Chapter 5
Urban Manufacturing for Circularity: Three Pathways to Move from Linear to Circular Cities

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5.1 Circular Economy in Cities in the Making

The world has become increasingly urbanised. Around 60–70% of the world's resources are consumed in cities and cities produce around 50% of all waste. More importantly, these trends are expected to exacerbate in the future, meaning that cities play a key role in leading the transition towards sustainability and more circular pathways of resource consumption (UNEP, 2017). Cities are the places where the distance between supply and demand can be shortened and where the concept of waste can theoretically be thrown away. Despite many cities launching circular economy policies, many are ill-equipped to roll it out because of the lack of suitable space and instruments to realise this.

Traditionally, the space and skills for processing large volumes of materials and goods were associated with industrial land and manufacturing. Urban manufacturing and manufacturers play a vital role in delivering circular economy ambitions through processing materials, providing skills and technology for repair or reconditioning goods and the capacity to deliver innovative technology (Domenech

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et al., 2020). However, since the 1960s and particularly since the 1970s, manufacturing was offshored (Urry, 2014). As a result, the footprint of manufacturing has shrunk radically in many developed cities, in favour of service-oriented and more mono-functional spaces. This has resulted in the separation between production and consumption spaces, with highly linear urban systems that rely heavily on their hinterland.

Despite volumes of policy and ambitions (Hill et al., 2018), there are very few signs that radical change is occurring (Circle Economy, 2020). This is unsurprising, considering that urban real estate is generally expensive (Van den Berghe & Vos, 2019; Williams, 2019) and large sites are scarce. Not all aspects of a product cycle are profitable, meaning that regulation or subsidies are required to cover the shortfall (CoM Brussels, 2019). Furthermore, there is often a need for new forms of collaboration (Sposato et al., 2017) to occur and to change policy and consumption habits (Sesini et al., 2020). Finally, public policy may be necessary to counter impulses that generate waste in the first place. Cities that are now looking at industrial-scale production to address circular economy locally are faced with a range of complex challenges such as defining how it should happen, where it should happen and what will be required to make it happen (Hill et al., 2018).

Urban environments are complex systems. The three narratives we address in this chapter, (1)circular economy, (2)spatial and (3)social and institutional, each have their dynamics and influence each other. Understanding the forces and problems occurring between these narratives requires the integration of knowledge from different realms. Urban manufacturing, and by extension, the circular economy, draws on a vast range of issues, such as logistics, resource management, urban planning and design, business and entrepreneurship, financing and innovation. Addressing such a complex topic requires academics, practitioners and local actors to look outside of disciplinary and institutional (or organisational) boundaries (Brandt et al., 2013). This presents a fundamental question: how can collaboration occur between actors with very different interests, expertise and knowledge?

The main challenge is that actors generally carry institutional and disciplinary baggage that influence how problems are interpreted and solved. This means that each actor involved will bring a different focus, priorities, mindset and language. Diversity of perspectives can render a project complex, but this complexity can also provide a richness to strengthen dialogue, collaboration, and even alignment if harnessed (Ramadier, 2004). The articulation of these different ways of reading and interpretation is a relevant step towards an integrated approach for both urban manufacturing and circular economy in cities.

However, transdisciplinary thinking can also result in further complexity or oversimplification. A framework is necessary that allows for both an exchange of knowledge and the capacity to address (technical) detail. Within the context of the research project Cities of Making (CoM), Hill et al. proposed in Foundries of the future (2020) a framework to facilitate the dynamic interactions between these layers and create leverage points for urban reindustrialisation towards circularity. A pattern language forms thereby the transdisciplinary mediation and co-creation instrument.

This chapter elaborates how different actors from different backgrounds and interests, read urban conditions differently (part two of this chapter) and how their readings can converge into a transdisciplinary instrument via collaboration (part three of this chapter). The developed instrument can help to address circular economies in cities with urban manufacturing more integral.

5.2 Three Readings of Urban Conditions

Over the following pages, we illustrate three pathways—three ways of addressing urban manufacturing, and by extension, circularity, within urban areas. These pathways were put central in the research of the CoM project to triangulate the facilitation of urban manufacturing from the perspectives of (1) material flows and technology, (2) spatial design, (3) people and networks.

The circular economy narrative often focuses on the flows of resources and understanding how these resources are extracted, processed and managed (during and after their use life). All these processes are mediated by technology, including know-how and technical competence, and importantly, considering the value network associated with the way resources are used and recovered. We refer to this dimension as 'circularity and technology'. Planners and researchers moving from theory into action, or policy into practice, commonly note that it is challenging to connect available meta-scale data about resources with the reality on the ground about how those resources are transformed, used and then disposed of.

The spatial narrative is concerned with where manufacturing can take place and what qualities a place has to offer. These issues are becoming increasingly crucial for achieving circularity in cities. This narrative is associated with urban design and planning and is referred to as 'urban integration'. It comprises the volumes of spaces, the flexibility of structures, the logistics of using space, the design of the public street space and network, the accessibility to key infrastructure, the environmental qualities, and altogether how the different urban functions can build a sustainable, liveable environment.

The social and institutional narrative relates to the policy, business and working conditions that allow for the production process to occur. This is what we have referred to as 'people, networks and policy' which is connected to sociology, governance, finance and (human) geography. This is a topic that is possibly the most challenging of the three to qualify as it depends heavily on how people interact with space and technology, the workplace culture, taxation and subsidies, local markets but also knowledge of production processes and materials.

Below we will illustrate how each pathway reads manufacturing and by extension the circular economy in cities. The research (2020) was conducted in Brussels, London and Rotterdam/The Hague involving mapping, extensive qualitative interviews and data analysis.

5.2.1 Circularity and Technology

Quantified assessments of the urban metabolism reveal that even highly developed cities such as London or Brussels, not only are producing large quantities of waste but are also very significantly growing their built-in stock, with huge amounts of embodied carbon being added to the socio-economic stock of cities every year (Ekins et al., 2020).

Innovative perspectives introduced by urban sustainability, urban metabolism and circular economy approaches prompt a new interpretation of the urban space. These perspectives offer new ways to reduce consumption of primary resources and minimise waste generation for which maintenance and nurturing of the urban and peri-urban productive base is key. Some characteristics of urban areas linked to scale and agglomeration economies provide the right set of conditions to enable circular approaches and new business models.

While much attention has been given to waste and waste treatment, most transformative elements of circular approaches lay precisely in avoiding waste and management of resources and building stocks. The concentration of structural elements of the technical and built-stock of societies in cities creates new opportunities to extend the life of technical materials and transform cities into resource reservoirs. Electronics is a good example of the opportunities unleashed by the circular economy. Waste electronics is the fastest growing waste stream in the EU. A large fraction of electronic goods is consumed in cities. The use life of electronic products, especially IT equipment, is rapidly decreasing due to changes in technology quickly producing obsolesce. While Extended Producer Responsibility regulations introduce obligations for producers to increase recycling and recovery of waste of electrical and electronic equipment (referred to as Waste from Electrical and Electronic Equipment), based on our observations, a large fraction of these products will not enter formal recycling processes. A range of high-value resources, including precious metals and rare earth, is lost or leaked to the environment (Hill, 2020).

Cities can break the cycle of linearity by nurturing inner loops, of repair and maintenance or outer loops of refurbishment and recycling. For this to happen though, cities have to provide spaces for making that allow bottom-up initiatives to emerge (e.g. Repair cafes) or more formal production spaces to support the recovery of products, materials and components, in a way that they can be recovered back by the city.

This and other examples in areas such as building and building components, textiles and plastics call for a rethinking of the flows of resources in cities and highlight problems associated with the disconnection between consumption and production processes. Greater circularity can only be achieved through a regenerative productive base in cities that help retain components through maintenance, repair and refurbishment, and enhanced data systems that increase traceability of technical components in cities and recover nutrients and energy from biological elements.

This requires a profound rethinking of how cities are organised and a reconsideration of the balance of activities in cities. Diverse cities need manufacturing, regenerative urban manufacturing that is nested in regional and supra-regional networks of manufacturing. The role of urban manufacturing in a circular economy is instrumental in:

- Enabling maintenance and repair activities which are part of circular 'inner loops'
- Providing opportunities for remanufacturing and refurbishment of elements of the built-stock to extend their use life and reduce further consumption of raw materials, especially for elements such as building materials where proximity to consumption is critical to ensure feasibility and adaptability
- Transforming waste materials through a) recycling, b) digesting and c) composting processes into resources for the city, helping to close the loop of cities (e.g. recycling of plastic bottles back into plastic bottles).

What is the current contribution of urban manufacturing to the circular economy? Despite the potential, fieldwork undertaken under the Cities of Making project (Domenech et al., 2020) indicates that the level of circularity in EU cities is minimal. While a manufacturing base is still maintained in cities, urban manufacturing, its diversity and capacity, are being compromised by approaches to planning and regeneration that rarely consider the needs of manufacturing or provide the right set of conditions for manufacturing to transform towards more regenerative forms of making. The research has revealed a diverse sector, including food production, textile manufacturing, furniture making and construction material fabrication. Urban manufacturing also demonstrated high levels of flexibility, customisation and innovative business models that blur the boundary of manufacturing and services. In most cases, urban manufacturing is also inextricably blended to high-value urban activities, such as R&D, design and culture or construction, providing the necessary material base for these other city sectors to develop.

These activities consume a large fraction of the cities' resources and are important generators of waste. Waste from manufacturing activities tends to be homogenised and therefore has greater potential for recovery. Also, the concentration of diverse activities and connections with commercial use has enabled synergies and opportunities to transform waste into resources. Food-related production is showing pioneering examples. Breweries such as Toast in London and the Brussels Beer Project brew beer using surplus bread from bakeries. Biohm in London uses food waste produced by food and drink manufacturing for the production of a range of insulation, packaging and construction materials. Rotterzwam in Rotterdam and Permafungi in Brussels use used-coffee grounds from local cafes. However, these examples are the exemption rather than the norm, and a large fraction of industrial waste still follows non-circular routes and ends in landfill or incineration. Inefficient resource flows are in many cases the results of a combination of lack incentives, poor infrastructural dotation and planning and, very importantly, almost absolute lack of detailed, geographically specified, data on how city resources and manufacturing resources flow in the space through the city and beyond.

Domenech et al. (2020) demonstrate how the reduced backyard spaces in manufacturing land and deficiencies in waste infrastructures mean that most industrial waste is collected non-segregated in single skips. This leads to cross-contamination and reduces the ability to introduce high-quality recovery and recycling of industrial and commercial waste. Similar conditions also affect the ability to recover resources from waste in Brussels and Rotterdam. Lack of awareness of the potential value of waste resources and lack of incentives to engage in collaborative initiatives to pool resources and minimise waste in industrial areas is also common. Despite potential, none of the industrial areas investigated had systems for heat recovery, water harvesting, cascading or penetration of renewable technologies. However, pressures to control potential negative emissions have led to greater electrification of processes, linked with reduced GHG emissions and local air pollution.

Our research has also shown that digitalisation of urban manufacturing is still limited and mostly concentrated in high-tech sectors, including chemical, pharmaceutical or medical devices. This slower rate of penetration of digital technology is not detached from spatial issues. Uncertainty linked to short leases and shrinking of manufacturing space creates a reluctance to invest in machinery and equipment. Digital technologies may provide opportunities for better use of resources and reduce processing waste and increase traceability of production, which may enable new business models to focus on customisation, the extension of life through maintenance or refurbishment. However, this potential is rarely realised in cities.

To sum up, this all means that while the manufacturing sector has potential for greater digitalisation, a transition to performance-based models and industrial symbiosis type of approaches to waste reutilisation, progress enabled by policy and adequate planning is required to ensure that urban manufacturers seek the opportunities and collaborate towards addressing local circular economy challenges.

5.2.2 Urban Integration

Industrial activities relate to and are dependent on the qualities a place provides. Until recently, manufacturing was often considered noisy, polluting, a generator of heavy traffic and thus separated from the everyday city. Most manufacturing companies are currently not integrated into populated parts of cities. Urban manufacturing and production are now commonly concentrated in industrial areas, and business parks. These specialised areas are often separated from housing and other 'incompatible' land uses at urban peripheries.

Two trends are changing the location of production in cities. Firstly, with increasing demand for housing, cheaper and low-density industrial land is under pressure for rezoning. Many cities are exploring 'mixed-use' zones to retain industrial surfaces while allowing for traditionally incompatible land uses to occur. Secondly, new and cleaner manufacturing and building technologies are being developed that are more compatible with other land uses. They have reduced the likes of noise, air pollution and other nuisances. This opens up new possibilities for integrating urban manufacturing (Muñoz Sanz, 2018; Muñoz Sanz et al., 2018) and offers opportunities, particularly for addressing the circular economy. Due to the high urbanisation of Europe's metropolitan areas, manufacturing companies may end up at closer proximity to urban functions seen as non-compatible at first sight, like housing. How these different functions can be integrated requires an understanding and differentiation of the different environmental qualities essential for urban functions as diverse as housing and manufacturing.

Protecting or creating space for manufacturing and production in urban areas remains challenging. One serious statistical challenge for manufacturing is that it occupies a lot of space: consuming on average 250 m^2 per employee than an average of 30 m^2 in general workplaces (ORAM, 2019), resulting in larger building footprints. As a result, there is a tendency to reduce the size of industrial areas while replacing space for production with other activities. Van den Berghe and Vos (2019) describe another aspect that reinforces the pressure on manufacturing space: strategic planning lately focuses on 'place as location' driven by 'finance and real-estate driven regime'. Consequently, historical locations for manufacturing, such as those along waterfronts, have become a prime location for high-end housing. Such processes reduce the amount of available space for manufacturing and impact its wider social and industrial ecosystem.

The urban integration pathway has three central questions. First, what are the main (potential) spatial settings of manufacturing in cities? Second, what spatial structures can provide conditions for urban manufacturing with proximity to other functions, and third, what local qualities allow liveable and affordable proximity? We approached these questions with synchronic and diachronic analyses. The synchronic analysis clarifies the relations and dynamics between spatial characteristics, and the diachronic analysis enables understanding places and their transformation dynamics through time.

Activities depend on the (urban) space provided. Research in urban morphology from the last years showed that the structure of urban form has a relation to the urban programme (Chiaradia et al., 2009; Hausleitner, 2012; Marcus, 2010; Nes, 2005; Wandl & Hausleitner, 2021), indicating what kind of space can afford what kind of function. The CoM synchronic urban morphological analysis focussed on the differentiation of building types, parcel sizes, built density, the centrality of locations, the landscape structure, and the transport infrastructure system.

The analytic mapping of all layers for the typical manufacturing locations in Rotterdam showed that manufacturing businesses have a wide variety of spatial needs. Proximity to transport infrastructure for efficient logistics is vital for all businesses. What kind of buildings, parcels, how much open space manufacturers need and what kind of neighbours can settle next to manufacturers differs. Some companies require larger floor space, which usually correlates with larger parcels and broader streets. In contrast, an increasing share of manufacturing companies, like design and 3d-printing hybrid businesses, benefits from shared premises, or smaller business units, which can be mixed with other land use more easily. Industrial areas containing a variety of business unit sizes provide possibilities for the shrinking and growing of companies and can accommodate a diversity of manufacturers and related services.

Urban configuration typologies (Hausleitner & Berghauser Pont, 2017) can indicate where the best spatial conditions for different types of manufacturing can be found. The CoM typology (Hausleitner et al., 2021) was based upon built density and network centrality. The typology describes the different but complementary spatial conditions within an urban system and indicates different urban environmental qualities. The design of the urban structure also sets the main spatial conditions for what kind of functions can be mixed where (Hausleitner, 2019) with manufacturing. The typology visualises where different structural qualities are in proximity. This allows an assessment of whether transitions are present or have to be created to organise transitions in environmental qualities from large to smaller footprint functions, noisy to quieter, more central to less central.

The diachronic mapping provided insight into the long-term dynamics of place and function. It showed that manufacturing commonly was located at the (inner) urban edges, while mixed-use is related to high streets (Hausleitner, 2019; Hausleitner et al., 2021). Both synchronic and diachronic mapping allows distinguishing three main urban settings that afford manufacturing: (1) the inner cities, (2) the highstreets and (3) industrial areas. Each of these three represents a different location in the urban agglomeration, namely core, transition or periphery. Each is related to different kinds of infrastructure, with locally different built densities and urban mix, indicating how much space is likely available, accessible and affordable. Providing gradients between central streets and urban edges creates livable transitions between the main functions on city and district scales.

From the spatial design perspective, it is important to understand how we can diversify the spatial conditions so manufacturing, related and complementary services, and other urban functions can be integrated with relative proximity. Larger buildings have to be possible next to smaller buildings. An example of this is the site of the Manner sweets factory in central Vienna, Austria that covers a building block in the regular nineteenth-century street grid and is organised vertically across six floors. This vertical intensification allows keeping the regular street grid which maintains the neighbourhood's permeability, and therefore walkability. The factory has public entrances and a shop along the main street, contributing to liveable street life. At the same time, the factory provides district heating through the exhaust air for 600 houses in its direct neighbourhood. Hence, the circular city ambition can take advantage of bringing manufacturing in closer proximity to other functions. Thus, local urban design should enable synergy effects and reduce conflicts between functions, to achieve liveable, cities that also 'make'.

5.2.3 People, Networks and Policy

Businesses and skilled workers are essential for manufacturing. Some manufacturing businesses are also important, if not critical to cities, particularly to address circular economy ambitions. Businesses can be attracted to cities, but they can also be costly places to work. Public authorities are under increasing pressure to ensure businesses that are vital for the cities remain, which may require correcting market trends through policy and planning instruments. However, few city-scale public authorities have been involved in understanding or engaging with local manufacturing processes or industrial land until recently.

The ‘people, networks and policy’ pathway is positioned between ‘circularity and technology’ and ‘urban integration’. Public institutions and private organisations (particularly unions, chambers of commerce and industry alliances) are generally the actors involved in protecting and supporting economic planning, innovation and business development, education and training.

Manufacturing and production depend on a range of conditions including relationships between producers, suppliers, retailers, availability of skilled workers and staff, local environmental policy, availability of industrial subsidies or the impact on taxation, the cost of logistics and a raft of other issues that can influence the viability of production. What makes this so complex is that there is no standard list of conditions required by all businesses. Creating suitable conditions to attract and support city-oriented manufacturing businesses requires nuanced public planning and coalition building.

Businesses the city depends on and businesses that need the city. Despite the difficulty and danger in generalising, city-oriented urban manufacturing businesses may fall into two groups. Firstly there are those businesses that the city depends on. ‘Regional processing’ refers to close links between the place of production and the place of use or consumption. For example, cement plants are often located within inner cities due to legislation limiting the time between mix and pour. Bakeries also often produce onsite to adjust for demand and minimise waste. The ‘foundational economy’ (The Foundational Economy Collective, 2018) refers to the mundane—things that the city requires daily—such as food, construction, transport or repair. By virtue of dependence on these activities, cities that cannot provide suitable space will likely result in paying higher prices (particularly the case for food) or simply being unable to provide certain services (particularly for repair, construction or waste management). Urban manufacturers focused on waste processing, repair and food production often operate on narrow margins, as some of these businesses provide the city with a certain service, such as managing waste. They may depend on government support to access affordable land, train staff, subsidise wages, purchase technology, and provide an adequate service level to the city. For example, in Brussels, CF2D is a social economy business that provides a public service by treating electronic waste, which depends on subsidies to cover wages, real estate costs and the investment in new equipment. An organisation like CF2D needs to be located near public transport and accessible for logistics.

Secondly, there are those businesses that depend heavily on the city. They are prepared to pay the costs of operating in a city due to reasons such as having access to a large pool of talent, a link to suppliers or clients and a close connection to research and development. Production and manufacturing businesses attracted to the city are often involved with innovation or in high-value production, which can be particularly important in developing local solutions to material demands. These types of businesses are increasingly looking at technology (automation) to cut labour costs and seek workers that have a combination of technical skills and expert knowledge. These businesses need the right incentives or market to be attracted to urban areas.

Those actors concerned with 'people, networks and policy' generally are interested in finding a clear place for manufacturing within economic planning to ensure it is suitably supported through policy such as a circular economy plan. Business networks and relationships with suppliers are also important as businesses can develop complex interdependencies. Many manufacturers feel isolated; a community manager or facilitator could support them. Furthermore, considering the limited amount of space in cities, businesses may require support in moving or growing and depend on a public real estate broker's support. Skills are critical, as manufacturing businesses often depend on a skilled workforce; education and training are essential for existing and future staff. This is particularly important for the circular economy in terms of reskilling the workforce. Finally, actors concerned with this pathway may be interested in using financial instruments to guide businesses. To move the local economy towards circularity, economic support can be critical.

5.3 Developing an Integral Approach Through Participation and Collaboration

The readings of the three pathways differ mainly in whether the spatial or the process dimension is emphasised. The pathway of urban integration is dominated by the spatial dimension, while the process dimension is, to some extent, underrepresented. On the other side of the chart, the circularity and technology pathway shows a dominance of the process dimension regarding the flows of resources and the technology used. However, it is challenging to grasp how much and what space is required to perform manufacturing processes. The pathway of people, network and policy, does not show dominance but embraces how the human or organisations fit within both dimensions.

In practice, it can be challenging to combine both a spatial and process-oriented thinking. The aim is not to eliminate the differences, but rather build upon the qualities of the different ways of reading. While urban integration could benefit from increasing its process dimension, the other two pathways could benefit from a clearer understanding of how they relate to spatial conditions, as this would help define where they could occur and what types of spaces they would need. The integration of the three pathways requires convergence while retaining the richness of the three perspectives. How can a dialogue be created between these pathways?

In the previous section, the three different ways of reading urban conditions were described. These pathways apply different approaches and have different goals. As introduced at the beginning of this chapter, the challenge is to find a common language that provides a comparable, operative framework for exploring possible solutions.

The CoM project (Hill, 2020) introduced three main considerations in approaching transdisciplinarity: (1) reducing the complexity of information, (2) reducing the complexity of combinations of possible solutions and (3), applying an accessible, applicable instrument for the solutions. This resulted in developing a pattern language following Christopher Alexander's seminal work (Alexander et al., 1977), integrating the three pathways.

A pattern language is a system that comprises individual solutions (patterns) and the relations among them. The CoM research developed 50 individual patterns based on policy and literature review, and interviews with key stakeholders, each initially embedded in the one discipline. In workshops with different types of stakeholders, in interviews with businesses, and discussions within the multidisciplinary research team, we established and verified relations between the patterns. Then, we sharpened each pattern through knowledge via the complementary perspectives that were not involved in the first draft. This process contributed substantially to the definition of the 'context', 'problem' and 'forces' that enable or hinder different types of 'solutions' possible in realising one pattern.

The pattern language is not only co-created in a transdisciplinary setting but is also an instrument enabling transdisciplinary collaboration. The information related to the three pathways is made accessible in the form of a set of cards and a companion book, with each pattern presented in a comparable way (see Fig. 5.1a). In current urban development practice, one of the main challenges is the high degree of specialisations, that steers thinking about solutions and binds budgets very much in silos of disciplines. One consequence is that complex problems are approached from a limited perspective of a discipline's or institutions' frame. The indication of relations among the patterns enables actors to understand which other patterns have to be implemented to make a solution work, as shown in Fig. 5.1b along with the example of 'Local collection points of segregated waste'.

The use of the cards and book are analogue tools to encourage dialogue. As experienced through testing the tools in workshop settings, it has allowed a high diversity of actors to participate in the development and decision-making process.

5.4 Discussion and Reflection

This chapter has described how there is potential for urban manufacturing to enable a circular economy transition in cities. However, competition for land uses in cities means that space for manufacturing is under pressure. The availability of urban spaces for maintaining manufacturing depends on designing legally binding, long-term planning. Long-term planning creates security of space, which promotes capital and personal investments of companies on a site. Since urban areas are in constant change, a robust spatial framework, which considers the diversity of land uses is essential. Such a robust spatial framework has to guarantee the availability of space with favourable conditions for making.

Urban manufacturing provides the potential for further explorations of innovative ways to connect production and consumption. Cities need a productive base to close the loops in a city. For that to be possible, spatial plans need to reserve sufficient

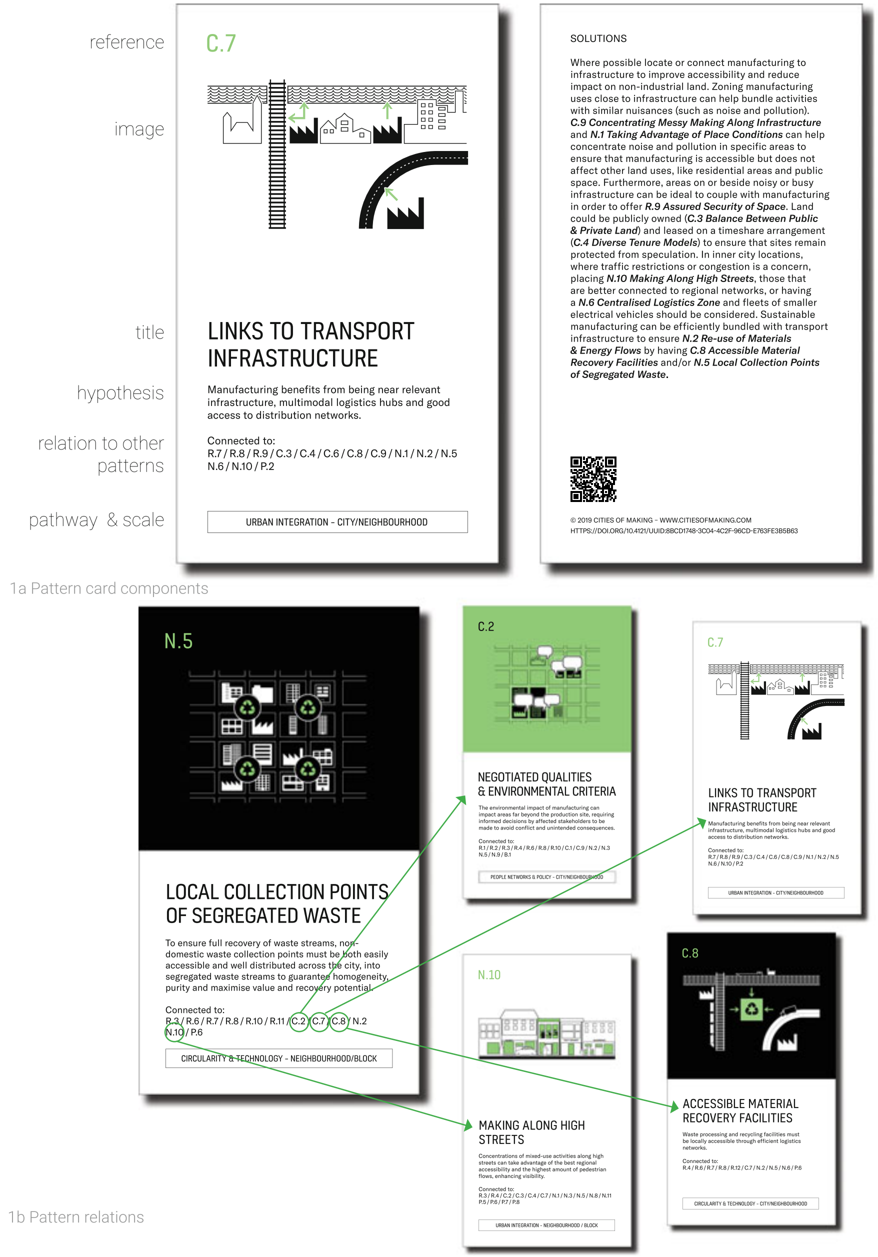

Fig. 5.1 **a** The pattern card with a comparable, operative frame for presenting solutions (@CoM). **b** A network of solutions-related patterns bridging needs from different pathways—C&T (black), UI (white), P,N,P (green) (@CoM)

space for circular processes to be realised (e.g. temporary storage spaces for resource recovery) locally which depends on a detailed understanding of how resources move in space.

To enable both urban manufacturing and the circular economy, a new form of dialogue is needed between stakeholders. Firstly, a better understanding of the role of manufacturing in cities is needed. Secondly, the provisions of adequate planning and spatial conditions for the opportunities mentioned above to crystallise are required. We presented, therefore, a pattern language, which addresses the requirements of space, production, and resources, generates dialogue and enables innovative planning approaches to create new, highly diverse and mixed-use areas.

In this chapter, we argued for the need for both expert knowledge and transdisciplinary collaboration. Firstly, we have presented three pathways for addressing urban manufacturing, and by extension, the circular economy. Secondly, to enable transdisciplinary collaboration, we have presented an instrument, based on patterns, which provides a flexible guide for integrating resources, planning and design. This guide safeguards the processes of manufacturing and the sustainable and liveable integration of manufacturing with other urban functions.

Such an approach allows for integrating a range of important actors such as academics, institutional actors, businesses and community interests. The pattern language is an open, accessible system, which can be adapted over time. Each pattern can be further developed, based on evolutions of knowledge. New relations between patterns can be established. The already defined relations help ensure consistent and holistic pathways of how separate patterns may be embedded and contextualised with related patterns. This approach provides a foundation for dialogue, which is critical in dealing with complexity. However, it depends on a suitable process facilitation. The role of 'The Curator', is one of the fifty patterns described by Hill (2020) which may act as a fundamental agent of change.

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