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Parcel lockers feasibility analysis considering multi-stakeholder perspectives

Nilesh Anand[a,b], Md. Sujan Mahmud[a], Ron van Duin[b,c]

[a]*Rotterdam Business School, Rotterdam Universit of Applied Science, Kralingse Zoom 91, 3063 ND Rotterdam, The Netherlands*
[b]*Centre of Expertise, Rotterdam Universit of Applied Science, 3089 JB Rotterdam, The Netherlands*
[c]*Delft University of Technology, 2628BX Delft, The Netherlands*

Abstract

The rapid growth of online shopping and B2C transactions, coupled with the increased demand for doorstep deliveries, has made last-mile delivery a major concern in the e-commerce industry. Traditional delivery methods are costly and unsustainable, leading to a rise in greenhouse gas emissions due to the increasing number of delivery vehicles. Parcel lockers at a public transportation location are one of the potential solutions for this problem. However, due to involvement of different stakeholders, it is important to consider perspective of these stakeholders before implementing a parcel locker. The research proposes a framework based on the MCDM methodology, particularly the Multi-Attribute-Multi-Criteria Analysis (MAMCA) approach using the best-worst method. A case of Beurs metro station in the city of Rotterdam is evaluated using the proposed framework. The result of case study concludes that parcel delivery companies and receivers are (highly) positive 142% and 119% respectively) for parcel locker delivery system at public transport location. However, the public transport operator is not very positive (only 5%) about installing lockers at the transport location. The transport operator is mostly concern about passenger safety as it shows negative perception in the result. The limited space available at the busy transport location, combined with the high volume of passengers using public transport, make it difficult to find suitable areas to install the lockers without impeding passenger flow demands meticulous planning and optimisation of available space. The result shows that safety is also concern of the receivers and the parcel delivery company. The research shows how the proposed framework can be used to assess bottleneck criteria for successful implementation of parcel lockers.

Keywords: City logistics; parcel locker; multi-stakeholder; MAMCA method

1 Introduction and motivation

There are six major different types of electronic commerce available based on their characteristics, such as Business-to-Business (B2B), Business-to-Consumer (B2C), Consumer-to-consumer (C2C), Consumer-to-business (C2B), Business-to-administration (B2A) and Consumer-to-administration (C2A) but among them, B2B and B2C are the most growing business models (Gupta, 2014) (Jain et al., 2021). As the B2C Business model offers a direct product flow to customers, which entails the transfer of products from a supplier to a consumer as well as any customer returns or service requirements, lots of logistics activities are involved with it which makes the procedure more complex.

Scholars acknowledge that the most concerning part of B2C e-commerce is the last-mile delivery (Boysen et al., 2018; CarbonCare, 2023; Wang et al., 2014). Since most e-commerce businesses provide a very quick delivery, sometimes even a next-day delivery, it is the responsibility of the transportation provider companies to meet these demands. Wang et al. (2014) mentioned that the last mile is more complicated than ever because of the rising demand for e-commerce, which also raises the demand for the delivery of parcels. According to van Amstel (2018), The traditional home delivery model by delivery personnel used today is a backdated method of handling the last-mile delivery process for transport provider companies which is more costly, time-consuming, and unsustainable. Over half of a company's transportation costs are linked to last-mile deliveries (over 53%) and the highest proportion is attributed to delivery employees (Tourmo, 2023). As an example, for PostNL, employee expenditure accounts to be for 72% of a single parcel's total delivery costs (J. Klerx, personal communication, June 12, 2023).

One area of focus for improving overall delivery efficiency lies in enhancing the handover process of parcels to customers. This involves activities such as parking, navigating buildings, and reaching the customer's location, and it holds significant potential for efficiency gains (Seattle Department of Transportation, 2019). In response to these challenges, postal operators and logistics companies have invested in value-added services, including the

provision of delivery to manned or automated collection points. These alternative delivery options, known as Collection-and-Delivery Points (CDP) solutions, can be classified into two main categories: pick-up points and automated parcel lockers.

When considering the integration of freight and passenger transportation through the assessment of parcel locker implementation locations, several studies have identified Contracting authorities, vehicle operating companies, and the public as key stakeholders (Kedia et al., 2017; Lee et al., 2019; Macharis et al., 2010). These stakeholders play vital roles, and their involvement is critical for the successful implementation and operation of parcel locker systems. Efficient location selection is paramount in maximising customer satisfaction and facilitating the widespread adoption of parcel locker solutions. The primary goal is to ensure the seamless and convenient utilisation of these lockers. This research specifically focusses on parcel lockers, considering their unique considerations, including security, accessibility, and interaction with automated systems. Parcel lockers offer distinct advantages over traditional pick-up points in shops or supermarkets, such as their availability 24/7, extending beyond the typical operating hours of retail establishments.

Inadequate location selection for parcel lockers can lead to significant financial losses, including missed revenue opportunities and unrealized investments. Despite the existence of various scientific models for facility location selection (Deutsch & Golany, 2017; Lee et al., 2019; Wang et al., 2017), a comprehensive framework tailored specifically for assessing the suitability of locations for establishing parcel lockers is lacking in the literature. Accordingly, this research focusses on evaluating suitability of parcel locker facilities at public transportation premises by considering perception of multiple associated stakeholders. This research aims at exploring factors that positively and negatively affecting parcel location implementation at public transportation premises.

The rest of the article is organised as following. Section 2 gives brief overview of the parcel locker research focussing mainly on criteria for successful implementation of parcel lockers. Section 3 gives details about research methods used in this research for evaluating parcel location. Section 4 gives detail analysis of perceptions of different stakeholders for parcel location at public transportation points. Finally, Section 5 gives insights gained from this research about implementation of parcel lockers in public transportation premises.

2 Literature review

Parcel lockers play a crucial role in streamlining logistics operations for service providers by effectively addressing issues such as failed home deliveries and optimising the utilisation of delivery trucks. Parcel lockers not only improve operational efficiency and punctuality but also reduce the environmental impact of last-mile delivery (Xiao et al., 2018).

Public transport providers are integrating parcel locker facilities into their infrastructure to enhance services and passenger convenience. Commuters can quickly pick up and drop off their packages at transit stations, alleviating the need to be present at home for deliveries. Transport for Greater Manchester (TfGM) in England and Deutsche Bahn (DB) in Germany are examples of public transport operators that have implemented parcel lockers at tram and train stations, respectively, to facilitate seamless package collection for their passengers (Dan Symonds, 2022; Muir, 2020).

The integration of passenger and freight transport through a parcel locker system requires careful consideration of various key factors (Wang et al., 2022). Lagorio & Pinto (2020) mentioned that these considerations encompass aspects ranging from infrastructure planning and system compatibility to security measures, locker design, location suitability and operational efficiency. Additionally, user experience, regulatory compliance, and sustainability must also be taken into account to ensure the system's success.

Parcel locker location: According to Lagorio & Pinto (2020), choosing the appropriate locations for parcel locker installations is crucial because there is not much potential to select a place which does have security, good accessibility, and interaction with the residents. Optimal locations would be strategically placed where they can cater to a significant volume of users while minimising the distance travelled for both deliveries and pickups (Peppel & Spinler, 2022). Additionally, considering the convenience of users, parcel lockers should be easily accessible and preferably located in well-lit and secure areas to ensure the safety of stored parcels.

Below, a brief overview of different important factors is given found in literature for parcel locker implementation:

Availability: The parcel locker system should ensure a high level of availability to accommodate both passenger and freight transport needs (Zenezini et al., 2018).

Accessibility: The system should be designed to be accessible to both passengers and freight carriers. The lockers should be conveniently located in easily accessible areas, such as transportation hubs, residential complexes, or commercial areas (Lemke et al., 2016). They should be designed to accommodate parcels of various seizes, including both small packages and larger freight shipments. Additionally, the lockers should be accessible for more hours possibly 24/7 as most customers utilise lockers on weekends or during branch closure times (Alexandra Lagorio & Roberto Pinto, 2020).

Cost: Both the consumers and the courier sides significant importance on cost because they are both seeking options that would lower the overall delivery cost (Lagorio & Pinto, 2020). Cost involves assessing the initial investment required for lockers, infrastructure modifications, and technological components, as well as ongoing operational costs like maintenance, power consumption, connectivity charges, and staffing (Peppel & Spinler, 2022) .

Security: Security is a crucial consideration to protect the parcels and ensure the trust of users. The parcel locker system should employ robust security measures, such as tamper-proof locks, surveillance cameras, and access control systems. Additionally, authentication methods, like unique codes or digital keys, should be used to ensure that only authorised individuals can access the lockers (Lachapelle et al., 2018).

User experience: According to Wang et al. (2022), the user experience should be a priority in the design of the parcel locker system. User-friendly interfaces, clear instructions, and intuitive processes should be implemented to ensure that passengers and freight carriers can easily access, deposit, and retrieve their parcels (Moslem & Pilla, 2023). Feedback mechanisms can also be incorporated to gather user insights and continuously improve the system.

Sustainability and Environmental Impact: Consider environmental factors and strive to minimise the carbon footprint of the integrated transport system. The design should prioritise sustainability and minimise the environmental impact of the parcel locker system (Peppel & Spinler, 2022). This can be achieved by using energy-efficient technologies, incorporating renewable energy sources, and promoting eco-friendly practices such as recycling and reducing packaging waste (Iwan et al., 2016).

In conclusion, according to Wang et al. (2022), designing a framework for integrating passenger and freight transport through a parcel locker system requires careful consideration of various factors. By considering these key factors, a well-designed framework for integrating passenger and freight transport through a parcel locker system can enhance convenience, efficiency, and sustainability in the transportation network.

3 Methods Applied

Multi-Actor Multi-Criteria Analysis (MAMCA) is a decision-making method that allows for the evaluation of multiple alternatives simultaneously, taking into account the opinions of different stakeholders (Macharis et al., 2010b). The key advantage of MAMCA over other Multi-Criteria Decision Making (MCDM) methods is its explicit consideration of stakeholder opinions. Macharis (2005) mentioned that by involving stakeholders early in the process, decision-makers gain a better understanding of the problem and insight into the perspectives of different stakeholders. The method involves multiple stakeholders to incorporate diverse perspectives and preferences. This research uses the MAMCA methodology for evaluating parcel lockers at public transportation locations. The method consists of seven phases namely defining alternatives, selecting actors, criteria and their weights, finding the indicators, normalizing the values, overall analysis and finally getting the result and implementation.

To decide weights for criteria, there are many MCDM methods are available. Ceballos et al., (2016) gives detail analysis of different MCDM method evaluating pros and cons of each method. For this research, we use BWM (Best-Worst Method) by Rezaei (2015). BWM is a simple yet effective decision-making technique for multi-criteria problems. It determines criteria importance based on best and worst rankings, offering valuable support for decision-making processes. Excel analysis refers to the use of Microsoft Excel or other statistical software like BWM solver to analyse and interpret the collected quantitative data. After receiving information about the preferences of different criteria from stakeholders, the following step was to calculate the weights of the criteria using BWM solver that is done with Excel. By using these weights and measuring indicator from desk research, this excel analysis determines the final score to select the best alternative to design a framework for implementing a parcel locker system.

In this research, interviews are conducted with stakeholders such as passengers and receivers, public transport companies, and parcel delivery companies. The interviews are semi-structured, allowing for flexibility in exploring relevant information for parcel locker framework. Both open and close-ended questions are used to encourage participants to provide detailed responses and share their perceptions, opinions, and suggestions regarding the implementation of a parcel locker. Once the data from interviews, surveys, and document research had been analysed, member-checking is being conducted. As this research uses MAMCA where experts are involved to review the results, this process involves sharing the findings with the stakeholders and experts who participated in the research or have knowledge about the integration. They were given the opportunity to review the findings, provide feedback, and confirm the accuracy and interpretation of their responses.

4 Evaluating parcel locker feasibility at public transport location using multi-stakeholder perspectives

Based on the literature research of BWM and MAMCA methods, the following framework for implementing an integrated parcel locker system has been developed.

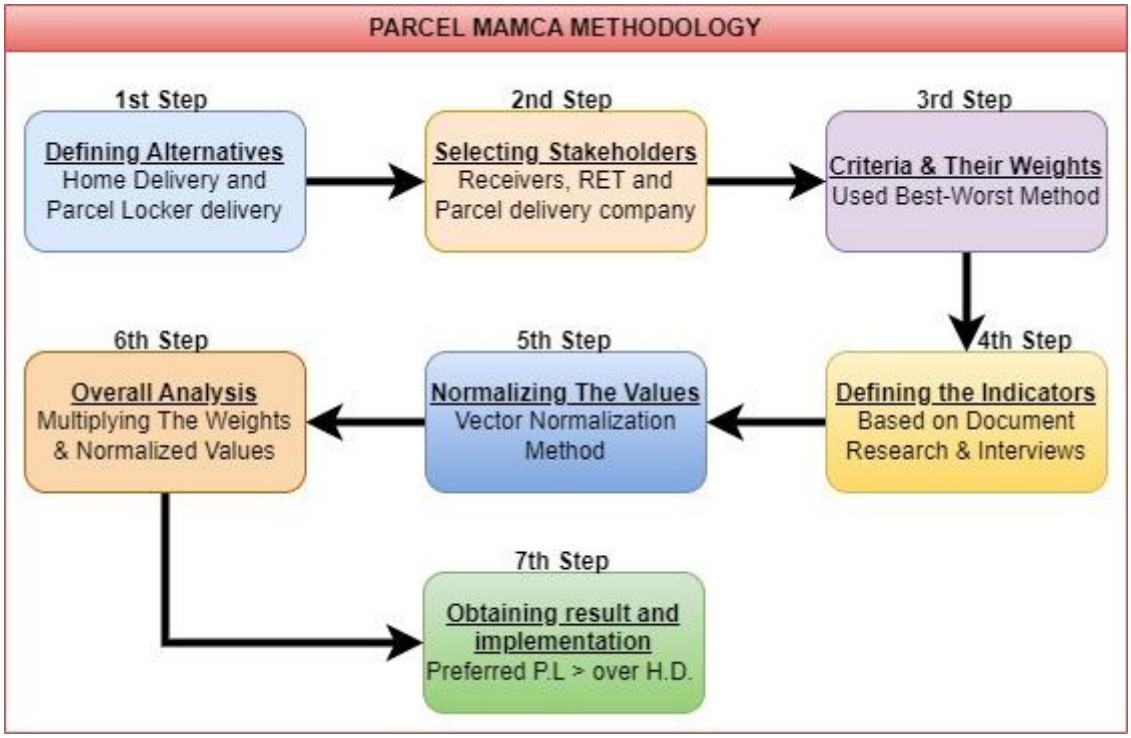

Figure 1: Generalized Integrated Parcel Locker Framework

In the following text, each step from the framework is executed and explained. Above mentioned framework is used for evaluating integrated parcel locker at Beurs metro location in the city of Rotterdam in The Netherlands.

4.1 Selecting alternatives:

For this research, we are evaluating between alternative of using of parcel lockers at a public transportation location and receiving parcel at home.

4.2 Selecting stakeholders:

Key stakeholders in this context may include logistics companies, transportation authorities, e-commerce businesses, parcel locker operators, passengers, local communities, and regulatory bodies. However, all the stakeholders and their perceptions are not important for any research (Brugha & Varvasovszky, 2000). In this research, the three most important stakeholders, namely Receivers/Passengers, Parcel Delivery Companies and Public Transport Operator are only considered. A brief description is given below for each main stakeholder.

Table 1: Brief description of three most important stakeholders associated with parcel lockers at public transport location

Stakeholder	Goal	Power and interest	Responsibilities
Receiver	Their objectives may include receiving packages in a convenient and secure manner, minimising missed deliveries, and having control over delivery timings.	Receivers have moderate power and high interest in the research as they are the ultimate beneficiaries of efficient and reliable parcel delivery. They can influence the demand for delivery services and provide feedback on their experience.	Receivers are the end customers who receive parcels through the delivery process.
Parcel delivery company	Their objectives may include improving last-mile delivery efficiency, reducing costs associated with failed delivery attempts, and enhancing customer satisfaction.	Parcel delivery companies have high power and interest in the research as they directly deal with last-mile delivery challenges. They have the expertise and resources to implement new solutions like parcel lockers.	Parcel delivery companies are responsible for transporting and delivering parcels to customers.

Public transport operator	Their objectives may include ensuring efficient and reliable transportation, reducing congestion, and improving the overall passenger experience.	Public transport operators have high power and interest in the research as they are directly involved in urban transportation and may benefit from the integration of passenger and freight transport through a parcel locker system. They have the authority to implement changes in their operations.	Public transport operators are responsible for providing transportation services to the public, including bus, train, or metro services.

4.3 Criteria and weights:

In previous section, an overview of important criteria for parcel lockers is given. Based on the list of criteria from literature and interviews with stakeholder as well as city logistics experts, a final list of criteria was derived. Best worst method (BWM) was employed as a multi-criteria method for identifying the ranking and weights of the criteria for each stakeholder. BWM allows for the systematic determination of relative importance among the identified criteria (Vieira et al., 2022). The method involves a pairwise comparison process, where participants are asked to evaluate the criteria in terms of their significance concerning the research objectives (Rezaei, 2015). In this research, each stakeholder was asked to indicate which criterion is the best and which is the worst in each comparison and compare each criterion with most and least important criteria. The collected data from these pairwise comparisons are then used to calculate the weights of the criteria through a mathematical process that considers the relative priority assigned to each criterion by the participants. Here, the nature of criterion ust be noted. If a criterion has negative impact on the perception of the actors, then having higher value of these criteria indicates lower preferences of the stakeholders. For example, higher value of the delivery cost means less preferred by the related actors. Such negatively impacting criteria are mentioned with underlines and normalising values are calculated differently for them.

Table 2: Criteria Weights as per stakeholders' perceptions

Receivers		Parcel Companies		Public Transport Operator	
Criteria	Weights	Criteria	Weights	Criteria	Weights
Delivery Time (-ve)	0.38	Operational cost (-ve)	0.28	Passenger Satisfaction (+ve)	0.28
Delivery Cost (-ve)	0.22	Delivery Time (-ve)	0.28	Passenger Safety (+ve)	0.27
Convenience (+ve)	0.2	Accessibility (+ve)	0.21	Number of passengers (+ve)	0.26
Safety of parcel (+ve)	0.11	Safety of parcel (+ve)	0.17	Accessibility (+ve)	0.13
Accessibility (+ve)	0.09	Emission (-ve)	0.06	Additional revenue (+ve)	0.06
Sum	1.00		1.00		1.00

Here -ve means More is worse and +ve means More is better

For the Receivers, who are the end-users of both public transport services and parcel delivery, "Delivery Time" is deemed the most critical criterion with a substantial weight of 0.38, indicating their strong emphasis on timely parcel deliveries. Safety of parcels (0.11) and Accessibility (0.09) aren't too much important to them. For parcel delivery companies, operational cost, delivery time and accessibility of parcel are the most important criteria with respective weights of 0.28, 0.28 and 0.21. These weights indicate their focus on optimising delivery operations to achieve cost efficiency and complete timely parcel deliveries to meet customer expectations. However, these companies show less significance on emissions. Transport operator places the highest importance on Passenger Satisfaction, Passenger Safety and Number of passengers (using public transportation) with almost similar weights that are 0.28, 0.27 and 0.26 respectively because they emphasize on improving the user experience by providing safety and security.

4.4 Defining indicators

Based on the document research and conducted interviews with the relevant stakeholders, the quantitative values of the indicators are identified. The criteria indicators related to receivers and parcel companies are considered based on information from literature such as (Giuffrida et al., 2016; Van Duin et al., 2020) (OV-Klantenbarometer-I&O Research, 2016) with additional information from interviews with passenger, parcel delivery companies and public operator representatives. The delivery cost for the receivers was calculated by adding 25% extra with the delivery cost of parcel company. The impact on the operation is the number of passengers and integration experts

predicts that the passengers will increase by around 5% while integrating the public and freight transport at Beurs metro station. So, the additional revenues and impact on operation are 5% higher for parcel delivery.

Tables 3, 4 & 5 show criteria indicators for each stakeholder. Here H.D (Home delivery) and L.D (Locker delivery) are the abbreviation of the two alternatives.

Table 3: Criteria indicators for Receivers

Receivers				
Criteria	Weights	H.D.	L.D.	Unit
Notation	w	x	y	
Formula				
Delivery Time (-ve)	0.38	24	12	Hours
Delivery Cost (-ve)	0.22	2.8125	0.9375	Euro/parcel
Convenience (+ve)	0.2	5	6.13	Factor (1 to 10)
Safety of parcel (+ve)	0.11	5	4.783	Factor (1 to 10)
Accessibility (+ve)	0.09	5	8	Factor (1 to 10)

Table 4: Criteria indicators for Parcel Companies

Parcel Companies				
Criteria	Weights	H.D.	L.D.	Unit
Operational cost (-ve)	0.28	2.25	0.75	Euro/parcel
Delivery Time (-ve)	0.28	24	12	Hours
Accessibility (+ve)	0.21	5	7.913	Factor (1 to 10)
Safety of parcel (+ve)	0.17	5	4.783	Factor (1 to 10)
Emission (-ve)	0.06	0.299	0.102	KG/parcel

Table 5: Criteria indicators for Public Transport Operator

Public Transport Operator				
Criteria	Weights	H.D.	L.D.	Unit
Passenger Satisfaction (+ve)	0.28	5	6.391	Factor (1 to 10)
Passenger Safety (+ve)	0.27	0.21	0.183	Factor (0 to 1)
Number of passengers (+ve)	0.26	5000	5250	Passenger/day
Accessibility (+ve)	0.13	18	18	Hours/day
Additional revenue (+ve)	0.06	15000	15750	Euro/day

4.5 Normalising the indicators:

As we can see the indicators are in different range and units for obvious reasons. It is difficult, if not impossible, to use them for comparing its impact on the perception of the stakeholders. One way to solve this issue is by normalizing them. Here, we use the vector normalisation method which ensures that the indicator values are transformed into a consistent range from 0 to 1, enabling a fair and standardised comparison across diverse criteria (Viikki & Laurila, 1998). While normalising values, the nature (+ve or -ve) of the criteria must be considered. Accordingly, different normalisation formula should be used. Use criteria indicators values of receivers to follow the calculation. For ease of understanding, Table 6 belonging to receiver stakeholder is given notation and formula as the calculation progresses. Accordingly,

- Normalised value for positively impacting criteria = Indicator value / Vector of the indicator
- Normalised value for negatively impacting criteria = 1 – (Indicator value / Vector of the indicator)

Where, Vector of the indicator = $\sqrt[2]{Indicator\ value\ for\ H.D^2 + Indicator\ value\ for\ L.D^2}$

Thus, Vector of Delivery time (for receiver, refer table 6) $= \sqrt[2]{24^2 + 12^2} = 26{,}83281573$. Since delivery time has -ve impact (more delivery time is worse) on perception of receiver,

- Normalised value for delivery time criteria for H.D =1- (24/26,83281573) = 0,105572809
- Normalised value for delivery time criteria for L.D = 1-(12/26,83281573) = 0,552786405

Table 6 shows normalisation indicator value for receivers for each criteria using the similar calculation.

Table 6: Normalisation of indicator values for the Receivers

		Receivers		
Criteria	Weights	Vector	H.D.	L.D.
Notation	w	v	a	b
Formula		SQRT(x^2+y^2)	x/v OR 1-(x/v)	x/v OR 1-(x/v)
Delivery Time (-ve)	0.38	26.83281573	0.105572809	0.552786405
Delivery Cost (-ve)	0.22	2.964635306	0.051316702	0.683772234
Convenience (+ve)	0.2	7.910556238	0.632066804	0.774913902
Safety of parcel (+ve)	0.11	6.919327207	0.722613608	0.691252178
Accessibility (+ve)	0.09	9.360318851	0.534169838	0.845377185

4.6 Overall analysis

The normalised values of each criterion indicated by column a and b in Table 6 must be multiplied by weight of the criterion to get true impact of each criterion. Table 7 shows the values for each criterion after multiplication with criterion weight.

Table 7: Overall stakeholder perception for Receivers

	Receivers	
Criteria	H.D.	L.D.
Notation	c	d
Formula	w*a	w*b
Delivery Time (-ve)	0.040117667	0.210058834
Delivery Cost (-ve)	0.011289674	0.150429891
Convenience (+ve)	0.126413361	0.15498278
Safety of parcel (+ve)	0.079487497	0.07603774
Accessibility (+ve)	0.048075285	0.076083947
Results	0.305383485	0.667593192

Table 8: Perception analysis in % for Receivers

	Receivers	
Criteria	H.D.	L.D.
Notation	Pr	Pa
Formula	(c-c/c)	(d-c/c)
Delivery Time (-ve)	0%	424%
Delivery Cost (-ve)	0%	1232%
Convenience (+ve)	0%	23%
Safety of parcel (+ve)	0%	-4%
Accessibility (+ve)	0%	58%
Results	0%	119%

By observing higher value for L.D 0.10 (in comparison to H.D 0.040) for delivery time, we can say that receivers prefer Locker delivery. However, this number still does not give very tangible picture of the perception in current calculation. Therefore, the perception of the stakeholder towards each criterium is converted to % increase/decrease by taking current alternative H.D as a base (see Table 8). The increase/decrease in perception due to delivery time for L.D is calculated as follow:

$$(0.210 - 0.040) / 0.040 = 424\%$$

This result implies that receivers perceive 424% positive impact on delivery time when switching to locker delivery. Similarly, receiver perceives 1232 % positive impact on cost of receiving parcel via locker due to lower cost of delivery via parcel locker. However, receiver feels a negative impact (-5%) of receiving parcel via locker at public transportation location. Similarly, Tables 9&10 give perceptions analysis for parcel companies and public transport operators.

Table 9: Perception analysis in % for Parcel Companies

Parcel Companies		
Criteria	H.D.	L.D.
Operational cost (-ve)	0%	1232%
Delivery Time (-ve)	0%	424%
Accessibility (+ve)	0%	58%
Safety of parcel (+ve)	0%	-4%
Emission (-ve)	0%	1164%
Results	0%	142%

Table 10: Perception analysis in % for Public Transport Operator

Public Transport Operator		
Criteria	H.D.	L.D.
Passenger Satisfaction (+ve)	0%	28%
Passenger Safety (+ve)	0%	-13%
Number of passengers (+ve)	0%	5%
Accessibility (+ve)	0%	0%
Additional revenue (+ve)	0%	5%
Results	0%	5%

5 Conclusion and discussion

Receivers have a positive preference for parcel locker mainly due to reduction in delivery time (instead of 24 hours, the parcel can be picked up in 12 hours from locker) and delivery cost. The parcel company can charge less to deliver parcel at locker than home delivery. Interestingly, convenience also shows positive for receivers. Normally, home delivery is more convenient than parcel delivery; however, if a missed parcel delivery forces a receiver to collect packet from parcel collection point, then compared to that collecting parcel from a locker at public transport location is more convenient. This feature needs more research and elaboration. Safety of parcel gives a negative preference for lockers due to possibility of theft or vandalism of the parcel lockers. This shows that parcel locker companies must give assurance to receivers about safety of their parcel when opting for locker facilities. Finally, accessibility of locker is higher due to proximity to public transport location. If the receiver is regularly using public transport to work, then accessibility can get higher positive score.

Similar to receivers, parcel companies show a high positive preference for lockers due to lower delivery cost and fast delivery (delivering multiple parcels at one location compared to home delivery). Reducing emissions shows very positive result when using locker. The number of km travelled by delivery van can be significantly reduced when delivering parcels at fewer locker locations. Accessibility for delivery parcels to locker is higher than delivering different home location. Parcel companies are also concerned about safety of the locker. Thus, security feature must be meticulously evaluated when implementing parcel locker facilities at public transport locations.

Public transport operator is slightly positive with parcel lockers as the passengers will be happy to have additional service. The addition of parcel locker can also contribute to increase the use of public transport system resulting in higher revenue for the transport company. However, passenger safety is their main concern due to loading and unloading of parcels by parcel companies with rolling containers. At the same time crime rate can increase due to valuable items in parcels causing concerns of transport operators. It was expected that accessibility of the passenger should be negatively affected; however, in this analysis no change is visible. This feature also needs further analysis.

Overall, it can be said that, parcel delivery companies and receives are (highly) positive 142% and 119% respectively) for parcel locker delivery system public transport location. However, the public transport operator is not very positive (only 5%) about installing lockers at the transport locations. It can be seen from the perception result that transport operator's main concern is about their passenger safety as it shows negative perception. The limited space available at the busy transport location, combined with the high volumes of passengers using public transport, make it difficult to find suitable areas to install the lockers without impeding passenger flow demands meticulous planning and optimisation of available space. This situation brings a concern for transport operator that poorly managed or obstructive lockers could lead to safety and security concerns. Rigorous safety assessments, adherence to regulations, and regular maintenance are essential to mitigate potential risks. Another significant challenge lies in integrating the parcel lockers into the existing infrastructure. As the infrastructure at Beurs metro station was not originally designed for such lockers, it will be difficult to identify appropriate locker locations and explore innovative designs or modular solutions that fit seamlessly into the available spaces.

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