

Reviewing Environmental Benefits of Urban Manufacturing: Arguments and Evidence for Carbon, Resource, and Space Efficiency

Marius Angstmann^{1,2} , Kerstin Meyer^{1,3} , Stefan Gärtner¹ ,
and Leonard Can Stratmann¹

¹ Institute for Work and Technology, Westphalian University of Applied Sciences, Germany

² Institute of Geography, Osnabrück University, Germany

³ TU Dortmund University, Germany

Correspondence: Marius Angstmann (angstmann@iat.eu)

Submitted: 31 January 2025 **Accepted:** 21 August 2025 **Published:** 23 October 2025

Issue: This article is part of the issue “Planning for Locally Embedded Economies in the Productive City” edited by Lech Suwala (Technical University Berlin), Robert Kitzmann (Humboldt University Berlin), Sebastian Henn (Friedrich Schiller University Jena), and Stefan Gärtner (Institute for Work and Technology), fully open access at <https://doi.org/10.17645/up.i436>

Abstract

Urban manufacturing has emerged as a key concept in the discourse on sustainable urban development, yet its precise contributions to sustainability remain incompletely understood. This article presents a systematic literature review that examines the role of urban manufacturing in promoting low-carbon, energy-, resource-, and space-efficient urban economies. By analysing 163 relevant articles on urban manufacturing identified in the Web of Science and Scopus databases, this review synthesises key sustainability arguments and empirical evidence with a focus on environmental impacts. Findings are structured along three key dimensions of efficiency: carbon, resource, and space. These are subdivided into two underlying logics that emerged as central themes in the scientific literature: sustainability by proximity and sustainability through urban synergies, which are possible when urban manufacturing is functionally integrated into the city. While theoretical and anecdotal claims of environmental benefits abound, empirical validations across different contexts are lacking and require further research. In conclusion, the positive impact of urban manufacturing on the environment depends on integrating advanced technologies into specific spatial, environmental, and socio-economic contexts. This does not mean that we lack confidence in the arguments regarding urban manufacturing's positive environmental impact. Rather, it is a call for more empirical research. Future research should prioritise the analysis of technologies and their implementation in different urban environments to engage with this discrepancy between the large number of arguments and the limited and only partially transferable evidence.

Keywords

circular economy; productive city; resource efficiency; urban manufacturing; urban planning; urban production

1. Introduction

Over the past decade, urban manufacturing has attracted growing attention from planning and economic development agencies, particularly in countries of the Global North. This renewed interest is driven by the decline of well-paid and diverse jobs (Brandt, Butzin, et al., 2017), as well as increasing concern over poor working conditions, environmental impacts, and global dependencies resulting from the relocation and concentration of production in rural areas and emerging countries (Gärtner & Schepelmann, 2023). At the same time, urban manufacturing faces challenges such as land scarcity and rising competition for land (industrial gentrification), which threaten the viability of manufacturing companies in cities and, by extension, the resilience and supply security of local economies (Ferm & Jones, 2017; Hill, 2020). This interest can be attributed to several interrelated developments.

First, the paradigm is shifting toward mixed-use urban areas (see e.g., the European New Leipzig Charter; Bundesministerium des Inneren, 2020), promoting the integration of productive activities and moving away from the traditional model of functionally separated zones outlined in the Charter of Athens. In this context, manufacturing is increasingly seen as a key element of mixed-use cities. For years, urban development focused on residential expansion and the service sector as the primary source of employment and growth. However, digital technologies and new work patterns—such as remote work—have led to new forms of employment, often less dependent on centralised office space. At the same time, it is increasingly acknowledged that not all workers can participate in such digital forms of employment and that employment in the (digital) service-sector may be challenged by artificial intelligence. Therefore, various cities aim to preserve and promote productive uses like manufacturing in the urban fabric. Examples include London's Strategic Industrial Locations (Mayor of London, 2016) or San Francisco's Strategy of Production, Distribution, and Repair (San Francisco Planning Department, 2002).

Second, the ongoing structural changes affecting urban landscapes due to globalisation and offshoring of manufacturing from the Global North, as well as the expansion of the service sector, require innovative approaches to urban land use and local economic development. Furthermore, presently arising challenges for global production networks due to shifts in trade policy or supply chain issues led to calls for reshoring (Ellram et al., 2013; Kalvelage & Tups, 2024) or for strengthening local supply security, combined with neolocalist ideas (Xu et al., 2024).

Third, the growing focus on green production and consumption practices that adhere to planetary boundaries highlights the potential of urban manufacturing in creating resource-efficient urban economies and enabling circularity (Hill, 2020).

From the latter perspective, urban manufacturing is said to offer a chance to address societal and environmental challenges and advance green urban economies, yet the exact interconnection between urban manufacturing, sustainability, smart technologies, and the green economy remains underexamined

(Amjad & Diaz-Elsayed, 2024). In this context, different authors have investigated the role of urban manufacturing or urban agriculture in promoting low-carbon, energy-efficient, and resource-efficient economies through synthesising knowledge in comprehensive literature reviews (Amjad & Diaz-Elsayed, 2024; Herrmann, Juraschek, et al., 2020; Salisu et al., 2024; Tsui et al., 2021; Ulrichs & Mewis, 2015). While these reviews give initial hints on different arguments and evidence, they are narrow in scope, as they focus only on specific sub-topics or methodologies (e.g., life cycle assessment [LCA]), include only literature listed in a single database, or use limited queries (“urban manufacturing”), all of which leads to the risk of overlooking relevant findings reported under other terms (e.g., “urban production,” “urban factory”), from other disciplines, or evidence collected using other methods.

A comprehensive assessment of the literature on the positive contributions of urban manufacturing to more sustainable urban economies is still lacking. This article addresses this gap by focusing specifically on the environmental dimension of sustainability. We examine how carbon, resource, and space efficiency can result from the geographic proximity between housing and production. The aims of this article are, therefore, threefold: (a) to summarise the current state of research by compiling empirical evidence on the environmental impacts of urban manufacturing, (b) to identify key arguments and underlying logics behind recurring claims, and (c) to derive questions that can guide further empirical assessment.

The objective is, thus, to synthesise the extant body of knowledge concerning urban manufacturing through a systematic literature review (SLR). This synthesis serves to identify evidence and arguments that demonstrate whether urban manufacturing reduces environmental impacts or simply redistributes them. For this, a range of queries applied in two databases were incorporated. The following selection and assessment involved three key steps: (a) systematic review of 711 articles on urban manufacturing listed in Web of Science and Scopus to identify a short-list of 163 relevant articles, (b) analysis of key arguments and empirical evidence in these, and (c) discussion of the findings and contextualisation with further research from planning, engineering, and environmental sciences.

2. Urban Manufacturing: An Ambiguous Concept With Uncertain Contributions to Sustainability?

Urban manufacturing describes producing and processing material goods in densely populated areas using local resources and value chains (Brandt, Gärtner, & Meyer, 2017). It is said to be based on low-emission and resource-efficient processes and transport methods due to proximity to residential areas (Brandt, Butzin, et al., 2017). As such, urban manufacturing is a concept uniting both spatial (“urban”) and sectoral (“manufacturing”) elements, which is why there are various interpretations of the phenomenon (e.g., Hill, 2020; Nischwitz et al., 2021; Piegeler & Spars, 2019).

While there are other conceptualisations which include the production of intangible goods, such as software, in the definition of urban manufacturing, this article builds on a sectoral understanding that emphasises the material nature of urban manufacturing (Brandt, Gärtner, & Meyer, 2017). Manufacturing is defined as the transformation of physical materials using labour, tools, and machinery (Hill, 2020). Our primary focus lies on the environmental benefits associated with the urban production of tangible goods and manufacturing processes. By this, we respond to recent calls for a stronger integration of materiality in spatial research, as it cannot be overlooked considering global challenges like climate change and environmental depletion—both

of which are connected to resource use and the material nature of manufacturing (Angstmann, 2025; Njøs et al., 2024).

The term “urban,” on the other hand, is conceptualised in a broad sense to encompass the diverse interpretations found in the literature we reviewed. Although we acknowledge the conceptual fuzziness connected to the term (Fedeli et al., 2020; Gärtner et al., 2021; Meyer & Schonlau, 2024; Mistry & Byron, 2011; Roost & Jeckel, 2021), we decided to not further restrict our understanding as urban manufacturing is a global phenomenon and can thus be found in different urban locations such as metropolises, larger conurbations, as well as smaller cities.

Urban manufacturing can be subdivided into different types. One taxonomy looks at distributed, local, and inclusive manufacturing (Bonello et al., 2022). Another one divides it into (a) small-scale urban manufacturing in the form of small and medium-sized enterprises that produce high-value goods on a small scale (often clean, high-tech, vertical; Park, 2023); (b) larger-scale urban industries that rely on automated processes and division of labour adapted to urban contexts; and (c) urban agriculture as the professional cultivation of crops (Brandt, Butzin, et al., 2017; Brandt, Gärtner, & Meyer, 2017; Hertwig, Werner, et al., 2024). While urban industries were central in the last century, when large industrial firms were integrated into the urban fabric and offered large-scale employment, this type of manufacturing is declining globally due to modern zoning approaches and competition for land (Hearn et al., 2023; C. Zhang, Di Yao, et al., 2022). As a result, the current academic debate often focuses on small-scale producers (Park, 2023) or novel solutions for urban agriculture. This article examines all three types and draws specific conclusions where appropriate.

With the New Leipzig Charter, European cities promote urban manufacturing to implement the productive city paradigm, aiming to reintegrate small-scale production and integrate urban agriculture while addressing global challenges (Bundesministerium des Inneren, 2020). Planners and urban development agencies often justify support for urban manufacturing based on its economic, spatial, and environmental advantages (Betker & Libbe, 2019; Brandt, Gärtner, & Meyer, 2017; Gärtner & Schepelmann, 2023; Haselsteiner et al., 2019). From this perspective, the outsourcing of polluting or resource-intensive production processes to countries with lower environmental standards must be seen as a negative development (Gärtner & Schepelmann, 2023). Urban manufacturing provides a strategy to reverse the long-standing spatial separation of housing and manufacturing—and, by extension, of consumption and production—through regulatory and planning instruments.

This article focuses on the concept of green urban manufacturing (GUM), which is derived from Deif's (2011, p. 1553) definition of “green manufacturing”: environmentally sound manufacturing embedded in urban areas, aiming for reduced emissions, efficient resource use, and spatial integration. By summarising the current state of research, we aim to clarify whether the widely claimed ecological benefits are supported by evidence or remain largely speculative (Gärtner & Stegmann, 2015) and outline directions for future research.

3. Methods and Dataset

We conducted an SLR to comprehensively identify and evaluate relevant literature and empirical evidence on how urban manufacturing can contribute to carbon, resource, and space efficiency in cities. The SLR method allows us to rigorously locate, select, and assess existing studies, ultimately synthesising data to

clarify what is known and unknown about a topic (Denyer & Tranfield, 2009). It provides objective and reliable findings by reducing potential biases (Tranfield et al., 2003). Denyer and Tranfield (2009) outline five key steps for SLR: (a) formulation of the research question, (b) location of studies, (c) selection and evaluation of studies, (d) analysis and synthesis, and (e) reporting and usage of findings. SLRs go beyond merely summarising literature, providing critical insights and identifying gaps (Briner & Denyer, 2012).

Literature reviews are not a novel approach in research on either GUM or its environmental aspects. Herrmann, Juraschek, et al. (2020) performed a literature review focusing on urban factories. Amjad and Diaz-Elsayed (2024) conducted an SLR with Web of Science data, limiting their search to “urban manufacturing.” Tsui et al. (2021) used the Scopus database to identify articles employing the LCA methodology.

To capture a wide range of contributions, we included articles, book chapters, and conference proceedings listed in two databases, Web of Science and Scopus. We applied various queries aligned with the diversity of terms existing in the discourse about urban manufacturing to reflect the regional and disciplinary diversity of research on this topic (see Figure 1). We opted not to use “sustainability” as a filter in the query to capture a broad spectrum of relevant literature, including studies that may not explicitly use the term but discuss related concepts (e.g., green manufacturing, low-emission factories, green economies) and thus decided to filter the results manually, considering their contribution to the sustainability discourse.

The initial queries identified 711 articles, which were screened based on pre-defined relevance criteria (Denyer & Tranfield, 2009, p. 671). For this, two coders assessed each article’s connection to “urban,” “manufacturing,” “planning,” and “sustainability” independently. Articles were earmarked as relevant, partially relevant, or not relevant. Those with unclear relevance underwent further review before inclusion or exclusion in the final dataset.

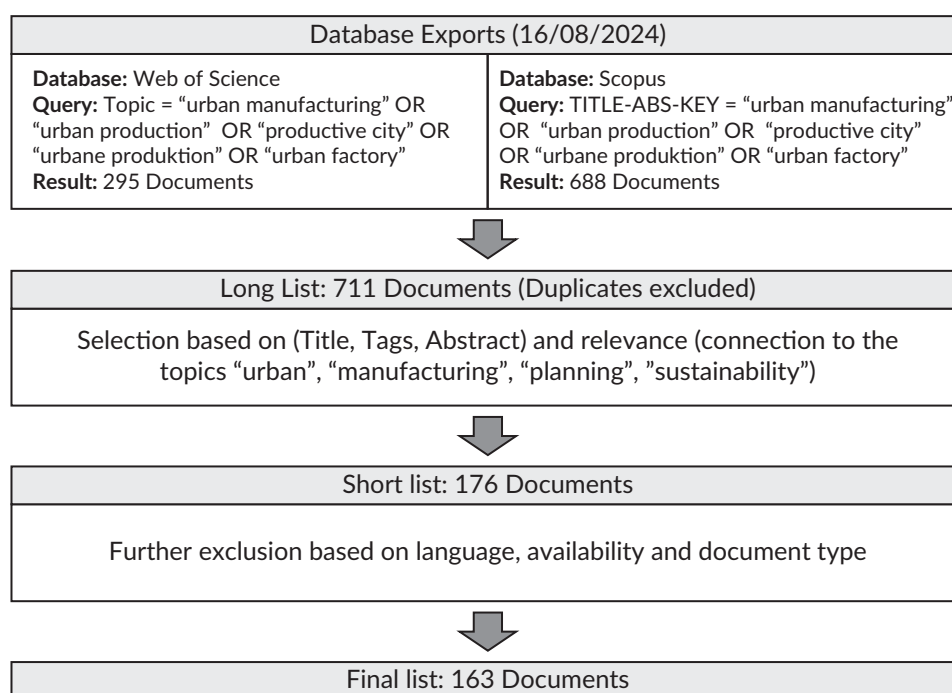


Figure 1. Dataset and systematic approach.

The final dataset comprises 163 documents published between 1993 and 2024, with most articles dealing with GUM published after 2019. The dataset consists of 79 peer-reviewed articles, 36 book chapters, 42 conference proceedings, and 6 other documents (editorials, reports, bulletins, short articles, or reviews; for details see Figure 2 or the supplementary material). We chose to retain a wide range of publications given the interdisciplinary nature of urban manufacturing research, with planners typically publishing articles or chapters and engineers often disseminating results through conference proceedings. This allowed us to capture a wide range of arguments and perspectives.

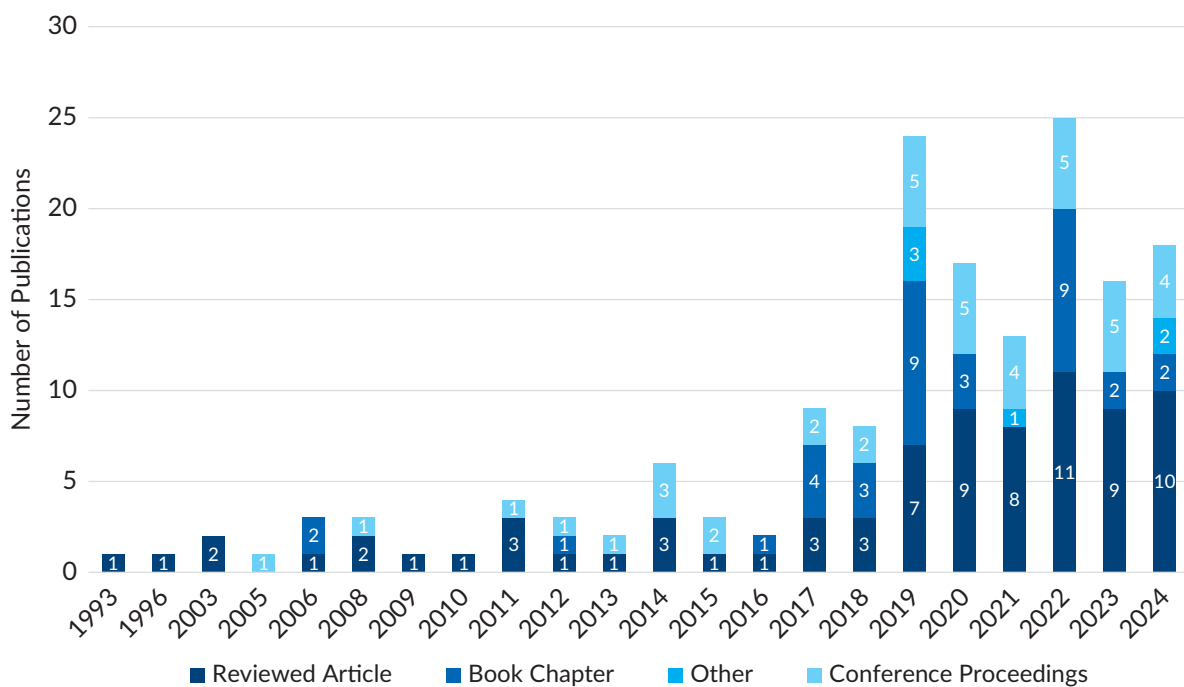


Figure 2. Publications dealing with urban manufacturing and sustainability by publication year.

The term “urban production” is used in 100 documents (61%), another 68 use the term “urban manufacturing” (42%), while 34 documents use both terms interchangeably (21%). The term “sustainability” appeared in 135 articles (82%), with most articles further specifying different types of environmental benefits (e.g., carbon efficiency and reduced emissions [82 documents, 50%], resource efficiency [77 documents, 47%], and space efficiency [38 documents, 23%]).

In our content analysis, we employed an inductive approach to derive insights from the reviewed literature without imposing predefined theoretical frameworks. We used MAXQDA to code key topics across the selected studies and to categorise findings following a grounded approach. Specifically, we first screened the articles and categorised statements, arguments, and evidence using the wording provided in each document. In a second step, we merged these codes into overarching categories (e.g., “lower CO₂ emissions” → “Carbon Efficiency”). To synthesise central findings (Denyer & Tranfield, 2009), we structured the analysis in two steps. First, we assessed the methods used in different studies and regional contexts to understand how evidence on the environmental effects of urban manufacturing was generated. Second, we focused on recurring arguments often connected to the ecological impacts of urban manufacturing, specifically carbon, resource, and space efficiency. These three categories illustrate the breadth of considerations regarding the various ways urban manufacturing may contribute to green urban economies.

Following a thorough analysis of GUM literature, we have identified two key logics: proximity and urban synergies. Proximity to consumers is beneficial in terms of reducing transport emissions and fostering a heightened awareness of production and its consequences. Here, geographical proximity is particularly relevant, as most articles suggest environmental benefits resulting from reduced transport distances. However, the reduced geographical distance between producers and consumers may also foster greater cognitive and relational proximity, thereby increasing awareness of production (Balland et al., 2022). Urban synergies describe a more complex relationship between manufacturing and other urban uses: Integrating manufacturing into the city's fabric may create or extend functional interconnections that lead to certain kinds of sustainability-focused agglomeration effects (Fahmy & Kamiya, 2019). This connects with perspectives from industrial ecology and urban metabolism research, depicting cities as complex systems where manufacturing can be seamlessly integrated with other urban functions (Kennedy, 2016). By employing different kinds of functional integration, urban manufacturing can enhance system-wide sustainability (e.g., city-wide energy efficiency), offering more profound benefits than (geographic) proximity alone.

Understanding these logics and how they are connected to different urban manufacturing categories (urban manufacturers, large-scale industries, and urban agriculture) and with respect to different goals of ecological sustainability, such as carbon, resource, and space efficiency, allows us to summarise the state of research on GUM and its effects thoroughly and across different institutional and regional contexts.

4. Methodologies and Approaches in Urban Manufacturing Research

Reviewing the literature on urban manufacturing reveals a growing body of evidence supporting its environmental benefits, although the overall evidence base remains limited. Out of the papers examined, 66 (40%) provide direct insights into areas like energy efficiency, carbon emissions, and resource use associated with urban manufacturing. Research in this field employs a variety of methods, including quantitative models, case studies, technological assessments and LCAs, each offering unique perspectives. These approaches are applied across different scales, from city-wide analyses to detailed examinations of individual companies or manufacturing processes.

4.1. Models, Quantitative and Spatial Analyses

Past research employed various models to analyse the impact of urban manufacturing systems (34 articles, 21%). These models focus on different impacts, for example on space (Burggräf et al., 2022), and on the local environment, due to pollution or water consumption (Görgens et al., 2023; Huang et al., 2021; Lopez, 2018; Zeng et al., 2017). These studies include city-wide assessments, particularly in the Asian context, analysing the nexus between manufacturing, environmental impacts, labour markets, and regulation (L. Chen et al., 2014; Feng et al., 2022; Ji et al., 2014), while others illustrate urban–rural interconnections (Güven, 2024). It is shown that the development of labour costs and environmental regulations is closely interconnected with the development of urban manufacturing (Daitoh, 2003, 2008; T. Zheng et al., 2019). While manufacturing is seen as a driving force behind increasing carbon emissions and water consumption (L. Chen et al., 2014), changes in urban emissions are closely connected to structural industrial change (tertiarisation), as decreased industrial activity leads to lower emissions (Zhao et al., 2014). In this context, urban economic modelling focusing on urban manufacturing also illustrates a shift from “producer” to “consumer” cities (S. Zheng et al., 2010). These

models primarily analyse urban economic systems rather than specific modes or technologies of production, depicting sectoral contributions to pollution and emissions.

4.2. Qualitative Case Studies

Beyond models, urban manufacturing research relies on context-specific or company-level case studies and urban design proposals (38 articles, 23%). Various case studies, mainly from the US, Europe, or Australia, show that urban manufacturing can address sustainability goals—environmental, economic, and social. For example, case studies on urban agriculture, including container gardens and rooftop farms, demonstrate how it can effectively utilise underused urban spaces (Bhatt et al., 2008) and illustrate how small-lot farming is compatible with other urban uses (Bonello et al., 2022; Di Maria et al., 2022). At the technology level, a variety of studies conduct experiments, compare technologies, or use production data to assess impacts. They often contrast large-scale conventional manufacturing with small-scale urban manufacturing (Juraschek, 2022), while case studies in urban industrial areas demonstrate how cross-sectoral synergies may enhance resource efficiency (Al-Asadi et al., 2024). Some studies use a multimethod approach to validate models by combining them with case studies (Sajadieh & Noh, 2024). Researchers employing case studies often report that their findings are closely connected to specific local conditions, for example geographical setting or institutional support (Büth et al., 2020; Rappaport, 2020).

4.3. Technology Analyses, Experiments, and LCAs

A third strand of research focuses on the assessment and simulation of technologies used in urban manufacturing, including their environmental impacts (Freeman et al., 2017; Rudolf et al., 2023). This encompasses evaluations of technology maturity (e.g., urban smart factories; Sajadieh & Noh, 2024) and analyses of infrastructure implications, such as increased strain on local transport systems (Juraschek, 2022).

To fully assess the environmental impact of specific technologies and their applications, it is essential to understand both upstream and downstream processes—such as indirect impacts from resource extraction, processing, and end-of-life handling—that are not directly attributed to the producing firm. LCAs, which incorporate the entire product life cycle, are therefore a central tool for thoroughly identifying these impacts. LCAs evaluate environmental effects from resource extraction to disposal, providing detailed insights into the sustainability of specific products and processes. For example, LCAs have highlighted successful strategies such as using composted coffee grounds in construction materials (Grodach et al., 2023) and achieving 50% water savings in aquaculture and hydroponics (Ulrichs & Mewis, 2015), demonstrating innovative approaches to end-of-life management and resource efficiency. However, findings are not always easy to interpret. Some studies report mixed results. For instance, urban manufacturing of eyeglass frames shows environmental benefits, whereas urban and non-urban asphalt production have similar impacts due to the dominant role of raw material extraction and transport (Juraschek, Becker, et al., 2019). Urban dairy systems emit more overall, but have the lowest emission intensity (Berhe et al., 2020). Rooftop greenhouses and photovoltaic systems are both viable but compete for space and depend heavily on local climate conditions, limiting the transferability of findings (Corcelli et al., 2019). Aquaponics can improve energy and water efficiency through symbiotic processes (Büth et al., 2020).

These findings, thus, show that urban system effectiveness is context-dependent when it comes to solutions in agriculture. While recent research indicates urban agriculture can emit six times more than conventional methods, using specific crops can reduce this footprint drastically (Hawes et al., 2024). One major topic in different studies is water consumption in urban agriculture, where vertical farming solutions may lead to a higher water use efficiency than conventional methods (Carotti et al., 2023). However, while hydroponics and aquaponics systems achieve water savings (Hasan, 2020; Salisu et al., 2024; Ulrichs & Mewis, 2015), studies examining other parameters, like nitrogen utilisation (Y. Zhang, Zhang, & Li, 2022) or energy expenditure (Benis et al., 2018), reveal that these technologies may only deliver benefits in some parameters compared to conventional agricultural practices.

4.4. Summarising Methods and Scope of Previous Research

Research on GUM provides a variety of insights on different scales of assessment. On a city-scale, there are analyses of whole urban systems and their associated pollution or environmental impact, which often allow only limited conclusions about specific cases or approaches. On a firm-level scale, there is a variety of studies that focus on specific firms in specific contexts. Case-based or technology-based findings provide detailed contextual information, and it becomes clear that findings always rely on specific geographic and operational conditions and challenges (Corcelli et al., 2019; Juraschek, Becker, et al., 2019).

As a result, findings require cautious interpretation. Local factors, such as water availability, access to renewable energy, or regulatory constraints, play a critical role in shaping both environmental outcomes and implementation feasibility (Tsui et al., 2021). In urban agriculture, for example, legal restrictions on livestock, soil imports, or chemical use can limit certain practices, even with policy support (Lawal-Adebowale & Alarima, 2011; Pfeiffer et al., 2015). In some cases, environmental conditions such as soil contamination may render specific solutions infeasible altogether (Bhatt et al., 2008).

This complexity of results challenges a general synthesis of previous empirical findings and generalisation. Nevertheless, understanding the granularity of previous interdisciplinary research—which combines various methods and perspectives to produce findings that may hold true in some contexts but not others—is fundamental for reviewing key arguments. These arguments propose that urban manufacturing could be a solution for enhancing ecological sustainability in urban economies, along with the underlying logics related to different types of environmental impacts.

Furthermore, most of the literature in our review did not empirically test hypotheses about the sustainability of urban technologies or manufacturing solutions. Research in urban planning and engineering often focuses on developing conceptual frameworks for integrating urban manufacturing, creating methods to assess environmental impacts, or conducting literature reviews on specific technologies. Only about 40% of the articles offered direct empirical evidence, while a significant portion derived sustainability claims indirectly—either by referencing other sources (39 articles, 24%) or through theoretical reasoning and logical argumentation (36 articles, 22%).

5. Exploring Sustainability Arguments in Urban Manufacturing Research

Although empirical evidence on the environmental benefits of urban manufacturing remains limited, most articles in our dataset (141 out of 164) contain arguments or claims about its potential to reduce environmental impacts. Using the analytical framework presented in Figure 3, we categorise and evaluate these claims across multiple dimensions. The framework focuses on key environmental factors—carbon, resource, and space efficiency—and identifies two overarching sustainability logics: proximity benefits (e.g., reduced transport distances, greater visibility of production) and urban synergies (e.g., industrial symbiosis, shared infrastructure, optimised land use). It further distinguishes between three types of urban manufacturing—urban industries, urban manufacturers, and urban agriculture—each of which contributes to environmental sustainability in different ways based on its interaction with urban settings.

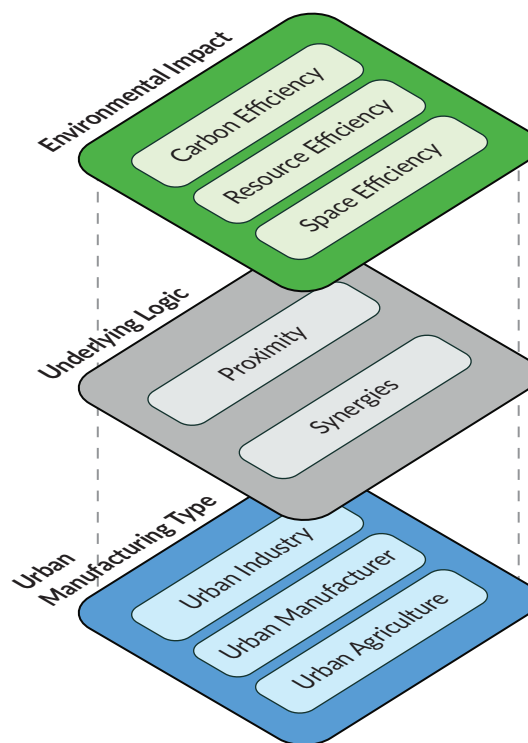


Figure 3. Synthesis: Environmental impacts, underlying logics, and types of urban manufacturing.

5.1. Carbon Efficiency

Urban production systems have been observed to exhibit higher emission intensities for both carbon dioxide and methane compared to economic activities in other sectors, highlighting their substantial impact on the environment (Berhe et al., 2020; L. Chen et al., 2014; L. Fu & Wang, 2022). Simultaneously, urban manufacturing is often conceptually linked to more sustainable modes of production compared to conventional manufacturing outside urban areas, with various authors promoting ideas such as “ultra-efficient urban manufacturing” (Singh, 2017, p. 324) or “ultra-efficient production systems” (Schutzbach et al., 2021, p. 1781). Furthermore, urban manufacturing is often associated with the use of green energy (Buchholz et al., 2005; Darling, 2020; Hasan, 2020).

5.1.1. Proximity

It is frequently argued that urban manufacturing may contribute to sustainability by reducing transport emissions and enhancing logistical efficiency (mentioned in 43 (26%) of the articles). Localising production in urban settings reduces distances to potential markets, shortening supply networks (Ball & Badakhshan, 2023; Barni et al., 2018, 2019; Diez, 2020; C. Fu et al., 2021; Grodach et al., 2023; Hertwig, Nowak, et al., 2024; Hildebrandt et al., 2021; Ijassi et al., 2023; Juraschek, 2022c; Krenz, Saubke, et al., 2022). This closeness to customers reduces delivery times and can improve resource sourcing (Barni et al., 2019). Studies suggest that shortening transport distances can reduce greenhouse gas emissions by 0.8–2.6%, reflecting potential environmental benefits (Tsui et al., 2021). Therefore, efficient city logistics are often seen as a critical component of urban manufacturing as they allow for streamlined supply chains and reduce transportation distances (Stiehm, 2019).

Urban agriculture, in particular, is frequently mentioned when it comes to proximity benefits, as it offers the dual benefits of reducing emissions and enhancing local urban ecosystem services. Local food systems are widely recognised for their potential to significantly decrease emissions by reducing the distance food must travel to reach urban consumers, thereby lowering the carbon footprint associated with food transportation (Ulrichs & Mewis, 2015). Several researchers conclude that maintaining local food production on-site and reducing food miles can significantly contribute to more sustainable urban environments (Benis et al., 2018; Bonello et al., 2022; Borowski et al., 2012).

Another strand of arguments draws the connection to positive impacts due to employees being able to lower emissions through lower commuting distances and the possibility for employees to use sustainable urban transport infrastructures (Bonello et al., 2022; Ferm, 2023; Hauge et al., 2021; Juraschek, Bucherer, et al., 2018; Juraschek et al., 2017; Lopez, 2018; Meyer, 2023; Rappaport, 2017; Singh et al., 2017; Yin & Yao, 2024).

Technological innovation is seen as fundamental as it enables low-emission production processes that can be situated in urban contexts (Ball & Badakhshan, 2023; Benis et al., 2018; X. Chen et al., 2024; Di Maria et al., 2022; Rappaport, 2017; Roost & Jeckel, 2021; Singh et al., 2017; Vidal et al., 2022). Throughout the literature, there is a broad consensus that urban manufacturing often leverages sustainable modes of production, evident in the concept of “city-compatible manufacturing” characterised by carbon efficiency and low-emission production processes (Antczak et al., 2023; Benis et al., 2018; Darling, 2020; Grodach et al., 2023; Herrmann, Juraschek, et al., 2020; Juraschek, Kreuz, et al., 2019; Kreuz et al., 2020; N. L. Martin et al., 2024; Meyer, 2023; Monaghan & Beacham, 2017; Roost & Jeckel, 2021; Singh et al., 2017; Spath & Lentjes, 2013; Tricarico, 2024).

Recent research often provides general advice on technological development strategies (e.g., biologically inspired green technologies; Schutzbach et al., 2021) or analyses specific technologies significant for small-scale urban manufacturing (e.g., vertical factories, CNC milling, additive manufacturing) that enable production facilities to be close to residential areas due to their reduced environmental impact (Barni et al., 2019; Meyer & Schonlau, 2024). This also encompasses technologies for sustainable urban agriculture (Benis et al., 2018) and synergistic, resource-efficient production in aquaponics systems (Y. Zhang, Zhang, & Li, 2022). A further strand analyses new materials for manufacturing processes, like biodegradable, reusable, or recyclable materials, as well as thermoplastics (Barni et al., 2019). In general, these strands of research

argue that innovation may enable city-compatible manufacturing processes, which inherently produce lower emissions and are thus particularly suitable for integration into urban environments (Matt et al., 2020; Singh et al., 2017).

Urban manufacturing based on city-compatible production, either due to its smaller scale (Bundesministerium des Inneren, 2020; Grodach et al., 2023) or use of specific technologies, is, therefore, often seen as sustainable manufacturing in general. Compact urban areas are conducive to fostering low-carbon lifestyles and production practices, which aid in reducing carbon emissions by minimising transportation needs (Yin & Yao, 2024). To conclude, the need to use efficient technologies when producing in an urban location, as well as proximity to consumers, are key mechanisms by which urban manufacturing is often said to be more energy- and carbon-efficient.

There are, however, caveats. First, high-tech does not always equate to low pollution, as demonstrated by Yoshida (2008). Second, although small-scale technologies may be well-suited for urban manufacturing, there is debate about the extent of their sustainability impact in a global context. Basic materials and components are often produced outside urban manufacturing processes—in distant facilities—contributing significantly to overall value chain emissions and environmental impacts (Singh et al., 2017). Further, the efficiency gains associated with larger manufacturing scales might be lost when production is downscaled to fit urban contexts. Consequently, although local environmental impacts might decrease, the global impact per unit produced could increase (Juraschek, 2022). Third, when it comes to the impact of transportation, only a limited number of sources provide detailed evidence to underscore how these operate and why their operation is, indeed, more efficient. Effective logistics flows may reduce traffic volumes and emissions, thereby providing a potential sustainability advantage for urban manufacturing (Reineke et al., 2021). However, transport emissions in many products or production processes only make a minor contribution to emissions when the whole life cycle of the product is analysed (Tsui et al., 2021). Fourth, the studies on urban agriculture provide mixed evidence on its impact. In some cases, the higher emissions associated with activities like energy consumption for vertical farming or resource-intensive practices can offset the gains achieved from reduced transportation (Berhe et al., 2020). This nuance suggests that the environmental performance of urban agriculture can vary significantly depending on the methods and technologies employed.

Producing in cities—especially in countries with strict environmental legislation on emissions and pollution and planning systems based on zoning—leads to the impetus to use low-emission technologies. However, positioning low-emission production as both a prerequisite for urban manufacturing and a justification for its sustainability may create a circular argument. This perspective suggests a scenario where urban manufacturing is seen as sustainable largely because it is designed to be low-emitting, which is a principal expectation set for its implementation, not being sustainable because it is urban. Meaning that the technology could also be applied in other non-urban contexts. These arguments, grounded in specific technologies, should, therefore, be seen with caution.

5.1.2. Urban Synergies

Further arguments emerge when considering carbon efficiency not only at the company level but also at the city level. Various proposals aim to functionally integrate manufacturing within the urban fabric, generating synergies both with other economic actors and with civil infrastructure.

Industrial agglomeration is argued to have the potential to lower emissions by enabling the efficient use of shared resources and infrastructure (Huang et al., 2021). The increased concentration of production facilities in urban areas may result in strain on existing infrastructure, necessitating careful management and strategic planning to maximise the potential sustainability benefits without overwhelming city systems (Herrmann, Juraschek, et al., 2020; Juraschek, 2022b), a consequence that is not often given sufficient consideration.

Additional solutions include companies acting as energy suppliers or green fuel producers (Barni et al., 2019; Juárez-Casildo et al., 2022; Tötzer et al., 2019). In these cases, the benefits of urban manufacturing arise from integrating manufacturing into the broader urban fabric or consumption and production systems, rather than from individual firms' technology use. Local companies and crafts are also needed to implement the urban energy transition (Meyer, 2023). A limited number of studies have explored integrating efficient production processes into the urban environment, harvesting potentials from the built environment. An example is the efficiency of rooftop greenhouses that capitalise on local energy and resources while optimising sunlight due to their exposure (Peña et al., 2022). However, while a variety of arguments support the contribution of urban manufacturing to carbon efficiency at the city level, empirical analysis often focuses on the firm or technology level.

5.2. Resource Efficiency

Urban manufacturing plays a key role in resource efficiency and circular economy integration (318 mentions in 44 documents). As cities consume 60–70% of global resources and generate about 50% of waste (Ijassi et al., 2023), they hold potential as hubs for sustainable production and consumption. Urban manufacturing is seen as integral to connecting local supply and demand cycles, promoting resource efficiency (Ball & Badakhshan, 2023; Ferm, 2023). Despite past trends favouring service-oriented space use, separating production from consumption, and creating linear systems dependent on the hinterland, scholars highlight urban manufacturing's role in circular economy practices (Hausleitner et al., 2022). By fostering symbiotic relationships and closing resource loops, urban manufacturing can turn waste into production inputs (Juraschek, Kreuz, et al., 2019; Matt et al., 2020). Therefore, researchers suggest that cities can advance a circular economy by supporting repair, refurbishment, and recycling in urban areas (Benis et al., 2018; Ijassi et al., 2024).

5.2.1. Proximity

Urban manufacturing companies focused on repairing, recycling, and reusing materials are crucial for resource efficiency, supported by technological advancements. A key circular economy strategy is reducing resource use. Distributed manufacturing employing additive technologies (e.g., 3D-printing) can lower energy and material consumption, enabling customised, efficient, small-scale, or spare part production with reduced environmental impact (Bonello et al., 2022; Kreiger & Pearce, 2013; Moerlen & Evrard, 2021; Tsui et al., 2021). Extrusion-based processes and platforms for resource reuse optimise material cycles, decreasing raw material dependence (Barni et al., 2019; C. Zhang, Di Yao, et al., 2022). Urban agriculture innovations, such as vertical farming and soilless cultivation methods like hydroponics, might increase yields while minimising resource inputs, especially water consumption (Carotti et al., 2023; Salisu et al., 2024; Ulrichs & Mewis, 2015).

As cities grow, the more crucial they become for reuse and recycling strategies (Benis et al., 2018). “Urban mining” repurposes end-of-life products for reuse, remanufacturing, or recycling, transforming cities into repositories of secondary resources (Herrmann et al., 2019; Juraschek, 2022a). Manufacturing in cities, from this logic, means manufacturing near a possible source of future secondary resources. Urban agriculture, in particular, illustrates how circular value chains may function, as it can utilise local compost and recycled water (Buchholz et al., 2005; Büth et al., 2020; Pfeiffer et al., 2015).

Beyond conventional manufacturers, makerspaces and Fablabs (373 mentions in 30 documents) are also depicted as pivotal for advancing urban resource efficiency and circular economy practices. They emphasise “reduce, reuse, and recycle” through repair cafés, second-hand shops, and Fablabs, fostering community-oriented sustainability and the circular economy (Elwakil et al., 2023). As hybrid environments for artistic and manufacturing experimentation, they foster innovative circular solutions and community sharing, building local circular economy circuits (Tricarico, 2024). The “Fab City” model envisions cities producing what they consume locally while sharing knowledge globally (Diez, 2020).

Despite its potential, urban manufacturing faces practical limitations. Many conceptual proposals lack operational feasibility, and although technologies like distributed manufacturing can reduce energy and material use, their impact in practice depends heavily on product design, production chains, and local regulations (Freeman et al., 2017). Furthermore, most urban and conventional factories focus primarily on the manufacturing phase of a product’s life cycle, while material sourcing and end-of-life processes often receive little attention in the urban context. As a result, circular practices have yet to be widely adopted (Juraschek, Becht, et al., 2018).

Furthermore, methodological challenges arise when comparing conventional and urban manufacturing. Some studies assume urban manufacturing technologies are inherently more resource efficient: “Waste reduction differentiates urban factories from classic industry, with disposable items replaced by reusables to avoid waste” (Moerlen & Evrard, 2021, p. 416). However, these findings do not confirm urban manufacturing’s inherent efficiency but show the benefits of using certain associated technologies or resources that are also applicable in non-urban locations.

5.2.2. Urban Synergies

For local manufacturing to become relevant in a global competitive economic environment and to foster the local sustainable transformation, it must focus on key benefits: situating production near consumption, leveraging local demand, and utilising urban resources (Krenz, Stoltenberg, et al., 2022). By fulfilling local demand and using urban resources, the concept of urban factories emphasises the potential of “urban mining” to repurpose waste as a secondary resource (Ijassi et al., 2024). In this context, end-of-life products can be reused, remanufactured, or recycled, reducing disposal and capitalising on waste materials (Herrmann et al., 2019; Juraschek, 2022a). Recycling factories participate in closed-loop flows, using local waste (Juraschek, 2022). Urban agriculture, utilising local compost, improves soil quality and yields (Dasylyva et al., 2018; Pfeiffer et al., 2015). Technological advances in recycling allow for the integration of local resources into sustainable systems (Krenz, Saubke, et al., 2022).

Urban industrial symbiosis (204 mentions in 45 documents) is one central strategy for local resource utilisation, connecting different urban economic actors through waste and by-product streams. Here, urban

manufacturing may be used to close material and energy streams, improving urban internal metabolism (Keeffe, 2012). Cities offer cooperation opportunities among manufacturers (Herrmann, Büth, et al., 2020). Collaboration boosts efficiency, optimising resource use with shared investments (Lentes & Hertwig, 2019). Zero-emission parks illustrate shared resources and cooperation for GUM (Hüttenhain & Kübler, 2021), and symbiotic relationships can cut waste up to 15%, as one study of an industrial park shows (Al-Asadi et al., 2024). In this context, firm networks of urban manufacturers can redirect waste outputs to reduce environmental impact and costs (Al-Asadi et al., 2024; Ben & Wang, 2011). Furthermore, companies benefit from shared infrastructure and resource sharing, which lowers expenses (Spath & Lentes, 2013). Synergies like these can be developed within eco-industrial parks or between manufacturers and other urban entities, for example waste heat utilisation for heating residential areas (Afshari et al., 2018). In this sense, multifunctional land use supports sustainable growth by enabling synergies and efficiency gains on the city level (van Veenhuizen, 2011; Yang et al., 2020).

While symbiotic relationships in urban manufacturing are desirable, their implementation remains challenging. The often-cited Kalundborg (Denmark) symbiotic network demonstrates the potential of this approach; however, its complexity has rarely been replicated elsewhere, illustrating that such networks are inherently tied to local contexts and cannot be easily duplicated (Hertwig et al., 2021). Although shared infrastructure offers benefits, it frequently exists only as proposals with limited validation (Lentes & Hertwig, 2019). Effective inter-company communication and transparency are critical for building synergies and thus depend not only on proximity but also on active intermediation (Lentes & Hertwig, 2019).

When it comes to urban symbiosis, integrating not only firms but also other urban entities highlights further challenges: The real-world implementation of the idea of urban symbiosis often manifests itself in solutions of energy and heat supply, while there is less attention given to material recycling or wastewater treatment (Fraccascia, 2018). This narrow focus might not suffice to provide a comprehensive framework for urban resource management. Furthermore, diverse examples in international research reinforce the idea that many potential urban symbiosis solutions, like municipal heat exchanges or localised material recycling projects, depend heavily on context-specific factors (Neves et al., 2020).

Functionally connecting production processes in urban contexts is, however, not only said to enhance environmental benefits but is also seen as a key strategy to improve economic resilience (Juraschek, Bucherer, et al., 2018). It is often promoted in local strategic plans for its ability to strengthen local economies and reduce their dependence on external supply chains (Grodach, 2022; Hasan, 2020; Rappaport, 2020). Here, urban agriculture is said to improve food security and nutrition, which are essential for urban health (Bhatt et al., 2008). Further benefits are social inclusion and equitable employment opportunities (Al-Asadi et al., 2024; Bonello et al., 2022; D. Martin & Grodach, 2023; Meyer, 2023; Tricarico, 2024).

Urban manufacturing must therefore be considered not only from the perspective of individual company practices, technologies, or their impact, but also from the perspective of its function within the city. Synergies enabled by manufacturing within cities thus contribute to economic and social sustainability. Urban manufacturing supports sustainable urban development through resource conservation and use of public transport (D. Martin & Grodach, 2023; Meyer, 2023).

5.3. Space Efficiency

Urban areas face space scarcity for manufacturing due to dense populations and the profitability of housing and office spaces (Ferm & Jones, 2017). Space conflicts arise from competing urban activities (Juraschek, Kreuz, et al., 2019), necessitating efficient industrial land use for urban manufacturing development (C. Zhang, Di Yao, et al., 2022). Urban manufacturing can efficiently use space by re-purposing existing areas, decentralising processes, and utilising vacant plots and rooftops (Hasan, 2020; Yang et al., 2020), which is why space efficiency of some kind is mentioned as an argument for urban manufacturing in 38 of the analysed documents (23%).

5.3.1. Proximity

Technological innovations are crucial for achieving space efficiency in urban manufacturing, particularly through vertical production and noise reduction. Vertical urban factories are suggested as solutions to space constraints, minimising land use while maximising output (Darling, 2020; Rappaport, 2020). This aligns with sustainable urban development trends addressing land use efficiency and environmental sustainability. Modular production systems enhance space efficiency, allowing functionality in small spaces (Büth et al., 2020). Advances in supply chain management and urban-specific warehousing support this efficiency (Abdoli et al., 2019; Amjad & Diaz-Elsayed, 2024). In urban agriculture, vertical farming exemplifies efficient space use with high-density planting and soilless systems, maximising yield and conserving resources (Carotti et al., 2023; Salisu et al., 2024). Vertical farming also limits urban sprawl (Benis et al., 2018). Vertical growth and mixed land use facilitate overlapping functions, like combining production with retail or residential spaces, enhancing economic viability and resilience (Singh et al., 2017; Yang et al., 2020).

From another perspective, space-efficient urban manufacturing close to residential areas also offers environmental advantages as the proximity allows consumers to understand the impacts of manufacturing processes, which increases awareness of manufacturing and its environmental impact (Barni et al., 2019). In this sense, urban manufacturing fosters awareness and sensitises urban inhabitants to production practices (Cima & Wasilewska, 2023; Hearn et al., 2023; Lowe & Vinodrai, 2020). In this context, geographical proximity fosters relational, organisational, or social proximity (Balland et al., 2022; Boschma & Frenken, 2010) as manufacturers create local jobs in these industries (Feltrin et al., 2022) or involve customers in co-creation processes, for example when products are highly personalised and, thus, highly customer-oriented, while reducing supply chain emissions and attracting skilled workers (Butzin & Meyer, 2020; Sajadieh et al., 2022). Similarly, studies indicate that localised food production benefits the environment, as local farmers are more environmentally conscious and use improved fertilisers (Hall et al., 2014, as cited in Tsui et al., 2021).

However, there is a risk that small-scale and highly efficient urban manufacturing may create a misleading awareness. Urban manufacturing typically involves operations that are small-scale, downstream, and low-emission. Basic industries that extract or process primary resources—often utilised in urban production—are primarily situated elsewhere. This can result in a skewed perception focused on industries that operate within urban areas (e.g., small-scale manufacturers), while neglecting essential upstream activities like resource extraction. As one study suggests, the efficiency of urban manufacturing might lead to rebound effects due to the perceived low environmental impacts and the increased local availability of products (N. L. Martin et al., 2024).

5.3.2. Urban Synergies

Multi-use spaces enhance urban manufacturing sustainability by integrating functions within confined areas. Combining manufacturing with activities like rooftop farming supports urban food supply and sustainability (Bonello et al., 2022; Darling, 2020). This approach utilises underused spaces and integrates green infrastructure into urban environments (Bhatt et al., 2008). Multifunctional urban agriculture is said to improve food security (Benis et al., 2018; Fahmy & Kamiya, 2019). Additionally, urban agriculture contributes to carbon sequestration (Büth et al., 2020; Peña et al., 2022). Techniques such as organic farming and urban horticulture enhance urban green spaces, which are crucial for maintaining ecological balance in metropolitan areas and reducing the heat island effect (Büth et al., 2020; Kouloumprouka Zacharaki et al., 2024). Urban agriculture, thus, extends biodiversity and provides ecosystem services (Gerster-Bentaya, 2013; Peña et al., 2022).

Shared infrastructure in urban manufacturing sites provides advantages, enabling reduced capital demand (Meyer, 2023; Spath & Lentes, 2013). Vertical factories prioritise multifunctionality in urban planning (Moerlen & Evrard, 2021; Rappaport, 2017). Urban environments can integrate biological and nature-inspired technologies (Antczak et al., 2023; Herrmann, Büth, et al., 2020). Systems combining hydroponics, aquaculture, and urban waste composting create a diverse technological landscape supporting sustainability (Büth et al., 2020).

Reusing space promotes sustainability in urban manufacturing by revitalising existing infrastructure. Detroit is an example where reusing industrial spaces fosters synergy between creativity and traditional production (Di Maria et al., 2022). This creative repurposing is said to preserve historical urban fabrics while bolstering local economies by creating vibrant innovation hubs. The use of brownfield sites and vacant buildings highlights the potential that reusing urban spaces offers for production purposes. Conversion of underutilised areas, such as rooftops, into productive sites is reportedly gaining traction due to multifaceted benefits (Corcelli et al., 2019; Stiehm, 2019).

However, multi-coding urban spaces for multiple economic activities can lead to conflicts. A study comparing rooftop crop production and renewable energy generation found both as potentially viable solutions that are, however, not compatible to be installed in the same place (Toboso-Chavero et al., 2019). Furthermore, multifunctional space use can also lead to the loss of manufacturing space in the long term (Grodach, 2022). Mixed-use areas can marginalise manufacturing sectors and lead to gentrification (Grodach et al., 2023). New industries face planning hurdles in urban environments, relying on planners to understand impacts (Grodach et al., 2023).

6. Discussion: What We Know and What We Don't Know

Efficient technologies are prerequisites for urban integration given space and resource limits (D. Martin & Grodach, 2023). These advanced technologies may reduce emissions and improve energy efficiency but are not exclusive to urban manufacturing: Technologies such as additive manufacturing can be applied in urban and non-urban settings. Furthermore, focusing solely on technology can lead to unvalidated technocratic visions, possibly excluding non-“city-able” processes. One major shortcoming of previous research is that urban manufacturing case studies often focus on the end points of the supply chain, neglecting upstream

activities that have greater environmental impacts. Research shows that 90% of the environmental impacts of goods stem from supply chains rather than production, with embedded emissions being much higher than direct ones (Bové & Swartz, 2016). Carbon emissions also differ largely across product types (Meinrenken et al., 2020), making it difficult to generalise results based on a single product or manufacturing process.

The scale of production is crucial in evaluating conventional versus urban manufacturing impacts. Small-scale urban manufacturing might increase global impact compared to large-scale operations due to missed scale effects (Juraschek, 2022). However, small-scale production can be better matched to local demand and reduce strain on urban systems or ecosystems, for example in terms of traffic congestion or water consumption (Juraschek, 2022; Krenz, Saubke, et al., 2022). Furthermore, an excessive focus on small-scale, low-emission urban manufacturing may obscure pollution from larger industrial activities outside cities and potentially distort overall awareness of environmental impacts. This narrow perspective overlooks burden shifting to hinterlands, where less-efficient processes may increasingly contribute to a product's overall environmental impact.

Proximity benefits like reduced transport emissions are less impactful than often assumed, with transport emissions being only a minor portion of total emissions in some manufacturing processes (Tsui et al., 2021). While proximity can help reduce transport-related emissions, greater environmental benefits typically result from minimising waste and increasing the use of recycled materials (Benis & Ferrão, 2017; Tsui et al., 2021). In this sense, the true potential of proximity lies in enabling functional interconnections and synergies between production, consumption, and resource flows within the urban context.

Furthermore, studies suggest that networks, not merely proximity, are essential for creating synergies and symbiotic relationships (Spath & Lenters, 2013). Proximity can underpin networks but requires active building and external facilitation to achieve synergy benefits (Krenz, Stoltenberg, et al., 2022). It is, therefore, not just proximity that matters, but synergies enabled by functionally connecting manufacturing with the urban setting. This harnesses firm, sector, and community interconnections to utilise urban form for efficiency, embodying “urban” manufacturing. These synergies leverage existing infrastructure for resource sharing, supporting broader sustainability goals (Kreuz et al., 2020).

The validity of different arguments may vary depending on the three different types of manufacturing: small-scale manufacturing, urban industry, and urban agriculture. While vertical factory proposals exist, implementations remain limited (Haselsteiner et al., 2019). In contrast, large-scale industrial production is space-intensive, posing integration challenges. Urban agricultural technologies and practices can often be integrated into existing structures like rooftops or vacant spaces, and small-scale manufacturing fits well in mixed-use zones, seamlessly incorporating into the urban fabric. Finally, technologies like vertical farming can enhance urban agriculture sustainability but depend on local circumstances, indicating that effective practices in one context may not suit others (Berhe et al., 2020). This highlights the need for context-aware strategies addressing each urban environment's unique traits, as articulated by Juraschek (2022b, p. 63): “Urban production systems are connected with the surrounding quarter, city and region through input and output flows of energy, materials and information.”

Finally, urban manufacturing reduces emissions through specific practices and consumer involvement, enhancing awareness for environmental impacts. Although this is a valid argument, this indirect type of

impact is particularly difficult to capture empirically, and the argument itself leads to questions concerning rebound effects (N. L. Martin et al., 2024).

Including a large international dataset allowed us to capture the breadth of the global scientific discourse on urban manufacturing. However, this approach has its limitations. Most empirical studies focus on China (21), the US (16), Germany (15), and other European countries (26). Therefore, these findings must be interpreted within the context of local economic dynamics—such as levels of deindustrialisation and tertiarisation—as the insights are shaped to some extent by the specific discourses and challenges of these regions. Furthermore, this means a lack of research on urban production and its sustainability effects in more informal planning contexts or less regulated environments. As formulated by Fahmy and Kamiya (2019), sustainability in urban settings typically results from deliberate political will and collective stakeholder engagement. Furthermore, cities that aim for sustained urbanisation in formal planning systems are more likely to preserve rural lands and environment, promote socio-economic development and inclusion, and reduce commuting time and distances, consequently minimising the cities' carbon footprints (Fahmy & Kamiya, 2019). The transferability of findings to informal planning systems is, thus, limited, highlighting the need for comparative research that considers diverse governance and spatial conditions.

The heterogeneity of empirical approaches must also be considered in relation to these regional contexts. Most of the qualitative case studies focus on North American (11), European (18), and Australian (3) cities and mainly examine specific firms while also reflecting on local planning approaches and policies. In contrast, most of the research from Asia (21), and primarily from China (19), frequently employs quantitative data and modelling at the city or country-level. This hinders our ability to compare results or generalise findings as they were gathered in different contexts, using different methods, and scopes.

In conclusion, urban manufacturing research is rich in proposals addressing carbon, resource, and space efficiency. Although ideas like vertical urban factories and modular systems are prevalent, they often lack empirical validation across different urban contexts. Suggested approaches include recycling factories with closed-loop systems (Juraschek, 2022) and urban mining (Spath & Lentjes, 2013). Energy and resource efficiency efforts leverage urban proximity for symbiotic networks (Hertwig, Nowak, et al., 2024; Lentjes & Hertwig, 2019; Schutzbach et al., 2021), while space efficiency targets vertical factories (Darling, 2020) and multi-use spaces (D. Martin & Grodach, 2023; van Driel, 2014). Despite numerous frameworks and strategies, empirical data are limited. Models extensively explore spatial and economic dynamics, including interactions between urban manufacturing and the city economy (Burggräf et al., 2022), as well as simulations of urban carbon emissions (L. Chen et al., 2014; Ji et al., 2014). Case studies (Al-Asadi et al., 2024; Di Maria et al., 2022) provide valuable insights, but their findings are often closely connected to the specific geographical and institutional context in which they were conducted. The same applies for technology assessments and LCAs, which typically address product- or technology-specific solutions (Carotti et al., 2023; Juraschek, Becker, et al., 2019; Ulrichs & Mewis, 2015). Certain solutions, such as rooftop greenhouses in the Mediterranean climates (Corcelli et al., 2019), or space-efficient factory designs—including vertical factories and brownfield redevelopments—may be fostered by particular planning systems (Bonello et al., 2022; Burggräf et al., 2022; Singh et al., 2017). However, transferring these solutions to different geographical or institutional contexts may not always be feasible.

Although urban manufacturing can help address some environmental challenges, it remains difficult to draw a comprehensive conclusion about its overall contribution to sustainability or to the circular economy. General models or technology analyses of “urban” and “conventional” production, often based on questionable assumptions, provide limited help. Instead, case-by-case research, especially comprehensive case studies of specific technologies in diverse real-world urban contexts (see Hawes et al., 2024), can significantly enhance our understanding.

7. Conclusion

Urban manufacturing has garnered significant interest as a potential catalyst for addressing contemporary challenges. Defined by its reliance on local resources and integration within densely populated areas, urban manufacturing aims to balance traditional production with emerging paradigms of mixed-use cities and sustainable practices. Despite widespread claims concerning the ecological and efficiency benefits of GUM, these are often based on theoretical assumptions and less on empirical validation.

Extensive research, including urban economic models, firm-level cases, and technology assessments, provides insights into specific questions within specific contexts. Modelling often provides general knowledge on sectoral developments and, most recently, developments in Asian cities, while firm-level case studies often explore Western economic and institutional contexts. Findings on technologies or specific technological solutions are typically context-dependent (e.g., agricultural technologies influenced by climate conditions) or shaped by assumptions about urban vs. conventional production (e.g., primary vs. secondary resource use).

Findings indicate that potential benefits may rely more on integration strategies than on technological solutions alone. Effectively leveraging urban manufacturing for sustainability, however, requires considering all levels (city, firm, technology) and benefits through proximity or synergies with other uses. This allows us to identify context-specific strategies that not only focus on technologies but also on their integration into the existing urban fabric. A perspective of urban manufacturing solely as production within the city falls short, as it does not include beneficial synergies with other urban functions, such as shorter commutes or the establishment of sufficiency to avoid rebound effects. Understanding interplay of solutions with the specific urban context is key to maximising urban manufacturing’s potential. Future research should investigate technology implementation in varying urban contexts as well as resource and energy systems, particularly validating urban symbiosis and resource efficiency models through detailed case studies highlighting tangible benefits that can be traced across different cases and cities. Such research can then guide sustainable practices, transforming urban environments into innovative, green manufacturing hubs.

While we maintain confidence in the environmental benefits of urban manufacturing and find the supporting arguments persuasive, there remains an essential need for more integrated empirical research. Expanding the evidence base is critical to substantiate these claims and to engage a wider scholarly and policy-oriented audience beyond the echo chambers of sustainability discourse.

A limitation of this article is its focus on the ecological dimension of sustainability—there is a need to examine the interaction of this dimension with economic and social aspects. Additionally, relying mainly on English-language databases may have led to the exclusion of relevant research from other regions.

Funding

Stefan Gärtner, Kerstin Meyer, and Leonard Can Stratmann are involved in the project FAB.Region Bergisches Städtedreieck – Transformation hin zu einer co-kreativen Kreislaufwirtschaftsregion, which focuses on sustainable innovation and circular economy. Funded by the European Regional Development Fund (ERDF) and the state of North Rhine-Westphalia, this involvement provided access to relevant data and insights. However, all analyses and conclusions in this article were conducted independently and do not necessarily reflect the project's official views.

Conflict of Interests

In this article, editorial decisions were undertaken by Lech Suwala (Technical University Berlin), Robert Kitzmann (Humboldt University Berlin), and Sebastian Henn (Friedrich Schiller University Jena).

LLMs Disclosure

To ensure responsible AI use and maintain publication integrity, we disclose using ChatGPT (GPT-4-Turbo) and DeepL (version 25.1.4.15077). ChatGPT helped combine data, which was then manually verified by researchers, while both tools enhanced our manuscript's grammar and style.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

References

- Abdoli, S., Juraschek, M., Thiede, S., Kara, S., & Herrmann, C. (2019). An investigation into holistic planning of urban factories. *Procedia CIRP*, 80, 649–654. <https://doi.org/10.1016/j.procir.2019.01.100>
- Afshari, H., Jaber, M. Y., & Searcy, C. (2018). Extending industrial symbiosis to residential buildings: A mathematical model and case study. *Journal of Cleaner Production*, 183, 370–379. <https://doi.org/10.1016/j.jclepro.2018.02.148>
- Al-Asadi, A., Almusaed, A., Al-Asadi, F., & Almssad, A. (2024). Enhancing urban sustainability through industrial synergy: A multidisciplinary framework for integrating sustainable industrial practices within urban settings—The case of Hamadan industrial city. *Open Engineering*, 14(1), Article 20240033. <https://doi.org/10.1515/eng-2024-0033>
- Amjad, M. S., & Diaz-Elsayed, N. (2024). Smart and sustainable urban manufacturing for a circular economy. *Environment, Development and Sustainability*. Advance online publication. <https://doi.org/10.1007/s10668-024-04671-w>
- Angstmann, M. (2025). From waste to value? Valuation and materiality in geographies of industrial by-product use. *Progress in Economic Geography*, 3(1), Article 100034. <https://doi.org/10.1016/j.peg.2024.100034>
- Antczak, E., Rzeńca, A., & Sobol, A. (2023). “Productive Cities” in Poland—A comparative analysis based on an aggregate measure of development. *Economics and Environment*, 86(3), 312–333. <https://doi.org/10.34659/eis.2023.86.3.643>
- Ball, P., & Badakhshan, E. (2023). Urban food production digital twin: Opportunities and challenges. In S. G. Scholz, R. J. Howlett, & R. Setchi (Eds.), *Sustainable design and manufacturing* (pp. 331–340). Springer Nature.
- Balland, P.-A., Boschma, R., & Frenken, K. (2022). Proximity, innovation and networks: A concise review and some next steps. In A. Torre & D. Gallaud (Eds.), *Handbook of proximity relations* (pp. 70–80). Edward Elgar Publishing.

- Barni, A., Carpanzano, E., Landolfi, G., & Pedrazzoli, P. (2019). Urban manufacturing of sustainable customer-oriented products. In L. Monostori, V. D. Majstorovic, S. J. Hu, & D. Djurdjanovic (Eds.), *Proceedings of the 4th International Conference on the Industry 4.0 Model for Advanced Manufacturing* (pp. 128–141). Springer.
- Barni, A., Corti, D., Pedrazzoli, P., & Rovere, D. (2018). A digital fabrication infrastructure enabling distributed design and production of custom furniture. In S. Hankammer, K. Nielsen, F. T. Piller, G. Schuh, & N. Wang (Eds.), *Customization 4.0* (pp. 173–190). Springer.
- Ben, T.-M., & Wang, K.-F. (2011). Interaction analysis among industrial parks, innovation input, and urban production efficiency. *Asian Social Science*, 7(5). <https://doi.org/10.5539/ass.v7n5p56>
- Benis, K., & Ferrão, P. (2017). Potential mitigation of the environmental impacts of food systems through urban and peri-urban agriculture (UPA)—A life cycle assessment approach. *Journal of Cleaner Production*, 140, 784–795. <https://doi.org/10.1016/j.jclepro.2016.05.176>
- Benis, K., Gashgari, R., Alsaati, A., & Reinhart, C. (2018). Urban foodprints (UF)—Establishing baseline scenarios for the sustainability assessment of high-yield urban agriculture. *International Journal of Design & Nature and Ecodynamics*, 13(4), 349–360. <https://doi.org/10.2495/DNE-V13-N4-349-360>
- Berhe, A., Bariagabre, S. A., & Balehegn, M. (2020). Estimation of greenhouse gas emissions from three livestock production systems in Ethiopia. *International Journal of Climate Change Strategies and Management*, 12(5), 669–685. <https://doi.org/10.1108/IJCCSM-09-2019-0060>
- Betker, F., & Libbe, J. (2019). Urbane Produktion: Ökonomischer Impuls, soziale Chance und ökologischer Mehrwert für die Zukunftsstadt. *GAIA – Ecological Perspectives for Science and Society*, 28(3), 316–317. <https://doi.org/10.14512/gaia.28.3.14>
- Bhatt, V., Farah, L., Luka, N., Wolfe, J. M., Ayalon, R., Hautecoeur, I., Rabinowicz, J., & Lebedeva, J. (2008). Reinstating the roles and places for productive growing in cities. In C. A. Brebbia, S. Gospodini, & E. Tiezzi (Eds.), *The sustainable city V. Urban regeneration and sustainability* (pp. 75–84). WIT Press.
- Bonello, V., Faraone, C., Leoncini, R., Nicoletto, L., & Pedrini, G. (2022). (Un)making space for manufacturing in the city: The double edge of pro-makers urban policies in Brussels. *Cities*, 129, Article 103816. <https://doi.org/10.1016/j.cities.2022.103816>
- Borowski, D., Poulimeni, N., & Janssen, J. (2012). Edible infrastructures: Emergent organizational patterns for the productive city. In J. Johnson, M. Cabrina, & K. Steinfeld (Eds.), *Proceedings of the 32nd Annual Conference of the Association for Computer Aided Design in Architecture* (pp. 511–526). Association for Computer Aided Design in Architecture.
- Boschma, R., & Frenken, K. (2010). The spatial evolution of innovation networks. A proximity perspective. In R. Boschma & R. Martin (Eds.), *Handbook of evolutionary economic geography* (pp. 120–125). Edward Elgar Publishing.
- Bové, A.-T., & Swartz, S. (2016). *Starting at the source: Sustainability in supply chains*. McKinsey Global Institute. <https://www.mckinsey.com/capabilities/sustainability/our-insights/starting-at-the-source-sustainability-in-supply-chains>
- Brandt, M., Butzin, A., Gärtner, S., Hennings, G., Meyer, K., Siebert, S., & Ziegler-Hennings, C. (2017). *Produktion zurück ins Quartier? Neue Arbeitsorte in der gemischten Stadt*. Institut Arbeit und Technik. <https://www.iat.eu/aktuell/veroeff/2017/Produktion-zurueck-ins-Quartier.pdf>
- Brandt, M., Gärtner, S., & Meyer, K. (2017). *Urbane Produktion. Ein Versuch der Begriffsdefinition*. Institut Arbeit und Technik.
- Briner, R. B., & Denyer, D. (2012). Systematic review and evidence synthesis as a practice and scholarship tool. In D. M. Rousseau (Ed.), *The Oxford handbook of evidence-based management* (pp. 112–129). Oxford University Press.

- Buchholz, M., Jochum, P., & Zaragoza, G. (2005). Concept for water, heat and food supply from a closed greenhouse—The Watergy project. *Acta Horticulturae*, 691, 509–516. <https://doi.org/10.17660/ActaHortic.2005.691.60>
- Bundesministerium des Inneren. (2020). *The New Leipzig Charter. The transformative power of cities for the common good*.
- Burggräf, P., Dannapfel, M., & Uelpenich, J. (2022). Sustainability of factories in urban surroundings enabled by a space efficiency approach. In A.-L. Andersen, R. Andersen, T. D. Brunoe, M. S. S. Larsen, K. Nielsen, A. Napoleone, & S. Kjeldgaard (Eds.), *Towards sustainable customization: Bridging smart products and manufacturing systems* (pp. 987–996). Springer.
- Büth, L., Juraschek, M., Cerdas, F., & Herrmann, C. (2020). Life cycle inventory modelling framework for symbiotic and distributed agricultural food production systems. *Procedia CIRP*, 90, 256–261. <https://doi.org/10.1016/j.procir.2020.01.097>
- Butzin, A., & Meyer, K. (2020). Urbane Produktion und temporäre räumliche Nähe in Produktionsprozessen. *Raumforschung und Raumordnung | Spatial Research and Planning*, 78(1), 5–20. <https://doi.org/10.2478/rara-2019-0061>
- Carotti, L., Pistillo, A., Zauli, I., Meneghello, D., Martin, M., Pennisi, G., Gianquinto, G., & Orsini, F. (2023). Improving water use efficiency in vertical farming: Effects of growing systems, far-red radiation and planting density on lettuce cultivation. *Agricultural Water Management*, 285, Article 108365. <https://doi.org/10.1016/j.agwat.2023.108365>
- Chen, L., Xu, L., Xu, Q., & Yang, Z. (2014). Decomposition analysis of carbon emissions and water consumption of urban manufacturing industry: A case in Dalian, China. In J. Crittenden, C. Hendrickson, & B. Wallace (Eds.), *ICSI 2014. International Conference on Sustainable Infrastructure 2014* (pp. 538–547). American Society of Civil Engineers.
- Chen, X., Huang, Z., Luo, C., & Hu, Z. (2024). Can agricultural industry integration reduce the rural–urban income gap? Evidence from county-level data in China. *Land*, 13(3), Article 332. <https://doi.org/10.3390/land13030332>
- Cima, O., & Wasilewska, E. (2023). Sensing urban manufacturing: From conspicuous to sensible production. *Urban Planning*, 8(4), 198–210. <https://doi.org/10.17645/up.v8i4.7272>
- Corcelli, F., Fiorentino, G., Petit-Boix, A., Rieradevall, J., & Gabarrell, X. (2019). Transforming rooftops into productive urban spaces in the Mediterranean. An LCA comparison of agri-urban production and photovoltaic energy generation. *Resources, Conservation and Recycling*, 144, 321–336. <https://doi.org/10.1016/j.resconrec.2019.01.040>
- Daitoh, I. (2003). Environmental protection and urban unemployment: Environmental policy reform in a polluted dualistic economy. *Review of Development Economics*, 7(3), 496–509. <https://doi.org/10.1111/1467-9361.00205>
- Daitoh, I. (2008). Environmental protection and trade liberalization in a small open dual economy. *Review of Development Economics*, 12(4), 728–736. <https://doi.org/10.1111/j.1467-9361.2008.00455.x>
- Darling, N. (2020). The potential for the sustainable urban factory. In R. N. Lane & N. Rappaport (Eds.), *The design of urban manufacturing* (pp. 135–150). Routledge.
- Dasylyva, M., Ndour, N., Sambou, B., & Toussaint Souldard, C. (2018). Les micro-exploitations agricoles de plantes aromatiques et médicinales: Élément marquant de l'agriculture urbaine à Ziguinchor, Sénégal. *Cahiers Agricultures*, 27(2), Article 25004. <https://doi.org/10.1051/cagri/2018011>
- Deif, A. M. (2011). A system model for green manufacturing. *Journal of Cleaner Production*, 19(14), 1553–1559. <https://doi.org/10.1016/j.jclepro.2011.05.022>

- Denyer, D., & Tranfield, D. (2009). Producing a systematic review. In D. A. Buchanan & A. Bryman (Eds.), *The Sage handbook of organizational research methods* (pp. 671–689). Sage.
- Di Maria, E., Micelli, S., Menesello, L., & Brocca, S. (2022). GVC-oriented policies and urban manufacturing: The role of cities in global value chains. *Sustainability*, 14(1), Article 478. <https://doi.org/10.3390/su14010478>
- Diez, T. (2020). Designing emergent futures for productive cities. In R. N. Lane & N. Rappaport (Eds.), *The design of urban manufacturing* (pp. 138–151). Routledge.
- Ellram, L. M., Tate, W. L., & Petersen, K. J. (2013). Offshoring and reshoring: An update on the manufacturing location decision. *Journal of Supply Chain Management*, 49(2), 14–22.
- Elwakil, R., Schroder, I., & Steemers, K. (2023). Circular maker cities: Maker space typologies and circular urban design. *Buildings*, 13(11), Article 2894. <https://doi.org/10.3390/buildings13112894>
- Fahmy, B., & Kamiya, M. (2019). Productive urban development: Linking planning and economy in Al-Alamein New City, Egypt. In S. Attia, Z. Shafik, & A. Ibrahim (Eds.), *New cities and community extensions in Egypt and the Middle East* (pp. 19–34). Springer.
- Fedeli, V., Mariotti, I., Di Matteo, D., Rossi, F., Dridi, R., Balducci, A., Firgo, M., Gabelberger, F., Huber, P., Kukuvec, A., Mayerhofer, P., Riegler, M., Tosics, I., Gerőházi, É., Somogyi, E., & Hill, A. (2020). MISTA – Metropolitan industrial spatial strategies & economic sprawl. Targeted analysis. Final report. ESPON. https://re.public.polimi.it/retrieve/e0c31c12-1e91-4599-e053-1705fe0aef77/ESPON_MISTA_Final_Report_0.pdf
- Feltrin, L., Mah, A., & Brown, D. (2022). Noxious deindustrialization: Experiences of precarity and pollution in Scotland's petrochemical capital. *Environment and Planning C: Politics and Space*, 40(4), 950–969.
- Feng, X., Li, Y., Zhang, L., Xia, C., Yu, E., & Yang, J. (2022). Carbon metabolism in urban “production–living–ecological” space based on ecological network analysis. *Land*, 11(9), Article 1445. <https://doi.org/10.3390/land11091445>
- Ferm, J. (2023). Hyper-competitive industrial markets: Implications for urban planning and the manufacturing renaissance. *Urban Planning*, 8(4), 263–274. <https://doi.org/10.17645/up.v8i4.7114>
- Ferm, J., & Jones, E. (2017). Beyond the post-industrial city: Valuing and planning for industry in London. *Urban Studies*, 54(14), 3380–3398. <https://doi.org/10.1177/0042098016668778>
- Fraccascia, L. (2018). Industrial symbiosis and urban areas: A systematic literature review and future research directions. *Procedia Environmental Science, Engineering, and Management*, 5(2), 73–83.
- Freeman, R., McMahon, C., & Godfrey, P. (2017). An exploration of the potential for re-distributed manufacturing to contribute to a sustainable, resilient city. *International Journal of Sustainable Engineering*, 10(4/5), 260–271. <https://doi.org/10.1080/19397038.2017.1318969>
- Fu, C., Tu, X., & Huang, A. (2021). Identification and characterization of production–living–ecological space in a central urban area based on POI data: A case study for Wuhan, China. *Sustainability*, 13(14), Article 7691. <https://doi.org/10.3390/su13147691>
- Fu, L., & Wang, Q. (2022). Spatial and temporal distribution and the driving factors of carbon emissions from urban production energy consumption. *International Journal of Environmental Research and Public Health*, 19(19), Article 12441. <https://doi.org/10.3390/ijerph191912441>
- Gärtner, S., Meyer, K., & Schonlau, M. (2021). Urbane Produktion: Ist da wirklich Speck dran? In T. Krüger, M. Piegeler, & G. Spars (Eds.), *Urbane Produktion. Neue Perspektiven des produzierenden Gewerbes in der Stadt?* (1st ed., pp. 48–69). Verlag W. Kohlhammer.
- Gärtner, S., & Schepelmann, P. (2023). Globale Umweltgerechtigkeit und urbane Produktion. In S. Gärtner & K. Meyer (Eds.), *Die produktive Stadt. (Re-)Integration der urbanen Produktion* (1st ed., pp. 179–193). Springer.
- Gärtner, S., & Stegmann, T. (2015). *Neue Arbeit und Produktion im Quartier. Beobachtungen und wishful thinking*. Institut Arbeit und Technik. <http://www.iat.eu/forschung-aktuell/2015/fa2015-07.pdf>

- Gerster-Bentaya, M. (2013). Nutrition-sensitive urban agriculture. *Food Security*, 5(5), 723–737. <https://doi.org/10.1007/s12571-013-0295-3>
- Görgens, S. J., Meyer, K. H., Wetzel, A., & Mennenga, M. (2023). Polygon interface analysis: A concept for analyzing production site interactions in urban areas. In D. Herberger & M. Hübner (Eds.), *Proceedings of the Conference on Production Systems and Logistics: CPSL 2023 – 2* (pp. 405–416). publish-Ing.
- Grodach, C. (2022). The institutional dynamics of land use planning. *Journal of the American Planning Association*, 88(4), 537–549. <https://doi.org/10.1080/01944363.2021.2006756>
- Grodach, C., Taylor, L., Martin, D., & Hurley, J. (2023). Regulating sustainable production. *Urban Planning*, 8(4), 186–197. <https://doi.org/10.17645/up.v8i4.7024>
- Güven, G. (2024). Urban unemployment, environmental preservation and trade policies in a small open economy with open access renewable resources. *Journal of Cleaner Production*, 440, Article 140912. <https://doi.org/10.1016/j.jclepro.2024.140912>
- Hasan, N. A. (2020). The spatial organization strategies of productive cities. *IOP Conference Series: Materials Science and Engineering*, 881, Article 012021. <https://doi.org/10.1088/1757-899X/881/1/012021>
- Haselsteiner, E., Madner, V., Frey, H., Grob, L.-M., Laa, B., Winder, M., Schwaigerlehner, K., & Haselsteiner, J. (2019). *VERTICALurbanFACTORY—Innovative Konzepte der vertikalen Verdichtung von Produktion und Stadt. Teil 1: Produktion und Stadt im Kontext*. Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie.
- Hauge, J., Birkie, S. E., & Jeong, Y. (2021). Developing a holistic decision support framework: From production logistics to sustainable freight transport in an urban environment. *Transportation Research Interdisciplinary Perspectives*, 12, Article 100496. <https://doi.org/10.1016/j.trip.2021.100496>
- Hausleitner, B., Hill, A., Domenech, T., & Muñoz Sanz, V. (2022). Urban manufacturing for circularity: Three pathways to move from linear to circular cities. In L. Amenta, M. Russo, & A. van Timmeren (Eds.), *Regenerative territories* (pp. 89–103). Springer.
- Hawes, J. K., Goldstein, B. P., Newell, J. P., Dorr, E., Caputo, S., Fox-Kämper, R., Grard, B., Ilieva, R. T., Fargue-Lelièvre, A., Ponížy, L., Schoen, V., Specht, K., & Cohen, N. (2024). Comparing the carbon footprints of urban and conventional agriculture. *Nature Cities*, 1(2), 164–173. <https://doi.org/10.1038/s44284-023-00023-3>
- Hearn, G., Foth, M., Camelo-Herrera, D., & Caldwell, G. A. (2023). Urban revitalisation between artisanal craft and green manufacturing: The case of Brisbane's Northgate Industrial Precinct. *Urban Planning*, 8(4), 249–262. <https://doi.org/10.17645/up.v8i4.7138>
- Herrmann, C., Büth, L., Juraschek, M., Abraham, T., & Schäfer, L. (2020). Application of biological transformation to foster positive urban production. *Procedia CIRP*, 90, 2–9. <https://doi.org/10.1016/j.procir.2020.02.138>
- Herrmann, C., Juraschek, M., Burggräf, P., & Kara, S. (2020). Urban production: State of the art and future trends for urban factories. *CIRP Annals*, 69(2), 764–787. <https://doi.org/10.1016/j.cirp.2020.05.003>
- Herrmann, C., Juraschek, M., Kara, S., & Thiede, S. (2019). Urban factories: Identifying products for production in cities. In A. H. Hu, M. Matsumoto, T. C. Kuo, & S. Smith (Eds.), *Technologies and eco-innovation towards sustainability I* (pp. 185–198). Springer.
- Hertwig, M., Bogdanov, I., Beckett, M., Waltersmann, L., & Lentjes, J. (2021). Symbiotic loss-free industrial production in ultra-efficient urban industrial parks. *Procedia CIRP*, 98, 637–642. <https://doi.org/10.1016/j.procir.2021.01.167>
- Hertwig, M., Nowak, M., Werner, A., Martineau, S., & Schlund, S. (2024). Smart glocal production—An assessment approach for the readiness level of manufacturing companies. *Procedia CIRP*, 122, 485–490. <https://doi.org/10.1016/j.procir.2024.02.014>

- Hertwig, M., Werner, A., Zimmermann, N., & Hölzle, K. (2024). Modular digital production twin as enabler for sustainable value creation—The case of urban environments. In T. Bauernhansl, A. Verl, M. Liewald, & H.-C. Möhring (Eds.), *Production at the leading edge of technology* (pp. 185–194). Springer Nature.
- Hildebrandt, L., Redlich, T., & Wulfsberg, J. P. (2021). Production planning and control in distributed and networked open production sites—An integrative literature review. In D. Herberger & M. Hübner (Eds.), *Proceedings of the Conference on Production Systems and Logistics: CPSL 2021* (pp. 274–287). publish-Ing.
- Hill, A. V. (2020). *Foundries of the Future: A guide for 21st century cities of making*. TU Delft Open.
- Huang, C., Li, X.-F., & You, Z. (2021). The impacts of urban manufacturing agglomeration on the quality of water ecological environment downstream of the Three Gorges Dam. *Frontiers in Ecology and Evolution*, 8, Article 612883. <https://doi.org/10.3389/fevo.2020.612883>
- Hüttenhain, B., & Kübler, A. I. (2021). City and industry: How to cross borders? Learning from innovative company site transformations. *Urban Planning*, 6(3), 368–381. <https://doi.org/10.17645/up.v6i3.4240>
- Ijassi, W., Evrard, D., & Zwolinski, P. (2023). Proposal of a circularity design approach for urban factories based on local stakeholders' engagement. *Procedia CIRP*, 116, 13–18. <https://doi.org/10.1016/j.procir.2023.02.003>
- Ijassi, W., Evrard, D., & Zwolinski, P. (2024). Development of a circularity design methodology for urban factories based on systemic thinking and stakeholders engagement. *Sustainable Production and Consumption*, 46, 600–616. <https://doi.org/10.1016/j.spc.2024.02.031>
- Ji, X., Chen, Z., & Li, J. (2014). Embodied energy consumption and carbon emissions evaluation for urban industrial structure optimization. *Frontiers of Earth Science*, 8(1), 32–43. <https://doi.org/10.1007/s11707-013-0386-7>
- Juárez-Casildo, V., Cervantes, I., & González-Huerta, R. d. G. (2022). Solar hydrogen production in urban areas of Mexico: Towards hydrogen cities. *International Journal of Hydrogen Energy*, 47(70), 30012–30026. <https://doi.org/10.1016/j.ijhydene.2022.06.137>
- Juraschek, M. (2022). *Analysis and development of sustainable urban production systems*. Springer.
- Juraschek, M., Becht, E. J., Büth, L., Thiede, S., Kara, S., & Herrmann, C. (2018). Life cycle oriented industrial value creation in cities. *Procedia CIRP*, 69, 94–99. <https://doi.org/10.1016/j.procir.2017.11.069>
- Juraschek, M., Becker, M., Thiede, S., Kara, S., & Herrmann, C. (2019). Life cycle assessment for the comparison of urban and non-urban produced products. *Procedia CIRP*, 80, 405–410. <https://doi.org/10.1016/j.procir.2019.01.017>
- Juraschek, M., Bucherer, M., Schnabel, F., Hoffschroer, H., Vossen, B., Kreuz, F., Thiede, S., & Herrmann, C. (2018). Urban factories and their potential contribution to the sustainable development of cities. *Procedia CIRP*, 69, 72–77. <https://doi.org/10.1016/j.procir.2017.11.067>
- Juraschek, M., Herrmann, C., & Thiede, S. (2017). Utilizing gaming technology for simulation of urban production. *Procedia CIRP*, 61, 469–474. <https://doi.org/10.1016/j.procir.2016.11.224>
- Juraschek, M., Kreuz, F., Bucherer, M., Spengler, A., Thiede, S., Herrmann, C., Schmidt, A., & Clausen, U. (2019). Urban factories—Identification of measures for resource-efficient integration of production systems in cities. In U. Clausen, S. Langkau, & F. Kreuz (Eds.), *Advances in production, logistics and traffic* (pp. 221–232). Springer.
- Kalvelage, L., & Tups, G. (2024). Friendshoring in global production networks: State-orchestrated coupling amid geopolitical uncertainty. *ZFW – Advances in Economic Geography*, 68(3/4), 151–166. <https://doi.org/10.1515/zfw-2024-0042>
- Keeffe, G. (2012). Bi-productive urban landscapes: Urban resilience through a redevelopment of postindustrial space in the United Kingdom. In P. Schmuck, M. Karpenstein-Machan, & A. Wüste (Eds.), *Initiating and*

- analyzing renewable energy transitions in Germany: The district, village, and farm scale* (1st ed., pp. 285–309). CRC Press.
- Kennedy, C. A. (2016). Industrial ecology and cities. In R. Clift & A. Druckman (Eds.), *Taking stock of industrial ecology* (pp. 69–86). Springer.
- Kouloumprouka Zacharakí, A., Monaghan, J. M., Bromley, J. R., & Vickers, L. H. (2024). Opportunities and challenges for strawberry cultivation in urban food production systems. *Plants, People, Planet*, 6(3), 611–621. <https://doi.org/10.1002/ppp3.10475>
- Kreiger, M., & Pearce, J. M. (2013). Environmental impacts of distributed manufacturing from 3-D printing of polymer components and products. *MRS Online Proceedings Library*, 1492, 107–112. <https://doi.org/10.1557/opl.2013.319>
- Krenz, P., Saubke, D., Stoltenberg, L., Markert, J., & Redlich, T. (2022). Towards smaller value creation cycles: Key factors and their interdependencies for local manufacturing. In D. Herberger & M. Hübner (Eds.), *Proceedings of the Conference on Production Systems and Logistics: CPSL 2022* (pp. 472–481). publish-Ing.
- Krenz, P., Stoltenberg, L., Markert, J., Saubke, D., & Redlich, T. (2022). The phenomenon of local manufacturing: An attempt at a differentiation of distributed, re-distributed, and urban manufacturing. In A.-L. Andersen, R. Andersen, T. D. Brunoe, M. S. S. Larsen, K. Nielsen, A. Napoleone, & S. Kjeldgaard (Eds.), *Towards sustainable customization: Bridging smart products and manufacturing systems* (pp. 1014–1022). Springer.
- Kreuz, F., Juraschek, M., Bucherer, M., Söfker-Rieniets, A., Spengler, A., Clausen, U., & Herrmann, C. (2020). Urban factories—Interdisciplinary perspectives on resource efficiency. In R. Elbert, C. Friedrich, M. Boltze, & H.-C. Pfohl (Eds.), *Urban freight transportation systems* (pp. 41–52). Elsevier.
- Lawal-Adebawale, O., & Alarima, C. I. (2011). Challenges of small ruminants production in selected urban communities of Abeokuta, Ogun State, Nigeria. *Agriculturae Conspectus Scientificus*, 76(2), 129–134.
- Lentes, J., & Hertwig, M. (2019). Towards ultra-efficient industrial areas. *Procedia Manufacturing*, 39, 804–813. <https://doi.org/10.1016/j.promfg.2020.01.426>
- Lopez, J. C. (2018). Interbasin water transfers and the size of regions: An economic geography example. *Water Resources and Economics*, 21, 40–54. <https://doi.org/10.1016/j.wre.2017.10.005>
- Lowe, N., & Vinodrai, T. (2020). The maker–manufacturing nexus as a place-connecting strategy: Implications for regions left behind. *Economic Geography*, 96(4), 315–335. <https://doi.org/10.1080/00130095.2020.1812381>
- Martin, D., & Grodach, C. (2023). Resilience and adaptation in gentrifying urban industrial districts: The experience of cultural manufacturers in San Francisco and Melbourne. *International Journal of Urban and Regional Research*, 47(4), 625–644. <https://doi.org/10.1111/1468-2427.13175>
- Martin, N. L., Rudolf, S., Grimm, P., Mennenga, M., Juraschek, M., & Herrmann, C. (2024). Simulation-based comparison of the material and energy efficiency of decentralized urban manufacturing systems. *Procedia CIRP*, 122, 223–228. <https://doi.org/10.1016/j.procir.2024.01.033>
- Matt, D. T., Orzes, G., Rauch, E., & Dallasega, P. (2020). Urban production—A socially sustainable factory concept to overcome shortcomings of qualified workers in smart SMEs. *Computers & Industrial Engineering*, 139, Article 105384. <https://doi.org/10.1016/j.cie.2018.08.035>
- Mayor of London. (2016). *The London Plan. The spatial development strategy for London consolidated with alterations since 2011*. Greater London Authority.
- Meinrenken, C. J., Chen, D., Esparza, R. A., Iyer, V., Paradis, S. P., Prasad, A., & Whillas, E. (2020). Carbon emissions embodied in product value chains and the role of life cycle assessment in curbing them. *Scientific Reports*, 10(1), Article 6184. <https://doi.org/10.1038/s41598-020-62030-x>
- Meyer, K. (2023). Next generation small urban manufacturing: Apprentices' perspective on location factors, mixed-use, and shared spaces. *Urban Planning*, 8(4), 236–248. <https://doi.org/10.17645/up.v8i4.7040>

- Meyer, K., & Schonlau, M. (2024). Heterogeneity of urban manufacturing—A statistical analysis of manufacturing companies in three German cities. *European Planning Studies*, 32(8), 1813–1836. <https://doi.org/10.1080/09654313.2024.2337305>
- Mistry, N., & Byron, J. (2011). *The federal role in supporting urban manufacturing*. What Works Collaborative. <https://www.urban.org/sites/default/files/publication/26966/1001536-The-Federal-Role-in-Supporting-Urban-Manufacturing.PDF>
- Moerlen, D., & Evrard, D. (2021). Proposal for a procedure to design multipurpose urban factories. *Procedia CIRP*, 98, 412–417. <https://doi.org/10.1016/j.procir.2021.01.126>
- Monaghan, J. M., & Beacham, A. M. (2017). Salad vegetable crops. In B. Thomas, B. G. Murray, & D. J. Murphy (Eds.), *Encyclopedia of applied plant sciences* (pp. 262–267). Elsevier.
- Neves, A., Godina, R., Azevedo, S. G., & Matias, J. C. O. (2020). A comprehensive review of industrial symbiosis. *Journal of Cleaner Production*, 247, Article 119113. <https://doi.org/10.1016/j.jclepro.2019.119113>
- Nischwitz, G., Chojnowski, P., & von Bestenbostel, M. (2021). *Urbane Produktion für eine Produktive Stadt Bremen. Eine Chance für mehr Beschäftigung?* Arbeitnehmerkammer Bremen; Institut Arbeit und Wirtschaft.
- Njøs, R., Sjøtun, S. G., Jakobsen, S.-E., & Fløysand, A. (2024). (Re)incorporating “the tangible” in industrial path development analyses: The role of sociomaterial contingencies in explaining potential emergence of hydrogen production in Western Norway. *Economic Geography*, 100(5/6), 437–458. <https://doi.org/10.1080/00130095.2024.2389858>
- Park, J.-I. (2023). Re-urbanization pattern of manufacturing and characteristics of urban manufacturing in South Korea. *Cities*, 137, Article 104330. <https://doi.org/10.1016/j.cities.2023.104330>
- Peña, A., Rovira-Val, M. R., & Mendoza, J. M. F. (2022). Life cycle cost analysis of tomato production in innovative urban agriculture systems. *Journal of Cleaner Production*, 367, Article 133037. <https://doi.org/10.1016/j.jclepro.2022.133037>
- Pfeiffer, A., Silva, E., & Colquhoun, J. (2015). Innovation in urban agricultural practices: Responding to diverse production environments. *Renewable Agriculture and Food Systems*, 30(1), 79–91. <https://doi.org/10.1017/S1742170513000537>
- Piegeler, M., & Spars, G. (2019). *Urbane Produktion—Konzept und Messung*. Bergische Universität Wuppertal. https://www.oekonomie-arch.uni-wuppertal.de/fileadmin/architektur/oekonomie-arch/Dateien/UrbaneProduktion_MP_GS_2019.pdf
- Rappaport, N. (2017). Hybrid factory, hybrid city. *Built Environment*, 43(1), 72–86. <https://doi.org/10.2148/benv.63.3.72>
- Rappaport, N. (2020). Considering industry as infrastructure. In R. N. Lane & N. Rappaport (Eds.), *The design of urban manufacturing* (pp. 185–202). Routledge.
- Reineke, P., Geusch, A. S., Büth, L., Mennenga, M., & Herrmann, C. (2021). Simulation-based evaluation of the hub-and-spoke concept to support the centrally managed supply of urban factories. In D. Herberger & M. Hübner (Eds.), *Proceedings of the Conference on Production Systems and Logistics: CPSL 2021* (pp. 308–318). publish-Ing.
- Roost, F., & Jeckel, E. (2021). Post-Fordist production and urban industrial land use patterns. *Urban Planning*, 6(3), 321–333. <https://doi.org/10.17645/up.v6i3.4272>
- Rudolf, S., Dellbrügge, M., Kreuz, F., Juraschek, M., Mennenga, M., Clausen, U., & Herrmann, C. (2023). Influencing factors of urban factories and their products for sustainable urban development. *Procedia CIRP*, 116, 167–172. <https://doi.org/10.1016/j.procir.2023.02.029>
- Sajadieh, S. M. M., & Noh, S. D. (2024). Towards sustainable manufacturing: A maturity assessment for urban smart factory. *International Journal of Precision Engineering and Manufacturing-Green Technology*, 11(3), 909–937. <https://doi.org/10.1007/s40684-023-00554-z>

- Sajadieh, S. M. M., Son, Y. H., & Noh, S. D. (2022). A conceptual definition and future directions of urban smart factory for sustainable manufacturing. *Sustainability*, 14(3), Article 1221. <https://doi.org/10.3390/su14031221>
- Salisu, M. A., Oyebamiji, Y. O., Ahmed, O. K., Shamsudin, N. A., Fairuz, Y. S., Yusuff, O., Yusop, M. F., Sulaiman, Z., & Arolu, F. (2024). A systematic review of emerging trends in crop cultivation using soilless techniques for sustainable agriculture and food security in post-pandemic. *AIMS Agriculture and Food*, 9(2), 666–692. <https://doi.org/10.3934/AGRFOOD.2024036>
- San Francisco Planning Department. (Ed.). (2002). *Industrial land in San Francisco. Understanding production, distribution, and repair*.
- Schutzbach, M., Full, J., Kiemel, S., Waltersmann, L., Sielaff, L., Miehe, R., & Sauer, A. (2021). Principles and design strategies for ultra-efficient production systems in the process industry. *Chemie Ingenieur Technik*, 93(11), 1781–1791. <https://doi.org/10.1002/cite.202100062>
- Singh, S. (2017). Conclusion, opportunities and challenges. In T. M. Vinod Kumar (Ed.), *Smart economy in smart cities* (pp. 323–328). Springer.
- Singh, S., Hertwig, M., & Lentjes, J. (2017). Economic impact of ultraefficient urban manufacturing. In T. M. Vinod Kumar (Ed.), *Smart economy in smart cities* (pp. 273–293). Springer.
- Spath, D., & Lentjes, J. (2013, July 28–August 1). *Urban production to advance the competitiveness of industrial enterprises* [Paper presentation]. 22nd International Conference on Production Research, Iguazu Falls, Brazil.
- Stiehm, S. (2019). Die bewegte Stadt—Freie Fahrt für die urbane Produktion und Logistik. In VDI Wissensforum GmbH (Ed.), 28. *Deutscher Materialfluss-Kongress 2019* (pp. 251–260). VDI Verlag.
- Toboso-Chavero, S., Nadal, A., Petit-Boix, A., Pons, O., Villalba, G., Gabarrell, X., Josa, A., & Rieradevall, J. (2019). Towards productive cities: Environmental assessment of the food–energy–water nexus of the urban roof mosaic. *Journal of Industrial Ecology*, 23(4), 767–780. <https://doi.org/10.1111/jiec.12829>
- Tötzer, T., Stollnberger, R., Krebs, R., & Haas, M. (2019). How can urban manufacturing contribute to a more sustainable energy system in cities? *International Journal of Sustainable Energy Planning and Management*, 24. <https://doi.org/10.5278/ijsepm.3347>
- Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, 14(3), 207–222. <https://doi.org/10.1111/1467-8551.00375>
- Tricarico, L. (2024). Placemaking in the post-pandemic context: Innovation hubs and new urban factories. *Sustainability*, 16(3), Article 1030. <https://doi.org/10.3390/su16031030>
- Tsui, T., Peck, D., Geldermans, B., & van Timmeren, A. (2021). The role of urban manufacturing for a circular economy in cities. *Sustainability*, 13(1), Article 23. <https://doi.org/10.3390/su13010023>
- Ulrichs, C. H., & Mewis, I. (2015). Recent developments in urban horticulture—Facts and fiction. *Acta Horticulturae*, 1099, 925–933. <https://doi.org/10.17660/actahortic.2015.1099.118>
- van Driel, J. (2014). Ashes to ashes: The stewardship of waste and economic cycles of agricultural and industrial improvement, 1750–1800. *History and Technology*, 30(3), 177–206. <https://doi.org/10.1080/07341512.2014.988426>
- van Veenhuizen, R. (2011). Inclusive, green and productive cities. The role of urban agriculture. *Journal of Environmental Protection and Ecology*, 12(3A), 1470–1483.
- Vidal, L., Ares, G., & Jaeger, S. R. (2022). Biterm topic modelling of responses to open-ended questions: A study with US consumers about vertical farming. *Food Quality and Preference*, 100, Article 104611. <https://doi.org/10.1016/j.foodqual.2022.104611>

- Xu, S., Bauman, M. J., Ponting, S. S.-A., Slevitch, L., Webster, C., & Kirillova, K. (2024). Neolocalism of craft brewery experience: Scale development and validation study. *International Journal of Hospitality Management*, 120, Article 103787. <https://doi.org/10.1016/j.ijhm.2024.103787>
- Yang, Y., Zhang, Y., & Huang, S. (2020). Urban agriculture oriented community planning and spatial modeling in Chinese cities. *Sustainability*, 12(20), Article Article 8735. <https://doi.org/10.3390/su12208735>
- Yin, K., & Yao, X. (2024). The impact of urban compactness on urban carbon emissions: A study of 281 Chinese cities. *Urban Climate*, 56, Article 102052. <https://doi.org/10.1016/j.uclim.2024.102052>
- Yoshida, F. (2008). High-tech pollution in Japan. In L. A. Byster, S. Chang, A. Hawes, W.-I. Tu, A. Watterson, & T. Smith (Eds.), *Challenging the chip* (pp. 215–224). Temple University Press.
- Zeng, X., Zhu, Y., Chen, C., Tong, Y., Li, Y., Huang, G., Nie, S., & Wang, X. (2017). A production–emission nexus based stochastic-fuzzy model for identification of urban industry–environment policy under uncertainty. *Journal of Cleaner Production*, 154, 61–82. <https://doi.org/10.1016/j.jclepro.2017.03.137>
- Zhang, C., Di Yao, Z., Yanlin, Z., Li, W., & Li, K. (2022). Mismatched relationship between urban industrial land consumption and growth of manufacturing: Evidence from the Yangtze River Delta. *Land*, 11(9), Article 1390. <https://doi.org/10.3390/land11091390>
- Zhang, Y., Zhang, Y.-k., & Li, Z. (2022). A new and improved aquaponics system model for food production patterns for urban architecture. *Journal of Cleaner Production*, 342, Article 130867. <https://doi.org/10.1016/j.jclepro.2022.130867>
- Zhao, R., Huang, X., Zhong, T., Liu, Y., & Chuai, X. (2014). Carbon flow of urban system and its policy implications: The case of Nanjing. *Renewable and Sustainable Energy Reviews*, 33, 589–601. <https://doi.org/10.1016/j.rser.2014.02.020>
- Zheng, S., Kahn, M. E., & Liu, H. (2010). Towards a system of open cities in China: Home prices, FDI flows and air quality in 35 major cities. *Regional Science and Urban Economics*, 40(1), 1–10. <https://doi.org/10.1016/j.regsciurbeco.2009.10.003>
- Zheng, T., Zhao, Y., & Li, J. (2019). Rising labour cost, environmental regulation and manufacturing restructuring of Chinese cities. *Journal of Cleaner Production*, 214, 583–592. <https://doi.org/10.1016/j.jclepro.2018.12.328>

About the Authors



Marius Angstmann is a researcher at the Institute for Work and Technology at the Westphalian University of Applied Sciences. He holds a master's degree in urban culture, society, and space from the University of Duisburg-Essen. His work focuses on issues at the intersection of decarbonisation, economic development, and urban planning.



Kerstin Meyer has been working as a researcher in the field of urban production and real-world laboratories at the Institute for Work and Technology since 2016. Her PhD topic at the Faculty of Spatial Planning at TU Dortmund was “Urban Manufacturing—A Building Block in the Mixed-Use City.”



Stefan Gärtner holds a PhD in spatial planning from TU Dortmund. He is head of the Institute for Work and Technology and the research department “Spatial Capital.” His research focuses on spatial economies, regional development and structural policy, regional banks in economic development, and urban manufacturing.



Leonard Can Stratmann holds a master’s degree in spatial planning from TU Dortmund University. He is currently a researcher at the Institute for Work and Technology, supporting the FAB.Region Bergisches Städtedreieck research project on regional development, the circular economy, and urban manufacturing.