

Efficient and Sustainable Land Use in Logistics Through Cooperation: A Literature Review and Empirical Research

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Abstract

In recent years, the issue of land consumption or land use has become increasingly important in many areas of our society. Logistics processes in particular take up a lot of space and have a significant impact on the environment. The question is how this use of land can be optimised. Based on a systematic literature review and interviews with experts in the period between May 2021 and July 2021, this paper presents indicators that constitute or influence space-efficient logistics in the context of cooperation. The results show that in addition to the established cooperation characteristics, there are other indicators that are directly related to land use. In the logistics sector, there is strong competitive pressure and, as a result, little trust between companies. It has been shown that with the help of a neutral moderator, the gap between trusting, land-efficient cooperation and one's own entrepreneurial interests can be narrowed, and cooperation can be profitable for all participants. In addition, digitisation actually does not seem to be sufficient to meet the information needs of a cooperation. The exchange of information not only serves to automate processes, but also makes cooperation more transparent. It shows that legal and municipal requirements need to be developed. It also becomes clear that the indicators have a mutual influence on each other and cannot be considered in isolation when it comes to the actual implementation of a cooperation. By increasing the efficiency of cooperative processes and value creation, it offers the opportunity to make land use more sustainable.

Keywords: logistics, cooperation, efficiency, land use, indicators

1. Introduction

In the last few decades, a continuous growth of logistics space can be observed in many logistics areas as well as in manufacturing companies with their own logistics activities (Veres-Homm & Weber 2019). In comparison to manufacturing companies without their own logistics activities, companies in the logistics sector have a more complex physical use of space. While in manufacturing companies, business activities are mainly carried out in the company's headquarters and production facilities, logistics activities usually require a multidimensional physical space consisting of headquarters, warehouses, transporters and customers (Kim et al., 2008; Sakai et al., 2018). Historically, the increasing space requirements for the expansion of logistics processes have led to increased traffic, high levels of noise and emissions, and the destruction of most landscapes (Jaller et al., 2015; Veres-Homm & Weber 2019). Excessive land use is associated with several environmental, social, and economic consequences. Increased land sealing leads to a loss of natural soil functions and a decrease in biodiversity. In addition, there is a loss of near-natural and fertile areas, landscape fragmentation, increased energy and resource consumption, and rising costs for mobility, supply, and disposal (Behrendt et al., 2010; van Wee, 2015). Careful use of the limited resource "land" is essential. In terms of sustainable development, careful and optimised land use should ensure that the development opportunities of future generations as well as the ecological condition of our planet are not damaged by today's—sometimes excessive and harmful—land use (Keesstra et al., 2018). This is also in line with the Sustainable Development Goal (SDG) 15.3, through which the UN General Assembly aims to limit and prevent further degradation of land and soil (United Nations). Despite the ever-increasing importance of logistics space and the risk of negative consequences due to excessive land use, the geographical considerations with regard to land efficiency in logistics have so far been neglected (Hesse, 2020).

One possible approach to increase space efficiency is a detailed consideration of multiple (supply chain) partners and a cooperative use of real estate during the planning process of logistics facilities (Kotzold et al., 2021). According to Audy et al. (2012), logistics cooperation occurs when two or more entities form a coalition and exchange or share resources (including information) to make decisions or carry out activities that generate benefits that cannot be achieved individually. There is evidence in literature that cooperation in logistics processes can have a positive impact on land use. One example is the establishment of cooperative, inter-firm relationships that increase the efficiency of logistics operations by sharing information and resources (Choy et al., 2008). In this way, costs can be saved by achieving economies of scale and optimising structures, while at the same time environmental goals can be achieved, for example by sharing warehouses (Hingley et al., 2011) or exchanging information in a way that minimises lead times (Pérez-Bernabeu et al., 2015) or rapidly reduces safety stocks (Soosay et al., 2008). In such cases, cooperating firms share demand and consumption information in a timely manner and use different approaches to efficiently synchronise their activities (Souza et al., 2013). This allows warehouses to be built in a space-efficient manner and leads to optimised land use. There is currently no systematic analysis of which form of cooperation provides the opportunities for an optimised use of land. This study aims to fill this research gap by addressing the following overarching question: ***How can cooperation in logistics be described to enable efficient land use?***

To answer this research question, the present paper is structured as follows. In a first step, a basic understanding of the concepts of logistics cooperation is developed through a structured literature review. Within this initial step a first insight on indicators concerning the efficiency of land use in the case of logistics cooperation is given. By means of a qualitative survey, the results of the literature analysis are complemented and evaluated by experts to answer the sub-question “***What categories/characteristics can be used to describe logistics cooperation in order to achieve space efficiency?***” to identify the main indicators for space efficient logistical processes. The article ends with a discussion and a conclusion.

2. Concepts of Cooperation in Logistics

Business cooperation offers a promising basis for increasing the value of the partners involved, reducing their costs or otherwise creating strategic advantages in the market (Narula & Hagedoorn, 1999). As various processes for the flow of materials and information within a company or between suppliers and customers revolve around logistics, it often serves as one of the most important interfaces for collaboration in a value chain. In many modern supply chains, logistics therefore provides the foundation that enables partners to “work hand in hand to achieve the goals of satisfying customer needs in terms of product selection, availability and price, while at the same time using resources rationally and keeping inventories as low as possible” (Ellerkmann, 2011, p. 233). In recent years, there has been a growing awareness of the importance of cooperation and partnerships in logistics, which can take a variety of forms to achieve the different objectives of the companies involved.

Cooperation between companies can have different characteristics and levels of intensity, often with the aim of achieving joint competitive advantages. According to Killich (2011), the characteristics of cooperation include: the direction, scope, intensity of commitment, liability, duration and target identity of a cooperation, as well as the cooperating departments (see Table 1). These characteristics and possible structures of cooperation are briefly explained below.

Table 1. Features of cooperation (Killich, 2011, p. 18)

Feature	Expression
Direction	Horizontal Vertical Diagonal
Extent	Local Regional National Global
Binding intensity	Low Moderate High
Liability	Agreement Contract Capital participation
Duration	Temporary Unlimited
Target Identity	Retributive Reciprocal
Cooperating Departments	Research and Development Distribution Purchasing Marketing Production Other

First, a cooperation can be classified according to its direction by looking at the value chain and economic level at which the cooperating enterprises are located. There are three main possibilities: Horizontal, vertical and diagonal cooperation (Killich, 2011). A cooperation is called horizontal if it takes place between companies at the same competitive and economic level, i.e., the cooperating companies are competing with each other within a market. However, according to Li et al. (2012), not only cooperation between individual firms should be

considered, but also horizontal cooperation across supply chains. Vertical cooperation, on the other hand, takes place between firms at different economic levels, often between suppliers in the same value/supply chain (Chen & Paulraj 2004). Vertical cooperation can take place either with suppliers from upstream production stages or with customers from downstream production stages (Huang et al., 2018). A third type of cooperation is diagonal cooperation. In this case, the partners belong to different sectors (Bahrami, 2002). In addition, cooperation can vary in scope, which refers to the spatial dimension of cooperative activities. Accordingly, there are possibilities for local, regional, national, or global cooperation. The scale should be in line with the respective objectives of the co-operating companies. For example, local or regional partnerships are often more appropriate for exploiting local resources, while global collaborations are more likely to be used for importing and exporting, and for developing global markets and workforces (Cohen & Mallik, 1997; Killich, 2011). Once a collaboration is established, the intensity of the partnership's commitment is of great importance. This intensity can be low, medium, or high and is determined, among other things, by the number of cooperating functional areas, the level of information exchange, the degree of coordination required or the planning of joint processes. There are also different levels of commitment from the collaborating partners. Depending on the intensity of cooperation, this commitment may be verbal, written or, in some cases, in the form of an equity investment by the partners. In case of such equity investments, companies may be tied to each other in such a way that the economic independence of individual partners no longer exists. According to Killich (2011), another important feature of business cooperation is the duration of the cooperation, which can be temporary or unlimited. In an open-ended cooperation, partners pursue common goals and act less opportunistically. The goal identity can be seen as an independent characteristic of cooperation and is divided into redistributive and reciprocal cooperation. In a redistributive approach, partners try to achieve the same goal by exchanging information and/or resources. In contrast, reciprocal cooperation occurs when the partners have different goals and see the cooperating firm as a solution provider for their own goals (Rotering, 1993; Killich, 2011). In addition to the characteristics described above, Killich (2011) also classifies the cooperating departments of the companies as an essential characteristic of a cooperation. The extent to which this and all other characteristics and their attributes are also relevant in the context of saving or optimising land use in logistics is discussed in this paper. The characteristics listed in Figure 1 and their attributes are analysed, adapted and extended accordingly.

In this paper, the terms 'land' and 'space' refer to any area used to organise, control, provide or optimise processes along a value chain. Specifically, the following is about improving land efficiency in logistics, which in the context of this work refers to this basic formula (Logistics Cluster Basel Region/Chamber of Commerce at Basel HKBB 2015):

$$\text{Space Efficient Logistics} = \frac{\text{Logistics Capacity}}{\text{Logistics Land Use}} \quad (1)$$

From this, one can conclude: "The more logistics on a limited area, the more land-efficient the logistical activities are. Thus, logistics stands for the quantity (e.g., deliveries/day or also shipments/day), while the land stands for the resource" (Logistics Cluster Basel Region/Chamber of Commerce at Basel HKBB 2015).

3. Literature Review

A systematic literature review was carried out to provide a scientific evidence base, following the guidelines of Webster and Watson (2002). In order to identify all relevant publications on reducing land use or increasing efficiency through logistics collaboration, the first step was to identify key words for the search. In addition to keywords in English, the predominant scientific language (Knievel & Kellsey, 2005), German keywords are also included, since land use in logistics also receives a great deal of attention in German-speaking countries (Veres-Homm & Weber, 2019; Veres-Homm et al., 2015). As a result, following keywords and their German equivalents were used, as they are close to the topic and widely used in the existing literature: "logistics, transport, supply chain", "cooperation", "land use, land consumption", "space, land, location, area", "efficiency". The search terms were combined into bundled search terms using a descriptor search with Boolean algebra—the logical operators AND and OR—and with the help of truncations to find leading journal articles through an extensive search in the online databases Science Direct and Google Scholar. These databases were selected for the search because of their international reputation (Pickering et al., 2015) and are therefore among the most important databases for scientific research (Seuring & Müller 2008).

The initial search yielded 1728 results. After a first analysis of title and abstract, 162 publications remained, which were then examined for thematic relevance. The results show that the focus of the publications is often not primarily on saving space, but rather on the application of different decision models for optimal location decisions, CO₂ savings and several other meta-themes. A forward and backward search resulted in 20 remaining

publications. The low number of publications found is confirmed by a quote from Aloui et al. (2021, p. 12): “[...] there is very limited research on cooperation with competitors and Logistics Service Providers (LSP). Most of the research focuses on upstream cooperation, among suppliers. Therefore, it would be interesting to study the cooperation with several internal and external entities”. This current and very broad literature analysis deals specifically with the topic of sustainable logistics and its current state of research, as well as the resulting research gaps. It can be concluded that there is currently no relevant literature dealing directly with the issue of land savings through cooperation in logistics. However, indirect saving potentials can be derived from the facts mentioned in the publications.

The results are summarised in Table 2. For clarity and structure, those results are grouped into categories. The characteristics are derived from literature. The first category summarises all concerns related to the framework conditions. The second category deals with important drivers of cooperation. The third category shows possible uses of resources. The fourth category describes what kind of cooperation is possible and under whose participation. In summary, it can be said that cooperation and its effects on land use have hardly been considered in the literature so far. For this reason, a survey of experts was conducted in a second step to deepen the findings.

Many academic publications deal with forms of cooperation and their concrete design and benefits for the logistics sector. Furthermore, well-known problems such as the Travelling Salesman Problem or the Vehicle Routing Problem are represented in the literature (Sathya & Muthukumaravel, 2015; Braekers et al., 2016). However, the results or objectives of most publications do not address the issue of optimising land use through cooperation but are primarily oriented towards decision models that can achieve CO₂ emission and cost reductions. There are also models for identifying the optimal location, but “only few papers analyse the environmental benefits of [...] cooperation” (Hacardiaux & Tancrez, 2020, p. 5) and many experiments or calculations on this topic are based on specific assumptions that cannot be fully applied in real situations, such as the complete restructuring of logistical processes when entering a cooperation (Hacardiaux & Tancrez 2020).

3.1 Strong Dependence on Price, Land Use and CO₂ Reduction

The literature shows that collaboration in logistics does not automatically reduce space requirements. In fact, it can sometimes increase. The reason for this may be a scenario where a merger of companies provides large financial resources to acquire cheap space for a common logistics infrastructure. Even when costs are high, distribution centre (DC) space continues to grow moderately. “We observe [...] that cooperation leads to increase the number of DCs [...]” (Hacardiaux & Tancrez 2020, p. 14). Verdonck et al. (2016) state that the cooperative use of logistical buildings can lead to a significant reduction in costs.

However, decentralised structures with many well-distributed buildings reduce the number of journeys and the distances travelled. The trade-off is an increase in land use, which has its own environmental impacts. Hacardiaux and Tancrez (2020, p. 18) say: “Moreover, to limit the impact of increasing order costs, the number of DCs is reduced, losing part of the environmental benefits related to the shorter distances.” CO₂ emissions and land use are therefore closely linked and have a relatively strong influence on each other.

3.2 Reaching Space-Efficient Logistics via Cooperative and Innovative Transport

It is not only the cooperative use of buildings and other logistical infrastructure that has an impact on space efficiency. For example, if cooperation results in fewer empty runs. This usually leads to a reduction in the number of vehicles needed, which in turn reduces the space required. So “cooperation also helps maintaining a higher loading rate [...], which reduces the number of trips per period [...]” (Hacardiaux & Tancrez, 2020, p. 14).

Wagner (2010) sees a possible increase in the efficiency of land use through cooperation, especially in the area of parking or road use. This is mainly achieved by better utilisation of the vehicles used. The (possibly cooperative) use of other modes of transport (e.g., rail) also offers space-saving potential. Palmer et al. (2018) supports the finding that greater efficiency in vehicle utilisation can be achieved through cooperation. The synchronisation of the last mile through extensive cooperation is beneficial for the quality of service and the market position of the cooperation participants, as explained by Yang et al. (2020, p. 17): “The cooperation among multiple logistics providers is recognized as an effective way to enhance the efficiency and benefits of the last-mile logistics industry in rural areas”. Furthermore, innovative concepts can contribute to a better structuring of the traffic volume. Pribyl et al. (2020) show that the cooperative use of autonomous vehicles in cities makes sense and has a positive impact on the quality of life. Although the logistics sector is not directly addressed, there is a clear need to focus on digitisation and sharing.

3.3 The Scope of Cooperation and the Importance of Corporate Framework Conditions

Quintero-Araujo et al. (2019) look at land use in the context of cooperation. Again, the focus is on the possibility of saving CO₂ through cooperation. The authors distinguish between semi-cooperative and fully cooperative horizontal approaches. In the fully cooperative scenario, decisions for or against an additional building are also made jointly. There is a strong focus on total costs. The authors find that the possibilities to reduce emissions and the number of buildings are strongly related to the typology of customers and suppliers. Using a computer model and a number of simulations, the authors also show that transport distances can be reduced through cooperation. It is only in the fully cooperative scenario that the number of buildings, and thus the space required, is reduced due to the close interlocking of the actors involved and the agreements between them. Hacardiaux (2021, p. 123) provides a similar result: “First, each partner has access to more shared DCs while the total number of DCs is lower than in the stand-alone case [...]”. This could potentially save space through very close and trusting cooperation. The simulations also showed that the number of buildings required can be increased in the semi-cooperative scenarios, as this can reduce travel distances and save CO₂.

Verdonck et al. (2016) state that especially in the scenario of cooperative use of logistics buildings, the number of cooperation partners or their size/influence is less relevant. The customer structure is very important. The publications mentioned above, on the other hand, assume in their simulations that the cooperation partners are equivalent in terms of size and influence.

3.4 Political Framework Conditions and Spatial Development as a Basis for Area-Efficient Cooperation

In addition to optimisation potential in the buildings used and their layout, and the influence of transport on land use, external conditions also play a role in the success of collaboration. Witkowski and Kiba-Janiak (2014) address the need for a political framework so that regulatory measures can promote cooperation and accompany the necessary process of building trust. Palmer et al. (2018) note that regulatory compliance plays an important role and can be an obstacle to successful cooperation. However, several municipalities can also cooperate more closely, for example in the development of joint logistics sites, to address decision-making and competence problems in a targeted manner. Van den Heuvel et al. (2013, p. 1) state: “There is a need for cooperation between municipalities, such that a regional policy can be developed, to attain the regional benefits of logistics concentration areas, while local disadvantages (like congestion and CO₂ emissions) can be reduced”. This means that, in addition to land use effects, cities and municipalities can achieve other important improvements by working together.

Land reductions or an increase in land use efficiency in the logistics sector also play an important role in urban spatial development. Good cooperation counteracts future challenges and promotes the attractiveness and sustainability of urban spaces (Lindholm, 2014). In Kotzold et al. (2021) the importance of planning new logistics settlements in the context of cooperation is discussed. Multiple or collaborative use of a logistics space or building will be easier to achieve if these aspects are considered in appropriate scenarios at an early stage of planning. In addition to collaboration with customers or suppliers, non-logistics uses—such as major regional events—should also be considered.

3.5 Trust and Willingness to Share Crucial Information

It is clear that trust between participants plays an important role in the success of collaboration (Eidhammer et al., 2016). For this purpose, a neutral moderator or a neutral stakeholder forum is a useful tool in the confidence-building process. Such a forum must adequately represent the different stakeholders. The joint development of collaborative management tools is also conceivable within these forums (Zunder et al., 2014).

Collaboration in terms of space efficiency requires appropriate digital exchange formats. Logistical processes can only be more efficient and collaborative if the necessary information is always available and up to date. Sharing critical information between stakeholders helps to coordinate services and synchronise collaborative activities. It also increases overall trust (Badraoui et al., 2020). A suitable degree of digitisation among the partners ensures the exchange of information among each other and supports cooperative processes and structures. 3PL logistics service providers in particular benefit from such IT structures in terms of cooperation (Song et al., 2020). When developing new IT systems, it is important to ensure that all stakeholders are involved in the development process. This increases the acceptance and benefits of the systems (Leonardi et al., 2014).

Table 2. Categories and characteristics of cooperation for space-efficient logistics based on the literature analysis

Category	Feature	Expression	Sources
1. Coordination and Framework of Cooperation	Moderator / Forum	External Among Partners	Eidhammer et al., 2016; Zunder et al., 2014
	Customer Structure	Demand Quantity Goods Others	Quintero-Araujo et al., 2019; Hacardiaux and Tancrez, 2020
	Organisation Structure	Centralised Decentralised	Quintero-Araujo et al., 2019; Verdonck et al., 2016; Kotzold et al., 2021; Hacardiaux and Tancrez, 2020
	Trust	Existent Non-Existent	Eidhammer et al., 2016
2. Pioneering Function in Cooperation	Politics	Framework Conditions Ordinances Laws	Witkowski & Kiba-Janiak, 2014; van den Heuvel et al., 2013
	Spatial Development	Attractiveness Future Challenges Costs	Lindholm, 2014
	Maturity of Digitisation	Low Medium High	Song et al., 2020; Leonardi et al., 2014; Pribyl et al., 2020
3. Scope of Cooperation	Space Usage	Use of Existing Infrastructure New Infrastructure	Wagner, 2010; Souza et al., 2013; Verdonck et al., 2016
	Traffic Usage	Vehicle Utilisation Number of Vehicles Means of Transportation	Wagner, 2010; Pribyl et al., 2020; Yang et al., 2020; Palmer et al., 2018
4. Type of Cooperation	Parties Involved	Inter-Municipal Cooperation Others	van den Heuvel et al., 2013

4. Empirical Research

Between May 2021 and July 2021, twelve semi-structured face-to-face interviews were conducted with experts in the field of space saving and space optimisation in logistics processes to validate and extend the findings of the literature review. The experts interviewed were selected using the Quick Ball system (Goodman, 1961). In this method, when a survey is conducted, the people who have already been interviewed (with the relevant characteristics) are asked to provide information about other people who have the same relevant characteristics. The interviews also provided clues to the identification of other relevant people. In addition, experts in and around the Osnabrück region in lower Saxony, Germany were interviewed in terms of the municipal and logistical structures. Osnabrück, located in Lower Saxony, Germany, has a large number of logistics facilities (Veres-Homm et al., 2015) and is therefore well suited for consideration. The different actors and their different perspectives on land use, its optimisation, and future developments, generate meaningful insights into the complex of issues. The expert interviews were conducted until no significant new insights emerged (Corbin & Strauss, 2015). A list of those experts can be found in Table 3.

Table 3. Interview partners

Interview #	Gender	Description
1	M	Professor for Supply Chain Management
2	M	Head of department for environmental protection in a municipal company
3	M	Business Unit Coordinator Logistics at a research institute
4	F	Professor of Business Administration and Logistics Management
5	M	Managing director of a municipal company (reference: city logistics)
6	M	Owner of a group of companies (logistics)
7	M	Fleet manager of a freight forwarder
8	M	Head of environmental management at a logistics company
9	M	Supply Chain Manager in a research institution
10	M	Managing director of a forwarding agency
11	M, M	Managing director and operations manager of a production company with its own logistics
12	M	Professor for Landscape Planning

The selection of interviewees mentioned above provides a deeper understanding of the individual perspectives relevant to a more sustainable use of land as a resource. The sample presented in Table 3 took into account this diversity of stakeholder views, e.g., companies from different industries with different structure and size, or the municipal and scientific perspective. Semi-structured interviews were chosen because they provide an

appropriate balance between rigour and flexibility (Patton, 2015). All interviews were digitally recorded, transcribed and translated verbatim. The interviews included both specific and open-ended questions.

4.1 Data Analysis

In analysing the qualitative data, the four researchers were guided by Werner et al. (2021) who analysed collected data using thematic analysis according to Braun and Clarke (2006), as this method allows for great flexibility and simplicity in application. The thematic analysis summarised the main features of the large amount of data collected and examined them for similarities and differences (Braun & Clarke, 2013). According to Werner et al. (2021) the analysis also aligns with Braun and Clarke (2006, 2013) recommended guide for qualitative data analysis. This includes (a) familiarizing oneself with the transcripts; (b) generating initial codes; (c) sorting the codes into overarching themes; (d) reviewing all codes; (e) defining as well as naming themes; and (f) ultimately writing up the results in concrete terms.

4.2 Results

The results of the interviews offered a wide range of possible indicators for more efficient and thus space-reduced logistics. They were divided into categories and associated indicators (or features) for better classification and clarity. Table 4 first shows an overview of the results in the form of evaluated categories and characteristics. The different categories and characteristics are explained in the next step.

Table 4. Categories and characteristics of cooperation for space-efficient logistics based on semi-structured interviews

Category	Features	Expressions	Count of Interviews
1. Coordination and Framework of Cooperation	Moderator	External Among Partners	2 of 12
	Ownership	Ownership Participation Rented Leased	4 of 12
	Motivation	Intrinsic Extrinsic	10 of 12
2. Pioneering Function in Cooperation	Level of Digitisation	Low Medium High	10 of 12
	Degree of Innovation	Low Medium High	5 of 12
3. Scope of the Cooperation	Expansion	Local Regional Global	3 of 12
	Direction	Horizontal Vertical Diagonal	1 of 12
	Liability/ Duration	Short-term Long-term	2 of 12
	Type of Use	Single Multiple Logistics Non-Logistics	5 of 12
4. Type of Cooperation	Form of Cooperation	Network Platform Others	5 of 12

4.2.1 Category 1: Coordination and framework of cooperation

1) Moderator

In context of this work, a moderator (facilitator) is understood as a person or a group of stakeholders who accompanies the cooperation by supporting and strengthening the associated companies in their cooperation through diverse communication and the establishment of a set of rules. According to one of the interviewees, “despite all the rationally conceivable advantages, horizontal cooperation between logistics companies alone has never really taken off and been implemented” (I4). This is because logistics companies offer services at the same level and are therefore in competition with each other. This is accompanied by internal resistance that must be overcome. This is why the role of the facilitator or moderator is particularly important. Its main task is to define a binding and accepted set of rules and regulations. (I4). This probably requires “some leading figures who keep pushing these issues [...] forward [...] If you cooperate to a certain extent and understand each other, then you can be competitors and also cooperation partners at the same time. But that’s a problem that’s not on everybody’s mind” (I6).

2) Ownership

This code divides the buildings used for logistics processes into municipal, purchased and rented/leased space. These characteristics are particularly important for the development of new sites, as interview 8 makes clear: “It is always a question of whether we are also the developer. Usually, as I said, the concept tends towards leasing. That means we have a developer or an investor who builds it. A developer who builds the building and we are ultimately just the tenant.” The fact that logistics companies also own a lot of land is clear from interviews 10 and 11. Some of the sites have been bought from several owners and combined into one large site (I11). This shows the importance of suitable sites (in terms of size and location) for the logistics sector. However, according to interviewee 6, in the region under consideration “the available rental space is quite low, [whereas] other

regions have much higher rental shares with investors”. Overall, it is clear that all constellations are possible and depend on the prevailing conditions and business models.

3) Motivation

The issue of motivation has a variety of influences on decisions about sustainability, cooperation and related land use reduction. A basic distinction is made between extrinsic and intrinsic motivation. Extrinsic motivation is influenced by a company’s external stakeholders and customers. These groups directly influence a company’s decisions through, for example, their purchasing behaviour or requirements. Intrinsic motivation, on the other hand, comes from within the company itself and is not (or only indirectly) subject to external influences. It should be noted that companies make their value creation more sustainable and less land-consuming “for image reasons” (I2) and actively use this positive external image to attract customers. They use it as a “competitive advantage” (I9) and for “communication reasons” (I3). The customer is an important driver and part of extrinsic motivation. Extrinsic motivation is mainly a result of the interplay between economic, environmental and social issues. “In this triad of sustainability, the economy is a very important factor in logistics” (I3).

4.2.2 Category 2: Pioneering function in cooperation

1) Level of digitisation

The degree of digitisation describes the extent to which business activities are already digitally supported or taken over. This can be reflected in many nuances—from simple information exchange to full automation. Digitisation is an important prerequisite for cooperative and space-saving approaches in logistics. It is clear from the interviews that digitisation plays a major role and will continue to be an important building block for well-functioning logistics in the future. Various motivational aspects were addressed, and a high “data-driven potential” (I9) is seen as driving companies to “digitise logistics in external areas across the board” (I9). For example, it is stated that digitised processes via IT structures “are a must to stay ahead in the market” (I6). According to various interviewees (I3, I5, I6, I10), digitised processes can thus also contribute to increased space efficiency in logistics. In addition, a high level of digitisation enables cooperation between companies, e.g., the creation of digital platforms (I3). However, there are still some obstacles to a high level of digitisation in the logistics sector, as there are “uneven conditions between companies” (I9). For example, companies often lack in “their own know-how and external know-how is [...] too expensive for [digitised processes] to be financially viable” (I10). These and other obstacles need to be overcome in the future.

2) Degree of innovation

Degree of innovation describes the extent to which business processes can be optimised through innovative planning and implementation. It is closely linked to the degree of digitisation, but also takes into account non-technological activities. Collaborative and space-saving approaches in logistics are constantly improved through innovative approaches, so that new standards are created. According to the interviews, various innovative approaches can certainly lead to space reduction in logistics. It is conceivable that “space consumption can be [systematically] reduced through automation” (I1). However, since “the willingness to innovate [of many of the companies involved] is moderate”, it will be difficult to achieve these benefits (I1). This lack of innovation can also be observed in other topics, such as blockchain technology. For example, one of the interviewees reported that a blockchain project should have been started with logistics service providers from the region, but it failed because “medium-sized companies in particular are very much influenced by what the customers want” (I1), and thus the idea of efficiency takes precedence over the idea of innovation. However, once the will to innovate is there, existing logistics space can be used more efficiently and in some cases even reduced. For example, the use of robotics in one of the companies surveyed helps to move “Euro pallets around production halls” more efficiently (I11). Furthermore, 3D printing can shift storage capacity (I3). In addition, automation generally leads to a reduction in the space required for employees (I1), which also increases the “quality of planning” (I1) and allows “more efficient construction” (I1). Through optimal implementation and a willingness to change, a high degree of innovation can therefore lead to space savings and space-efficient logistics.

4.2.3 Category 3: Scope of Cooperation

1) Expansion

The expansion or scale level “refers to a definition for the consideration of a section of the earth’s surface according to a relative spatial size. Terms such as “local”, [“regional”, “national”] or “global” denote a respective scale level” (Lexas, Maßstabebene). Logistics services along the supply chain can therefore take place, for example, locally (in small areas), regionally (in large areas), nationally (within national borders) or

globally (worldwide). The importance of the scale level was mentioned in the interviews in the context of regional clusters and the associated allocation of regional territories to companies. This “leads to regional clusters in which only one or a few actors are active” (I1). This was illustrated by an analogy in interview 6: “And I always say that it is very important that we make the pond big in which we want to fish. If it’s small, we shouldn’t be surprised that we take each other’s fish and they become expensive. But these are the steps of realisation that need to be brought home to people, and that is sometimes not easy. It probably takes a few leaders to keep bringing these issues to the fore.” One example of regional cooperation to save land was mentioned by interviewee 12: the “Kreuzberg Alliance” in Bavaria, in which four “municipalities have committed themselves not to designate new areas, but to use the money they save [by not providing new space for companies] to promote the conversion of existing areas”. In this case, the municipalities involved wanted to encourage local businesses to use their land more efficiently. They decided to develop the existing sites and provide extrinsic motivation and support to local companies.

2) Direction

The direction characteristic mainly describes whether cooperation takes place vertically - along the supply chain - or horizontally - between direct competitors at one level. This characteristic is important because, among other things, trust seems to be easier to implement in vertical cooperation. Although cooperation (especially in the transport sector) also works on a horizontal level and “makes sense [...] if they exclude each other in some way” (I1), so that no business is taken away from the partner involved. The food sector can serve as an example: “There is a regional haulier who supplies a certain region, but then not only from P&G, but also from Unilever or somebody else. They join forces [horizontally], so to speak, [...] because [the logistics service provider] naturally supplies different customers from one sector [...]” (I1). In the case of a vertical orientation, the advantage of cooperation is easier to see and can be well derived from the example of the bullwhip effect. “If I have the bullwhip effect under control, I have eliminated or at least reduced this overreaction and thus the high degree of uncertainty, which is usually countered with higher stocks [...] and then I also need less space for warehouses etc. That has an effect, of course. [...] The bullwhip effect lives from the fact that I do not communicate bilaterally, but multilaterally [...] and] try ... to supply all levels of the supply chain with information” (I1). It is therefore primarily a matter of exchanging data to increase efficiency. “In the vertical world there is much more cooperation because there is just pressure. The supply chains are mostly vertical - there are horizontal ones, but the main tendency is mostly vertical” (I1).

3) Liability /Duration

Commitment describes the binding nature of a collaboration. It can range from a loose agreement to long-term contracts with capital commitments. It therefore has different effects on the stability and seriousness of a cooperation. One of the interviewees also mentions the consequences of decisions in this respect: “Either I build a warehouse or I don’t build one, and if I have built one, then I have it for now and I can’t tear it down” (I1). Long-term must therefore be integrated into existing structures in a meaningful way and should always fit in with the commitments behind them. “Projects/businesses arise [...] in the context of contract logistics [...] and usually only last] 1 or 2 years and then such a long-term decision would not make any sense at all” (I1). Long-term cooperation that involves real estate or ties up large amounts of capital also limits a company’s flexibility. “If I say I’m going to build a warehouse in Potsdam and I’m not going to do it alone [...] then you have a warehouse in Potsdam and you are more or less part of this cooperation” (I1). This is also the crucial difference to transport logistics. “The investment behind such a warehouse or distribution centre is incomparably higher than for a truck. This means that I can be more variable in transport: I can make it bigger or smaller” (I1).

4) Type of use

Logistics buildings can be used in different or multiple ways, so there are different types of use. These include both the shared use of a property within logistics (use of vacant space) and the extension by other operators (‘commercial or office space above’, I2). This approach of planned multiple use does not appear to be widespread at present. One interviewee stated that he “does not know of any examples where people have said ‘I’m going to use this alternatively. Except for empty buildings that are then used as sports halls” (I3). It seems to be important “already in [...] the planning stage [...] to consider where [...] alternative capacities [...] are available, perhaps also existing areas” (I9). In this context, the implementation of comprehensive cooperation is sometimes problematic or at least costly. It is said that “it is not so trivial on the existing areas, but we only carry out conversion measures” (I5). On the other hand, there are also examples of cooperation on a smaller scale, which further promote shared use. One interviewee works with a delivery company and gives them access to one of its buildings “where they have been able to set up a mini depot on the ground floor and now serve the city

centre with two cargo bikes and [...] are supplied by a feeder who comes two or three times a day and then takes care of replenishing it with new parcels” (I5). In addition, free spaces are not easy to market. Often the plots are “only available seasonally” (I6), which makes planning difficult. There is also “the impression [...] that people try to use logistics areas that are obviously not being used [...] for other purposes [...] even if it is only to park cars from a large manufacturer or other equipment that is then left out in the open. Just so that there is an economic justification for a few euros” (I9). In addition, there seems to be a general change in attitude and openness to cooperation: For example, the car park of a supermarket could be used at night as a parking area for lorries, as there is no customer traffic at that time. Thought should be given to “hybrid solutions that can then also be implemented together with other parties who already have spaces that are not fully used” (I9).

4.2.4 Category 4: Type of cooperation

Different forms of cooperation can describe the framework in which companies work together to jointly carry out processes or market cooperative business models. The interviews focus on two forms of cooperation: the network and the platform. These two forms of cooperation can achieve different effects. For example, the necessary logistical space can be used more efficiently or even minimised, because “in theory, cooperation always brings economies of scale”, so that “a cooperative network” pays off (I1). One of the companies surveyed is therefore represented in several networks at the same time, to obtain “consolidated loads for single-pallet shipments”, cooperation in the freight sector based on “geo-coordinates”, “joint purchasing” or even a general “entrepreneurial exchange” (I10). As a result, more and more alliances are emerging “in the transport sector, but also in the warehousing sector” (I1). In recent years, this has been particularly true of digital platforms, which, according to interviewee 6, “will continue to develop, especially in the transport sector [...]”. This is because digital platforms can use the “digital way [...] to bundle and allocate supply and demand better than is currently the case” (I3). In this way, “new business models are constantly being launched” (I9). One of these innovative business models is carried out by a company that “contractually commits its own logistical resources and then releases these capacities and then sets up a quasi on-demand concept. Logistics service providers [...] can book their free requirements here” (I9). This means that storage space is increasingly being used cooperatively. City logistics is also identified as a special form of cooperation in interview 4: “[...] the issue of city logistics [...] that is such a special form of cooperative systems. [...] In any case, these are important approaches that need to be promoted, because only through cooperation will there be opportunities to avoid traffic or land use through better capacity utilisation, but also simply by coordinating certain logistical processes in such a way that they can be eliminated from the outset. That’s why this kind of cooperation is important, and that brings us to the topic of city logistics”.

5. Discussion

Based on the literature review and empirical analysis, it is evident that the topic of efficient land use and the reduction of land consumption through cooperation has received only limited attention. Due to a lack of theoretical and practical debate, further considerations in the discussion will therefore initially focus on elementary principles describing efficient logistical land use through cooperation. In this context, the characteristics of cooperation identified by Killich (2011) will be taken up and it will be shown whether the characteristics identified in the context of this work are already present there and can therefore also be directly applied to space efficiency, or whether they are newly added in the sense of space-efficient logistics. The discussion will therefore focus on the sub-question of this paper:

What categories/characteristics can be used to describe cooperations in logistics to achieve space efficiency?

Based on the results, four different categories/characteristics can be identified to describe logistics collaboration to achieve space efficiency. Table 5 summarises the characteristics identified in the literature and in the empirical study and the attributes evaluated.

Table 5. Categories and characteristics of cooperation for space-efficient logistics based on literature and interviews

Category	Features	Expressions
1. Coordination of Cooperation and Framework (Internal and External)	Moderator	External Moderator Internal Moderator
	Existing Organisational Structures	Ownership Participation Rental Leasing Centralised Decentralised
	Existing Customer Structures	Demands Quantity Goods
	Intrinsic Motivation	Low Medium High
	Extrinsic Motivation	Low Medium High
	Trust	Existing Trust Non-Existing Trust
	Politics	Framework Conditions Ordinances Laws
2. Pioneering Functions of Cooperation	Spatial Development	Attractiveness Future Challenges
	Degree Maturity of Digitisation	Low Medium High
3. Scope of Cooperation	Degree of Innovation	Low Medium High
	Expansion	Local Regional National Global
	Direction	Horizontal Vertical Diagonal
	Liability Duration	Short-Term Medium-Term Long-Term
	Type of Use	Vehicles Halls Processes
	Space Usage	Use of Existing Infrastructure Implementation of a Completely New Infrastructure
4. Form of Cooperation	Traffic Usage	Vehicle Utilisation Number of Vehicles Means of Transportation
	Form of Cooperation	Network Platform Others
	Parties Involved	Inter-Municipal Cooperation Others

The first category includes the coordination of the cooperation and the existing frameworks or circumstances to use the logistical space as efficiently as possible. This also includes who is responsible for moderating the cooperation. This moderation can be conditioned by the ownership structure of the actors involved, the motivation (intrinsic or extrinsic) or the goals of the cooperation partners. Each partner has different goals that need to be reconciled in a successful cooperation scenario. In addition, it is conceivable that the facilitation is carried out by an external person or team to increase equality and mutual understanding in the context of the newly emerging cooperation. The existing company structures and their customers are also relevant in this context. In addition, there are the existing or to be developed political framework conditions as well as the spatial development potential. Finally, and most importantly, the trust of the stakeholders involved is relevant in this category. Important existing framework conditions need to be taken into account and adapted to the new cooperation concerns. Killich (2011) does not include these aspects in his indicators of business cooperation, so the first category identified in this paper can be seen as an extension in the context of space-efficient logistics.

The second category describes the extent to which the cooperation partners are already pioneers in terms of the degree of digitisation and innovation that can lead to success in terms of space efficiency through the appropriate joint development of such structures, e.g., through extensive information exchange. Depending on the existing characteristics, there are different starting points for cooperation. For example, if two logistics cooperation partners have a high level or maturity of digitisation and innovation, it may be easier to develop new digital interfaces for cooperation in the short term. These characteristics of space-efficient logistics extend the cooperation characteristics of Killich (2011) to include technological aspects. Coordinated technologies and the resulting exchange of information can lead to more efficient processes that optimise or reduce the space requirements of the cooperation partners.

The third category describes the extent to which the cooperation is designed to make efficient use of logistical space. This includes, for example, the geographical scope (e.g., local vs. global), the direction of cooperation (e.g., vertical vs. horizontal), the duration (e.g., short vs. long term and thus the liability), the type of use (e.g., a common loading area for transport or cooperation along the entire value chain) and, finally, cooperative transport or spatial issues. In this category, the model of Killich (2011) model of space-efficient logistics is comprehensively confirmed and supplemented by the cooperation medium or type of use (e.g., as an extension of the “type of department”), including cooperative transport and spatial issues. The aspects mentioned are therefore essential for cooperation in general, irrespective of the objective of saving space.

The fourth category concerns the form of cooperation, or the parties involved. Cooperation can take place between municipalities as well as between private sector organisations. Mixed forms are also possible. The first

three categories and their characteristics form the basis for cooperation, with different emphases of course. Thus, depending on the degree of each aspect, different forms of cooperation for efficient land use are possible. For example, logistics networks can help smaller companies to compete in the market by sharing resources, information and even employees. Different types of commitment can be observed in such networks, from temporary to long-term, as well as different levels of trust (contractual vs. non-contractual). A more flexible form of cooperation is offered by digital platforms. Here, available space and resources that are not used by the owning company can be shared with other companies that need transport space, storage space or even machines for packaging or handling products. The most common form of logistics collaboration is within existing supply and value chains. Companies within the same value chain often work together to share space, resources and information. For example, manufacturing companies, different types of suppliers, logistics service providers and distributors may work together to create a common type of packaging so that products can be transported and stored efficiently throughout the supply chain.

A special form of cooperation is also crucial for urban logistics, which deals with all logistics processes within an urban area (Dolati Neghabadi et al., 2019). As space is usually scarce in urban areas, cooperation between logistics service providers, manufacturing firms and municipal actors is crucial for the efficient use of available space for the storage and distribution of products within cities.

6. Conclusion and Outlook

The study investigated the question of how cooperative ventures can be described to enable space-efficient logistics. Based on a literature analysis and qualitative interviews with experts, it became apparent that this question has not received much attention in business practice or in scientific debates. Therefore, this paper focused on identifying basic categories and characteristics that describe cooperation in logistical processes that enable efficient land use. The evaluated categories provide insight into how concrete characteristics could be developed to make cooperation successful. They are thus often directly related to the characteristics identified by Killich (2011). On the other hand, these characteristics can also be understood as barriers, which, if unfavourably expressed, impede successful cooperation in the sense of area-efficient logistics. An example of this is the degree of digitization among logistical companies. Here, it could be hypothesized that if the logistics cooperation partners involved do not have the same (or nearly the same) digital systems, it will be difficult to digitally bring those two partners together (and vice versa). A number of practical consequences for companies can be derived from the results for the future, to use land more efficiently and thus more sustainably. If, for example, the company's goal is to use logistical space efficiently through cooperation, concrete initial parameters can be analyzed on the basis of the evaluated categories and characteristics (Who takes over the moderation? To what extent is the cooperation realized? What are the general conditions to keep in mind?). Concrete value creation models can also be considered on the basis of the evaluated forms of cooperation.

7. Limitations and Future Research

This research on the impact of cooperation on space saving in logistics has several limitations that require further research. There is a need to examine whether the results from the Osnabrück region can be transferred to other regions in Germany or around the world, and to work out how Osnabrück differs from these other regions (e.g., availability of available logistics space, the location itself, transport infrastructure) and what the effects of the individual characteristics are.

This study only analysed which potential indicators exist and not how they are correlated. Furthermore—at this state of research—no management advice can be given. Further research will address this issue. In addition, an analysis of specific logistics cooperation could be an interesting approach to investigate whether there are other indicators or framework conditions for the potential benefit of saving space by increasing the level of cooperation. For future research, it would be of particular interest to analyse the effect of different forms of cooperation on land use. It is possible that some forms of cooperation have a significantly stronger effect on land use than others. Furthermore, this analysis could only show to a limited extent which characteristics need to be present and to what extent in order to achieve a particularly high effect on reducing land use. A quantitative approach would also be interesting for future analyses. This would make it possible to quantify the effects. Given the benefits of cooperation in logistics, future research should also analyse the acceptance of different forms of cooperation. During the interviews it became clear, for example, that the competitive situation or historically grown conflicts are an obstacle to the realisation of cooperation. A better understanding of the stakeholders involved, and their level of acceptance could possibly provide solutions for more cooperation. In summary, this research provides an overview of potential indicators that are important in the context of cooperation and have the ability to save space in all logistics processes.

Availability of data

The data that support the findings of this study are available from the corresponding author, Dennis Kotzold, upon reasonable request.

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