

Article

What e-Consumers want? Forecasting parcel lockers choice in Rome

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Abstract: E-commerce sales surge represents a huge challenge for urban freight transport. Parcel lockers constitute a valid solution for addressing the challenges home deliveries imply. In fact, eliminating courier-consumer contact (also relevant for health-related issues, as made evident by COVID19 pandemic) and delivering in few predefined places might help coping with missed deliveries substantially. Furthermore, this option enables consolidated shipping and reducing delivery trip costs. This paper analyses and compares consumers' preferences for alternative collection strategies. It investigates home delivery vs parcel locker use and forecasts their future market shares. This is performed based on both customers' socio-economic variables and attributes characterising these alternative logistic fulfilment strategies. The case study considered rests upon a stated preference survey deployed in the city of Rome. The investigation specifically targets young people (i.e., population under 30 years) since they represent early adopters. Discrete choice models allow both quantifying the monetary value of parcel lockers attributes (i.e., willingness to pay measures) and estimating the potential demand for this innovative delivery scheme. Results show that distance and accessibility are the main choice determinants. Furthermore, there is an overall high propensity to adopt parcel lockers. This research can support policymakers when implementing such solutions.

Keywords: parcel locker; last mile delivery; home delivery; City Logistics; urban freight transport; stated preference; discrete choice modelling; consumer behaviour; e-commerce; channel choice; collection points

1. Introduction

E-commerce is soaring worldwide. In fact, e-commerce share doubled total global retail sales in the 2015 to 2020 period rising from 7.4% to 14.6% (Liscia, 2020) and global online shoppers rose from 18% to 53% with an annual turnover growth of 19.3% (RetailX, 2020a). More online traffic, shifting to mobile shopping coupled with easy and convenient deliveries stimulate this exceptional growth (RetailX, 2020b).

Covid-19 outbreak strengthened this global trend since new consumers, products and retailers are embracing e-commerce due to health-related considerations. Older people have started to shop more online thanks to its ease and convenience. This has happened while shopping online for food, groceries, personal hygiene products and sports equipment increased drastically. At the same time Small Medium Enterprises (SMEs) are now starting to sell online by opening up shops on online marketplaces and by investing in their own websites, strengthening an already existing omnichannel trend. Nowadays, in fact, stores operate as collection points for online purchases (i.e. click-and-collect), as drop-off point for returns and micro-fulfilment centre for faster, more cost-efficient and greener product deliveries (so-called ship-from-store) (Buldeo-Rai, 2019).

Despite the potential, e-commerce represents an highly inefficient sector, in particular due to the difficult management of last mile logistics. Nowadays, in fact, the rise of e-commerce sales imposes more cost to pure-players and multi-channel retailers as well as to their logistics providers.

The mismatch between what consumers are willing to pay due to new supply-driven trends¹ and the cost of providing the delivery service represents the main source of the low profitability (Allen et al., 2018). In particular, an overstressed last mile delivery logistics exacerbates these issues since it accounts for 28% of total delivery costs (Ranieri et al., 2018).

Parcel lockers (PL) represent one of the solutions that might favour last mile delivery efficiency.

This research aims to assess consumer preference toward PL in comparison to home deliveries (HD).

The analysis took place in Rome, a car-based city (Comune di Roma, 2019), where parcel lockers implementation can prove challenging. In fact, the modal split in Rome bodes poorly for the effectiveness of the solution this paper studies.

Therefore, assessing PL's adoption in one of the theoretically worst-case scenarios could better clarify the potential for PL's market adoption.

The paper studies e-consumer's behaviour through stated preference (SP) acquired via a dedicated survey. Choice data are modelled using a multinomial logit model (MLM) to estimate marginal willingness to pay (mwp) and market demand. Both elements are helpful in clarifying how PLs characteristics might influence the delivery method chosen.

The structure of the paper is as follows. Section 2 reports a focused, synthetic, and comprehensive literature review while Section 3 discusses the methodological approach adopted, case study and sampled data used. Results are discussed in section 4, while Section 5 illustrates some policy implications of the results obtained while Section 6 concludes.

2. Literature review

This section describes what we already know about parcel lockers especially concerning consumer preferences.

Parcel lockers are typically unattended and located in residential areas, workplaces, or public utility places, such as shopping malls or railways stations (Cagliano et al., 2020). Alternative PL definitions, appearing in the literature, are 1) automated delivery stations (ADVs), 2) collect and delivery points (CDPs) or automated delivery points (ADPs) (Kelli Oliveira et al., 2017). One should note that automation differentiates them from other delivery techniques.

The PL is one of the most tested schemes in European cities (Cagliano et al., 2020). More than thousand parcel lockers are currently located in Germany, France, UK, Italy, Poland and Finland with an 8000 person/parcel locker density in Spain (AGCOM, 2020).

Iwan et al. (2016) describe their typical functioning. The online buyer selects the PL as delivery point, subsequently receives a confirmation email/ text message with a QR code containing the corresponding number of the locker to use.

Research shows that PLs can provide economic benefits. This is mainly due to the elimination of courier-consumer contact which generates additional value and meaning within a COVID-19 context. In fact, this element allows a substantial reduction of missed deliveries (Kelli Oliveira et al., 2017) normally ranging from 2% to 35 % of total deliveries attempted (Maere, 2018). In addition, delivering to a few predefined places instead of each single final customer's homes favours consolidating freight deliveries and preventing freight vans from stopping frequently, thereby reducing total kilometres travelled (Edwards et al., 2009) while improving driving cycle characteristics that are responsible for a relevant amount of fuel consumption (Kancharla & Ramadurai, 2018).

A successful implementation of this delivery technique necessarily rests upon a clear understanding and estimation of consumers' satisfaction deriving from the high flexibility

¹ E-shoppers are demanding ever faster, more reliable and convenient delivery services (Liscia, 2020; Buvat et al., 2018; Allen et al., 2018).

this solution permits thus enhancing the convenience sites availability generates for final consumers. Even if research has focused on PL, only few studies have focused on consumers' attitude toward PL. In fact, recent research mainly assesses the environmental and economic sustainability of this solution using delivery-data (Giuffrida et al., 2016; Bouton et al., 2017; World Economic Forum, 2020; Arnold et al., 2018; Duin et al., 2019; Refaningati et al., 2020; Pham & Lee, 2019; McLeod & Cherrett, 2009; Boyer et al., 2009; González-Varona et al., 2020; Dell'Amico & Hadjidimitriou, 2012).

Methodologies used to investigate consumers' delivery preferences vary a lot.

(Iwan et al., 2016) and (Moroz & Polkowski, 2016) investigate descriptively PL's e-consumer utilisation via questionnaire data highlighting the importance of accessibility, proximity to home/work and low delivery price. (Xu & Hong, 2013) apply multinomial logit to questionnaire data showing the importance of age, value of parcel, and online shopping frequency in PL's delivery choice. (Kedia et al., 2017), instead, employs focus groups to study spatial location importance and parking availability as PL's choice enhancer. (Zhou et al., 2020) and (Chen et al., 2018) use structural equation models to investigate the underlining psychological factors (perceived risks, perceived satisfaction) and technology readiness influencing consumers' choices.

However, only (Kelli Oliveira et al., 2017) alone estimates the impact PL's attributes have on e-commerce fulfilment strategies and their potential market demand.

To the best of Authors' knowledge, there is no evidence of homogenous consumer delivery choices across inhabitants of different city typologies (e.g., dense cities vs suburban cities, developed dense city vs undeveloped dense city).

3. Methodology

This paper adopts a SP perspective to study consumers' preferences when deciding whether to use or not PLs for e-commerce-related deliveries. SPs allow assessing yet not existing but plausible scenarios thus overcoming the typical lack of data and providing valuable insights on consumer's delivery preferences. Furthermore, an SP-based approach is well suited for comparative evaluation of alternative policy options.

In practice, choice experiments allow respondents choosing from hypothetical e-commerce delivery options (i.e., HD and PL) characterised by different trade-offs among the attributes.

The paper uses discrete choice models (DCMs), in particular a multinomial logit model, to estimate the underlying agents' utility functions capable of predicting consumers' choices between HD and PL.

Furthermore, the paper delves in consumer's delivery choice for a-priori effect adding socio-economic and behavioural info to agents' utility function.

Mwtp and market demand illustrate the impact of single PL's attribute in consumer delivery choices, offering an e-consumer delivery choices' synthetic description.

Next sections discuss in further detail the methodological phases, survey's structure (SP's part and revealed preference's part), sample's features and case study description.

3.1. Phases of the methodological approach

The phases are the following:

- Draft of the SP's part of the survey.
- Spread of the survey.
- Data analysis using a multinomial logit model.

3.1.1. Design creation

Choice tasks setting characterizes the first methodological part. Literature review is based in particular on (Iwan et al., 2016; Moroz & Polkowski, 2016; Kelli et al., 2017; Lachapelle et al., 2018). In practice the interviewee is asked to select a delivery choice out of three alternatives in each choice task:

- a generic HD (status quo scenario).
- PL 1, with specific features.

- PL 2, with other specific elements.
- The features of every PL with the corresponding possible attributes and levels were:
- Distance (500, 1000 or 1500 metres from home or work)
- Accessibility (a PL can be available 24 hours or during normal working hours (8-18))
- Typology (automated or assisted)
- Environmental sustainability (the PL can have a certification of low environmental impact or not have it)
- Location (stations, shopping sites, service sites (school, gym, bank, post office))
- Monetary incentive (is the monetary difference between delivery in a PL and at home, it can be of 0,1 or 2 euro).

Imagine to have purchased online and to choose the delivery mode

	Parcel locker 1	Parcel locker 2	Home delivery
Accessibility	8-18 - 5-7	8-18 - 5-7	
Distance	500 m	1000 m	
Location	Shopping centre, supermarket	Gas station, metro station	
Green certification	No	Yes	
Typology	Assisted	Assisted	
Incentive	0€	0€	
What would you choose?			

Figure 1. presents an example of a choice task. (Source: own elaborations).

An orthogonal design was used to develop a pilot for the specific choice scenarios presented to the interviewees. After acquiring the first wave of data and estimating a MNL model the results were used to develop a D-efficient design as suggested by (Kanninen, 2002) for the second wave of interviews.

3.1.2. Test Administration

In the second part, the final version of the survey was administered among Roma Tre University's students under the supervision and coordination of TRELab² personnel in 2019.

- The survey was structured as follows:
- The first part investigates e-commerce related behaviour through RPs data focusing on place of delivery, frequency, type of trip, knowledge, use of parcel locker.
- The second part includes the choice experiments where every respondent was asked to choose the most preferred option in the six choice tasks each pertaining to six different blocks.
- Third part explores the socio-economic data of each respondent.

3.1.3. The model

After acquiring and cleaning the data they were processed via the statistical software R. We estimated a multinomial logit model (McFadden, 1973) and used Pseudo R² to evaluate the best fitting model to the data.

The theoretical framework of multinomial logit hinges on random utility theory, where a deterministic and a random part define consumer satisfaction levels. Therefore, one can express utility as follows:

² TRELab is the Trabsport Research Laboratory of the University of Roma TRE, Rome Italy. (<http://www.trelab.it/>).

$$U_{HD} = V_{HD} + \varepsilon_{HD}$$

$$U_{PL1} = V_{PL1} + \varepsilon_{PL1}$$

$$U_{PL2} = V_{PL2} + \varepsilon_{PL2}$$

Attributes described in section **Error! Reference source not found.** compose the deterministic part³:

1. $V_{PL1} = \beta_{D_PL1} * D + \beta_{AC_PL1} * AC + \beta_{AS_PL1} * AS + \beta_{GRC_PL1} * GRC + \beta_{INC_PL1} * INC + \beta_{LOC_PL1} * LOC$
2. $V_{PL2} = K_{PL2} + \beta_{D_PL2} * D + \beta_{AS_PL2} * AS + \beta_{AC_PL2} * AC + \beta_{GRC_PL2} * GRC + \beta_{INC_PL2} * INC + \beta_{LOC_PL2} * LOC + \beta_{LE_PL2} * LE + \beta_{UP_PL2} * UP + \beta_{UCP_PL2} * UCP + \beta_{HP_PL2} * HP$
3. $V_{HD} = K_{HD} + \beta_{LE_HD} * LE + \beta_{UP_HD} * UP + \beta_{UCP_HD} * UCP + \beta_{HP_HD} * HP$

Legenda: K-Costant; AC-Accessibility; AS-Assistance; GRC- Green Certification; D-Distance; INC-Incentive; LOC- Location. The socio-economic and behavioural attributes are:LE-Level of Education; HP-Presence of someone at home to collect the parcel; UP-Previous use of parcel locker, UCP-previous use of collection points.

The coefficient β measures the marginal utility of each attribute variation. Acronyms are respectively for PL's attribute:

According to theoretical model, market demand corresponds to single alternative's choice task probability.

$$P_{n(i)} = \frac{e^{V_{in}}}{\sum_{j \in S} e^{V_{jn}}}$$

Where $P_{n(i)}$ is individual i-alternative's choice probability from choice set S.

In the specific context of the paper, it will be:

$$P_{n(PL)} = \frac{2 * e^{V_{PL}}}{2 * e^{V_{PL}} + e^{V_{HD}}}$$

Mwtp⁴ for a variable x, instead, is calculated as follow:

$$mwtp(x) = \frac{\beta_x}{\beta_p}$$

Where p indicates the price attribute variable.

4. Results

This section presents the results of the research and policy implications and is articulated in 3 sub-sections:

1. Case studio overview, sample description and e-purchaser's descriptive preferences and behaviour.
2. Econometric results analysis and further related elaborations.
3. Policy implications.

4.1. Case study description

³ PL1 is the reference alternative, therefore K, LE, UP, UCP, HP are set to 0.

⁴ WTP is the amount of money that respondents are willing to pay to obtain a further (additional) not monetary attribute (Aizaki et al., 2015)

The data collection took place in Rome, Italy. The capital of Italy has 2.8 million of people living in a 1285km² area. The city is one of the largest in Europe (6th in Europe, and 85th in the world) with a relatively low population density⁵. Limited public transport density and a motorised vehicle-culture make Rome a car-based city. In fact, nowadays, private vehicles' trip represent 65% of the total. These factors and the shift from inner city centre (GRA) to small towns near Rome (from 18% of 1998 to an estimated 30% in 2021) explain the:

- high level of congestion (second in the world according to (INRIX; 2019).
- number of fine particles that exceed OMS' recommendations.
- number of accidents (pedestrians' accidents are six times higher than in London, Paris and Berlin)(Kodukula & Rudolph, 2018).

The Sustainable Urban Mobility Plan (SUMP), approved in 2018, considers logistics a crucial pillar to overcome these issues and deem PL one of the medium-term key actions to be deployed so to achieve the much hoped for improvements the city is seeking to achieve.

In this context, in 2019, we interviewed 330 people with 98.5% of them living or commute daily to and from Rome.

4.2. Sample description and e-consumer preferences

The sample is made up of 51.5% man and 49.5% women. More than 75% of the sample consists of students, with a median age of 23. 55.5% obtained a degree and only 14.6% of the respondents had more the 30. The age distribution in our sample is not representative of the population in Rome due to the over-representation of young people. For this reason, after having noticed different choice pattern, we decided to delete the observations of individuals above 30 years. In this way, the research focuses on a specific age segment of the population. Therefore, the final sample consists of 282 respondents each answering to 6 choice tasks thus generating 5076 observations in total.

When it comes to e-consumer habits in our sample, the median consumer purchases 1 item per month, with an expenditure of 28.5€, selecting mainly, in descending order, clothes (mainly shoes, t-shirts and sweaters), free time related objects (mainly books and videogames) and electronic related (mainly audio/video equipment, telephony and pc equipment). These data are in line with the results obtained by another e-commerce report (Idealo, 2020).

Overall, the spread of PL delivery mode is low. In Rome, data indicate a low PL knowledge and usage, respectively of 22.1% and 8.2%. E-purchaser usually prefers home (81.5%) or work/study place (8.4%) as delivery points, especially if there is someone ready to receive a parcel at home (70.9% of the respondents). The most used travel mode to reach a PL is car (51.7%) followed by feet (44.8%) and metro (3.4%). Romans' travel habits and the average distance travelled to reach a PL (almost 1km) explain these data.

4.3. Econometric analysis

The first MNL output we discuss are the coefficients of the econometric model. *Error! Reference source not found.* reports the results.

Table 1. MNL LOGIT.

Parameters	Coefficient
Intercept [PL2]	-0.101529
Intercept [PL3]	0.435139 *
Assistance	-0.051814
Incentive	0.281412 ***
Green certification	0.211605 **
Location (public transport)	-0.074414
Location (shops)	0.043570

⁵ London and Madrid with a similar extension have double the density.

Distance 500 metres	0.689798 ***
Distance 1500 metres	-0.501715 ***
Accessibility	0.462071 ***
Previous use of collection points [PL2]	-0.012961
Previous use of parcel locker[PL2]	-0.090487
Presence of someone at home to collect a parcel [PL2]	0.071480
Level of education [PL2]	0.042427
Previous use of collection points [HD]	-1.279940 **
Previous use of parcel locker[HD]	-1.069055*
Presence of someone at home to collect a parcel [HD]	0.794460 ***
Level of education [HD]	-0.585778 ***
Pseudo r ²	0.131

*means $Pr>|z|=[0.05-0.01]$, **=[0.01-0.001],*** [0.001-0].

Overall, the model offered a discrete performance, given a Pseudo R² value of 0,131. Most parameters are highly significant with the exception being the individual specific parameters for alternative PL2 (eg. Level of education PL2). The not significant difference implies on average a perceived equality between the two unlabelled PLs options confirming the goodness of experimental design, where one creates balanced theoretical choice probability between the two PL's.

The outcomes indicate the influence of distance, accessibility, incentive and to a lesser extent green certification in PL's choice. By contrasts, location and assistance have a weakly significant effect. Furthermore, it is remarkable to mention the importance of individual features in the choice. In fact, the coefficients of the individual specific variables are highly significant. In particular, high level of education and the lack of someone at home to collect a parcel are positively associated with PL's choice. Finally, the significant coefficients of the variable "previous use of collection points" and "previous use of parcel locker" depict a-priori effect's existence underlining persistent habits' impacting on e-consumer's choices.

However, attribute's effect on PL's choice is not clear and discussed in the next two sections through mwtp and market demand analysis.

4.3.1. Marginal willingness to pay

The table highlights the role of PL's distance (in particular, PL's distance shift from 1000 to 500 metres) and accessibility h24, depicting respectively a willingness to pay of 3.11 euro and 1.64. Furthermore, PL's mwtp changes more than proportionally with respect to the distance's shift (3.11 from 1000 to 500 metres vs 1.11 from 1500 to 1000).

Table 2. Marginal willingness to pay.

Variables	Coefficients
Distance from 1000 to 500 metres	3.11***
Accessibility h24	1.64***
Distance from 1500 to 1000 metres	1.11***
Green certification	0.75**
Assistance	0.18
Location (stations or parking)	0.26
Location (shops)	-0.15

By contrasts, the importance of green certification (0.75) is minimal thus highlighting the unwillingness to go to assisted parcel locker and PL located next to stations (metro, train, petrol, or parking)

4.3.2. Market demand

Mwtp's analysis shows the role of distance and accessibility in PL's choice. In fact, the market demand's analysis undertaken in this section refers to four scenarios based on possible different PL configurations with respect to traditional delivery (HD):

- Scenario I- PL's distant 500 metres from home/work and available h24

- Scenario II- PL's distant 500 metres from home/work and available in the working hours
- Scenario III – PL's distant 1000 metres from home/work and available h24
- Scenario IV – base scenario – PL's distant 1000 metres from home/work and available in the working hours.

The paper considers these scenarios within a varying socio-economic and behavioural context, thereby supplying a thorough impacts' analysis of these variables and a more detailed market demand estimate.

Because of that, this paper applies these scenarios to an average individual characterised by the following features:

- Not graduated, with someone at home ready to receive parcel
- Graduated, with someone at home ready to receive parcel,
- Graduated, no one at home ready to receive parcel,
- Not graduated, no one at home ready to receive parcel

Figure 2. Scenario I – Curve Demand-Incentive.

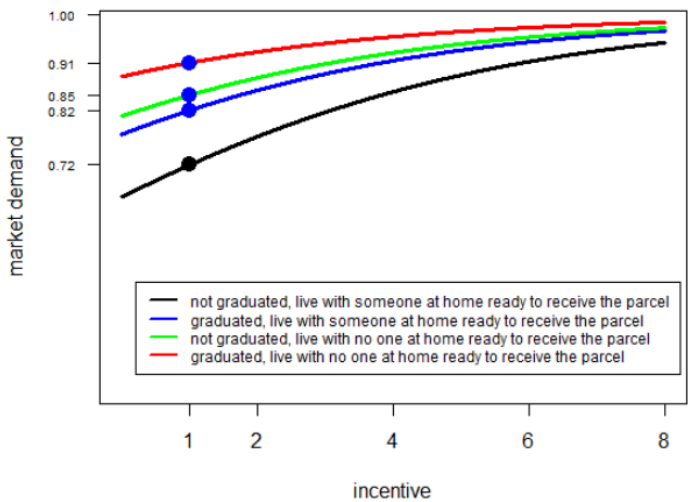


Figure 3. Scenario II – Curve Demand-Incentive.

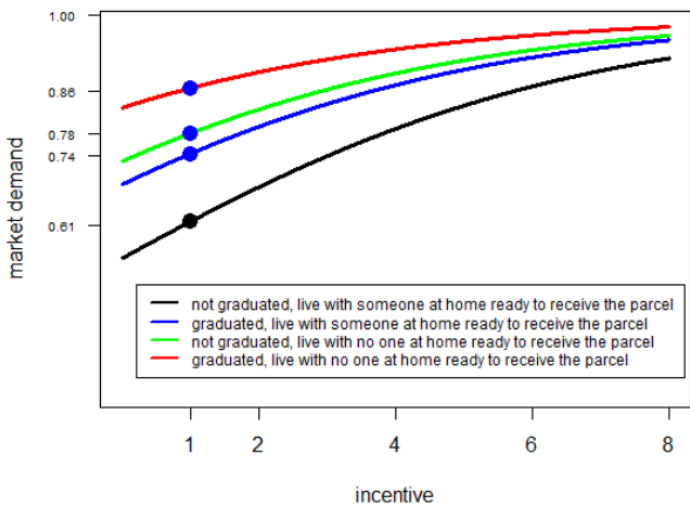
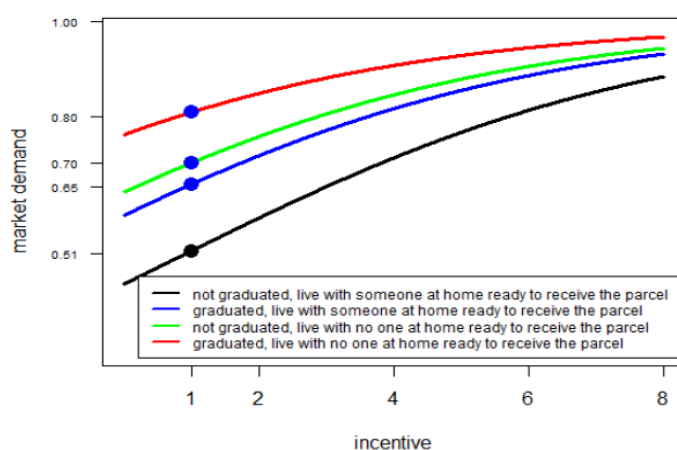
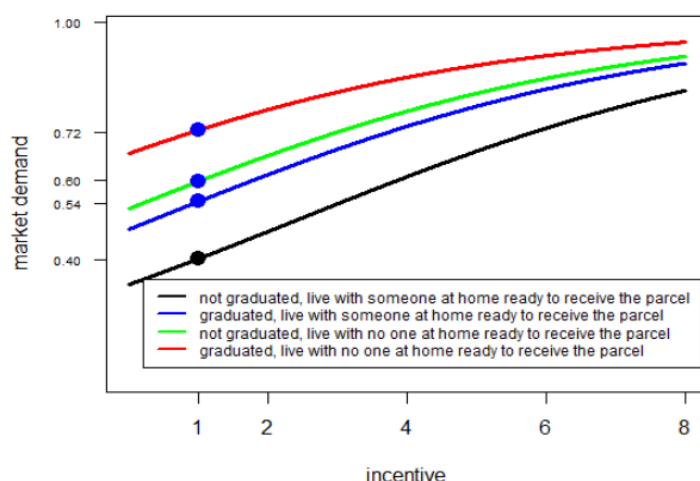


Figure 4. Scenario III – Curve Demand- Incentive.**Figure 5.** Scenario IV- base scenario- Curve Demand- Incentive.

Overall, data depict unexpectedly high willingness to PL's usage. Scenarios' estimations indicating a widespread PL's presence (Scenario I and II) provide the highest market demand while scenario III and base case evaluate a smaller but high and significant demand. Level of education and presence at home of someone ready to receive a parcel highly affect e-consumer choices, with an increasing heterogeneity from scenario I to base scenario IV. For instance, market demand in Scenario I varies from 91% to 72% while in the base scenario it ranges from 72% to 40%. An elevated study title and the absence of someone at home ready to receive the parcel increase a lot the forecast PL's market demand denoting a market demand share higher respectively of 19%, 25%, 29% and 32%.

The paper shows also that who collects parcel through collection points has a higher marked demand highlighting thus the possible shift from collection points to PLs.

Furthermore, attributes such as location, accessibility, and green certification, as witnessed by a low or not significant mwtp, weakly influence market demand.

5. Discussion

This paper investigates e-consumer delivery choice focusing on PL's attributes in comparison to status quo scenario (HD). Model estimations forecast a huge PL's market penetration among youngest generation most likely due to high preference for on foot

dedicated trip. This goes against the hypothesis that citizens of a car-based city could less appreciate PL's delivery mode.

Some insights for policymakers are proposed by this study. Capillarity and accessibility h24 result as crucial elements to be considered when planning a network of PL's with the highest possible market demand. By contrasts, focus on green certification, specific location or PL's typology is not important in a market-oriented approach.

The correct implementation of best market scenario requires, however, the edification of more than 325 PLs, only in Rome's denser areas. This task could turn out to be not so easy considering that one cannot easily guarantee accessibility h24 since the majority of PLs is located in commercial establishments. Metro and train stations could offer a quasi-optimal solution if one could resolve security and spatial issues. However recent discussion between stakeholders in the roman Living Lab seem easily overcoming these concerns. Slow bureaucracy, instead, could represent another hindrance, if these must be built in a public space. In every case, policymaker support could be crucial in their implementation, establishing and favouring easy and quick procedures or direct investing in PL, especially if PL's network should be neutral⁶.

This research suggests also that not necessarily a widespread PL's implementation must take place. A still high market demand could be reached through a lesser widespread PL's network (a PL distant average 1 km) targeting individual that do not have someone at home to receive a parcel or already use similar delivery mode such as collection points.

Furthermore, results could hint at an aggressive PL's market strategy raising incentive up to 3⁷ euro as pointed out by high willingness to pay for a PL distant up to 500 metres.

Overall, these results support the decision to insert PLs as medium-term key actions' pillars to improve logistics sector in 2018 roman SUMP.

In fact, reduction of stops and vehicle-kilometres due to a better load consolidation could offer advantages for all the stakeholders:

- Delivery operators could reduce costs
- Customers could collect parcels anytime
- Retailers could exploit a cheaper delivery service
- Urban ecosystem, due to less commercial vehicles, could be less polluted, bustling and safe.

In particular, a widespread PL's network (PL's average distance up to 500 metres from home) could favour environmental sustainability encouraging travel mode's shift otherwise not possible in a car-based city such as Rome.

6. Conclusion

The research examined delivery preferences of consumers in Rome and assessed the potential market demand related to their e-commerce related choices. Balancing the drawbacks of e-commerce's raise and adaptation of city logistics to the new paradigm represent the background of the research.

Methodology used an approach based on SP survey (similar to **Kelli et al., 2017**) for estimating demand of the consumer.

Results depict the wide acceptance of PL as delivery solution among youngest generations.

Short distance, accessibility h24 and a small incentive (1euro) are the key features to foster PLs' adoption. In particular, reaching PL far not more than 500 metres from home/work could drive a demand surge at least for young generations.

This research provides a useful tool for policymakers potentially helping informed PL's implementation choices.

⁶ Neutral means that everyone can use PLs

⁷ No, the incentive practised by a famous e-retailer is 1 euro

However, next research must target representative sample and use more sophisticated econometric model than multinomial logit (e.g., mixed logit). Furthermore, consumer's preference-based approach should be employed to enhance insight on PL's environmental side, still not yet explored, acquiring mobility and delivery data.

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