
Monitoring, measurement and statistical analysis-based methodology for improving city logistics of shopping malls in Budapest

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Abstract: Urban freight transport poses significant problems in cities around the world: trucks play a major role in congestion, environmental and noise pollution and damage the roads. Shopping centres are problematic, in particular, as they concentrate a large number of retail stores in a relatively small space. There are 18 shopping malls in Budapest alone, each containing 180 stores on average, therefore there is great potential in streamlining their deliveries. The most effective solution is a cooperative city-logistics system, a freight consolidation scheme. However, there is a shortage of available data regarding the logistical operations and freight quantities of shopping malls, so it is inescapable to develop a methodology by which the logistical characteristics of any shopping centre can be obtained. After testing our methodology, we concluded that it is capable of serving as the basis of such systems. This paper presents the development, structure and testing of this methodology

Keywords: city logistics; consolidation scheme; shopping mall; shopping centre; urban freight distribution; methodology; research; environment; green logistics.

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1 Introduction

In the case of shopping centres there appear to be a number of logistical problems that could be alleviated with a specifically designed city logistics system. In general, during the design and operation of shopping malls, the primary focus is to satisfy the needs of shoppers and to maintain a high level of shopping experience, therefore the design and optimisation of their logistical processes are often neglected to some extent.

Shopping malls concentrate a large number of stores into a relatively small space. Budapest’s 18 malls contain 180 stores on average (Meszaros et al. 2016). Inner city malls are only accessible using the city’s roads, therefore trucks play a major role in congestion, environmental and noise pollution and the deterioration of roads. These problems are not prominent to the public in the case of shopping malls, since their logistical areas are usually out of sight, and it is not always obvious that freight vehicles play a role in congestion. Moreover, it can be said in general that there are no available data regarding the freight traffic quantities, storage management and other logistical processes. Thus, in order to establish an integrated development concept, it proved to be necessary to create a methodology that helps to uncover the problems and challenges in the current, real life processes, as well as to quantify the quantity of inbound deliveries and amount of storage needed.

A modern and environment friendly freight transport system would consist of an urban consolidation centre (UCC) located on the periphery of the city, from which after the consolidation goods could be shipped to shopping centres in a coordinated manner by using eco-friendly vehicles (Bakos and Bona, 2012; Allen et al., 2014). This scheme could utilise the city’s railway network, the waterways, but even the road network with certain innovations (e.g.: electric vehicles). The transport network of Budapest has enormous potential. The tram network is 155 km long (Budapest.hu, 2011) and there are existing tracks in the close vicinity of nearly all shopping malls from which side tracks could provide direct access to the malls’ logistical areas.

Utilising the city’s railways for freight transport would not be an entirely new concept/phenomenon in Budapest as up until 1997 several factories were served via the

tram network (Fejes, 2013). Currently a couple of European cities exploit the potential in their railway network outside passenger transport. Zurich uses it for garbage collection (Zürich, 2016), and in Dresden a large Volkswagen company employs it as a freight shuttle service through Dresden's city centre (Hofman, 2017).

Another environment friendly possibility for Budapest would be to take advantage of the immense potential that the river Danube offers. In this scenario so called cargo ships would function as floating warehouses carrying electric vehicles that could serve nearby shopping malls after docking. This system layout could not reach all of the shopping malls in Budapest, but more than half, specifically 12 of them would be within reach. A similar system is in operation in Amsterdam, where DHL utilises cargo trams for small parcel deliveries (Stevenson, 2009).

2 UCCs around the world

The most comprehensive literature review of UCCs was done by the University of Westminster (Browne et al., 2005). They identified 67 such projects around the world, out of which 13 were pilots and 26 operational. It is worth noting that almost all such initiatives (63) were located in Europe. Even though the literature review is quite dated, it is still the most thorough and exhaustive one in existence, therefore an excellent starting point.

For us only a limited number of foreign projects may be considered as best practice, because of our focus on shopping malls. However, the Broadmead Freight Consolidation Scheme appears to be quite similar since it caters to a large shopping mall in the centre of Bristol, England, therefore we consider it to be a benchmark. The scheme is a cooperative goods delivery service that includes 53 retailers in a 300 store shopping mall. Data after the scheme's first two years of operation is more than encouraging: between 2004 and 2006 vehicle movements were reduced by over 72% on average, which equates to a reduction of over 96,000 truck kilometres. This in turn has contributed to an environmental improvement through reductions of CO₂ emission by 11.3 tons, NO_x by 1.75 tons and PM₁₀ by 243 kg's. Retailers have also benefited from an improved delivery service with no lost or damaged stock and 100% on time deliveries to date. A retailer satisfaction survey carried out revealed that 94% would recommend the service to another retailer and more than half of retailers are saving over 20 minutes per delivery, additional time they can spend on the shop floor (Allen et al., 2014; Hapgood, 2009, 2005, 2006; Minihane, 2009; Moore, 2011; Lovelace, 2013).

An other example that offers valuable insights for our research is the consolidation system at the Heathrow International Airport, because we believe airports are fairly similar to shopping malls in many aspects. Moreover, in an airport the management has significant leverage over its stores, complete authority of the logistics operations and financing the delivery scheme appears to be much less problematic. These factors mean that it is essentially 'city logistics in a vacuum', and the results excellently demonstrate the potential in a consolidated delivery scheme. The results are extraordinary: 80% reduction in the number of vehicles entering the area, 70% reduction in the total length of vehicle trips (180,000 km/year), 17.2 kg reduction of PM₁₀, 600 kg less NO_x, 521 tons less CO₂ (Allen et al., 2014, 2002; Panero et al., 2011; Allen, 2002; Moore, 2011).

Fortunately, there are more recent initiatives as well, such as the Binnenstadservice.nl project in The Netherlands, where they proved that consolidation systems are also

possible to be built using bottom-up methods (van Rooijen and Quak, 2010). Research methodologies to establish the foundations of such systems vary greatly, but researchers in Belgium showed that even methods such as scenario building are suitable (Janjevic et al., 2015).

3 Presentation of the methodology

Such complex and intricate systems must not be designed without proper input data, even though that has usually been the case in city logistics. Therefore, the main objective of our methodology is to fill that void and provide a way to uncover, gauge and quantify the logistical problems that may arise regarding shopping centres' operations. To achieve this, we employed both qualitative and quantitative approaches that complement each other. The first part of our methodology is an exploratory research which includes a structured expert interview and standards for field study. These methods help to closely observe and understand in detail the shopping mall's internal logistical processes (e.g.: freight traffic volume, loading and unloading, inverse logistics) as well as the external characteristics (e.g.: location, access, limited freight zones). The topics of the exploratory research phase can be found in Table 1.

Table 1 Topics of the exploratory research segment of the methodology

<i>External characteristics – final approach</i>	<i>Internal characteristics</i>	
Limited zones for freight traffic in the neighbourhood of the mall, congestion charges	Size of the mall, number of shops in the mall	Collection and transport of waste
Tram lines in the vicinity of the mall	Inbound delivery periods of the mall	Handling of hazardous waste
Proximity of the Danube	Freight receiving areas of the mall, capacity and size	Number and location of storage areas in the mall
Bus lanes in the area of the mall	Moving of goods inside the mall	Possibilities for renting warehouses in the area of the mall
Other limitations on the roads in the area of the mall	Places for loading and unloading in the mall	Summary of discovered problems

The other part of our methodology is a descriptive research. It includes a comprehensive questionnaire that is to be filled out by all of the shopping centre's retailers. We used a census survey since our target population and their locations are well defined, and furthermore the objective of the questionnaire is to obtain data on the shopping mall as a whole. The reason why we chose to include a questionnaire is that it is a great tool for quantifying the mall's logistical properties and problems.

The 26 questions in the questionnaire make up seven topics, which may be found in Table 2. The most important topic that also includes the most questions, deals with the properties of inbound deliveries. This comes from the main objective of the methodology; in order to establish the basis of a cooperative delivery scheme it is imperative to determine the volume of freight traffic, its distribution in time and other properties. Questions of the survey can be found in the Annex section.

Table 2 Topics of the questionnaire

<i>Topics of the questionnaire</i>	<i>Number of questions</i>
Basic properties of the shops	5
Properties of inbound deliveries	12
Properties of the storage areas	3
Reverse logistics of the shops	1
IT background of the shops	1
Electronic commerce in the mall	3
Willingness to participate in the cooperative delivery scheme	1

We tested our methodology at the end of 2015 in Budapest, in Allee Shopping Centre, which represents an average Budapest shopping mall very well due to its location and size (159 stores). Shopping centre designs are fundamentally identical, as malls comprise similar retail stores and face similar challenges due to their location. Furthermore, there is a clear tendency that shopping malls are becoming the dominant form of retail, since they provide consumers with greater spatial convenience compared to inner city shopping strips, therefore store locations are getting more and more concentrated (Reimers and Clulow, 2004). As a result, the conclusions drawn from researching one shopping centre will mostly pertain to other, similar shopping malls as well. We designed our questionnaire to be applicable to any shopping centre, but a few questions and their answer options may be modified according to the given mall's regulations and the physical parameters of their logistical areas.

4 The results of the testing

4.1 Issues discovered during the exploratory research

We found a number of problems regarding the researched shopping centre during our exploratory research. In some cases, the lack of adequate storage capacity led to the goods and empties being placed in such positions where they interfered with the loading and unloading of freight vehicles. There had often been congestion at the entrance of the logistical areas because of the stochastic arrival times of trucks. Numerous stores have not been owning direct access to their storage areas, therefore they have been needing to move their goods through the shopping areas interfering with consumers, even causing risk of accident. Many times bottlenecks (e.g., elevators) contributed to an increase in waiting times, hence transferring goods to the stores became slower. The biggest issue outside of the building has been that if a vendor's truck exceeds the allowed weight limit for a limited freight zone he has to pay a significant amount of fee per vehicle.

All the problems listed above underscore the need and potential impact of logistics innovations.

4.2 Testing the questionnaire

Field work lasted 12 days during which we collected data from 149 of Allee's 159 retail outlets. Ten stores cannot be integrated into a cooperative delivery scheme because of their logistical uniqueness. Two banks, a lottery and a money exchange office only require money shipments while six ticket offices require virtually no deliveries. We managed to reach 140 shops because in nine cases the competent person was unavailable. Out of these 140 stores, 105 filled out the questionnaire which means a response rate of 75%. Eleven stores declined because their regulations prohibited them from answering, eight stores could not find time to fill out the questionnaire and 16 stores did not wish to participate. We feel our high response rate is partially caused by the support of Allee's management who asked all of the retailers to participate in our study.

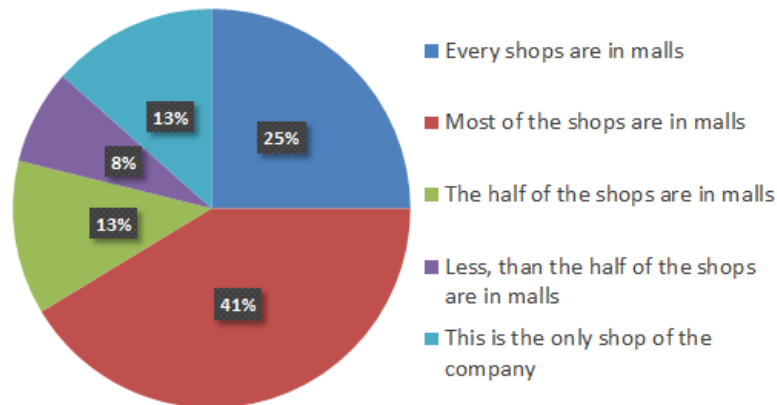
We entered the answers into Microsoft SQL Server Management Studio where we ended up with 49 by 105 data table then exported it to Microsoft Excel. The evaluation of the data was done by this two software and also by SPSS Statistics. We applied descriptive and inductive statistics built various diagrams to showcase our data and examined the relationships between the answers to certain questions.

In the followings we provide the number of respondents for each question with N , and the reliability – as a probability of our sample representing the whole population at $\varepsilon = 0.2$ – with R .

4.3 Demographics – basic properties of the shops

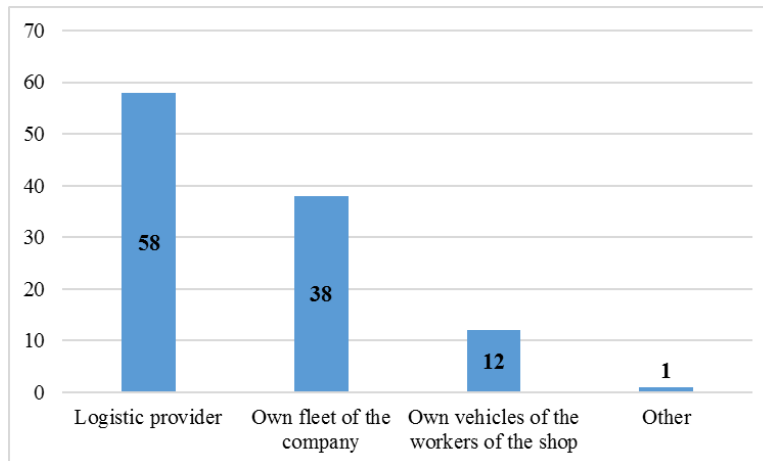
The stores that filled out the questionnaire marked 15 different profiles. For the category miscellaneous we received answers that could all be assigned to one of the categories already on the questionnaire. This showed us that our categories need to be clarified. The profile with the most shops was clothing, underwear and bags (25 stores), shoes (16) and fragrance and beauty products (12) ($N = 104$, $R = 22.46\%$). 90.38% of the respondents possessed one main profile, while the rest had two or more. The average floor size of the shops was 159.84 m^2 , with a standard deviation of 465.73 m^2 ($N = 90$, $R = 48.34\%$). The smallest shop among the respondents was 4 m^2 , and the largest $3,900 \text{ m}^2$. This supports our hypothesis that a mall's retail outlets are very heterogeneous both in their profile and size.

The ensuing questions showed that 51.92% of the responding stores were under Hungarian ownership (44.23% under foreign, rest was both) ($N = 104$, $R = 31.67\%$), 54% were chain stores (23% were franchises and 23% individual stores) ($N = 100$, $R = 72.56\%$). 25% of the responding retailers stated that all of their outlets were in shopping centres and an additional 41.3% said the same for over half of their outlets. Overall, 78.85% retailers had at least half of their shops in shopping malls, which is a very important result, because these stores' deliveries (or at least half of them) could be integrated into a cooperative delivery scheme that spans all shopping centres. 13.5% of the respondents only own the one store in Allee that we included in our research ($N = 104$, $R = 44.4\%$) (see Figure 1).

Figure 1 Where are the companies' shops located? (see online version for colours)

4.4 Properties of inbound deliveries

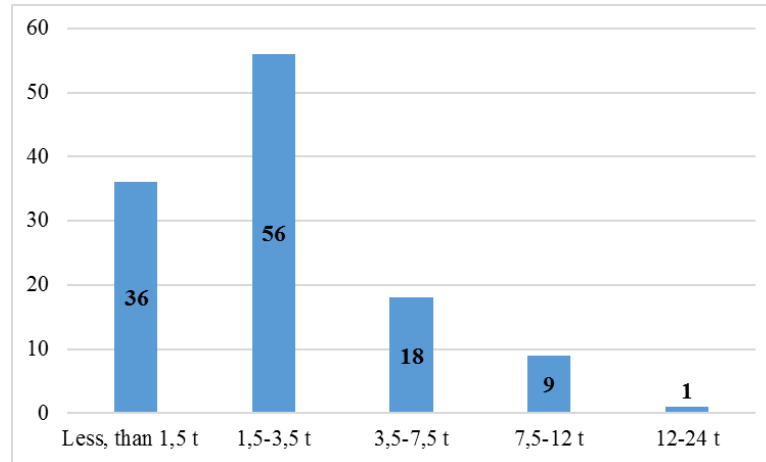
In the case of 56.31% of shops there was a contract supplier handling the deliveries, 36.89% used their own fleet and 11.65% of them utilised their own employees' vehicles (see Figure 2). The overwhelming majority, 94.17% of the stores only had one method of getting their supplies, however in the case of others, logistics providers and own fleet were used simultaneously ($N = 103$, $R = 53.73\%$).

Figure 2 Who handles your store's inbound deliveries? (see online version for colours)

Regarding the distribution of types of vehicles used, for 35.64% of the stores it was passenger cars, 55.45% indicated small to medium trucks, while the use of larger trucks was rarer (see Figure 3). Vehicles over 12 tons were used by only one retailer, thus we can only determine the payment of entrance fees into the limited freight zones in this one case. This goes to show that smaller deliveries are more typical. 84.16% of the shops used only one kind of vehicle; the rest did two or more ($N = 101$, $R = 22.45\%$). During

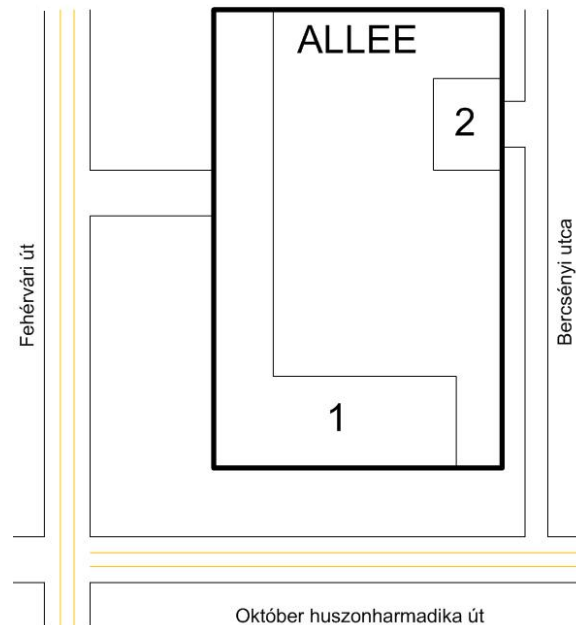
our field study we found that deliveries were not always carried out by motor vehicles but by bikes or motorcycles as well.

Figure 3 The number of utilised freight vehicles by capacity (see online version for colours)



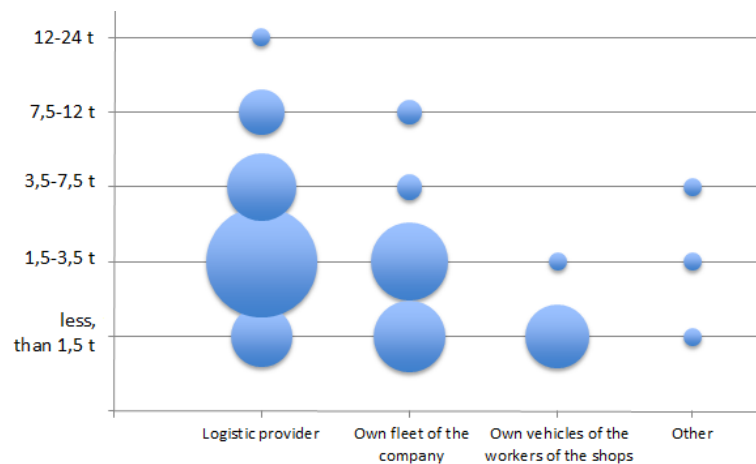
Allee has two loading areas for receiving deliveries. Most stores (48.81%) used the larger, more accessible one that opens to Fehérvári street, while 17.86% shipped to the one on the Bercsényi street side. This reveals that many shops handle their deliveries through the parking lot. It is worth noting that several respondents had trouble identifying these courtyards ($N = 84$, $R = 60.61\%$).

Figure 4 Layout of freight receiving areas in Allee (see online version for colours)



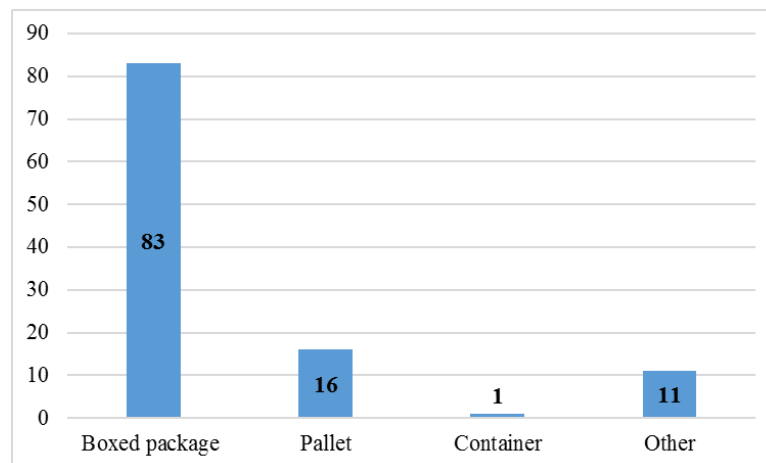
It is interesting to examine the relationships and interplays between the answers to the previous three questions. Since all of these were choice questions, we cannot calculate correlation coefficients, but so-called bubble graphs are a good way to visualise the connections. For example, we revealed that contract logistics providers predominantly use small trucks, and that retailers' fleets seldom contain vehicles upwards of 3.5 tons (see Figure 5).

Figure 5 The correlation between the capacity of the vehicles and the type of the provider (see online version for colours)



The received answers showed that 81.4% of the retailers had their goods delivered in boxed packages, and 15.7% on pallets ($N = 102$, $R = 22.47\%$). There was only one store using containers and for miscellaneous we received answers such as crates, bags, plastic bags, hangers, and others (see Figure 6).

Figure 6 Types of delivery units (see online version for colours)



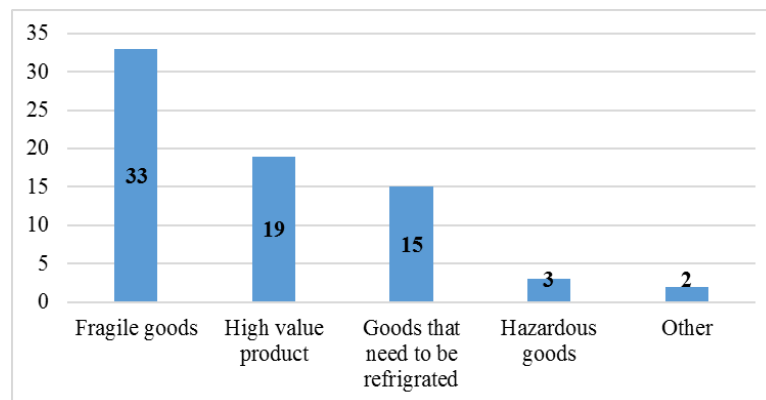
Such high share of boxes presents some difficulties regarding the scaling of the cooperative delivery scheme, since the weight and volume of boxes vary on a rather large

scale. In the case of pallets this does not seem to be an issue because of their standardised dimensions. Our respondents said that an average delivery meant 21.73 boxes (min. 1, max. 160, std. deviation: 35.73, $N = 63$, $R = 66.19\%$) and 5.55 pallets (min. 1, max. 20, std. deviation 5.68, $N = 11$, $R = 46.84\%$). In the case of half of the stores, shop assistants were required to transfer the goods from the point of delivery up to the store, while altogether 64.7% of the stores marked employees of the shop (meaning assistants and shop managers as well). This confirmed our hypothesis that moving goods take up some of the employees' time in the majority of shops, which interferes with their core competencies such as sales and sometimes they are not physically fit either. 35.3% of the respondents said that employees of the delivery firm transfer the goods ($N = 102$, $R = 59.84\%$).

The subsequent two questions about the number of products and product groups carried created the most confusion among respondents. Thus these questions had to be modified and amended both during data collection and for our refined questionnaire as well. According to our answers, shops in Allee carried 9.73 product groups on average (min. 1, max. 100, std. deviation 18.12, $N = 77$, $R = 65.11\%$), and 905.73 different products (min 1, max 20,000, std. deviation 3,067.84, $N = 73$, $R = 38.45\%$). If we exclude the exceptionally high values for the latter (17,000 and 20,000) the average becomes 410.11; the maximum 4,000, while the standard deviation remains large at 722.89.

These results are further proof for the notion that in shopping centres the product assortment and heterogeneity are remarkably large. These data excellently demonstrate the appeal of shopping malls resulting from their extensive product diversity and their ability to serve every need of the consumers; however it also shows that a common delivery scheme is going to be faced with a very complex task. Nevertheless, it can also be argued that product diversity is not such a big issue if almost everything is delivered in boxes anyways, since they could be handled together in smaller containers, maybe even designed specially for the delivery scheme.

Figure 7 Number of stores requiring special care for their goods (see online version for colours)



47.6% ($N = 102$, $R = 27.41\%$) of the shops carried products that necessitate special care. Thirty-three of 102 shops needed shipment fragile goods (on average 52.36% of the goods were fragile for these stores), 19 had high value products (70.31% of their goods), and 15 had goods that needed to be refrigerated (38.33% of their goods). There were no

stores in Allee requiring shipment of live animals and only a few needed hazardous goods (see Figure 7).

The average proportion of goods that needed special handling for all stores that submitted a comprehensible answer (including the ones that did not have any) was 24.61% (std. deviation 37.1%). Nineteen stores indicated two or more different types of special care. The above mentioned ratio can be considered as high, therefore the cooperative delivery scheme will most definitely be required to not only consolidate and transport goods but to be capable of providing special care and handling for some of them as well. This does not seem to be an insurmountable task however, because with properly designed freight vehicles the special care-goods can be handled in groups.

The following question in our questionnaire instructed respondents to estimate the two most typical frequencies of their inbound deliveries, and also the proportion of their products for which that frequency was applicable. Unfortunately, this question highly perplexed our respondents, which is apparent from both the relatively low number of answers (96), many erroneous answers, and our experiences during data collection. Shop managers interpreted the question in different ways, therefore our data are not entirely consistent, they are to be treated with some reservations. Nevertheless, it is apparent that only 31 stores had two distinct shipment frequencies for their deliveries. Twenty stores indicated daily shipments as their primary answer, with an average of 2.47 instances (std. deviation 2.72), together with 63 shops indicating weekly deliveries, with 3.58 instances (std. deviation 12.48) ($N = 96$, $R = 100\%$). After tallying our data, we see that 86.5% of shops had 2.98 shipments per day, which validates our hypothesis regarding frequent inbound deliveries in the case of shopping malls. Furthermore, even according to the secondary answers, 61.3% of the stores had shipments at least weekly, 1.92 times per day in total ($N = 31$, $R = 86.73\%$). For the ensuing question, 23 stores indicated that they have significant deviation from their typical shipment frequencies, for 13.47% of their products on average (std. deviation 11.56%) ($N = 95$, $R = 97.47\%$).

Summing up all the responses, we were able to calculate an aggregated daily traffic. According to our data, there were 88 vehicles for the 96 stores that submitted a comprehensible answer. As an experiment we scaled that up to the whole mall (159 stores), and it resulted in 146 vehicles arriving to Allee per day, which gives us a basis for the volume of the inbound deliveries. The ratio between boxes and pallets is known from a previous question, and their masses and volumes may be estimated with an upper and a lower value in a way that their actual dimensions likely fall in the intervals. In the case of Allee, we used 3 and 10 kg for boxes and 0.5 and 1 tons for pallets. Using these values, we obtained 43,000 kg and 92,000 kg as the whole quantity of freight traffic. In the former case, the entire shopping mall's shipments could be realised using only three 20 ton-vehicles, and even in the latter, five of them would suffice. Using the same methodology for volumes we estimated 0.125 m³ and 0.5 m³ for boxes and 1 m³ and 1.44 m³ for pallets (standard size: 800 × 1,200 × 1,500 mm). We determined that in the best case scenario 4 m³, while in the worst case eleven 70 m³ trucks could serve the needs of the mall. It is interesting to note however, that according to our exploratory research, there were 180–200 vehicles entering Allee each day.

Examining the relationship between shipment frequencies and other properties of the stores promises to be greatly insightful. After binning the floor area of Allee's stores, the F-test showed a weak but significant relationship between the stores' size and their

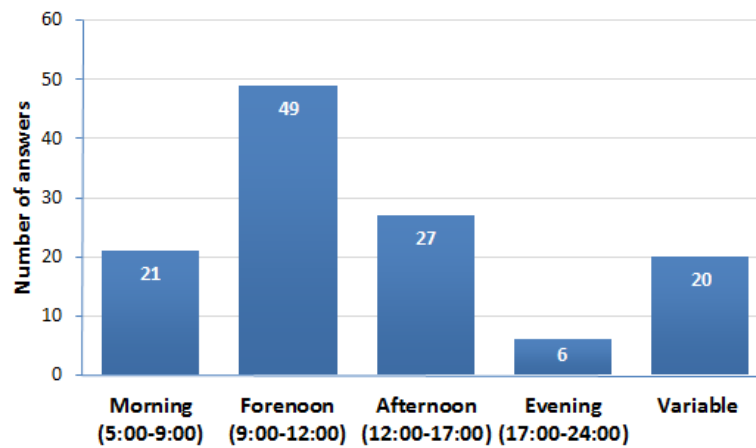
average number of daily deliveries (sig = 0.019, Eta squared = 0.128). Basically, the larger the shop is, the more shipments it needs (see Table 3).

Table 3 Relationship between the floor size of shops and their shipment frequencies

Area (m ²)	N	Average number of daily deliveries	Standard deviation
0–25	20	0.367	0.62
26–40	18	0.450	0.41
41–83	16	0.499	0.51
84–140	19	0.675	1.14
141+	17	1.863	2.99

Seventy-six of 104 stores received their deliveries between 9:00–17:00, thus we are able to conclude that freight traffic shows only a limited amount of overlapping with passenger traffic whose peak is typically between 6:30–9:30 and 16:30–18:30. Twenty-one stores received shipments before the 9:00–17:00 interval and 6 later (see Figure 8). Seventeen stores indicated multiple intervals that are typical for them (N = 104, R = 38.45%).

Figure 8 Typical delivery periods of stores in Allee (see online version for colours)

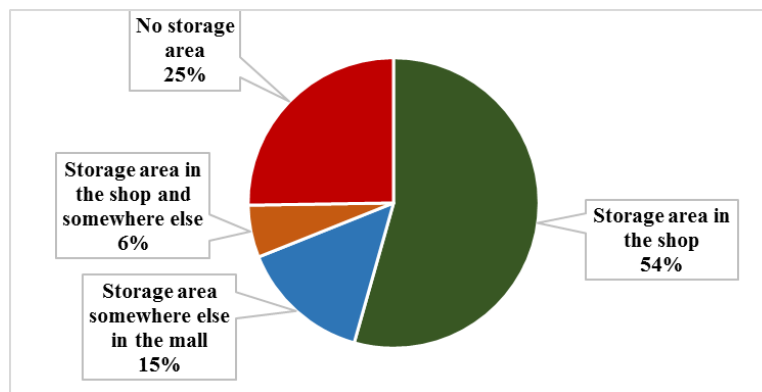


Ninety-seven stores responded to our question regarding the starting point of their inbound deliveries. Thirty-two of them indicated that they only receive shipments from outside of Budapest, while 25 stores only shipped from inside of the city. Fifteen stores did both (R = 72.51%). In Allee, 25 retailers utilised shipments between their own stores, but the quantity of these was negligible since it involved merely 3.58% of their products on average (R = 26.97%). Moreover, based on our questionnaire, one might calculate the proportion of delivered quantities from outside and inside of the city, compared to the shops' entire goods traffic. In our case 47% of the goods originated from inside (N = 63, R = 90.13%) and 53% from outside (N = 67, R = 95.03%) – a ratio that we expected to be more tilted towards outside. This means that an appropriate delivery scheme should be able to integrate goods flows originating from both places.

4.5 Properties of the storage areas

Nearly 75% of shops possessed storage spaces, which was consistent with the 80–85% we expected based on our expert interview, however it somewhat contradicts the hypothesis that retailers lack adequate storage options in shopping malls in general. Sixty-two retailers owned storage areas in their shop, 21 had them at other locations in the shopping centre (6 did both) while 26 did not have any storage (see Figure 9) ($N = 103$, $R = 38.63\%$). The average storage size was 40.79 m^2 but the standard deviation is very large, 78.65 m^2 that is in connection with the range of the answers: from 2 m^2 up to 500 m^2 ($N = 62$, $R = 58.33\%$). If we exclude the five largest values, the average becomes 20.34 m^2 with a standard deviation of 15.36 m^2 . The inventory kept in storage was sufficient for 33 days on average, but the standard deviation and range were substantial here as well (54.86 days; min. Zero days, max. 1 year, $N = 57$, $R = 62.32\%$).

Figure 9 Existence and location of storage areas (see online version for colours)



Similar to other topics, we believe that is insightful to test the relationship between the properties of the stores' storage areas and their other answers. We examined whether larger storages equal longer supply, and found that there is no statistically significant relationship, just like there is none between the main profile of the stores and the length in days that their inventory kept in storage is sufficient for. This can most likely be explained with the stores' intention of gradually moving towards just in time deliveries and decreasing the inventory they are required to keep. At the same time, it can be observed that stores with different profiles are capable of storing products for noticeably different periods of time. Additionally, the profile of a store determines whether it possesses storage options at all; the association is medium based on cross-tabulation (Cramer's $V = 0.432$). We found it exceptionally surprising that there is no significant correlation between neither the size of shops nor their inventory turnover and the frequency of their inbound deliveries.

4.6 Properties of reverse logistics

67.3% of stores conducted backwards shipments. Forty-seven of them shipped unsold products, 17 shipped reusable packaging, and 13 retailers shipped to their other location(s). Twenty-four stores indicated that they employ more than one type of the

reverse logistics processes ($N = 101$, $R = 55.80\%$). The frequencies of the backward shipments told us the followings: the most frequent answers were weekly and half-yearly, and typically the shipped quantities could be best described in months and/or years, therefore they paled in comparison to the daily and weekly quantities of inbound shipments.

4.7 IT background of stores

Forty of the 94 responding stores in Allee used no ERP systems at all, and only 21 wished to identify their software in use. Out of these, there were 16 different systems (only SAP came up more than once) with four developed in-house ($R = 90.49\%$). Based on these results, it would be a significant challenge in Allee to establish the integration and compatibility between the common delivery scheme's and the stores' informatics systems.

4.8 Electronic commerce in the mall

During the research of e-commerce in shopping malls, the most important information is the number of stores shipping from their own inventory to consumers' homes, because the proposed common delivery scheme would need to deal with those deliveries. In Allee, nearly half of the retailers, 46 utilised e-commerce, however only 30 of them shipped from the shopping centre at least partially ($N = 102$, $R = 41.65\%$). Additionally, only 6.64% of the total number of products sold was shipped to the consumer (including all stores providing a comprehensible answer, $N = 84$, $R = 58.91\%$), therefore we concluded that e-commerce in Allee has not yet reached a critical mass that would justify integrating home deliveries into the common delivery scheme. However, that might soon change as e-commerce has shown exponential growth in Hungary, and in 2014 3.7% of all retail trade was conducted online (eNET, 2015). It seems that shopping centres are leading the way, and if that trend holds up, a common delivery scheme should be able to make deliveries to consumers as well.

4.9 Willingness to participate in the common goods delivery scheme

We measured retailers' willingness of joining the cooperative delivery scheme on a five-point scale, 1 meaning absolutely not, and 5 meaning definitely willing. Our questionnaire asked them to indicate their willingness in case of five different potential outcomes of the implementation of the scheme. All in all, the reduction of environment pollution turned out to be the most important for retailers (2.96, $N = 80$, $R = 99.6\%$), and the improved reliability of shipments the least important. Based on our exploratory research we expected financial gains to be the most compelling, but it came in third of the five aspects (2.7, $N = 77$, $R = 99.61\%$). It is important to note that the willingness of retailers remained under 3, i.e., indifferent for all five aspects, therefore it is crucial to devise an excellent communication strategy before the implementation of the scheme.

To assist with reaching the communication goals, we propose assigning stores into homogenous groups using cluster analysis, and then examine the properties of these groups. In our case, for Allee's stores the creation of four clusters seemed appropriate, they can be seen in Table 4.

Table 4 Output of cluster analysis in Allee (see online version for colours)

<i>Name of cluster</i>		<i>Environmentally conscious</i>	<i>Uncertain</i>	<i>Positive</i>	<i>Opposing</i>
<i>N</i>		<i>23</i>	<i>14</i>	<i>12</i>	<i>27</i>
Potential outcomes of the delivery scheme	Improved reliability of inbound deliveries	2.61	2.57	4.25	1.00
	Financial gain	3.52	2.86	4.58	1.00
	Environmental protection	4.22	2.43	5.00	1.00
	Enhancement of the city's transportation	3.91	2.36	4.83	1.00
	The time spent on order processing	3.22	2.43	4.83	1.00

5 Continuing the research

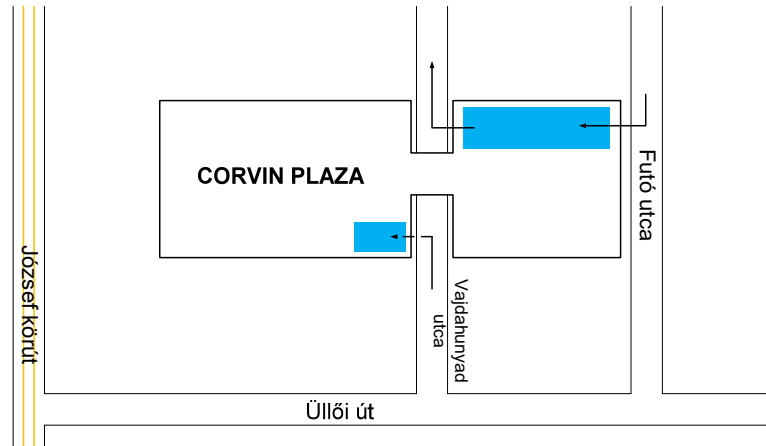
In February 2016 we decided to continue our research placing special emphasis on the topics of deliveries between a retailer's own stores and cycle logistics. The latter one is significant for us because the share of two-wheeled vehicles driven with human power (sometimes with the help of electric motors) is increasing in city logistics and it offers immense environmental savings opportunities. One study estimates that as much as 37,000 tons of CO₂ emission per year could be eliminated (Reiter, 2014). Researching only the fundamental logistical aspects of shopping malls however, we could not have gained the necessary data, therefore we needed to expand both the exploratory part of our research and the questionnaire as well.

The exploratory research was amended with two things. One is a traffic count which aims at providing better insight regarding the strain put on the neighbouring street by the shopping mall's goods traffic. Also, it was extended with a multi-moment analysis which aims at revealing the makeup of the freight vehicles' time while at the shopping centre. We wanted to measure in particular how much time they spend on standing by while waiting for the goods to be carried up to the shops, and what percentage this means from their total time. The form for registering the data was created after test-measurements.

The questionnaire includes numerous new questions, for instance regarding the possibility of using cargo bikes and the quantity of goods that can be stored on shelves. There are three new questions in the topic of between-stores shipments (location of the other shop in case of inbound and outbound deliveries, reason for not having such shipments), and also three questions relating to home-deliveries (time of order fulfilment, frequency and length of home-deliveries).

During our renewed research we plan to investigate four shopping malls in Budapest with 400 stores in total. Firstly, we completed the analysis in Corvin Plaza which is a smaller downtown shopping centre (see Figure 10). We included 76 of Corvin's 79 stores in our research and managed to contact 73 of them, out of which 51 filled out our questionnaire in the end. This means a response rate of 67%.

Figure 10 Layout of the freight receiving areas and transport connections of Corvin Plaza
(see online version for colours)



Our work at Corvin Plaza presented several interesting results regarding the centre's logistical operations. During the exploratory research we found out that it is easily accessible via road and that opportunities exist to incorporate it in a complex city logistics system utilising the river Danube or even the city's tram network. Time windows for freight deliveries are very strict, but shops are allowed to have night-deliveries. This remains a theoretical possibility however, even though it can be a beneficial concept from the standpoint of city transport as a whole. The size and layout of the goods receiving areas is satisfactory, overcrowding only occurs rarely in the mornings. The number and capacity of freight elevators is also adequate, only special shipments can cause problems from time to time. Waste recycling is not mandatory even though Corvin has the necessary facilities in place for handling and transporting plastic and paper packaging. From an environmental protection viewpoint it would be worth it to make it mandatory because the capabilities seem to be there. Rentable storage areas are scattered throughout the parking garage but they are not very popular despite their appropriate number and dimensions. The most likely reason is that most of them are quite far from the goods receiving areas.

The descriptive research provided plenty of intriguing results as well. The bulk of Corvin Plaza's shops were clothes, undergarments, bags and shoe stores, more than half being a member in a chain. More than three quarters of the retailers said that the majority of their stores are located in shopping centres. 48% said that at least six stores belonging to them are in Budapest's shopping malls which indicates that introducing roundtrips and consolidating the between-stores freight traffic offers great potential. Most of the inbound deliveries are done with freight vehicle between 1.5 and 7.5 tons. 86% of the stores utilise boxes, while 30% use pallets too at least occasionally. We asked retailers whether they could utilise the $70 \times 50 \times 50$ cm cargo bike shown in Figure 11 and for what purpose. In total 22% of the shops could utilise it, nine for between-stores shipments, 6 for inbound shipments and 2 for home deliveries.

More than half of the stores receive goods that require special handling most often fragile and high value products. Thirty-five out of 51 retailers dispatch outbound shipments from the shopping centre out of which 19 is towards their other stores. For us the key information here is that 72% of these 19 stores ship to other Budapest shopping malls. Moreover, 26 stores answered that they receive goods from the retail chain's other stores, out of which 77% is in Budapest shopping centres. Based on these data we conclude that in Corvin Plaza's case the inclusion of between stores shipments into the delivery scheme seems viable because of the freight volume.

Figure 11 BULLITT type cargo bike (see online version for colours)



Retailers in Corvin Plaza use multiple kinds of ERP systems, with SAP being the most popular. Regarding e-commerce, we found that more than half does not employ it at all. Out of stores that do however, the majority provides home delivery options as well, and 70% of them ships daily. This denotes that home delivery is not overly prominent in general, but stores that provide such opportunities, do it often.

Our respondents were most willing to join to a consolidated delivery scheme if that system would result in a reduction of environmental pollution and would improve the city's transportation conditions. Only these two outcomes triggered the average willingness to exceed 3, meaning indifferent.

We've done a number of correlation tests and found that neither the size of a store nor the size of its storage areas show a statistically significant correlation with the frequency of inbound deliveries. Similar to Allee's case this signals fast inventory turnover and JIT shipments. The applicability of a cargo bike did show a medium correlation with which cluster the store belonged. It is telling, that stores completely rejecting the participation in such innovative approaches are not even able to utilise cargo bikes. There was also a medium correlation between the existence of shipments to a retailer's other stores and from another store.

Recently we extended our research to WestEnd City Centre, which is the largest shopping centre of Budapest's internal areas with over 350 stores. Out of these, we included 308 into our research, and collected 171 responses. This yielded our lowest response rate at 55,5%, but due to the massive size of WestEnd, it still more than doubled our database. Because of this spike in the number of respondent stores and the fact that now we have researched a small, a medium and a large shopping mall, we were able to make estimates for the other malls in Budapest and develop different models. First a mezosopic simulation model was created to compare the current processes with some innovative city-logistics solutions that utilise alternative road vehicles, or cargo trams for instance. These simulations indicated significant savings opportunities in regard to CO₂

emissions or vehicle-kilometres. Additionally, a macroscopic model was developed to investigate the possibilities of including cargo bikes to the supply chains of Budapest's shopping malls (Sardi and Bona, 2016).

Currently a supplementary research effort is underway to tailor the original research methodology for shopping strips by modifying the questionnaire and testing it on Fashion Street Budapest.

6 Conclusions

Based on our results, and the gathered data, we are able to conclude that our methodology is capable of researching a shopping centre's logistical characteristics, quantifying the amount and heterogeneity of goods to be consolidated and delivered and to collect the challenges to be solved. Based on our results and experiences during data collection we modified our questionnaire to be easier to comprehend, and to provide us with more exact information. To further test our methodology and to gain a more comprehensive knowledge of shopping malls, we are continuously examining additional shopping centres in Budapest. Our methodology is capable of establishing the basis of a cooperative delivery scheme, but there are numerous additional tasks to be carried out in the future, primarily a pilot-project would be practical. The involved retailers would need to be identified, for which a suitable communications and marketing strategy has to be devised. Financing of the project needs to be taken care of; e.g., a list of possible tenders is required to be compiled. In order to launch a pilot project, certain logistical-technological and organisational developments are to be carried out. All these pose significant challenges to both the involved professionals, users and city management as well.

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Annex

Questions of the survey:

- 1 What is the main category of the store? (Multiple choice).

- 2 What is the approximate size of the store? [m²]
- 3 What is the nationality of the store's ownership?
- 4 What is the operational model of the store?
- 5 Where are the other stores of the company located?
- 6 How do the deliveries take place? (Multiple choice).
- 7 What is the typical freight vehicle used for deliveries? (Multiple choice).
- 8 Which storage receiving area is typically used? (Multiple choice).
- 9 What is the typical delivery unit of the store, and how many of them does the store need for one delivery on average? (Multiple choice).
- 10 Who moves the goods to the store after they've arrived to the shopping malls? (Multiple choice).
- 11 How many product groups does the store carry?
- 12 How many different products does the store carry?
- 13 Are there any goods or products that need special handling during delivery, and what is their ratio in your portfolio? (Multiple choice).
- 14 What are the two most typical delivery frequencies of the store?
- 15 What percentage of the goods require a significantly different delivery frequency?
- 16 In which time interval does the store typically receive inbound deliveries? (Multiple choice).
- 17 Does the store possess storage areas? If yes, where are they located?
- 18 What is the total size of the store's storage areas? [m²]
- 19 What is the approximate time that the inventory kept in storage is sufficient for? [days]
- 20 Does the store have backward shipments (excluding home deliveries)? If yes, what does the store ship? (Multiple choice).
- 21 What is the origin of the store's inbound deliveries?
- 22 Does the store utilise informatics systems (e.g., ERP systems)?
- 23 Does the store offer e-commerce possibilities?
- 24 What is the origin of home deliveries?
- 25 Approximately, what percentage of all products sold by the store are delivered to the customers' homes?
- 26 Would the store be willing to participate in a cooperative delivery scheme that extends to the whole shopping mall, in case the system leads to the following results?