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ANALYSIS OF THE POTENTIAL DEMAND OF AUTOMATED DELIVERY STATIONS FOR E-COMMERCE DELIVERIES IN BELO HORIZONTE, BRAZIL

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Abstract

The problems related to home delivery become increasingly evident with the growth of electronic commerce. Automatic delivery stations represent a solution to reduce mislaid deliveries and consolidate parcels drop-off, minimizing the kilometers traveled, and the costs of urban goods distribution. In order to better understand online shoppers' attitudes towards new delivery services, we analyze the potential demand of automatic delivery stations (lockers) in the city of Belo Horizonte, Brazil. For this purpose, we develop a survey according to stated preference and revealed preference methods, and we assess potential users considering two

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deliveries services: home delivery and automated delivery stations. The results indicate that, although home delivery is the preferred option, automatic delivery stations score high potential demand for online shoppers. This paper provides an approach to integrate the impact of final consumers' preferences on shaping last-mile operations, and it thus helps policymakers to identify the most suitable innovations to specific urban settings.

Keywords
e-commerce; last mile problem; home delivery; pick-up points; stated preference survey.

Classification codes
R410, R000, R130, R420.

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Abstract
The problems related to home delivery become increasingly evident with the growth of electronic commerce. Automatic delivery stations represent a solution to reduce mislaid deliveries and consolidate parcels drop-off, minimizing the kilometers traveled, and the costs of urban goods distribution. In order to better understand online shoppers' attitudes towards new delivery services, we analyze the potential demand of automatic delivery stations (lockers) in the city of Belo Horizonte, Brazil. For this purpose, we develop a survey according to stated preference and revealed preference methods, and we assess potential users considering two deliveries services: home delivery and automated delivery stations. The results indicate that, although home delivery is the preferred option, automatic delivery stations score high potential demand for online shoppers. This paper provides an approach to integrate the impact of final consumers' preferences on shaping last-mile operations, and it thus helps policymakers to identify the most suitable innovations to specific urban settings.

1. INTRODUCTION

The number of Internet users in Brazil has grown thoroughly over the last years. In 2014, there were around 94.2 million Internet users that represents 55% of the country's population over 10 years old. In 2008, the percentage of users was only 34% of the population in this age range (CGI.br, 2014). The National Broadband Plan (PNBL), elaborated by the Brazilian government to expand fiber network and broaden access to Internet services, has enhanced this trend. Thus, purchase and consumption habits are changing fast, and shopping online is increasingly popular. Traditional retail sales increased 4.2% in 2015, compared with the first semester of 2014. In contrast to that, the e-commerce had an increment of 16% in the same period (IBGE, 2015a). According to E-bit (2015), 61.6 million Brazilian online shoppers, which represents 30.7% of the Brazilian population, made at least one online purchase in 2014 (Figure 1). In the Brazilian context, 70% of the consumers are between the ages of 25 and 49 years; 43% have an income above US $790 per month, and 52% have at least a university degree (E-bit, 2016).

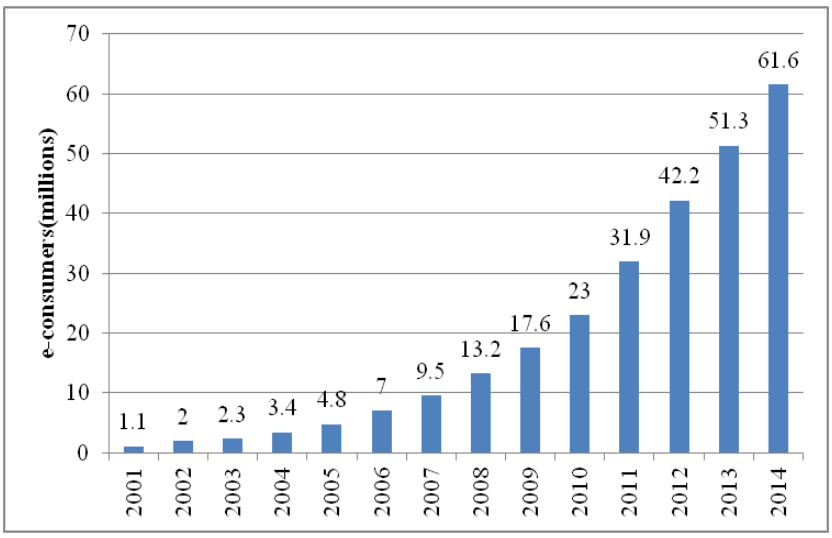


Figure 1 – Evolution of e-commerce consumer growth in Brazil (E-Bit, 2015).

In 2014, 103.4 million online orders were made in Brazil, resulting in revenues of US $9.42 billion. The average order value of online shopping is US $91, and the more common categories of products sold online are: fashion and accessories (17%), cosmetics, perfumery, personal and health care (16%), appliances (11%), books and magazines (8%), telephony and mobile (7%), IT (7%), interior design (6%), electronics (6%), sporting goods (5%), and toys and games (2%). As reported by E-Bit, 54% of orders had no shipping costs for the consumer, generating them savings of US $286 million per year. Nevertheless, lead time is a major concern regarding online shopping (E-bit, 2015): in 2015, the average lead time was 9.4 days, and in 2014, it was 8.4 days (E-bit, 2016). The percentage of delayed deliveries was reduced from 12% (2014) to 8% (2015) (E-bit, 2016).

In a broader perspective, the increase in online orders leads to raising the number of home deliveries. Van Duin et al. (2016) indicate that one of the major problems of home delivery is the high number of missed deliveries (25%), which results in more kilometers travelled, higher pollution emissions, and additional costs. In order to overcome parcel delivery issues, alternative solutions, such as pick-up points and automatic delivery stations (ADSs), have been implemented in Europe and in the United States, consolidating the final deliveries in selected spots (Morganti and Dablanc, 2014; Morganti et al., 2014).

According to Comi and Nuzzolo (2016), the increase of various delivery solutions generates changes in the pattern of urban freight flows and vehicles' movements in cities. Online shoppers' attitudes and preferences should thus be the object of additional investigation to integrate their impact on shaping last mile operations. Moreover, Pourabdollahi et al. (2012) argue that urban logistics models are more effective when they include local elements. A more comprehensive framework, as well as a detailed behavioural research over freight movement, is thus recommended to assess policies and to examine the effects of changes in the system-level elements.

So far, little is known about the potential demand for delivery services in ADSs, declared by Brazilian online shoppers. Among the few ongoing trials, there is the pilot test run by the Brazilian post (Correios) in Brasilia and other cities, implementing an ADS network in post offices and high-traffic public areas, such as subway stations and shopping malls (Neopost, 2014). This paper focuses on online shopping delivery options and presents a method to estimate consumer preferences. The methodology applied to Belo Horizonte is a priori suitable to other cities in other countries where ADS does not exist yet.

The main goal of this paper is to analyze the potential of ADSs in the Brazilian context and define the demand for those consolidated delivery points regarding online consumers in the city of Belo Horizonte. In particular, the paper investigates: (i) consumer preferences in relation to selected attributes of deliveries, such as location, delivery time, information and traceability, and cost of transportation, and (ii) the willingness to use automatic delivery stations.

2. LITERATURE REVIEW

This section describes delivery systems for small packages originated from the e-commerce and illustrates recent contributions under the city logistics' point of view. Then, we present a review of different methodological approaches to behavioural research on freight movement and stated preference.

2.1 Studies related to automatic delivery stations

Delivery systems for small packages, such as automatic delivery stations (ADSs), which are also called collect and delivery points (Browne et al., 2001) or automated lockers (Punakivi, 2003; Morganti et al., 2014), have been investigated since the last decade as a solution to consolidate end consumer deliveries and to improve the efficiency of urban goods distribution. According to Browne et al. (2001), an increased amount of ADSs can enhance the efficiency of supply chains: at that time, 23% of consumers stated that they would be more comfortable to buy online if home deliveries were more flexible. This percentage increases to 34% if consumers could choose a more suitable place to pick up the packages.

Quak et al. (2012) and Dell'Amico and Hadjidimitriou (2012) indicate that ADSs represent an innovative solution for urban logistics, being an alternative solution to the last-mile problem. In some countries, such as France, convenience-store-based pick-up points represent a relevant alternative to home deliveries (Morganti et al., 2014). In contrast to that, the usage of ADSs and lockers have high growth rates in various Western countries (Iwan et al., 2016).

ADSs can be located in residential areas, shopping malls, public transport stations, within stores and business centres, as well as in public areas where many clients can access them through short-distance trips. ADSs, as a delivery option, contribute to raising both consumer satisfaction and last-mile delivery optimization. Those benefits are related to higher flexibility regarding time windows and convenient sites available to end consumers. Additionally, there can be a reduced number of missed deliveries and travelled kilometers by delivery services

providers. Besides that, other advantages are: (i) customers can collect their products at these points when they cannot be delivered at home (McLeod et al., 2006), (ii) high customer satisfaction (Edwards et al., 2010), and (iii) redelivery failure rate (McLeod et al., 2006). Finally, the largest benefit is to perform 100% of the deliveries (Van Duin et al., 2016) generating a reduction in travelled kilometers by delivery vehicles (Edwards et al., 2010).

The Bentobox was one of the solutions tested in Berlin (Germany) and Turin (Italy) by the European project CITILOG. Pilot test users were satisfied, and this test indicated that the location of the Bentobox in commercial establishments is one of the most successful implementation factors (Quak et al., 2012). Retailers hosting the Bentobox reported increased flexibility of the service offered by the store to users. Dell'Amico and Hadjidimitriou (2012) have compared 38 deliveries, considering home deliveries and pick-up points. The results indicated financial advantages for the logistics operator when automatic delivery stations are located next to the customers.

DHL implemented the system called Packstation in Germany, with a network of 2,650 locations, including a test for fresh-food deliveries in refrigerated lockers. Postal and logistics operators have implemented ADS services in France and many other European countries (Morganti et al., 2014), as well as in Colombia, Australia, Russia, Saudi Arabia, Finland, Estonia, Ukraine, Slovakia, Lithuania, and the Czech Republic, as reported by Folkert and Eichhorn (2007) and Iwan et al. (2016).

According to Folkert and Eichhorn (2007), city size is not a relevant criterion to implement this system. Costs can be low, since ADSs usually only require adjustments in infrastructure, for example, using the retailers' facilities for delivery. The implementation time of this project is low (less than three years), involving private companies, public authorities, urban planners, and users of the system. An unwanted effect of the system is the possible increase in the number of private vehicles to collect the parcels. To minimize this problem, Dell'Amico and Hadjidimitriou (2012) emphasize the importance of ADSs' location.

Xu et al. (2012) analyze the applicability to China, with a focus on investment patterns and on the flow process of the parcels. Ding (2013) conducted a study to investigate alternatives to last-mile logistics in China. The results indicated that a competitive advantage can be obtained with a network of pick-up points if there is a high density of orders as well as differentiated delivery windows. The author points out that a high density of orders destined for an automatic delivery station is positive for the system. However, the cost of the service can be a negative factor for the popularity of this solution.

Iwan et al. (2016) analyzed the usability and efficiency of automatic collection points based on the postal company's experience in Poland. The authors indicate that time, price, tracking, availability, and location are important elements for the use of the system. Among customer expectations, the location should be close to the residence (33%), on the way to work (21%), close to shopping centres (10%), close to public transport stations (5%), close to parking (19%), and in secure locations (11%).

In the Brazilian context, the use of pick-up points was one of the first solutions for urban logistics to be investigated by Dutra (2004) and Oliveira et al. (2010a). Dutra (2004) evaluates the applicability of different solutions to urban e-commerce deliveries. In this context, the author proposes the adoption of ADSs located at strategic points of the urban centres and equipped with a technological structure that complies with security requirements, both for parcels and customers, assuring confidentiality throughout the whole procedure. Oliveira et al. (2010a) assess the feasibility of the use of automatic delivery stations, obtaining results such as a reduction in the number of vehicles, due to the consolidation of the goods, a reduction in the distance travelled and, consequently, fewer emissions of pollutants. The authors used system

dynamics in their methodological approach. Although scholars have explored issues related to urban freight optimization and ADSs, none of the studies examined the potential demand of ADS services in the Brazilian context.

The studies previously described show the importance of ADSs to improve the efficiency of urban goods distribution; nevertheless, policy related to city logistics has been overlooked, and a few recommendations have addressed urban planning issues. Those studies were presented to subsidize the definition of the most important factors that lead online consumers to utilize the ADS solution.

2.1 Review on methodological approaches

The literature indicates some relevant features in ADS implementation. Nevertheless, a few studies evaluate the acceptance of this delivery option by online shoppers. Thus, to determine consumers' preference for delivery options, considering online orders is crucial to taking the right steps towards an efficient public policy. The main objective of the behavioural research over freight is to understand the freight agents' behaviour and how they react to each policy. For that, some techniques are available, such as focus groups, survey using revealed preferences and stated preferences, disaggregated models based on choice observed, and behavioural models. To Gatta and Marcucci (2014, p.249), "behavioural models constitute a sub-set of disaggregated models that assume that stakeholders strive to maximize utility". Therefore, stated preference survey allows the acquisition of the necessary data to accurately estimate the most likely effects of the policies.

A limited number of papers have considered specific stated preferences (SP) and behavioural models towards freight analysis (Anand et al., 2012; Gatta and Marcucci, 2016) to capture freight stakeholder's opinions and to warrant a better understanding of policy effects (Gatta and Marcucci, 2016).

Marcucci et al. (2007) quantify the willingness of private operators to use urban distribution centres. Puckett et al. (2007) used a stated choice experiment to capture independent preferences and the effects of interactivity among buyers and sellers on urban freight services. The methodological procedure is to administer one questionnaire to assess sensitivities of buyers and sellers of urban freight services, considering the trade-offs between travel time and cost. Holguín-Veras et al. (2007, 2008) analyze the effectiveness of off-peak delivery, considering the point of view of retailers and carriers. Holguín-Veras et al. (2007) describe the results corresponding to receivers' scenarios that encourage off-peak deliveries. Holguín-Veras et al. (2008) focus on carriers and estimate the market shares for joint scenarios. Afterwards, they look at policy implications.

Oliveira et al. (2010b, 2012) and Domínguez et al. (2012) used SP to evaluate solutions with stakeholders. Oliveira et al. (2010b) identify the attributes required to accomplish overnight goods delivery in urban areas from the point of view of researchers, carriers, and retailers. Oliveira et al. (2012) evaluate the adoption of urban distribution centres by retailers and carriers in Belo Horizonte and Fortaleza. Domínguez et al. (2012) investigate the adoption of urban distribution centres and off-peak delivery by retailers in Barcelona. None of those works have evaluated the potential market for ADSs.

Marcucci and Gatta (2013) analyze the impact that variations of policy characteristics (for instance: time windows, the number of bays for loading and unloading, entrance fees, etc.) cause on own-account agents' behaviour. Gatta and Marcucci (2014) evaluate alternative scenarios to urban freight transport in Rome, considering the point of view of own-account freight agents, retailers, and transport providers. Gatta et al. (2015) compare the finite sample performance of methods to build confidence intervals for the measure of the willingness to pay

in a choice-modelling context. Marcucci et al. (2015) investigate transport providers' preference for an alternative to traditional loading bays and for pricing policy. Gatta and Marcucci (2016) analyze the behavioural implications of non-linear effects on urban freight transport policies, investigating the impact of the number of bays for loading and unloading, and the probability of parking in those spaces without fees. They investigate the impacts that entrance fees have on retailers and transport providers. Marcucci and Gatta (2016) investigate the respective capabilities of retailers and transport providers to predict each other's responses regarding agents' preferences for alternative urban freight policies.

Most of the studies presented in this section have the ambition to describe stakeholders' preferences regarding solutions for the urban freight distribution. We assessed the previous works to determine the best methodological approach for this paper, as described in Section 3.

3. METHODOLOGY

First, this study is based on revealed preference data, collected in order to understand consumer behaviour in relation to e-commerce deliveries. This approach allows the identification of the most relevant attributes for the use of ADSs. In addition, the authors used a stated preference survey to obtain data to estimate the demand for ADS. In this section, we describe the phases of the investigation and characterize the sample and its representativeness.

3.1 Phases of the methodological approach for the investigation

The study was organized in four phases:

(i) draft of the questionnaire for the profile of the respondents and the revealed preference survey;
(ii) draft of the Stated Preference (SP) survey;
(iii) data collection;
(iv) data processing.

In the first phase, we developed a questionnaire to get respondents' profiles (gender, age, income, education, neighborhood, and occupation) and revealed preference data about e-commerce habits (frequency, products purchased, average purchase price). Another data that we intended to acquire in this step was to understand the preferences regarding ADSs (features, location, mode of transportation, distance, time, and information system available).

In the second phase, we designed the SP survey, including the variables of interest (attributes) and values (options) of the variables to be evaluated by respondents (Kroes and Sheldon, 1988). Based on literature review (Folkert and Eichhorn, 2007; Dell'Amico and Hadjidimitriou, 2012; Quak et al., 2012; Morganti et al., 2014; Iwan et al., 2016), we selected four attributes: location, delivery time, information and traceability, and cost of transportation. Two delivery options (home delivery and ADS) were considered for each attribute. The attributes and respective options were:

- location: the user can receive the product at home or at the ADS;
- delivery time: the user does not know the delivery time, and it happens usually during business hours, or there is flexibility to collect the parcel at the most convenient time for the customer;
- information and traceability: the user knows only that the parcel will be delivered in a given delivery time, or the user can monitor all stages of delivery and plan the collection of the product;
- cost of transportation: amount to be paid for shipping delivery; we assume that this cost is the reference price, and the delivery price decreases with the use of the ADSs.

We used factorial design to combine attributes and options in a few alternative scenarios. To define the scenarios, we used the factorial arrangements developed by Cochran and Cox (1978) and adapted them for the use of the SP method (Souza, 1999). The four attributes and the two respective options resulted in 16 scenarios. With the arrangements, we obtained four sets with four scenarios, each presented in Table 1.

Table 1 – Sets and scenarios.

Set	Scenario	Location	Delivery Time	Information and Traceability	Cost of Transportation
Set 1	1	Home delivery	Business time	No	Reference price
	2	Automatic station	Flexibility time	Yes	Reference price
	3	Automatic station	Flexibility time	No	Reduced p[rice
	4	Home delivery	Business time	Yes	Reduced price
Set 2	1	Automatic station	Flexibility time	No	Reference price
	2	Home delivery	Business time	Yes	Reference price
	3	Home delivery	Business time	No	Reduced price
	4	Automatic station	Flexibility time	Yes	Reduced price
Set 3	1	Automatic station	Business time	No	Reference price
	2	Home delivery	Flexibility time	Yes	Reference price
	3	Home delivery	Flexibility time	No	Reduced price
	4	Automatic station	Business time	Yes	Reduced price
Set 4	1	Home delivery	Flexibility time	No	Reference price
	2	Automatic station	Business time	Yes	Reference price
	3	Automatic station	Business time	No	Reduced price
	4	Home delivery	Flexibility time	Yes	Reduced price

Among the different survey methods, this study used the ranking of alternatives technique: a set of alternatives is presented to the respondents, which are questioned about their preference towards those options. Figure 2 shows an example. The respondent should also supply a list of the alternatives in descending order of preference.

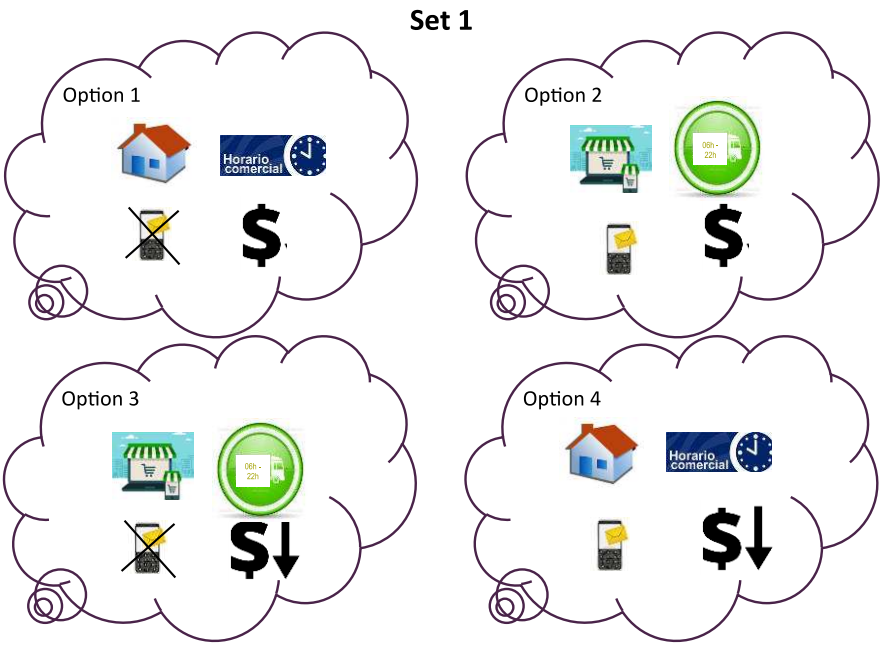


Figure 2 – Example of set of alternatives presented to the respondents for the ranking of options.

In the third phase, we used the Internet to disseminate and administer the questionnaire. The respondents were invited to participate in the survey through email (on a voluntary basis). After answering the profile and the revealed preference survey, the respondents were also invited to participate in the SP survey (the SP survey was not applied to the whole sample). A sample analysis is presented in the next sub-section.

In the fourth phase, data regarding online shoppers' profile and revealed preference were processed and analyzed using electronic spreadsheets. To discuss the results, it is important to notice that the average profile of our respondents matched the average Brazilian online shopper's profile, described by E-bit, a national reference on e-commerce data. The revealed preference results were then compared with data from the literature review (especially Browne et al., 2001; Morganti and Dablanc, 2014; Iwan et al., 2016).

Moreover, SP data was processed using the "LMPC" software developed by Souza (1999), which provides the coefficient of each attribute and statistical tests to check the validity of the results. The validation of the data is done automatically in the data processing. The analyst can check the results of this validation using statistical outputs, such as the coefficient of determination (R^2) and t-test.

The general fit of the model was evaluated using the R^2, which varies between 0 and 1 (full-compliance data). We used the coefficients to analyze the probability of use of ADS in the scenarios analyzed through the multinomial logit model. For that, a utility function of each scenario analyzed was determined, and a multinomial logit model was estimated to determine the probability of an alternative to be chosen, considering the proposed ones.

After this, we calculated users' willingness to pay for the ADS, considering the attributes of the stated preference survey. Willingness to pay (WTP) has been defined as the amount of money an agent (i.e., online shopper) would pay to obtain a desired good or service, and reliable WTP measures are fundamental in transportation economics (Gatta et al., 2015). WTP measures for a given attribute were estimated by dividing a given attribute coefficient by the cost coefficient (Gatta and Marcucci, 2014; Gatta et al., 2015).

3.2 Description of the sample

Belo Horizonte, the capital of the state of Minas Gerais, has approximately 2.5 million inhabitants, distributed over 331,401 km². This city is Brazil's sixth-largest urban area in terms of population. Belo Horizonte Metropolitan Area (BHMA) has 5.8 million inhabitants distributed over 34 municipalities. It is the third-largest urban agglomeration in Brazil and represents the political, financial, commercial, educational, and cultural centre of Minas Gerais, representing about 40% of the economy and 25% of the state population. BHMA is the 62nd-largest urban agglomeration in the world, the seventh largest in Latin America, and the largest in Brazil, outside the Rio-São Paulo area. Belo Horizonte has the fifth-largest GDP of Brazil's cities and a motorized population of 1,714,233 vehicles (July 2015) (68% cars, 16% light freight vehicles, 12% motorcycle, 3% heavy freight vehicles and 1% buses), indicating a motorization index of 1.46 inhabitants per vehicle (IBGE, 2015b).

During the month of June 2015, we interviewed 534 people, of which 470 were living in Belo Horizonte and 64 in the Metropolitan Area. We considered every member of the population having equal probability to answer the survey (simple random sampling). Therefore, the sample has a confidence level of 95% and a margin of error of 5%.

The sample is made up of 48.75% women and 51.25% men. The sample has most young consumers; 78% are 20–49 years old (Figure 3); 71% have an income above US $1,252 per month (Figure 4); and 74% have at least a university degree (in addition, 17% are enrolled in higher education) (Figure 5). The survey indicates that the most purchased products are small

appliances (e.g., TV, radio, and kitchen equipment) (22%), followed by household appliances (refrigerator, microwave, electric oven, stove) (19%), and books, CDs, and DVDs (17%), as shown in Figure 6.

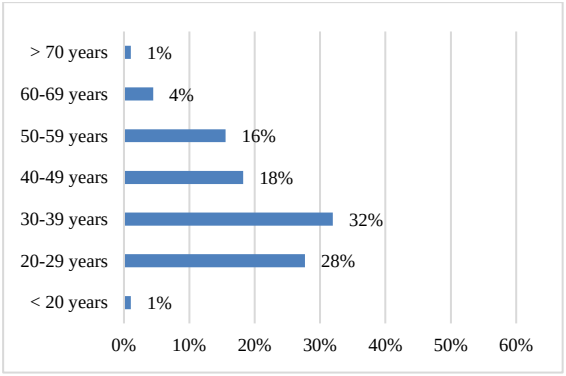


Figure 3 – Age range of respondents.

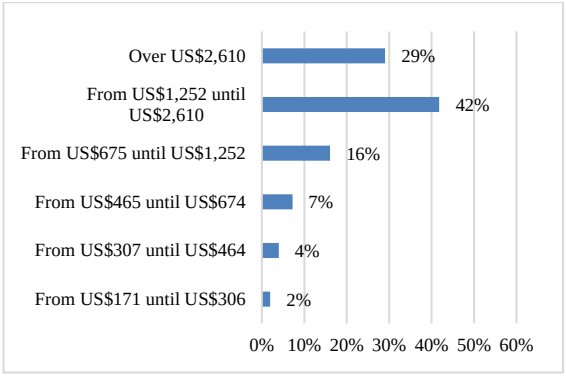


Figure 4 – Income level of the respondents.

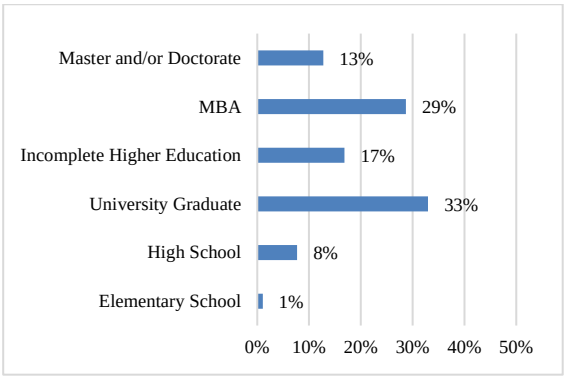


Figure 5 – Educational level of respondents.

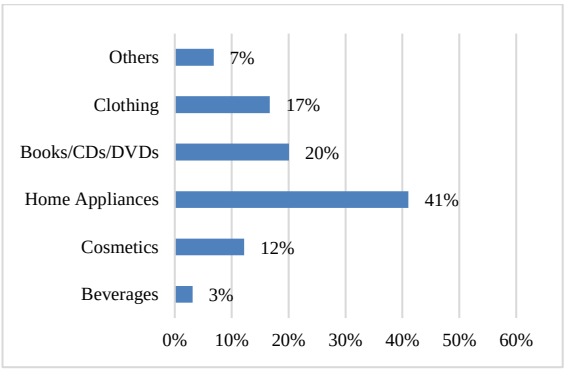


Figure 6 – Products purchased in e-commerce.

Most respondents (94%) purchase online physical goods, and out of these, 35% buy at least once a month (Figure 7). For 72% of respondents, the average purchase price is between US $26 and US $132 (Figure 8).

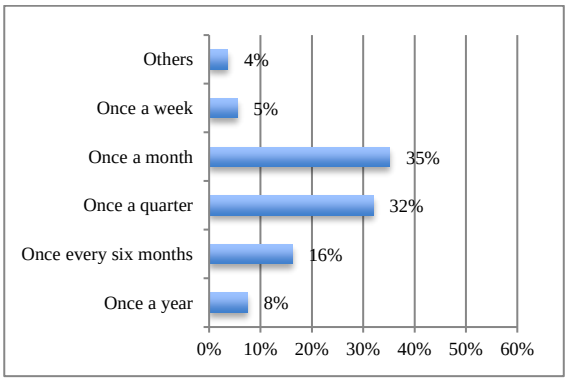


Figure 7 – Purchase frequency in e-commerce.

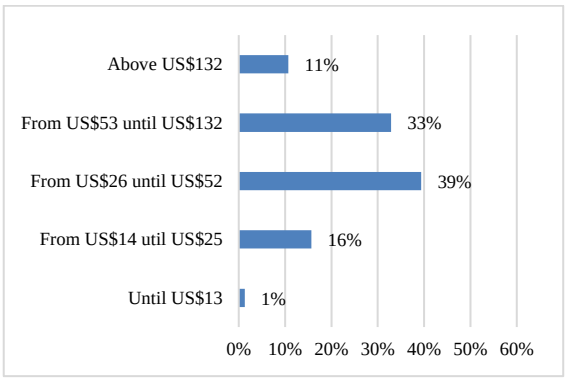


Figure 8 – Average value of purchase in e-commerce.

We compared these results with those acquired from Brazilian online shoppers, as previously presented (E-bit, 2015, 2016), and identified some similarities: most of the consumers are between the ages of 25 and 49 years; most of them have an income above US $790 per month; and the majority have a university degree. Therefore, we concluded that the

answers could be considered representative regarding socioeconomic attributes, compared with Brazilian online shoppers.

Complementarily, we have some results about respondents that do not buy online (6%). The reasons are: privacy issues (30%), which could be somewhat avoided using ADSs, distrust in the Internet (15%), preference to buy in traditional shops (48%), and others (7%).

It is also important to analyze the representation of the population spatial structure through the sample. Hence, the monthly average household income by districts in Belo Horizonte and the populational density (IBGE, 2012) are confronted with the sample size in each district (Figures 9 and 10).

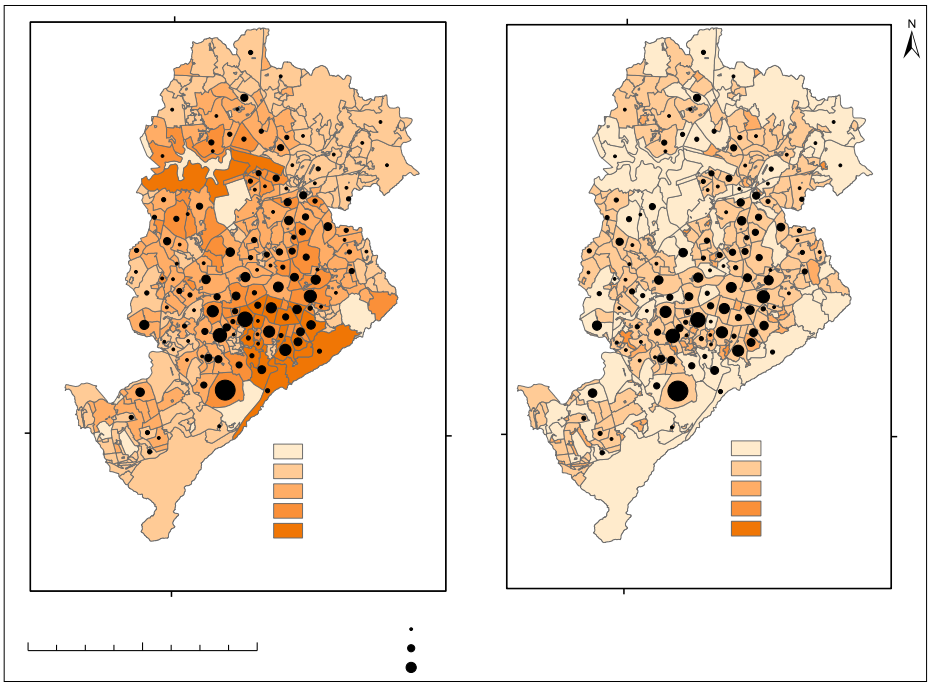


Figure 8: (a) Monthly average household income and sample size; (b) population density and sample size.

The spatial structure of the sample data follows the same spatial pattern identified for the populational density, with more questionnaires completed in the areas with higher density. Almost 78% of Belo Horizonte's population live in areas with a populational density ranging from 745.16 hab/km^2 to 3,165.18 hab/km^2. As for the sample data, around 79% of the answers came from people who live in these districts. This indicates that, spatially, the sample is well distributed in the city and represents the concentration of residents.

Considering the monthly average household income, we can notice that the occurrence of responses is more concentrated in districts with medium class income (72% of the answers were from people who live in households located in the districts with monthly income on the range R$ 2,202.99 – R$ 9,029.35). This is expected, since the questionnaire was web-based and we believe that people from lower classes don't have that much access to the Internet, as those of higher income groups do. Nevertheless, the highest income range showed 18% of the observed questionnaires, and the people in households of less than R$ 2,202.99 of monthly income represented less than 9% of the collected data.

Part of this sample (124 people) answered stated preference survey. Each interviewee imply in 4 answers (one for each set of alternative), resulting 496 answers. We considered the treatment of outliers, which is built in the LMPC software, to identify the divergent interviews

in relation to the general behaviour of the population sampled. According to Souza (2006), LMPC software considers the probability value of each individual utility interview and determines, by descriptive methods, data diverged from the sampled set. Divergent interviews occur due misinterpretation of the alternatives by the respondents. To identify the discrete data, Souza (1999) proposed a review of the data through a specific algorithm, which considers the individual utility of each interview and determines, through descriptive methods, the data that deviate from the sampled set. Using this approach, 41 interviews were removed (individual utility between 0.0331 and 0.0398). Table 2 presents the frequency distribution of the utility of interviews, grouped into class intervals, which presented the indicator of skewness equal -0.59.

Table 2 – Frequency Distribution of the Utility of Interviews.

Frequency	**Range of classes of utility**								
	0.0331 to 0.0398	0.0398 to 0.0464	0.0464 to 0.0531	0.0531 to 0.0597	0.0597 to 0.0664	0.0664 to 0.0730	0.0730 to 0.0796	0.0796 to 0.0863	0.0863 to 0.0929
Simple	41	30	36	15	39	109	87	34	66
Cumulative	41	71	107	122	161	270	357	391	457

Our final sample to the stated preference analysis is composed of 457 interviews. We considered the approach proposed by Souza (2009) to determine the sampling size. For an error estimate of 0.05, the adjusted exponential function indicates the need of 422 samples, with the confidence interval [403; 441] and the explanation coefficient of 100%.

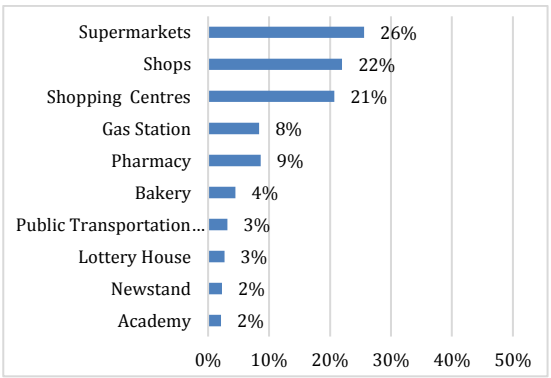
4. RESULTS

This section describes the results on the revealed preference and the stated preference surveys. The discussion of the results and the analysis of policy implications are also presented.

4.1 Description of the revealed preference survey

This section provides information about actual behaviour of respondents. Considering additional questions focused on delivery options and ADSs systems, 63% of the respondents reported that they would use the system if it were implemented in Belo Horizonte. Moreover, 83% would like to receive a security code to accomplish the parcel pick-up process. Safety of the location and security issues related to ADSs are valued as important or very important for 54% of the respondents, and necessary for 45%.

Concerning ADSs' locations, respondents ranked their preferences in the following order: supermarkets (26%), stores (22%), and shopping malls (21%) (Figure 11). The most preferred access time windows to the lockers are 18:00–20:00 (24%), 20:00–00:00 (19%), and 14:00–18:00 hours (16%) (Figure 12).



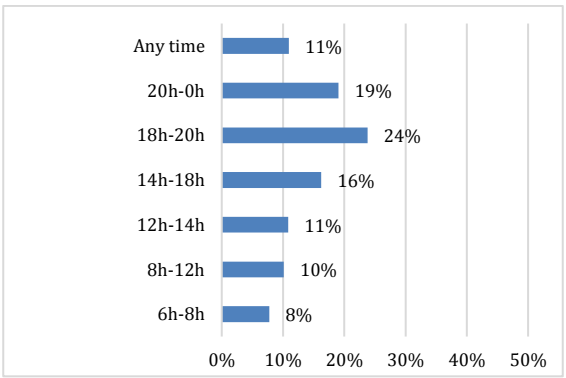


Figure 11 - Automatic delivery station location.

Figure 12 - Time to pick up the products.

As shown in Table 3, the respondents would use mainly private vehicles (59%) to collect parcels, with a travel time of 15–30 minutes (39%). The survey does not indicate a relationship between the mode of transport and the location of automatic delivery system.

Table 3 – Travel Time versus Transportation Mode.

Travel Time	On Foot	Bicycle	Private Car	Bus	Total
Max 5 minutes	10%	0%	16%	1%	**12%**
Between 5 and 15 minutes	37%	1%	58%	4%	**46%**
Between 15 and 30 minutes	16%	2%	39%	5%	**28%**
Between 30 and 45 minutes	3%	0%	7%	3%	**6%**
Between 45 minutes and 1 hour	1%	0%	2%	2%	**2%**
No change in travel time	3%	0%	7%	1%	**5%**
Total	**32%**	**1%**	**59%**	**7%**	

4.2 Results of the stated preference survey

The stated preference technique was applied to 124 respondents, all living in Belo Horizonte. The results are presented in Table 4. R^2 value obtained (0.26) is acceptable, considering that values between 0.2 and 0.4 are considered excellent (Ortúzar and Willumsen, 2011). Similar goodness-of-fit was found by Gatta and Marcucci (2014). Once divergent interviews (i.e., outliners) had been removed from the analysis, as described in Section 3.1 of this paper, the result improved by 5.9% regarding its performance when compared to the log likelihood and Pseudo-R^2 tests.

Each attribute has statistically significant parameters (significance level = 0.01). The location of the ADS has a negative and statistically significant impact on utility, showing that respondents would like to receive the products at home. Reductions on transportation costs have a positive and statistically significant impact on utility, showing that our assumption (the reference price decreases with the use of the ADSs, because home delivery is costlier than ADS delivery) is valid.

Table 4 – Multinomial logit model results.

Attribute	Coefficient	t-stat	Interval Confidence Level (2.5%)
Information and Traceability	1.4642	17.97	[1.301; 1.627]
Delivery Time	1.0213	12.77	[0.861; 1.181]
Cost of Transportation	0.8259	10.79	[0.673; 0.979]
Location	-0.4165	-5.66	[-0.564; -0.269]
R^2 = 0.2619			
Log likelihood function= 760.70			
Number of interviews: 547			

The results indicate that the attribute “information and traceability” is the most important attribute in the experiment (importance of 39%), followed by “delivery time” (27%), “transportation cost” (22%), and “location” (11%).

A utility function of each analyzed scenario was determined, and a multinomial logit model was applied to estimate the probability of an alternative to being chosen, considering the

status quo scenario. Table 4 describes the scenarios and the respective demand probability. As expected, the best home delivery scenario (corresponding to scenario/set 4/4) is to receive the goods at home, with a flexible time of delivery, information and traceability, and reduced cost of transportation (96% of demand probability considering status quo scenario). The scenario that proposes flexible time of delivery and information and traceability (corresponding scenario/set 2/3) has a 92% demand probability. These results indicate that the respondents would like improvements in home delivery with additional services, such as flexible delivery times, information, and traceability. Considering ADSs scenarios, scenario/set 4/2, which considers delivery in ADS, a flexible time of delivery, information and traceability, and reduced cost of transportation, has the best probability (94% of demand probability). We highlight that scenario/set 2/1, which considers the reference cost of transportation, has 88% of demand probability, i.e., ADSs can be proposed to the potential consumer with the reference cost of transportation.

Table 4 – Scenarios and respective demand probability, considering the Status Quo Scenario.

	Scenario/Set	**Scenarios**	**Demand Probability**
Home delivery scenarios	4/1	Home delivery, delivery in business time, information and traceability, and reduced cost of transportation	90%
	2/2	Home delivery, delivery in business time, information and traceability, and reference cost of transportation	81%
	3/2	Home delivery, delivery in business time, no information and traceability, and reduced cost of transportation	69%
	2/3	Home delivery, flexibility time delivery, information and traceability, and reference cost of transportation	92%
	3/3	Home delivery, flexibility time delivery, no information and traceability, and reduced cost of transportation	86%
	1/4	Home delivery, flexibility time delivery, no information and traceability, and reference cost of transportation	73%
	4/4	Home delivery, flexibility time delivery, information and traceability, and reduced cost of transportation	96%
Automatic delivery station scenarios	2/1	ADS, flexibility time delivery, information and traceability, and reference cost of transportation	88%
	3/1	ADS, flexibility time delivery, no information and traceability, and reduced cost of transportation	80%
	1/2	ADS, flexibility time delivery, no information and traceability, and reference cost of transportation	64%
	4/2	ADS, flexibility time delivery, information and traceability, and reduced cost of transportation	94%
	1/3	ADS, delivery in business time, no information and traceability, and reference cost of transportation	40%
	4/3	ADS, delivery in business time, information and traceability, and reduced cost of transportation	86%
	2/4	ADS, delivery in business time, information and traceability, and reference cost of transportation	88%
	3/4	ADS, delivery in business time, no information and traceability, and reduced cost of transportation	60%

Therefore, home deliveries were confirmed as the most attractive delivery solution. Nevertheless, if available, ADSs has a considerable potential market share for delivery services. Moreover, the results emphasize the need to meet customers' needs, especially regarding delivery time windows.

Some transport operators have developed traceability services, such as contact by telephone before delivery and notice of delivery via email. However, the traceability is not fully implemented and represents an obstacle to the development of e-commerce. Regardless of the type of delivery (home delivery or to automatic stations), our survey and questionnaire showed the importance of offering a service in consonance with customer needs.

4.3 Discussions and policy implications

We estimated the impacts of ADSs in Belo Horizonte, where circa 0.76 million of consumers shop online every year, namely 30% of the 2.5 million inhabitants. Assuming one order per consumer per year, it implies 330,025 orders per year. If implemented, ADSs could attract 43% of the orders, i.e., 27,502 parcel deliveries per month. Expected impacts in city logistics operations would include an improved consolidation of deliveries, fewer kilometers travelled, reduced deliveries costs, and, overall, a better urban environment.

Another interesting result is the user's willingness to pay for ADS deliveries, stated at 0.50R$ per delivery. This is a considerable amount if we consider that transportation costs are often free or offered by the online retailer.

Results from this study converge with the results presented in the literature: consumers would be more willing to buy online if delivery windows for home deliveries were more flexible (an increase of 23%, according to Browne et al. (2001), and 24%, according to our investigation). Similar results are observed, considering that the consumer could choose a more suitable location for picking up parcels. The results also indicate similarity to the analysis presented by Iwan et al. (2016), confirming that price, tracking availability, and location are important elements for the use of the ADS, since all these attributes have statistical significance.

Some insights for policymakers are proposed by this study. Security and safety issues result as a crucial element to be considered when planning a network of ADSs. In Latin American cities, on-street, unattended goods can represent a temptation for thieves and increase the risk for users during the collecting operations. Public spaces, such as train stations, bus stops, bus terminals, and public buildings, are potential sitting areas for ADSs. However, these solutions may require some changes in regulation and the implementation of public consultations. There must be an integration of the schemes into urban mobility plans and master plans. Finally, for cities that do have urban freight modelling, ADSs-related delivery/pick-up trips must be incorporated into those models.

The automated stations should be strategically located where non-motorized access (biking or walking) is possible, since this solution aims to reduce the impact of home delivery and to contribute to urban mobility. Compared to France, where pick-up points are located near public transportation stations (Morganti and Dablanc, 2014), it is important to mention that, in Belo Horizonte, the number of public transportation stations is low, therefore, these locations did not apper as a result of the preferred places to host ADSs, considering the perception of online shoppers. The more suitable locations are Correios facilities. The national post operator has 68 outlets in Belo Horizonte, with a widespread coverage, and has experience in implanting ADSs trials.

Additional concerns must be addressed to the aesthetics of ADS. This solution can add "ugly" urban equipment to city streets, thus, it would be recommended to design equipment with the main city architecture characteristics in mind.

ADS solution has some policy implications in terms of: (i) urban planning, (ii) urban security, (iii) urban aesthetics, and (iv) traffic engineering. Promoting this solution results is an important city logistics measure, which contributes to the reduction of the impacts from urban freight transport, since the consolidation of deliveries implies a reduction of stops and vehicle-kilometers. ADSs are advantageous for retailers, delivery operators, and customers: retailers can improve their income if they host delivery services; delivery operators reduce vehicle-kilometers and, consequently, costs; and customers can pick up parcels anytime. From a municipality's point of view, ADSs are an interesting solution, contributing to a reduction in the number of commercial vehicles, therefore, providing a net reduction in commercial vehicles' emissions (PM, NOx, and CO_2) and preventing traffic congestion caused by freight vehicles double-parking during delivery (double-parking for deliveries is quite common in home deliveries, due to the absence of loading/unloading zones in residential areas).

5. CONCLUSION

The study explores the use of a stated preference survey to detect online shopper attitudes regarding home delivery and ADS services. Determining the potential demand for these deliveries services contributes to adapting city logistics models to the ever-changing complexity of urban freight flows, considering the growing position of end-consumers on defining freight logistics services. Applied to the city of Belo Horizonte, this methodology may be suitable for a large variety of cities.

Automatic delivery stations have the potential to reduce home delivery problems, as these may be increasingly exacerbated with the growth of e-commerce. This research contributed to the investigation of e-consumers' points of view regarding a new urban logistics service, the automatic delivery systems, and taking into consideration the importance of incorporate stakeholders' behaviour in the evaluation of policies for urban freight transport.

The results of our study indicate a high potential use of ADSs in Belo Horizonte (Brazil). However, respondents emphasize attributes such as location, associated with easy access and security. Supermarkets are the commercial facilities with the highest potential for siting automatic delivery stations, which may be related to the shopping habits of respondents. Among the evaluated attributes, we highlight as positive points the flexible hours to collect the parcel from pick-up points. Moreover, the usage must be conditioned to the advantages to the user (such as lower cost of transportation). In addition, many are willing to pay more to be better informed, probably because of negative past experiences with the current way deliveries are provided in Belo Horizonte.

Thus, it is necessary to plan the steps for the implementation of the system, such as providing incentives to retailers who host pick-up points and disseminating the experience of large retailers that sell over the Internet, allowing collection in physical outlets. The identification of automatic delivery stations as an item worth investigating for urban freight public policy could be a first step towards encouraging the spread of innovative practices in Brazilian cities, which do not have city logistics measures implemented. In fact, the results obtained in this paper allow decision makers to better understand e-consumers' reactions and to fine-tune freight public policy in urban areas.

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