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## Analysis of parcel lockers' efficiency as the last mile delivery solution – the results of the research in Poland

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### Abstract

Last mile deliveries are one of the major effectors of heavy traffic of commercial vehicles in the whole city area. Due to e-commerce's generic specificity, its functioning on B2C market is based on home deliveries. In recent years very interesting and popular solution became the parcel lockers as the efficient last mile delivery system. This paper is focused on the analysis of usability and efficiency of this measure based on the example of Polish InPost Company system. It introduces the results of pilot survey realized in Szczecin (Poland), as well as the general expectations regarding the efficient utilization of this kind of solution.

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### 1. Introduction

Last mile deliveries are one of the major effectors of heavy traffic of commercial vehicles in the whole city area. Their essential features, significantly lowering the rational functioning of the transport system, include high degree of fragmentation and low range of use of the cargo load compartment of vehicles. The importance of this type of deliveries grows with the increasing interest in remote shopping. Currently, its biggest inducer on B2C market is e-commerce.

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According to “Global B2C E-commerce Report 2014”, B2C e-commerce sales have been increasing steadily since 2010 (Fig. 1) and the growth rate has been quite consistent over the last four years with average value of 23,6 % (Nagelvoort et al., p. 20). Development of e-commerce on B2C market is well illustrated by the example of Poland. The authors of the report published by Internet Standard Magazine, focused on e-business functioning analysis, highlighted that despite the global crisis the B2C e-commerce growth rate in Poland achieved the value of 20% in 2013 (E-commerce 2014, p. 6).

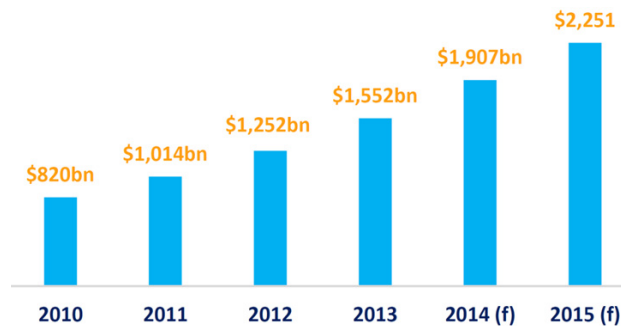


Fig. 1. B2C e-commerce sales increase since 2010. Source: Nagelvoort et al., p. 20.

Due to e-commerce’s generic specificity, its functioning on B2C market is based on home deliveries. It is possible to divide home deliveries into three categories (Durand, Gonzalez-Feliu 2012, p. 512):

- **Home deliveries from a supermarket**, where orders are prepared by a picker (store-picking), mainly on the outskirts of the urban area without major changes in the supply strategy; the purchased products are either delivered directly to home or picked up by the consumer, mainly by car, avoiding queues and waiting times at the checkout (car picking services are also known as “shopping drive”). However, car is not the only transport mode for end consumers for supermarkets or commercial centers with good public transport accessibility. In all cases, these trips can be assimilated to personal trips for shopping purposes.
- **Home deliveries from a specific warehouse**, where orders can be prepared (warehouse-picking) and where important changes are noted in the supply chain, because the warehouse is not located in a peripheral area. Then, the ordered products are delivered to the place of consumption using light goods vehicles through an optimized route. These trips are made by small city freighters and can be assimilated to traditional e-commerce HDs with more restrictive constraints.
- **Out home deliveries** through proximity reception points, where the supply changes consist of new local depots. In this case, the ordered products are prepared directly in a depot (depot-picking) located near the place of consumption in which they are picked up by the final consumer.

A popular solution among customers, due to its convenience, is direct home delivery usually realized by external courier services. One of the biggest problems with the organization of the supply of goods to customers in e-commerce is that there is a significant fragmentation of the orders. Individual customers usually buy small amounts of products, while expecting fast delivery. This forces the competitive market of transport services to respond dynamically to the emerging demand for transport. Often, in order to satisfy the customer, commercial vehicles provide their services regardless of the degree of use of their loading space. On the other hand, at this point it is worth to highlight the problem of inadequate fleet of transport companies, which is not adapted to the needs of e-commerce, particularly in the context of the size of the vehicle in relation to the volume of deliveries. Additionally very often local authorities implement not enough efficient measures to reduce negative impact of urban freight transport. For example, in Poland these measures usually are focused on access restrictions (Kiba-Janiak, Cheba 2014), what resulting many problems in home deliveries. This is important problem taking to the account the significant role of local authorities in development of city logistics (Witkowski, Kiba-Janiak 2014).

Therefore, one of the most important categories of good practices in current urban freight transport systems become solutions to rationalize the last mile delivery. The key solutions of this type include (Allen et al. 2007, pp. 41-49):

- **Reception boxes**, permanently fixed to a wall outside the customer's home, to which access is possible using a key or an electronic code; customer can be alerted of the delivery by mobile phone or email; used mostly for parcels, but can be used for foods if the boxes are temperature controlled;
- **Delivery boxes**, owned by the retailer or delivery company; filled with the goods at the distribution depot, and then temporarily attached to the home via a locking device fixed on the wall in a secure place at the customer's home; empty boxes or boxes containing returned goods are then collected by the delivery company either as a separate collection round or as part of the next delivery;
- **Controlled access systems**, provide the delivery driver with a means of gaining access to a locked area to leave the goods in; a key may be sealed inside a unit, which is mounted in a location where delivery staff can access it; the driver enters an access code into the sealed unit to release the key and open the nominated delivery location to leave the goods;
- **Collection points**, based on the use of locations other than customers' homes to which goods are delivered (the nearest Post Office, convenience store or a petrol station; often have long opening hours. Goods are delivered by the retailer or their carrier to the collection point and the customer is informed that their order is ready for collection. Customers may arrange with the collection point for the goods to be delivered to their home. Collection points result in fewer delivery locations and improved drop density.
- **Locker-banks are groups of reception box units (lockers)**, which are similar to collection points although they are not sited at each customers premise but sited in apartment blocks, work places, car parks, railway stations etc. Customers are not usually assigned to their own locker to optimize usage (lockers have electronic locks with a variable opening code, and can be used for different customers on different days). They may be dedicated to one delivery company or used by many. Customers may be notified by message about when their delivery has arrived, the box number and location, and the code to open the box. Locker-banks require the customer to make the final leg of the journey. However, locker-banks are located to make the deviation in customers' journeys as short as possible. Example of this type of solution is Packstation by InPost.

Table 1 shows the comparison of the last mail delivering systems, presented above.

Table 1. A comparison of last mile delivery systems. Source: Allen et al. 2007, p. 49.

	Attended delivery	Reception box / Delivery box	Controlled access system	Locker-bank	Collection point
Who covers the last mile?	Delivery company	Delivery company	Delivery company	Customer	Customer
Customer present?	Yes	No	No	No	No
Types of products	Any	Packages, groceries	Packages, groceries	Packages, groceries	Packages
Failed deliveries	High	Virtually none	Virtually none	Virtually none	Virtually none
Delivery window	Fixed delivery hours	Delivery company operating hours	Delivery company operating hours	Delivery company operating hours	CP opening times
Times at which goods can be collected	Not appropriate	24 hours	24 hours	24 hours	CP opening times
Retrieval time for customer	None	Very short	Very short	Short-Long	Short-Long
Drop-off time	Long	Short	Short	Very short	Very short
Initial investment	Low	High / Medium	Medium	Medium	Low / Medium
Delivery Costs	High	Low	Low	Lowest	Lowest

	Attended delivery	Reception box / Delivery box	Controlled access system	Locker-bank	Collection point
Possible operational problems	High failed deliveries. Poor use of vehicle capacity	Large number of boxes needed. Need to collect boxes	Customer concerns about safety. Need for suitable delivery location	Customer has to travel to collect	Customer has to travel to collect
Potential reduction in goods vehicle activity compared to attended delivery	—	Some reduction	Some reduction	Greatest reduction	Greatest reduction

A particularly interesting solution are locker-banks, as they favour the reduction of traffic and improve the use of cargo compartment by consolidating deliveries and making them more independent from the available time slots. This concept is realized by Polish company InPost, which has been implementing their parcel lockers (previously called “packstations”) around the world for many years.

## 2. Parcel lockers as the last mile delivering system

### 2.1. InPost parcel lockers

Parcel lockers are an unattended delivery machines, located at chosen, mostly attended places (Fig. 2). It is a system of reception boxes, which enable to both receive and send parcels 24 hours a day, 7 days a week.



Fig. 2. InPost Company parcel locker. Source: Bilik 2014.

Parcel lockers, which are developed by Polish company InPost, are one of the most interesting examples of innovative last mile solution in the world. There are more than 3000 machines implemented in 20 different countries (Fig. 3).



Fig. 3. InPost Company parcel locker. Source: Bilik 2014.

## 2.2. Functioning of parcel lockers

To a large extent using parcel lockers aims at delivering parcels in e-commerce. Customers send parcels using customer's account, previously created on the system operator's website. After payment and preparation of special label affixed to the parcel, it is sent either personally by the sender through the chosen parcel locker or received by an employee of the InPost Company. Collecting the parcel involves the following steps:

- Internet shopper selects the parcel locker while making online shopping,
- After ordering a package for the parcel locker, internet shopper receives an e-mail confirmation,
- Within 2 business days, the parcel is delivered to the chosen parcel locker and then the customer receives short e-mail and SMS message with the code to open a specific reception box in the specific machine.
- The customer shall provide the code with the phone number using the touch screen on the selected parcel locker,
- During the service the customer can track the shipment.

The above procedure usually takes about several seconds. The customer has 3 days to collect the shipment from the selected parcel locker. If a package is not collected within this period, it will be transported to the nearest branch of InPost. In order to ensure the safety of both the senders as well as consumers, parcel lockers are placed in the monitored locations (e.g. petrol stations, 24h car parks, supermarkets). In addition, each machine of InPost is equipped with 4 video cameras and alarm system. According to the data available on the website of InPost, at the end of February 2013 the company had 631 stations in 181 Polish cities. It is worth noting that this solution is also available in many other countries.

A distinguishing feature of parcel lockers in comparison to the traditional courier services is a significant reduction in the number of supplies and the lack of drop deliveries resulting from the absence of the recipient. Parcel lockers are usually sited in public places (e.g. shopping centres, train stations or bus stations, schools and universities, etc.). Therefore, this enables to receive shipments at a convenient time, often while doing other things, such as shopping or refuelling the car.

With the selection of appropriate locations, parcel lockers can provide not only significant economic benefits, but also, or even primarily, they can have a positive impact on the reduction of pollutants emitted into the environment by urban freight transport.

### 2.3. Parcel lockers in practice – the drivers and barriers

Parcel lockers seem to be a very interesting and innovative solution for any type of city, beneficial to both customers and online stores. Taking into account the growing number of B2C e-commerce customers, this measure meets the needs of present and future society. It gives many benefits, such as (Bilik 2014):

- Extra income from rent paid by InPost Company,
- Commercialisation of non-utilised outdoor space,
- Extra revenue resulting increased footfall (research conducted in Poland showed that 52% of customers attending locker site visited shop to make purchase),
- Be a focal point for the community,
- Opportunity to become part of international operation from cross-border deliveries,
- Reverse use of locker for potential advertising space,
- Building of reputation as city supporting sustainable development.

Additionally, this measure could be combined with other ones, like utilization of environmentally friendly vehicles, development of environmental zones or areas with access restrictions as well as the implementation of urban consolidation centres. Table 2 shows SWOT analysis of parcel lockers.

Table 2. SWOT analysis of parcel lockers. Source: Torrentellé et al. 2012, p. 127.

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>• Customers have the possibility to access to their packages 7 days per week and 24 hours per day</li> <li>• Customers are informed of deliveries via SMS or e-mail</li> <li>• Reduction of freight transport trip km in comparison with attended delivery, thereby reduction of emissions, noise and energy consumption</li> <li>• Low delivery costs</li> </ul>	<ul style="list-style-type: none"> <li>• Parcel lockers are a private action, and the public authorities do not have information about the impacts</li> <li>• The final leg of the journey have to be made by the customers</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>• Efficiency gains for logistic providers</li> <li>• Transferable to other cities</li> </ul>	<ul style="list-style-type: none"> <li>• E-commerce is expected to grow further in the future, and this can cause a higher freight mileage due to high number of parcel lockers</li> </ul>

Nevertheless, implementation and efficient utilization of parcel lockers requires the support of local residents, courier/delivery companies and the owners of places where parcel lockers are located. Additionally, local authorities must be involved in the stage of implementation with regard to the permission and the selection of sites.

However, the most important condition of efficiency of parcel lockers is the willingness of internet retailers to deliver goods to the location, which does not match the address of the purchaser and, on the other hand, the willingness of internet shops' customers to receive their goods from parcel lockers. For the purchaser the most important barrier of utilization of parcel lockers is the fact that the final leg of the journey must be made by them.

Special role in proper development of parcel lockers is played by authorities. At the local level it is important to initiate and promote the installation and development of parcel lockers based upon strategies and policies shared with relevant local key stakeholder representatives and associations. Additionally, local authorities should share or rent public space for the installation of parcel lockers and provide planning and building permission for pack station installations. Also they should support parcel lockers implementation by the involvement of them in transport planning and fleet monitoring system. Additional role in parcel lockers development is played by national authorities.

They should promote both, parcel lockers and similar alternative delivery systems as the environmentally friendly solution. Moreover, they should support local initiatives in this area.

### 3. Efficiency of parcel lockers – case of Szczecin

#### 3.1. Influence of parcel lockers on reduction of negative environmentally impact of urban freight transport

The most important aim of parcel lockers' implementation is to reduce the number of deliveries in the city area, including failed deliveries and the subsequent return of goods by couriers and postal services. It helps to reduce unnecessary vehicle mileage with associated energy use and congestion impacts. According to the results of analysis made by researchers from the Department of Robotics and Mechatronics at the AGH University of Science and Technology in Krakow (Poland) realized in October 2013, the courier servicing InPost parcel lockers is able to deliver 600 parcels in just one day, with travel distance of about 70 km in comparison to respectively 60 parcels and 150 km in traditional delivery system – Table 3 (InPost... 2015).

Table 3. Comparison of parcel lockers and courier deliveries. Source: InPost... 2015.

	Courier	InPost parcel lockers
Number of km during a day	150	70
No of parcels delivered during a day	60	600
CO2 emission; tons per annum	32 500 T	1 516 T
Annual fuel consumption in litters	22 500 000 l	1 050 000 l
Results	100 %	< 5 %

Similar results were achieved in analysis of influence of parcel lockers on environment in the city area, realized also by the Department of Logistics and Transport Systems at the Maritime University of Szczecin as the part of international C-LIEGE project ([www.c-liege.eu](http://www.c-liege.eu)). The calculations were based on data from InPost Company, who recorded a total of 5682 average deliveries to the 17 parcel lockers located in Szczecin in the period from January 2012 to April 2013.

#### 3.2. The importance of proper location of parcel lockers on their efficiency

The most important factor of efficient utilization of parcel lockers is their proper localization in the city area. According to data received from InPost Company, the best locations for this kind of measure are related to availability of:

- Local hot spots within suburbs – next to convenience stores (high density of population living in the neighbourhood),
- High traffic pedestrian areas in city centres,
- Shopping centres and supermarket car parks,
- Bus/underground stations next to local commuting hubs,
- Petrol station forecourts,
- Service stations,
- Business centres.

To assess the influence of locations of parcel lockers on their efficiency, the experiment regarding relocation of chosen machines were realized in Szczecin. Based on the analysis of monthly number of parcels delivered by each parcel locker, the set of the most and the least popular machines was prepared (Fig. 4).



Fig. 4. Locations of 17 InPost parcel lockers in Szczecin before relocation. Source: own work.

Taking to the account assumptions described above, the analysis of potential better locations for parcel lockers in Szczecin was realized. Based on the results as well as taking to the account availability of chosen locations and strategic plans of InPost Company, five underperforming machines were relocated. Additionally one new machine was implemented.

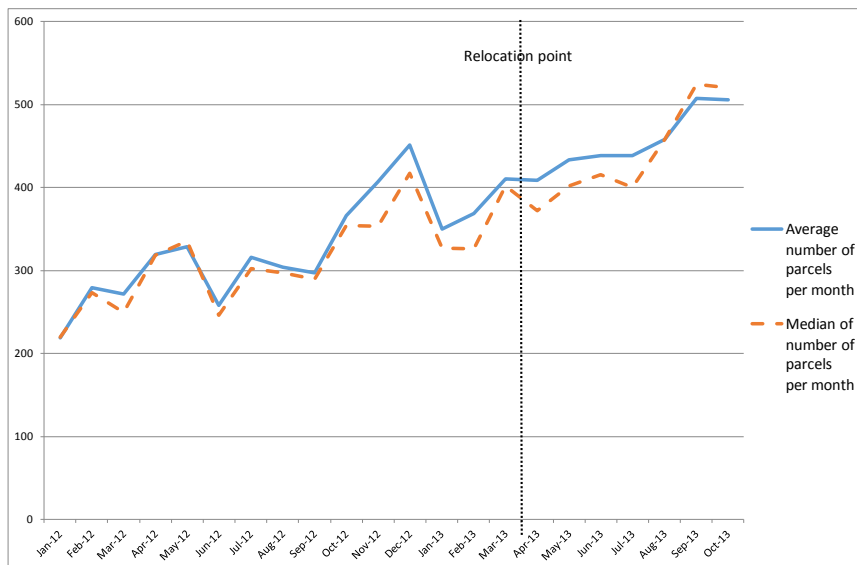


Fig. 5. The monthly number (average and median) of picked-up parcels. Source: own work.

Based on data from the parcel locker operator, from January 2012 to April 2013 the average number of parcels delivered by 17 parcel lockers in Szczecin amounted to 335 per month. After relocation of five underperforming machines to the new, better suited locations, as well as implementation of one additional parcel locker, this number



increased to 443 deliveries per month (32%). Average increasing in deliveries in four cases amounted to 79 parcels per month. Only one relocation was inefficient (the number of deliveries decreased). The most important criterion of relocation in this experiment was the proximity of gas stations, university and shopping centres. The most efficient growth (more than 200 parcels per month) was achieved in the case of machines located near the shopping centre. Fig. 5 shows the monthly number (average and median) of picked-up parcels during 22 months period.

### 3.3. Parcel lockers from the customer point of view – results of the first stage of surveys in Poland

One of the activities realized under GRASS project is analysis of usability of parcel lockers from the users' point of view. In order to assess this topic, the first stage of survey was realized in the area of Szczecin. Standardized interview method was applied based on the use of questionnaire. Respondents were asked for:

- Overall rating of parcel lockers,
- Reasons for parcel lockers' utilization,
- Expectations regarding the location of parcel lockers,
- Rating of the current locations of parcel lockers in Szczecin.

Additionally they were asked for proposals of better locations of parcel lockers in Szczecin.

The questionnaire was available on-line for one month. During the survey period 83 persons sent the answers. It was the pilot stage of the surveys, which are realized throughout Poland. The final results are planned to be presented in July 2015.

According to the collected data, customers of internet shops (the survey was focused on this group of users) are satisfied with utilization of parcel lockers. 28% of respondents rate them with 10 points in 10-point scale, with 1 being the worst value and 10 the best value. Weighted average overall rate for parcel lockers usability equalled 8,18 points – Fig. 6.

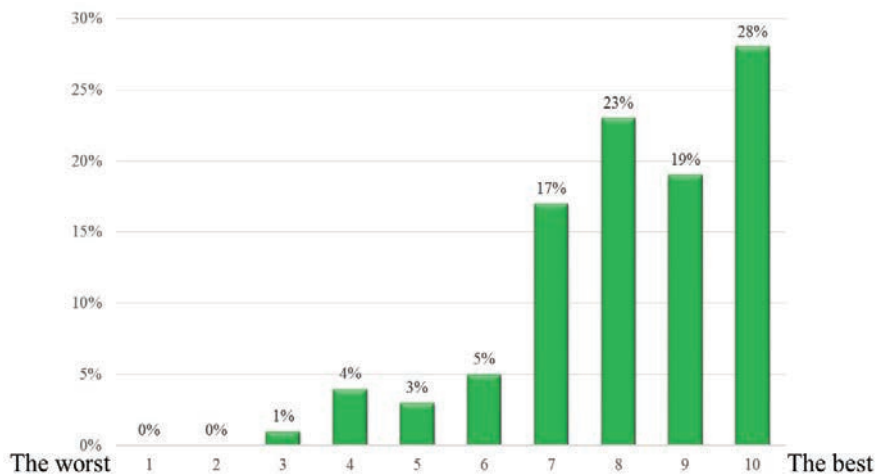


Fig. 6. Overall rating of parcel lockers by customers from Szczecin. Source: own work.

The most important reason of utilization of parcel lockers is the price of deliveries (Fig. 7). It is important that average costs of deliveries realized by three major operators in Poland are respectively: 9.15 PLN (2.18 €) for InPost parcel lockers, 10.81 PLN (2.57 €) for Polish Post and 14.24 PLN (3.39 €) for couriers (based on data from 100 most popular internet shops in Poland, for parcel value of less than 20 € and payment realized by credit card).

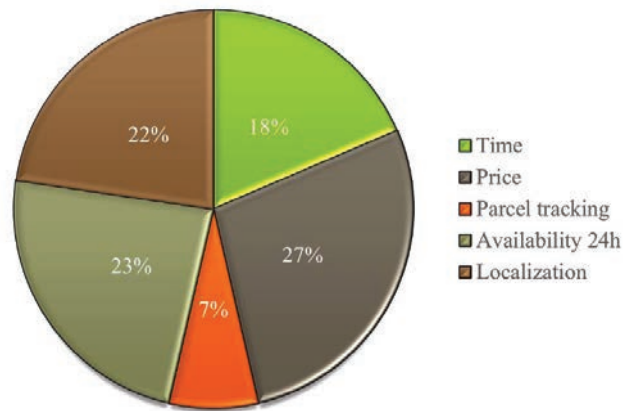


Fig. 7. The reasons for parcel lockers' utilization. Source: own work.

The other most important reasons for parcel lockers' utilization are their availability and localization. The most important expectations of parcel lockers' users regarding the localization include: close location from home, on the way to work and availability of parking spaces (Fig. 8).

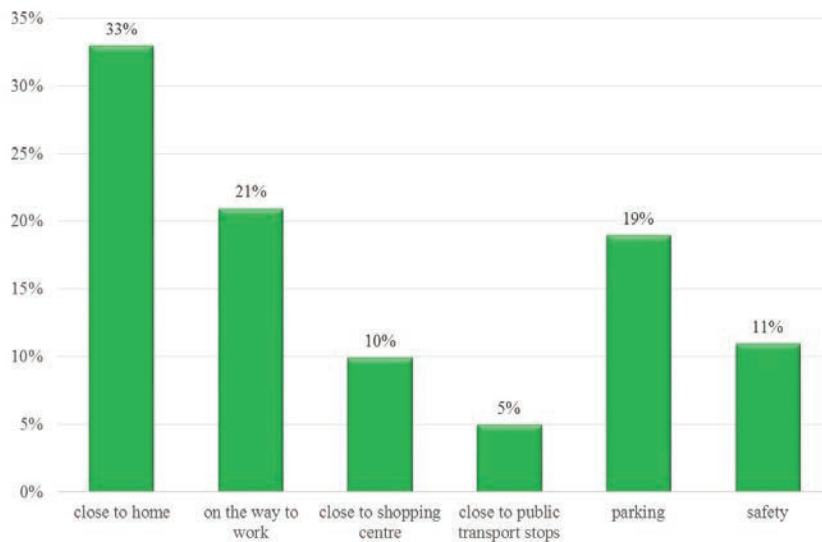


Fig. 8. Customers' expectations regarding the location of parcel lockers. Source: own work.

The opinions of parcel lockers' users in Szczecin regarding the current locations of utilized machines show that 28% rated them with the highest value (Fig. 9). Weighted average rating for this factor equalled 7,46 points in 10-point scale.

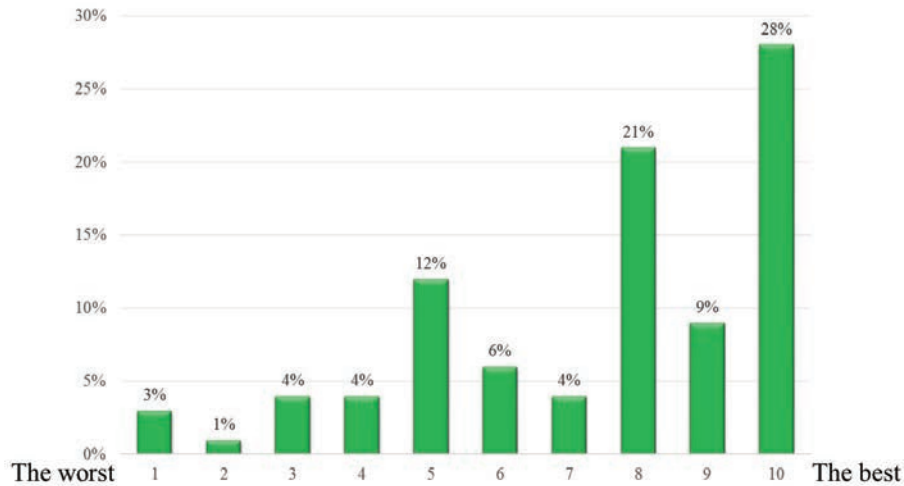


Fig. 9. Evaluation of the current locations of parcel lockers in Szczecin. Source: own work.

#### 4. Conclusion

The growth of B2C e-commerce market results in the increase of importance of last mile deliveries in the city area. It has an influence on the growing demand for last mail delivering, which consequently could have the impact on traffic and congestion problem. The way to reduce the number of deliveries realized by traditional transportation system, based on utilization of road transport vehicles, includes alternative methods of delivering. One of them is utilization of parcel banks, such as parcel lockers, operated by Polish company InPost.

Constant growth of InPost parcel lockers utilization (implementation of the system in many different countries in the world) shows that this is a very interesting and important solution. It seems to be the major direction for the shaping of future delivering systems in cities and good opportunity to reduce their negative environmental impact. According to the results of the analysis presented above, the most important factor of efficiency of this kind of solution is the proper location of the machines used for deliveries. This survey was the first pilot part of analysis, which is currently being realized in the area of Poland. The final results shall show the most important strengths as well as the barriers and expectations from the users' point of view. Moreover, it can help to make the system of parcel lockers more efficient.

It is planned to expand the surveys to other countries, where InPost parcel lockers are utilized.

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