A qualitative analysis of multimodal hub concepts in Dutch national transport and land-use policy

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Abstract: The multimodal hub is put forward in a plethora of current transport policies to solve various transport problems. The concept proves to be ambiguous and lacks consensus over an exact definition. We identified historical concepts in Dutch transport and land-use policy sharing similarities with the multimodal hub through keyword analysis. Moreover, we highlighted the key policy objectives, implementation barriers and enablers, and outcomes using structured expert interviews. The results suggest that central coordination between local governments, creating a just and stimulative framework for market parties to invest in multimodal transport, and a demand-oriented multimodal chain perspective are preconditions for implementing multimodal hub concepts. Furthermore, we conclude that multimodal hub concepts historically shift towards integrating multimodal transport, intensive land-use, and increasing link with shared resources in both transport supply and demand.

Keywords: Multimodal transport, Multimodal hub, Policy analysis, Transport history, Formal Concept Analysis

1. Introduction

There is broad recognition in academia that private automobile usage is a primary source of transport problems, such as road congestion and air pollution. Multimodal transportation is put forward in academic literature and policy practice as a (partial) response to these problems by replacing dispersed travel patterns through bundling transport flows. The (un)balancing of transport flows occurs mainly at transfer points connecting different transport modes and increasingly links with land-use planning (McLeod et al., 2017). The Netherlands faces the everlasting challenge of mobilising a strongly urbanised delta, suffering from congestion, environmental pressure, and scarcity of space. Hence, the public sector has a longstanding tradition of restricting car usage, applying measures to calm traffic and coordinating spatial planning and public transport (Pojani & Stead, 2014). The Dutch national government recognises a growing burden of private automobile usage on urban areas in its recent National Environmental Vision from 2020. As a solution, it observes the efforts of decentral governments to develop multimodal hubs at strategic locations where transport modes are linked to integrate transport systems and offer travellers comfortable transfers (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020). Despite these recent policy efforts, only 4-5% of all trips are multimodal in the Netherlands (Hamersma & de Haas, 2020).

The 'multimodal hub' proves to be ambiguous and lacks consensus over an exact definition. In literature, a multimodal hub facilitates transfers between public transport and other (shared) modes to improve first- and last-mile connections at specifically designated locations (Anderson et al., 2017; Miramontes et al., 2017).

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Therefore, a multimodal hub is not an entirely new phenomenon as the concept shares similar characteristics with other concepts that have emerged in transport planning in the past, such as Transit-Oriented Development (TOD) and Park-and-Ride (P+R). Likewise, the logistics sector employs hub-and-spoke models for transhipping goods via distribution centres at different scales (Hesse & Rodrigue, 2004). To this end, this paper aims to identify related multimodal hub concepts in Dutch national policy. The rationale is that the diverse meanings attached to the ambiguous concept impede the transferability of policy lessons to alternative contexts. For instance, Pojani & Stead (2014) found that the policy transfer of the TOD concept in the Netherlands served as inspiration for policymakers but was irregularly translated into action or tangible results. One of the main reasons entailed the complexity and many-sided nature of the concept. The second aim is to draw lessons from these concepts to inform future policy-making concerning multimodal hubs.

The remainder of this paper is divided into four sections. Section 2 makes a theoretical argument for the relevance of multimodal transport policy to tackle unimodal passenger and freight transport inefficiencies. Section 3 discusses the pursued methodological approach. Section 4 presents the multimodal hub concepts that were identified in the period from 1958-2020. Section 5 entails the Formal Concept Analysis conducted to discover the policy objectives, the implementability and the outcomes of the selected multimodal hub concepts. Finally, section 6 concludes the paper by recognising a trend towards an integrated multimodal hub concept and discusses the study's limitations and pathways for further research.

2. Theorising multimodal hubs

Travel behaviour is often considered a derived demand for the societal need to reach activities at spatially distributed locations. Hence, a general definition of accessibility considers the extent to which transport and land-use systems enable individuals to reach destinations by (a combination of) different transport modes (Geurs & van Wee, 2004). The interaction between transport and land use has a longstanding tradition in transport planning (see, e.g. Kelly, 1994; Mitchell & Rapkin, 1954). Trip-making patterns, traffic volumes, and modal splits are primarily functions of land-use characteristics (Meyer, 1999). Therefore, regional integration of land-use development and transport investments can enhance proximity to activity destinations, potentially reducing trip length and frequency, and can change modal splits (Banister, 2008). The most critical factors are spatial density, the degree of a functional mix, origin-destination distances, and nodes (Van Wee, 2011).

A multimodal hub is such a node within a transport network facilitating a minimum of two transport modes. Hence, hubs facilitate multimodal instead of unimodal trips – where one mode is used during a single trip. In passenger transport, multimodal transport involves a single trip using two or more modes during which the traveller has to make a transfer (Van Nes, 2002). In freight transport, multimodal transport relates to cargo shipment involving more than one mode during a single, seamless journey (Jones et al., 2000). The main advent of multimodal transport at a system level is that the transport flows can be bundled in a particular trip leg. Bundling transport flows ideally responds to adverse environmental impacts, mass urbanisation and high costs of individual movements. The idea of bundling transport flows via hubs is not new. The logistics sector traditionally employs hub-and-spoke networks to bundle flows of goods. The logistics chain's geographical expression can be divided into flows, nodes (including their immediate environs), and networks (Hesse & Rodrigue, 2004). Logistics hubs are nodes and infrastructure facilities that form transhipment points in logistics networks. Consequently, the hub facilitates storage,
ordering, and (un)bundling of goods (Huber et al., 2015) and processing or creating added value. As every transhipment involves extra uncertainty in the supply chain (e.g. costs, time), industry players benefit from seamless transhipments to secure their business models (Woxenius, 2001).

Contrary to passenger transport, freight transport is less integrated into governmental transport policy. Private logistics service providers shape the market, and shippers manage the transportation of goods independently. The competition between market players can obstruct collaboration and results in unnecessary movements of underutilised vehicles, generating negative externalities, like congestion or air pollution (Sousa & Mendes-Moreira, 2015). This first- and last-mile problem involves the initial and final stage in a business-to-consumer delivery service of parcels to a recipient’s home or collection point. It is considered the most expensive, least efficient, and most polluting section of the total logistics chain (Gevaers et al., 2011). Paradoxically, the first and last mile in passenger transport is usually the least expensive and least polluting leg of an intermodal trip as these can be undertaken by active modes and public transport (Arvidsson et al., 2016). Several authors underline the potential to integrate logistics and passenger transport operations for efficiency gains (Arvidsson et al., 2016; Trentini & Mahléné, 2011). Shared modes can sustain accessibility by extending multimodal options in first- and last-mile transport, so blind spots in transit networks can be covered (Shaheen & Chan, 2016; Shaheen & Cohen, 2019). The potential symbiosis between passenger and freight transport is the rationale to study both policy sectors in this paper.

2.1. Analytical framework

The analytical framework presented in this paragraph comprises a set of dimensions for studying historical policy concepts related to multimodal hubs. Multimodal transport considers the travel between origins and destinations using at least two different transport modes (Hamersma & de Haas, 2020), implying the need for an interchange taking place at a multimodal hub. Following the categorisation of Egeter et al. (2000), multimodal hub concepts potentially intervene on 1) origins and destinations, 2) transfer nodes, and 3) transport supply (i.e. first-/last-mile and main trip). A multimodal hub concept is selected for further study if it intervenes within this trip chain (Figure 1).

Figure 1: Multimodal hub concept intervention scheme (based on (Egeter et al., 2000)).

Transport and land-use planning are instrumental to the triad above. As individual measures might have limited or adverse effects within the multimodal trip chain, multimodal hub concepts are considered part of a policy package, including ancillary policies. For example, park-and-ride facilities might be used to promote a modal shift from car to public transport. However, road infrastructure expansion could also induce new car traffic, requiring, e.g. restrictive parking policies (Zijlstra, 2020). To arrive at the lessons from multimodal hub concepts, we study policy objectives, implementability and outcomes. First, policy objectives for public intervention arise from the underlying political views determining the optimal functioning of the transport system. In this case, successfully implementing the desired policy, a multimodal hub concept, is referred to as implementability (Givoni, 2014). This definition encompasses the barriers and enablers as transactional factors that affect the overall outcome. The outcome involves evaluating the effects and the proportionality of a multimodal hub concept concerning
its policy objectives. A schematic overview of the analytical dimensions is presented in Figure 2.

Figure 2: Analytical framework.

3. Methodology

A two-step analytical structure was adopted. A keyword analysis enabled us to discover related multimodal hub concepts from the past. Moreover, a qualitative analysis was used to explore lessons from concepts.

3.1. Keyword analysis

The first step involved a keyword analysis of international academic literature to explore the definitional structure of a multimodal hub. This was done by searching on keywords that co-occurred with the term 'hub' in international academic literature. We used the following query in Scopus to allow for a broad scope in transport(-related) literature:

( KEY ( hub ) AND ABS ( transport ) )

The Scopus database search resulted in 691 publications. All index keywords were extracted and ordered based on their occurrence frequency. Here, the upper 50 per cent of all keywords were used as the cut-off threshold to select the most relevant keywords. The resulting keyword selection narrowed down by removing keywords from non-transport research fields, methodology-related keywords, articles and auxiliary verbs. Moreover, similar duplicates were merged. The final selection of keywords was translated and complemented with synonyms that better fit the Dutch language context. Figure 3 shows the results from the keywords search query in Scopus.

Figure 3: Results from the keyword analysis

Scopus keywords co-occurring with 'hub'
The second step was to identify multimodal hub concepts in strategic policy documents through autocoding policy documents using the keywords. The guiding principle for document selection involved national strategies for transport and land-use planning from 1958 to 2020. This start year marks the explosion of individual car ownership and derivative road infrastructure investments and allows for analysis of governmental stances towards multimodal transport over time (Arts et al., 2016; Molnár-in ‘t Veld, 2019; Wee et al., 2013). The autocoding procedure was set to highlight paragraphs in which keywords appeared. The coded documents were analysed to extract the first selection of multimodal hub concepts.

3.2. Qualitative analysis
A qualitative interview analysis was used to identify lessons from the selected multimodal hub concepts. Eight interviewees were selected by reviewing historical transport analyses and their practical experience in multimodal transport and logistics planning. The experts had significant experience at institutes concerned with the consultancy (College of State Advisors), formulation (Ministry of Infrastructure and Water Management, the Senate), implementation (Rijkwaterstaat, Province of Zuid-Holland), and evaluation (Netherlands Institute for Transport Policy Analysis, research universities) of national transport policy. The interview guideline consisted of questions operationalised from the analytical framework, feedback on the concept selection's completeness, and a discussion of the interviewee's preferred multimodal hub concepts based on the analytical framework. The interviews were conducted via video call between November 2020 and February 2021, each lasting between 45 and 90 minutes. Finally, the interviews were recorded and transcribed with the respondent's consent. Using ATLAS.ti software, the transcripts were analysed through a deductive coding procedure. First, all utterances from the respondents were coded according to their belonging concept. Second, quotations were attached to an emergent code that fit within the analytical framework's dimensions. The codes were further optimised and clustered using axial and selective coding procedures (Bryman, 2016, p. 568). The resulting deductive code tree entailed a confrontation between the emergent codes and characteristics per multimodal hub concept.

Finally, a Formal Concept Analysis (FCA) was adopted to identify the main lessons from the selected multimodal hub concepts. Analysing formal concepts allows for discovering patterns in categorical data and introducing a hierarchical structure, identifying the related concepts' most relevant characteristics. According to the underlying concept theory by Laurence & Margolis (1999), a concept relates to a unit of thought consisting of objects and their attributes. In this study, multimodal hub concepts are objects and the codes that emerge from the empirical data define as attributes. Drawing a network of objects and attributes enables discovering the so-called formal context of the multimodal hub concept. The result was a co-occurrence matrix representing whether or not objects and attributes have an incidence relation.

4. Results section

4.1. Identified multimodal hub concepts
This section describes the selected multimodal hub concepts (marked in bold) for passenger transport, freight transport, and land use.

4.1.1. Passenger transport
From the 1970s on, the private automobile's negative impacts become apparent, and the car facilitation paradigm shifts towards alternative modes. The large-scale investment in highway networks, the increased car ownership, and the spatial distribution of residential and employment areas had become an essential basis for road congestion and environmental problems. The Park-and-Ride concept is introduced in the Multi-year Passenger Transport Plan 1976-1980. The concept assumes that parking facilities near train stations will incentivise car drivers to replace the last part of a car trip to urban areas with public transport. After its introduction in the early 1970s, the Second Traffic and Transport Structure Plan (SVV-II, 1988) gained the insight that merely linking parking facilities to public transport is not sufficient to achieve the desired effects. For passenger transport, the SVV-II aimed to halve the projected 70% growth in car use between 1986 and 2010. One of the means to come here was the transferium pilots, which further develop the P+R concept by focusing on travel information and comfort. At eight pilot locations, high-quality parking facilities are constructed in collaboration with NS, ANWB and market parties, focusing on (transfer) comfort, travel information and parking safety (both physical and social). The policy proposal of SVV-II also provided an incentive for congestion charging as a supporting measure but was turned down because of societal and political resistance. In the Vinex Update (1997), the New Key Projects' introduction focuses on transit-oriented development. The concept brought attention to the high-speed line to make the Netherlands internationally competitive as a networked urban unit. Six stations were designated for large-scale area development catalysed by high-speed rail investments on a national level, providing urban densification and last-mile connections via public transport, bicycle and walking. The station locations' investments should generate their spin-off for centre development, with the arrival of offices and housing for medium and higher incomes in particular. Ministries made agreements with municipalities in which the timing and coordination of government investments for infrastructure and the spatial quality of the immediate surroundings were laid down.

4.1.2. Freight transport
From the Second Memorandum on Spatial planning (1966) onwards, spatial planning supports freight transport hub development by allocating land for the seaport industry and inland shipping. The Fourth Memorandum on Spatial Planning (1988) responds to the economic downturn of the 1980s, which was empowered by a deindustrialising economy, leading to higher unemployment. With the advent of a European internal market in 1992, urban areas were expected to compete internationally. Therefore, the policy explicitly seeks a trade-off between social renewal policy and the improvement of internationally competitive production environments. Governments and market parties developed Rotterdam harbour and Schiphol following the Mainport concept. The latter brought port-hinterland relations into focus. The SVV-II aimed to achieve economic efficiency, limit the environmental impact and relieve its pressure on the motorway network. Investments in rail and inland waterway infrastructure and inland terminal subsidies aimed to stimulate synchronomodal transport as a competitor to road transport. At the urban level, the Ministry of Transport and Water launched a series of pilots with Urban Consolidation Centres (UCC) in 1992. This concept entailed the horizontal collaboration between logistics providers at a terminal in the urban fringe to smaller and less polluting vehicles. In the early 1990s, the Ministry of Transport, together with industry organisations, started a series of pilots in various cities to test the commercial feasibility and the optimal location of SDCs.
4.1.3. Land-use
In the Fourth Memorandum on Spatial Planning Extra (Vinex, 1992), spatial planning became a vital instrument limiting car traffic and stimulating public transport use. It marks a shift in thinking about multimodal transfer points, from the node as only the functional link between different modalities to a location where transport and land use are complementary. The VINEX concept anticipates an urbanisation strategy in which functional mixing had to ensure proximity to daily amenities and transport demand. The national government made agreements with municipalities to develop new residential areas, linked to land cost subsidies and contributions for public transport connections and green spaces. In 1990, the ABC location policy was introduced in coordination with the SVV-II. The starting point was that concentrating employment at (multimodal) accessible locations will lead to car mobility avoidance and the stimulation of public transport and bicycle use (Ministry of VROM et al., 1990). Under the credo 'the right company in the right place', the national government set a framework for municipalities to allocate employment locations to companies differentiated on transport generated impacts. Locations were assigned an accessibility profile, relying on public transport infrastructure, road infrastructure, or a combination of both. Businesses and facilities categorised according to a mobility profile, depending on employment intensity, car dependency, business activity, visitor intensity and road supply. This decentralisation trend continues in the Structural Vision Infrastructure and Spatial Planning (2012), where the Ladder for Sustainable Urbanisation introduces an instrument that aims to allow spatial development to occur within urban areas and at multimodal accessible locations. Justification for deviating from this principle becomes legally binding.

4.2. Formal Concept Analysis
The FCA enabled us to link the emergent lessons of the multimodal hub concepts to the analytical framework’s dimensions. Table 1 confronts multimodal hub concepts from passenger transport, freight transport and land-use with their (shared) policy objectives, implementability, and outcomes, which are discussed in this paragraph and intermittently complemented with quotes from the interviews.

<table>
<thead>
<tr>
<th>Policy objectives</th>
<th>Passenger transport</th>
<th>Freight transport</th>
<th>Land-use</th>
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<td>Limiting road transport</td>
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<td>Limiting environmental burden</td>
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<td>Economic competitiveness</td>
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<td>Efficient use of space</td>
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<td>Implementability</td>
<td>Confictive policy arrangements</td>
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<td>Market adoption of multimodal transport</td>
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<td>Market organisation under asymmetric competition</td>
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<td>Integrated chain approach</td>
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<td>Compete on GTC</td>
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<td>Destinational area restrictions</td>
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<td>Demand-oriented land-use</td>
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<td>Upscaling transport capacity</td>
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<td>Outcomes</td>
<td>Disputed justification of infrastructure investments</td>
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<td>Counterproductive sprawling effects</td>
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<td>Decentralised instrumentation lacks power</td>
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Table 1: FCA confrontation matrix
4.2.1. Policy objectives
The results suggest that limiting road transport, limiting environmental impact, efficient spatial usage, and improving economic efficiency are the most important policy objectives of the studied concepts. Limiting road transport and its environmental burden is a central objective for all concepts. Land-use oriented policies sought to limit commuter travel through a spatial clustering of housing and employment centres near public transport facilities. Moreover, through transit-oriented development and, to a lesser extent, park-and-ride, it was sought to establish a (partial) modal shift from the car to public transport. For freight transport, it was mainly road congestion and growing passenger rail transport that emphasised the urgency to invest in rail and waterway infrastructure and prevent a reverse shift to the road.

Regarding efficient spatial use, the densely populated Netherlands faces a continuous paradox. The polycentric spatial structure, with medium-sized urban and economic centres scattered across the country, is well connected by various infrastructures. From a transport point of view, further concentrating spatial development is an effective way of stimulating transport via nodes. On the other hand, there is a desire to preserve the scarce rural or green areas. Finally, economic competitiveness was an objective for investing in mainports and inland terminals, given the importance of the logistics sector for the Dutch economy. Moreover, the New Key Projects were strategic locations for strengthening the overall accessibility of vital economic centres.

4.2.2. Implementation barriers
A vital implementation barrier included conflictive policy arrangements, categorised as unsynchronised investments in multimodal and road infrastructure and the erosive competition between multimodal alternatives. The latter potentially obstructs the role of shared modes as complementary to public transport in the last mile (Shaheen & Chan, 2016). The market adoption of transport models that live up to a multimodal hub concept is crucial as travel resistance (GTC) increases with adding transfers in the trip chain. The results suggest that stakeholder support for such initiatives thrives on a shared sense of urgency and necessity. In this argumentation line, subsidising multimodal hub concepts should only be performed once a business case is viable after a period of subsidisation:

“The risk lures that public administrations support market initiatives that are not intrinsically viable.”

Government intervention in the transport market might lead to asymmetric competition among transport providers. For instance, vendor lock-ins might occur when one actor combines terminal and surrounding land ownership, selective subsidisation of logistics providers can create monopoly positions, and price dumping can result from multimodal transport subsidies. Hence, mapping the (in)direct effects of government interventions on different stakeholders operating in the same market is essential to prevent efficiency loss of policy interventions.

4.2.3. Implementation barriers
The discovered enablers indicated that integrated chain approaches could release the burden for people and goods to transfer between modes. An advocated solution is to provide seamless interchanges that meet the heterogenous travel demand to overcome the intermodal transfer burden of multimodal compared to unimodal transport. As one respondent explains:
“The door-to-door movement is powerful. Hence, we seek competing alternatives in terms of convenience, time and cost.”

Second, parking measures for private automobiles and access restrictions for logistics companies in urban areas are disincentives for unimodal transport that arise from the data. Experiences with land-use policies hint at public transport as the structuring mechanism for mixed-use and high-density spatial development in attractively designed urban spaces to generate multimodal transport demand. Correspondingly, in freight transport, cluster development can stimulate shared terminal usage, reduce vehicle mileage, and prevent spatial fragmentation of distribution centres. Next to this societal advantage, supply-chain-related companies can benefit from cost reduction due to shared terminal usage and proximity. However, market competitors generally lack the willingness – except if they operate in market niches – to participate in such shared logistics practices and benefit from collaborative advantages (i.e., horizontal cooperation). Sousa & Mendes-Moreira (2015) argue that shared logistics business models can be viable under profit improvement or a cost-sharing model. Lastly, upscaling transport capacity was a means to allow larger freight volumes and increase frequency for inland rail and waterway transport. This policy materialised in rail and waterway infrastructure expansions, terminal subsidies and organisational innovations to compete with road transport on GTC.

4.2.4. Outcomes
A disputed justification of infrastructure investments occurred in both passenger and freight transport. As one respondent distinctively explains:

“Improving travel convenience is not necessarily found in large megalomaniac constructions. Practical, simple solutions might be satisfactory.”

Moreover, the spatial fragmentation of OD-pairs, insufficient public transport supply evoked automobile usage. In freight transport, uncoordinated municipal acquisition for distribution centres, lack of clustering, and road-oriented location decisions obstructed multimodalisation. To conclude, negative experiences with decentralisation efforts concerning multimodal hub concepts imply that the availability of public transport, inter-municipal coordination in conforming to nationally defined planning frameworks, and a compelling set of instruments to limit parking capacity are essential preconditions for land-use oriented hub policies.

5. Discussion
This paper explored the historical policy lessons of multimodal hub concepts in Dutch transport and land-use planning to inform future policy-making. Central coordination between local governments, creating a just and stimulative framework for market parties to invest in multimodal transport, and a demand-oriented multimodal chain perspective appear to be essential preconditions for implementing multimodal hub concepts. Furthermore, we argue that multimodal hub concepts from passenger transport, freight transport, land-use development appear to shift towards integration. We identify three overarching directions: 1) **Multimodalisation** relates to stimulating the use of multiple modes during a single trip and disincentivising unimodal transport (e.g. terminal subsidies or car parking fees); 2) **Spatial intensification** includes the spatial clustering of trip origins and destinations instead of sprawled spatial patterns (e.g., TOD or logistics parks); and more recently 3) **Resource sharing** involves the
promotion of sharing resources (e.g. infrastructure, terminals, modes) among transport market actors (e.g. bicycle-sharing or cooperative terminal usage). The multidirectional nature of multimodal hub concepts suggests a position within a broader policy package of ancillary measures (Givoni et al., 2013). Figure 4 depicts a triangle in which every corner represents a policy direction, and arrows indicate multimodal hub concepts to show their development over time.

The results of this study are subject to some limitations. First, the qualitative evaluation of multimodal hub concepts using a small orchestrated sample of experts does not allow for an objective historical evaluation. However, the interviews' normative nature does allow to filter the most vital lessons from the respondents' knowledge. Second, the interpretative clustering of interview data using FCA was inevitably subject to author biases. Hence, the results should instead serve as a starting point for discussion than an exhaustive manifest for future policy-making concerning multimodal hubs. Future research could discover the conditions under which competitive erosion between, e.g., public transport and last-mile transport can be avoided. Moreover, the conditions under which shared terminal usage among market competitors can take place can be focal. Finally, developing a coordinative framework for decentral governments to place multimodal hub development within a perspective transcending small-scale and short-term interests.

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