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Analytic hierarchy process for city hub location selection - The Viennese case

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Abstract

Growing urbanization and rising urban freight volumes contribute to increasing congestion, noise and pollution which negatively impact a city's population. City hubs are one means of mitigating this problem by consolidating goods of different suppliers at the hub and cooperating in the last mile delivery. Because of the general shortage of urban space, a major challenge is finding an appropriate location for such a hub. This paper provides a decision support tool based on the analytic hierarchy process for the hub location selection problem, which considers quantitative and qualitative criteria. By involving three stakeholder groups – the municipality, logistics companies and citizens – the approach insures a comprehensive view. The application of the model is tested for the location selection of a midi-hub – a medium-sized city hub – in Vienna. Hence, our results show that a good compromise between different stakeholder views regarding a mid-hub location selection problem can be achieved by the application of our AHP-based decision support tool.

Keywords: Analytic hierarchy process; City hubs; Hub location selection

1. Introduction

Increasing urbanization, growing urban freight transport volumes as well as the main goal of the European Commission's White Paper on Transport, to achieve essentially CO_2-free city logistics in major urban centres by 2030, all require radical changes in current urban freight transport patterns. This is especially important because urban freight

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distribution represents a remarkable share of up to 20% of the total vehicular traffic in urban areas (Campagna et al. 2017).

An additional driver of this development is the fact that urban freight vehicles use a continuously smaller fraction of their load capacity while at the same time they drive longer distances (Olsson and Woxenius 2012). Furthermore, growing e-commerce and increasing numbers of parcels cause additional traffic volumes (Statista DMO 2018). In summary, these trends contribute to rising congestion, noise and pollution especially in urban areas, which have a negative impact on people living there as well as on the climate.

A promising solution to these problems is the use of urban consolidation centres or city hubs with a two-stage urban delivery process (Macharis and Kin 2017). The first stage involves the delivery of goods from outside of the city to the city hub located within the city area. The second stage includes a consolidated last mile distribution of goods to the end receivers. Thus, the number of vehicles entering the urban area can be reduced by a better utilization of freight vehicle capacities. If the second stage is done by electric vehicles or other low-emission vehicles, air pollution and also noise can be decreased even further (Allen et al. 2012).

A major challenge of such a two-stage urban delivery process is finding appropriate transhipment facilities in urban areas, which face a general shortage of urban space anyway. Therefore, the aim of this work is to develop a generic model for inner-city hub location selection taking into account quantitative as well as qualitative factors and different stakeholder groups. An appropriate method to achieve this is the analytic hierarchy process (AHP).

2. Literature review

The idea of city hubs or urban consolidation centres, which are situated near the final delivery area to shorten the final-leg routes as well as to increase responsiveness, is extensively described by Allen et al. (2012). Typically, such centres are used to bundle the flow from outside the city area into the city by means of consolidation (van Rooijen and Quak 2014). Especially if such a centre aims at delivering goods within its near vicinity with emission-free vehicles like cargo bikes, it is usually called a micro-hub or micro-consolidation centre (Bogdanski 2017; Janjevic and Ndiaye 2014). Nevertheless the distinction between urban consolidation centres and micro-consolidation centres is not consistently used in the literature.

An important issue when planning any kind of city hub, is an appropriate location for this hub. Typical criteria for this decision are costs and transportation conditions. Additionally to these economic criteria, environmental as well as social criteria can also be taken into account to tackle all aspects of sustainability. Rao et al. (2015) considered 13 different criteria from all aspects of sustainability to deal with the location selection of a city logistics centre. Muerza et al. (2018) added an operative aspect to the three aspects of sustainability when dealing with the location selection of automated parcel delivery terminals. A different approach is taken by Gogas and Nathanail (2017), who divided the criteria used into qualitative and quantitative ones to find a good location for an urban consolidation centre. Depending on the type of hub specific criteria can also be of importance when, for example, dealing with a military context (Sennaroglu and Varlik Celebi 2018).

Traditionally, hub location selection deals with minimizing costs and/or time (Farahani et al. 2013). Thus, common methods for location selection are rather quantitatively oriented and range from company-driven and pure utility-based analyses to optimization-based facility location and hub location problems (Campbell and O'Kelly 2012; de Keizer et al. 2015). In general, only one objective is tackled in these optimization problems. Nevertheless, also qualitative criteria can be incorporated in such a model quite easily by transforming them into costs (Guyon et al. 2012). On the other hand, also multi-objective optimization can be used to deal with more than one objective (Xifeng, Ji, and Peng 2013). An extensive literature review on facility location problems for city hub location selection can be found in Rao et al. (2015), who focused on weighting chosen indicators by experts and used this information in their decision support tool.

The idea of weighting criteria was already used in the 1980s in the first AHP, which represents an approach to solve complex decision problems (Saaty 1980). With the AHP both, quantitative and qualitative criteria, can be used for a multi-criteria decision-making process. This method can be applied to any decision process and, thus, also for location selection problems. Hong and Xiaohua (2011) deal with the location selection of emergency logistics centres in a multi-objective environment. They used the AHP as constraint in their optimization model. The location selection of a military airport considering multiple objectives can also be done by using a multi-criteria preference index and a compromise ranking list (Sennaroglu and Varlik Celebi 2018). Muerza et al. (2018) combined the AHP with a geographic information system (GIS) for the location selection of automated parcel delivery terminals. Zhao et al.

(2018) considered an AHP to select hubs in a metro network to be used for freight transport in off-peak hours. To our knowledge there is no paper which considers an AHP for the selection of an urban logistics hub from the point of view of different stakeholders, which constitutes the focus of our paper. Furthermore, the type of hub considered in this paper is significantly larger than the micro-hubs mentioned in previous literature.

3. Problem context

We consider a specific type of hub. Important assumptions for our hub are that it has to have the capacity to provide goods to a larger neighbourhood than a micro-hub. Furthermore, our hub should be used by several logistics service providers in a cooperative way (in contrast to proprietary hubs, which are used only by the operating company). This results in a much larger area required than for average micro-hubs. Therefore, we name the type of hubs dealt with in this paper, 'midi-hub'.

To increase the acceptance of a midi-hub and to enhance the chance of a midi-hub's long-term survival, the interests of different stakeholders (city administration, citizens, and logistics service providers) need to be integrated in the decision-making process by balancing interests between transport trips, living space for people and the ecosystem.

Thus, finding an appropriate location for a midi-hub requires a multi-criteria method which takes quantitative as well as qualitative factors into account. Furthermore, considerations of the municipality, the logistics service providers and also the citizens living near a midi-hub are included in our model.

4. Methodological approach

The method used in this paper is based on the AHP. The criteria used for the hub location selection are based on criteria found in the literature which are then discussed with experts/members from all stakeholder groups considered. After the assignment of appropriate weights to all selected criteria, alternative locations for a midi-hub in Vienna are assessed by our decision support tool.

4.1. The analytic hierarchy process

The AHP developed by Saaty (1980) is based on a mathematical procedure that weights individual criteria and assigns points by means of pairwise comparison to these criteria. We follow the methodological structure summarized by Yang and Lee (1997). The hierarchical structure allows the systematic subdivision of the complex overall problem into fundamental components, taking into account their interdependencies (Sipahi and Timor 2010). Thus, the main idea of the AHP is splitting up a complex problem into its constituent elements and then setting up all these elements into a functional hierarchical structure. At the top of the hierarchy, there is only one single element, called the focus. It is the major and overall objective of the decision-making process. The levels below the focus all consist of criteria that usually include five to nine elements per level.

One main task is defining the main criteria for the hub selection process based on the analysis of best practice examples as well as on the scientific literature. In addition, experts are interviewed to combine their insights with the findings from the literature review.

After selecting the criteria which are considered in our decision support tool, experts are asked for their estimations concerning the pairwise comparison of these criteria. This step results in a comparison matrix for each stakeholder group considered. Before using any such matrix for selecting the preferred location of a midi-hub out of a pool of alternative locations, the consistency of each matrix has to be checked (Saaty 1980).

Finally, different hub location alternatives are evaluated based on the selected criteria with respect to the specific criteria weights for each stakeholder group. This yields a preferable alternative for each stakeholder group which provides decision support for the final decision-making step.

4.2. Location selection criteria for midi-hubs

As a basis for our catalogue of criteria for the midi-hub location selection, we checked the respective literature for city hub selection (Gogas and Nathanail, 2017; Muerza et al., 2018; Rao et al., 2015) and adapted the criteria considered in these papers for the decision-making problem at hand.

The resulting collection of criteria was then discussed with experts/members from the city administration, and logistics service providers. The view of citizens was investigated by a workshop with three round table discussions. These steps were conducted to include only those criteria in the location selection process which are seen as essential by all stakeholder groups (city administration, logistics companies, and citizens). Therefore, we do not use aspects like the impact of a hub on the cityscape or labour costs, which are also mentioned as a relevant criteria in the literature, in our model.

The nine criteria initially considered were investment cost, operating cost, transport and distribution cost, reduction of climate-relevant greenhouse gases, reduction of health-relevant emissions (particulate matters, NO_x) and noise, increase in safety and security, inbound logistics to the hub, outbound logistics from the hub and existing/available infrastructure at the hub. As these criteria consider three main types – costs, environmental and social aspects and location-specific characteristics and features, we used a two-level criteria scheme for our AHP depicted in Fig. 1.

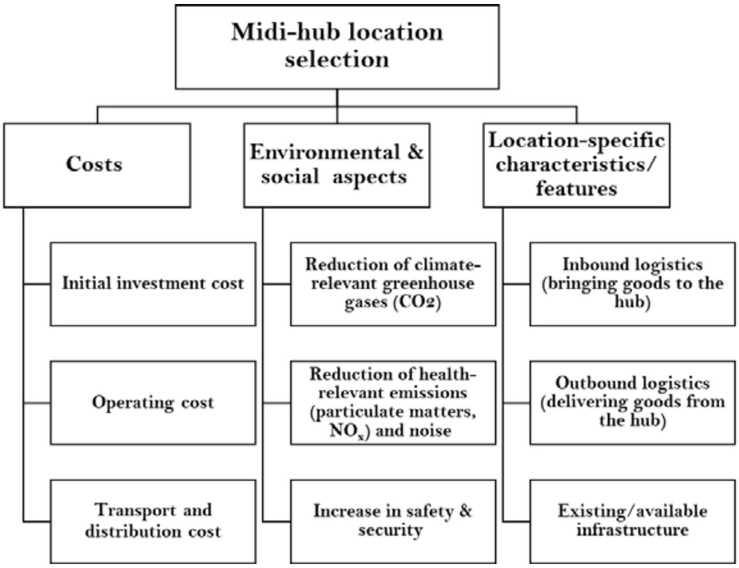


Fig. 1. Two-level criteria scheme for midi-hub location selection.

4.3. Weighting of location criteria

We set up an online survey to facilitate the pairwise comparison of the selected criteria first on the main level and then on the sub-levels (see Fig. 1). For each pair of criteria we first asked which criterion is seen as more important or if they are seen as equally important (see Fig. 2).

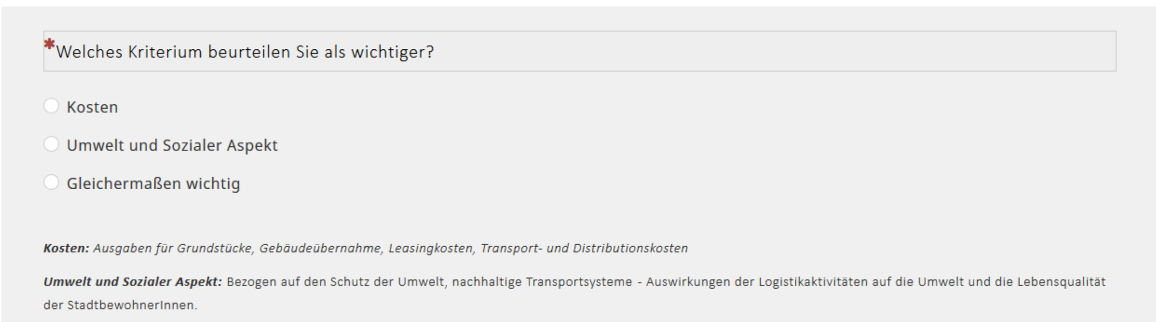
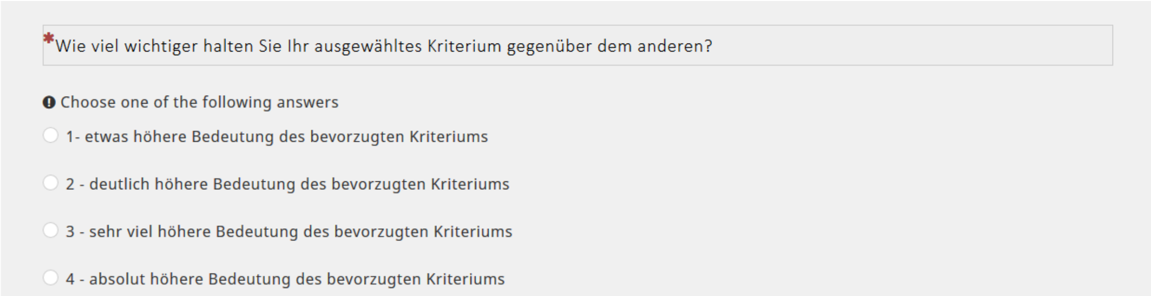


Fig. 2. First part of survey question; survey available in German only.

This corresponds to an evaluation value of 1 in the standard AHP. If one criterion is seen as more important, a second question pops up in which the relative importance is rated (see Fig. 3). The answers correspond to an evaluation value of 3, 5, 7 and 9 respectively in the standard AHP (Goepel 2018).


*Wie viel wichtiger halten Sie Ihr ausgewähltes Kriterium gegenüber dem anderen?

Choose one of the following answers

1- etwas höhere Bedeutung des bevorzugten Kriteriums

2 - deutlich höhere Bedeutung des bevorzugten Kriteriums

3 - sehr viel höhere Bedeutung des bevorzugten Kriteriums

4 - absolut höhere Bedeutung des bevorzugten Kriteriums

Fig. 3. Second part of survey question; survey available in German only.

This survey was forwarded to heads and staff members of the departments 'City-planning', 'Organization of traffic' and 'Economy, labor and statistics' of the city administration and several logistics companies which work in Vienna. The survey was answered by eight members of the municipality of Vienna and 16 participants from logistics companies. To cover the view of Viennese citizens we conducted a stakeholder workshop, where we explained and discussed the criteria and the general idea of pairwise comparison before guiding the 22 participating citizens through the survey.

For all evaluation steps in the AHP we used the spreadsheet tool by Goepel (2018), which provides all required calculations and consistency checks. Some minor adaptions for single survey answers were done to guarantee consistency, but the general direction of preferences was never required to be changed.

Table 1. Summary of weighting of criteria by all stakeholder groups.

Main criteria	**Sub-criteria**	**City administration**			**Logistics companies**			**Citizens**		
		Weights	Weights	Importance	Weights	Weights	Importance	Weights	Weights	Importance
Costs		0.322			0.367			0.125		
	Initial investment cost		0.243	7.8%		0.233	8.6%		0.171	2.1%
	Operating cost		0.292	9.4%		0.295	10.8%		0.367	4.6%
	Transport and distribution cost		0.465	15.0%		0.472	**17.3%**		0.462	5.8%
Environmental and social aspects		**0.464**			0.204			0.421		
	Reduction of climate-relevant greenhouse gases		0.392	**18.2%**		0.316	6.4%		0.241	10.1%
	Reduction of health-relevant emissions (particulate matters, NO_x) and noise		0.405	**18.8%**		0.477	9.7%		0.427	**18.0%**
	Increase in safety and security		0.202	9.4%		0.206	4.2%		0.333	14.0%
Location-specific characteristics and features		0.214			**0.429**			**0.455**		
	Inbound logistics to the hub		0.312	6.7%		0.380	16.3%		0.309	14.1%
	Outbound logistics from the hub		0.571	12.2%		0.444	**19.0%**		0.386	**17.6%**
	Existing/available infrastructure at the hub		0.116	2.5%		0.176	7.6%		0.304	13.8%

The evaluation of the survey results (a summary of the weighting of criteria of all stakeholder groups is depicted in Table 1) shows that the city administration sees the environmental and social aspects as the most important ones with focus on the reduction of health-relevant emissions and noise first and the reduction of climate-relevant greenhouse gases second. The group consensus is moderate with values from 65.4% to 70.2% and the consistency ratios range from 0.4% to 1.0% (for details on the calculation of consistency ratio and group consensus we refer the interested reader to Saaty (1980) and Goepel (2018)).

Logistics companies see the location-specific characteristics and features as most important with a focus on the outbound logistics from the hub. Although the inbound logistics to the hub is also seen as important (on third place), the second important sub-criterion is the transport and distribution cost. The group consensus is moderate to very high with values from 67.5% to 86.7% and the consistency ratios range from 0.0% to 0.5%.

The evaluation of the surveys of citizens yields an interesting result because the location-specific characteristics and features are seen as slightly more important than the environmental and social aspects. Nevertheless, the reduction of health-relevant emissions and noise are the most important sub-criterion followed by the outbound logistics from the hub. The group consensus is low to moderate with values from 51.4% to 68.4% and the consistency ratios range from 0.1% to 0.7%. Because of the low group consensus we split this stakeholder group in parts to see if there are more homogeneous groups and found that there are two groups both with a high group consensus of 81% and 76.5%. The first group puts a clear focus on the environmental and social aspects with the highest importance to the reduction of health-relevant emissions and noise and then to the increase in safety and security. The second group puts a clear preference to the location-specific characteristics and features seeing existing/available infrastructure at the hub as most important and inbound logistics to the hub taking second place.

4.4. Weighting of alternatives

After deriving the comparison matrices for the stakeholder groups six potential hub locations (A, B, C, D, E and F) were identified in cooperation with the project partners. All hub locations considered are in vicinity to the inner districts of Vienna but the specific locations are not named in detail in this paper because of the work-in-progress status of the underlying project.

For the pairwise comparison of hub locations, indicators for the selected sub-criteria need to be identified, which are listed in Table 2.

Table 2. Sub-criteria and indicators.

Sub-criteria	**Indicator**
Initial investment cost	Real estate prices near hub location
Operating cost	Based on discussions with logistics companies
Transport and distribution cost	Based on discussions with logistics companies
Reduction of climate-relevant greenhouse gases	Number of E-charging stations in vicinity Access to bike lanes
Reduction of health-relevant emissions (particulate matters, NO_x) and noise	Noise/air-quality maps Population density in vicinity
Increase in safety and security	Number of accidents
Inbound logistics to the hub	Traffic situation Access to high-level roads Access to rail
Outbound logistics from the hub	Access to E-charging stations Access to bike lanes
Existing/available infrastructure at the hub	Based on field-trip to potential hub locations

Because of the work-in-progress status of the project, discussions with logistics companies are not finished yet. Therefore, we evaluate sub-criteria operating cost and transport and distribution cost equally for all locations. Comparing the six alternative locations in a pairwise manner yields the comparison matrix shown in Table 3.

Table 3. Weighting of alternatives A-F for each criterion.

Sub-criteria	A	B	C	D	E	F
Initial investment cost	0.126	0.275	0.033	0.393	0.15	0.023
Operating cost	0.167	0.167	0.167	0.167	0.167	0.167
Transport and distribution cost	0.167	0.167	0.167	0.167	0.167	0.167
Reduction of climate-relevant greenhouse gases	0.167	0.167	0.167	0.167	0.167	0.167
Reduction of health-relevant emissions (particulate matters, NO_x) and noise	0.029	0.078	0.14	0.257	0.045	0.45
Increase in safety and security	0.044	0.268	0.027	0.438	0.138	0.085
Inbound logistics to the hub	0.121	0.26	0.26	0.065	0.034	0.26
Outbound logistics from the hub	0.388	0.081	0.283	0.151	0.061	0.036
Existing/available infrastructure at the hub	0.053	0.253	0.032	0.434	0.149	0.08

The ranking of alternatives for each stakeholder group is then derived by multiplying the weights for each criterion of a specific alternative (see Table 3) by the respective criterion weights depicted in Table 1. Detailed results depicted in Table 4 show that all stakeholder groups favor alternative D and alternative E is the least preferred alternative. Candidates on second place are alternatives F and B. Here, the difference in the group of the citizens is obvious: group 1 behaves like the city administration and group 2 is comparable to the logistics companies (see right part of Table 4).

Table 4. Ranking of alternatives for each stakeholder group.

City administration	Logistics companies	Citizens	Citizens group 1	Citizens group 2
D	D	D	D	D
F	B	B	F	B
B	C	C	B	F
C	A	A	C	C
A	F	F	A	A
E	E	E	E	E

To sum up, for the midi-hub location selection problem in Vienna a clear preference of all stakeholder groups to alternative D can be distinguished, which gives a strong decision support to all parties involved for placing a midi-hub at this location.

5. Conclusion

In this paper, we consider the use of the AHP for a midi-hub location selection problem. We define a midi-hub as an urban hub which is located in the vicinity of the city centre but which is significantly larger than already discussed micro-hubs. The advantage of the AHP is its multi-criteria approach which can take into account quantitative as well as qualitative criteria. In addition, different points of view of several stakeholder groups can be incorporated.

We include the view of three different stakeholder groups (city administration, logistics companies and citizens) represented by different comparison matrices in our decision support tool. The basis for this tool is a literature review on location selection criteria. These criteria were then discussed with experts of all stakeholder groups to figure out the important criteria for the location selection of a midi-hub in Vienna.

Based on the defined indicators for each criterion the selected potential hub locations are evaluated in a pairwise manner to get the second relevant part of our decision support tool. Weighting this weighted list of hub locations by the comparison matrix of each stakeholder group shows differences but also commonalities in preferences for the potential hub locations. Hence, a good compromise between different stakeholder views regarding a midi-hub location selection problem can be achieved by the application of our AHP-based decision support tool.

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References

Allen, Julian, Michael Browne, Allan Woodburn, and Jacques Leonardi. 2012. 'The Role of Urban Consolidation Centres in Sustainable Freight Transport'. *Transport Reviews* 32 (4): 473–90. https://doi.org/10.1080/01441647.2012.688074.

Bogdanski, Ralf. 2017. *Nachhaltigkeitsstudie 2017: Bewertung der Chancen für eine nachhaltige Stadtlogistik*. Berlin: Bundesverband Paket und Expresslogistik e. V. http://www.biek.de/index.php/studien.html?file=tl_files/biek/Nachhaltigkeitsstudie%202017/BIEK_Nachhaltigkeitsstudie_2017.pdf.

Campagna, Andrea, Alexander Stathacopoulos, Luca Persia, and Elpida Xenou. 2017. 'Data Collection Framework for Understanding UFT within City Logistics Solutions'. *Transportation Research Procedia* 24: 354–61. https://doi.org/10.1016/j.trpro.2017.05.100.

Campbell, James F., and Morton E. O'Kelly. 2012. 'Twenty-Five Years of Hub Location Research'. *Transportation Science* 46 (2): 153–69. https://doi.org/10.1287/trsc.1120.0410.

Farahani, Reza Zanjirani, Masoud Hekmatfar, Alireza Boloori Arabani, and Ehsan Nikbakhsh. 2013. 'Hub Location Problems: A Review of Models, Classification, Solution Techniques, and Applications'. *Computers & Industrial Engineering* 64 (4): 1096–1109. https://doi.org/10.1016/j.cie.2013.01.012.

Goepel, Klaus D. 2018. 'Implementation of an Online Software Tool for the Analytic Hierarchy Process (AHP-OS)'. *International Journal of the Analytic Hierarchy Process* 10 (3): 469–87. https://doi.org/10.13033/ijahp.v10i3.590.

Gogas, Michael A., and Eftihia Nathanail. 2017. 'Evaluation of Urban Consolidation Centers: A Methodological Framework'. *RelStat-2016: Proceedings of the 16th International Scientific Conference Reliability and Statistics in Transportation and Communication October 19-22, 2016. Transport and Telecommunication Institute, Riga, Latvia* 178 (January): 461–71. https://doi.org/10.1016/j.proeng.2017.01.089.

Guyon, Olivier, Nabil Absi, Dominique Feillet, and Thierry Garaix. 2012. 'A Modeling Approach for Locating Logistics Platforms for Fast Parcels Delivery in Urban Areas'. *Seventh International Conference on City Logistics Which Was Held on June 7- 9,2011, Mallorca, Spain* 39: 360–68. https://doi.org/10.1016/j.sbspro.2012.03.114.

Hong, Liu, and Zhang Xiaohua. 2011. 'Study on Location Selection of Multi-Objective Emergency Logistics Center Based on AHP'. *CEIS 2011* 15 (January): 2128–32. https://doi.org/10.1016/j.proeng.2011.08.398.

Janjevic, Milena, and Alassane Ballé Ndiaye. 2014. 'Development and Application of a Transferability Framework for Micro-Consolidation Schemes in Urban Freight Transport'. *Procedia - Social and Behavioral Sciences*, Eighth International Conference on City Logistics 17-19 June 2013, Bali, Indonesia, 125 (March): 284–96. https://doi.org/10.1016/j.sbspro.2014.01.1474.

Keizer, Marlies de, René Haijema, Jacqueline M. Bloemhof, and Jack G.A.J. van der Vorst. 2015. 'Hybrid Optimization and Simulation to Design a Logistics Network for Distributing Perishable Products'. *Computers & Industrial Engineering* 88 (October): 26–38. https://doi.org/10.1016/j.cie.2015.06.017.

Macharis, Cathy, and Bram Kin. 2017. 'The 4 A's of Sustainable City Distribution: Innovative Solutions and Challenges Ahead'. *International Journal of Sustainable Transportation* 11 (2): 59–71. https://doi.org/10.1080/15568318.2016.1196404.

Muerza, Victoria, Emilio Larrodé, Jose-María Moreno-Jimenez, and Alejandro Jiménez. 2018. 'Modelling the Problem of Parcel Distribution in Urban Environments and Analysis of the Determining Factors'. *XIII Conference on Transport Engineering, CIT2018* 33 (January): 347–54. https://doi.org/10.1016/j.trpro.2018.10.112.

Olsson, Jerry, and Johan Woxenius. 2012. 'Location of Freight Consolidation Centres Serving the City and Its Surroundings'. *Procedia - Social and Behavioral Sciences* 39: 293–306. https://doi.org/10.1016/j.sbspro.2012.03.109.

Rao, Congjun, Mark Goh, Yong Zhao, and Junjun Zheng. 2015. 'Location Selection of City Logistics Centers under Sustainability'. *Transportation Research Part D: Transport and Environment* 36 (May): 29–44. https://doi.org/10.1016/j.trd.2015.02.008.

Rooijen, Tariq van, and Hans Quak. 2014. 'City Logistics in the European CIVITAS Initiative'. *Procedia - Social and Behavioral Sciences*, Eighth International Conference on City Logistics 17-19 June 2013, Bali, Indonesia, 125 (March): 312–25. https://doi.org/10.1016/j.sbspro.2014.01.1476.

Saaty, Til. 1980. *The Analytic Hierarchy Process: Planning, Priority Setting, Resources Allocation*. New York: McGraw.

Sennaroglu, Bahar, and Gulsay Varlik Celebi. 2018. 'A Military Airport Location Selection by AHP Integrated PROMETHEE and VIKOR Methods'. *Transportation Research Part D: Transport and Environment* 59 (March): 160–73. https://doi.org/10.1016/j.trd.2017.12.022.

Sipahi, Seyhan, and Mehpare Timor. 2010. 'The Analytic Hierarchy Process and Analytic Network Process: An Overview of Applications'. *Management Decision* 48 (5): 775–808. https://doi.org/10.1108/00251741011043920.

Statista DMO. 2018. 'ECommerce Report 2018'. did-42404-1. Statista Digital Market Outlook - Market Report. Hamburg: Statista. https://de.statista.com/statistik/studie/id/42404/dokument/ecommerce-report-2018/.

Xifeng, Tang, Zhang Ji, and Xu Peng. 2013. 'A Multi-Objective Optimization Model for Sustainable Logistics Facility Location'. *Transportation Research Part D: Transport and Environment* 22 (July): 45–48. https://doi.org/10.1016/j.trd.2013.03.003.

Yang, Jiaqin, and Huei Lee. 1997. 'An AHP Decision Model for Facility Location Selection'. *Facilities* 15 (9/10): 241–54. https://doi.org/10.1108/02632779710178785.

Zhao, Laijun, Huiyong Li, Meichen Li, Yan Sun, Qingmi Hu, Shirong Mao, Jianguang Li, and Jian Xue. 2018. 'Location Selection of Intra-City Distribution Hubs in the Metro-Integrated Logistics System'. *Tunnelling and Underground Space Technology* 80 (October): 246–56. https://doi.org/10.1016/j.tust.2018.06.024.