes were important in the CE transition of this city. For instance, I am interested in how the municipality did stimulate the CE transition or what difficulties you encounter in the CE transition. The interview will take about one hour.

B. Confidentiality

To increase the accuracy of my transcripts I would like to record the interview. The records will be handled strictly confidential.

- Do you agree with this interview being recorded for transcribing purposes?
- Am I allowed to use your name in my thesis?

C. Stimulating and hindering factors

Theme	Main question	Possible follow-up questions
Geographical factors	Why do you think that this city is attractive for circular initiatives to establish?	• What locations in the city are according to you the most attractive for circular firms? • What geographic factors did influence the localization of circular firms?
Urban management	What do you think about the current public procurement of the municipality regarding the CE transition?	• Can you name any examples of urban planning projects that stimulate or hinder the CE transition of the city?

Engagement	How does the local government stimulate cooperation between circular firms and other local parties?	• What public-private partnerships stimulate the city's CE transition? • How important do you perceive the awareness of citizens for the CE transition and what strategies are implemented by the municipality to increase awareness?
Economic factors	How does the local government support circular initiatives financially? (subsidies/funds etc.)	• How are effective are these financial measurements?
Regulation	Do you experience local regulation as a driver or a barrier for circular businesses? Why?	
Remaining questions	What other factors are influencing circular initiatives in this city?	

D. Conclusion

Thank you very much for participating in my research. Can I contact you if I need further clarification on any issue?

Appendix F. Overview of all circular initiatives

Table F1

All circular initiatives established in Rotterdam

		Type of industry					
		Consumption goods	Construction	Manufacturing industry	Plastics	Biomass and food	**Total**
Type of R-strategy	R1 Refuse & Rethink	21	2	0	0	8	**31**
	R2 Reduce	0	1	1	0	5	**7**
	R3 Re-use	154	0	0	0	0	**154**
	R4 Repair	1338	486	199	1	0	**2024**
	R5 Recycle	122	96	52	12	4	**286**
	R6 Recover	1	0	2	0	22	**25**
Total		**1636**	**585**	**254**	**13**	**39**	**2527**

Table F2

All circular initiatives established in Amsterdam

		Type of industry					
		Consumption goods	Construction	Manufacturing industry	Plastics	Biomass and food	**Total**
Type of R-strategy	R1 Refuse & Rethink	21	2	0	0	4	**27**
	R2 Reduce	2	3	1	0	2	**8**
	R3 Re-use	403	0	1	0	0	**404**
	R4 Repair	1726	1475	271	1	0	**3473**
	R5 Recycle	124	81	20	6	13	**244**
	R6 Recover	2	0	0	0	17	**19**
Total		**2278**	**1561**	**293**	**7**	**36**	**4175**

Appendix G. Neighbourhoods in Amsterdam

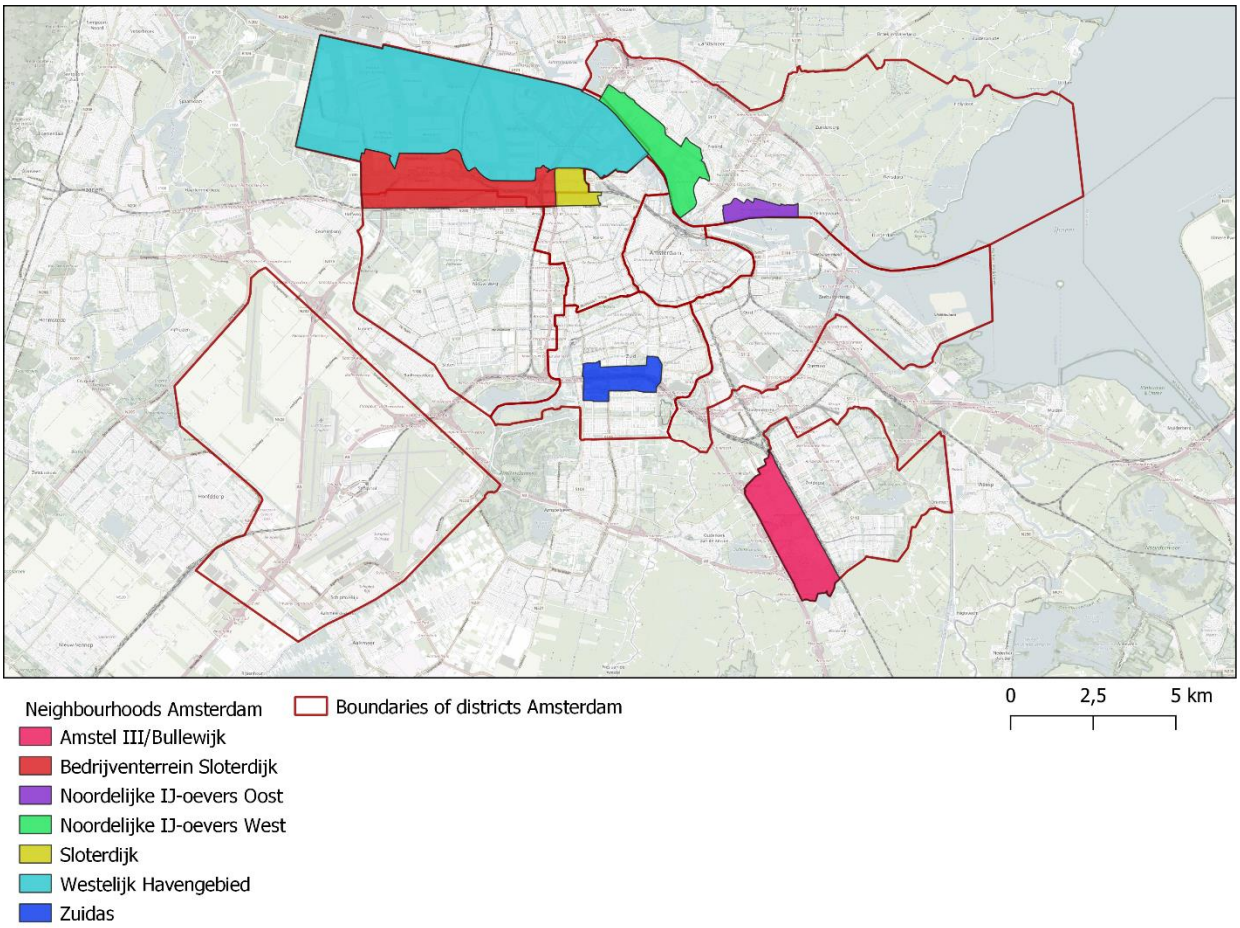


Figure G1. Neighbourhoods in Amsterdam. To create a clear overview we only visualized neighbourhoods that are mentioned in the text