The Study of the 5-min Walking Accessibility for Pickup Points in Thessaloniki: Enhancing Logistics' Last Mile Sustainability

Antonio Russo[1], Socrates Basbas[2], Efstathios Bouhouras[2], Giovanni Tesoriere[1], and Tiziana Campisi[1](✉)

[1] Department of Engineering and Architecture, University of Enna Kore, 94100 Enna, Italy
tiziana.campisi@unikore.it

[2] School of Rural and Surveying Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Abstract. The UN World Health Organization deemed COVID-19 to be over as a public health emergency on May 5, 2023. Nonetheless, COVID-19 continues to impact every facet of human existence, encompassing urban planning. Today, e-commerce is a commonplace purchasing choice that has led to significant changes in city logistics, particularly in last-mile deliveries. Consequently, there is an increase in CO_2 levels and traffic congestion.

Therefore, there is need to analyse the existing and potential pick-up point networks, so to understand how easy it is for the user to pick up products and avoid home delivery. The present research focused in the central area of the city of Thessaloniki, Greece. The under-study area is characterised by the presence of many pick-up points which were identified with on-site surveys. Following the calculation of the 5-min walk isochrones, it was found that there are many (mainly) lockers. In addition, their location is mainly in the central area, while they also appear, but in reduced numbers, in the pericentre.

The evaluation of accessibility reveals that 50% of the residents in the central area resides within 5 min walking distance from a pick-up point while the respective percentage is about 25% of the residents when considering the pericentre.

The research findings can support the design of efficient strategies directed to the service management companies. The findings can also improve the customers' experience as far as online shopping is concerned by offering a better shopping experience, i.e., easiness to choose pick-up points, save on delivery etc.

Keyword: Last mile logistics · pickup point · 5-min walking isochrones · Thessaloniki metropolitan area

1 Introduction

E-commerce has experienced a strong growth in last years, especially after COVID-19 pandemic [1]. It has heavily modified the shape of last-mile logistics in urban area in last decades [2, 3]. Several consequences have arisen from that: fragmentation of deliveries,

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missed deliveries, returns, elements that contributed to negative externalities of last-mile logistics in urban environment [4].

A study conducted by [5] highlighted the preponderance of home deliveries with an increasing demand for fragmented and smaller goods.

At the same time during the various pandemic phases, e-commerce volumes increased, but unevenly according to the types of goods and with fluctuations during the various lockout periods.

A study conducted by [6] traced the evolution of the COVID-19 pandemic and logistics binomial from a spatial and temporal point of view, considering scientific articles published from 2000 to 2021, emphasising the need to adapt commercial activities to the changing situation by anticipating people's needs, creating e-commerce sites capable of accompanying customers during this delicate phase.

Pick-up points are useful tools that often e-commerce operators offer to customers. They serve role to aggregate deliveries in points (i.e. lockers or store), giving customers the opportunity to pick-up the parcel when needed. This may reduce negative externalities arising from missed deliveries; also, it can contribute in reduction of total km travelled by logistics vehicles [7].

Several criticalities emerge from pick-up points distribution. It has been evidenced how pick-up points are considered a viable alternative to traditional home delivery if the point is reachable in less than 5 min from customer's home [8]; it has been also highlighted that pick-up points are unsustainable if private cars are used as mode to reach them [9]. The combination of these two considerations lead to this initial result: pick-up points have to be reachable in 5 walking minutes to be considered a viable alternative and, at the same time, to be environmentally friendly.

The core study of pick-up points analysis has focused on accessibility of points network. Several studies [10–12] have highlighted that the population living in the five-minutes walking isochrone as a good indicator to consider the performance of a pick-up points network.

Starting from the highlighted research, the study aims to provide a general assessment on the diffusion of pick-up points in a local European reality. The study of the accessibility of the points allows, in fact, to define a first level of demand coverage and to study the penetration of this strategy. In particular, with the growth of e-commerce in many EU countries, driven by the COVID-19 pandemic [13], it has led to fragmentation of deliveries and an increase in vehicles linked to urban logistics [10, 14]. It is appropriate to consider that a high percentage of air pollution in urban areas derives from city logistics vehicles [15]; the reduction of total vehicle-km traveled is an objective to be pursued, also in light of the Sustainable Development Goals of Agenda 2030 [16]. More specifically, the reduction of carbon emissions is the core of Goal 13, "Climate action"; in the specific case, the interested target is 13.2, "Integrate climate change measures into national policies, strategies and planning". It has been determined that good location of pick-up points can lead to a reduction in the negative externalities of transport, if they are effectively distributed in such a way as to prevent the user from considering the car as an alternative to reach the point [17, 18]. In this context, it is useful to study the pedestrian accessibility of the points; this element, if appropriately studied, influences vehicular routing assumes a greater importance also in the definition of Sustainable

Urban Mobility Plans (SUMPs) and Sustainable Urban Logistics Plans (SULPs) [19, 20]. Analysis of location of pick-up points may help planners and companies to define better strategies to optimize vehicles routing, in order to reduce total vehicle-km traveled. This type of analysis also suggests a study on where logistics companies find it useful to position pick-up points; This analysis is also useful as a basis for the study of integrated on-demand mobility systems for passengers and goods (DRTL).

In this work, main goal is the analysis and characterization of a case study in mediterranean Europe. The study area proposed is Thessaloniki, Region of Central Macedonia (Greece).

Section 2 provides a description of the study area. Section 3 shows the methodology used in-depth. Section 4 describes the main results. Finally, results are described in Sect. 5, where main conclusions are also presented.

2 Background

E-commerce is an established yet evolving phenomenon, still growing steadily, so much so that it is one of the best-performing engines in the world economy. Concerning Greece, a recent report highlights the fact that the country "*can boost its digital macroeconomy by shifting its level of digital commerce maturity in the next three to five years*" [21]. Pick-up points are becoming the preferred delivery option, but many retailers still do not have this option for their customers.

Shoppers who spend a lot online are reassured by pick-up points. They reduce users' anxiety about having to stay at home to receive parcels and eliminate the stress of having to double-check whether they have agreed on a safe place with that particular courier. It is a fact: offering a pick-up point reduces the rate of shopping cart abandonment, particularly by shoppers with high-value baskets.

Pick-up points are in fact a free service and are used for the release and retrieval of goods ordered online. In many cases, they are also storage points for return items. Their main peculiarity is their location in busy or 'strategic' areas, combined with their accessibility at all (or nearly all) times. There are different types of pick-up points:

- smart lockers, i.e. self-service lockers that open by means of a code or scanning a QR code;
- commercial establishments (shops, tobacconists, bars, post offices…) participating for certain couriers or services;
- outlets of the same eCommerce brand.

Pick-up points are now a service offered by major retailers to increase online sales while making life easier for consumers.

The main advantage of a pick-up point and a smart parcel locker is the possibility to collect the parcel at a convenient time without having to entrust friends and relatives with this task. Moreover, since today no one can stay at home and wait for the courier, offering a pick-up point provides a flexible and convenient solution for those who like to shop online but have a hectic life.

Finally, picking up your parcel at a pick-up point increasingly means combining business and pleasure, as they are generally located in places with catering services or

shops, or it is an opportunity for a break at work, if your company has adopted a smart parcel locker service.

We can therefore say with certainty that being able to receive a purchase made online at a pick-up point or smart parcel locker means avoiding stocks and waiting for the courier at home.

There are, therefore, many advantages for both the sender and the recipient, advantages that respond to the ever-increasing spread of e-commerce sites and the constant growth of online shopping, especially during the festive period.

There is also a trend in recent years to install delivery lockers or smart parcel lockers, which more and more companies are making available to their employees as part of their corporate welfare policies and which are an increasingly popular benefit.

According to [22] the advantages of pick-up points for merchants can be summarized as follows:

- 100% successful delivery attempts;
- lower shipping costs, due to fewer courier trips;
- greater omnichannel integration, in the case of shipments to their own shops.

The benefits for eCommerce customers are numerous and significant:

- convenience;
- faster delivery;
- greater privacy;
- easier returns.

Another benefit, from which everyone benefits, is the decrease in CO_2 emissions, thanks to load-optimised deliveries and at night or less busy hours [23].

To increase the efficiency of last-mile delivery, online retailers can adopt pick-up points in their operations and the retailer can then incentivise customers to switch from home delivery to the pick-up point to reduce costs [24].

There are few quantitative publications on logistics distribution mode selection with logistics service providers as the main body and last-mile distribution time, price and mode selection from a strategic perspective [25].

A study conducted by [26] found a significant gap between the delivery options available on e-commerce websites and consumer preferences for last-mile delivery. In particular, it was emphasized that delivery time and accuracy are the biggest obstacles in the delivery chain, while highlighting the lack of home delivery services in the market.

In order to be able to better explore the concept of sustainability, it is considered appropriate to focus on the accessibility of these pick-up points on foot in order to further limit emissions and further reduce the use of private vehicles to reach them.

3 Study Area

The Thessaloniki Metropolitan Area includes the Municipalities of Thessaloniki, Kalamaria, Neapoli-Sykies, Pavlos Melas, Kordelio-Evosmos, Ampelokipoi-Menemeni and Pylaia-Hortiati, Themraikos, Thermis and Oraiokastro (see Fig. 1). The total population is over 1mo residents, and the area covers over 1,200 km^2.



Fig. 1. Thessaloniki Metropolitan Area map [27].

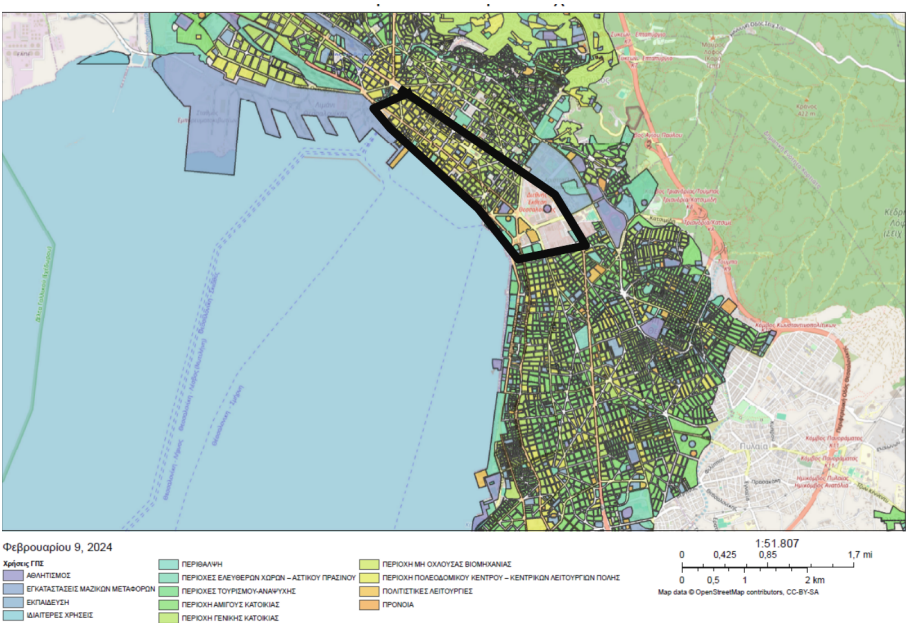

Fig. 2. Land uses map if the Municipality of Thessaloniki [34].

The Municipality of Thessaloniki is the most important administrative, cultural and business center in northern Greece, as well as the second largest city in Greece. There is a coastal line of over 50km length, with a newly constructed waterfront [28]. The Municipality covers almost 19km^2 [29] and its total population is almost 325,000 residents [30] and the population's density is 17,105 residents per km^2 [31]. The road network length is roughly estimated between 300km and 320km, while in the Regional Unit of Thessaloniki, there are almost 100,000 registered commercial vehicles (both public and private usage) [32]. As the city of Thessaloniki is the commercial center of the Regional Unit, it can be assumed that the majority of these commercial vehicles are mobilized inside the borders of the city. Although outdated, the distribution of the properties in relation to their usage in the Municipality during the period 2000–2007 was the following: 84% residential, 6% commercial, 9.6% services and 0.4% auxiliary [33].

Figure 2 presents the types of land uses of the Municipality of Thessaloniki [34]. The central area of the city (the area inside the black lines) is the historical and commercial area, in which many retail shops are located as well as services.

4 Methodology

Section 4 concerns the methodology developed aiming to study components of accessibility to a set of points in urban area, by taking into consideration among others elements of demand.

The elements required to study a pick-up points network are:

- Study area, characterized by a population POP divided into n = 1,2,…N zones, each of them characterized by a surface An and a population residing POP_n;
- Pick-up point set p = 1,2,…P. Each point has to be characterized by its position in the study area;
- A road network. Because of the topic of the work, great emphasis is on pedestrian roads;
- A quantitative parameter for defining the accessibility to pick-up points.

Pick-up points are elements of the supply system. Elements recalled are mainly linked to supply system (Pick-up points and road network), while Population is considered as the main demand-related variable. As a preliminary study, the use of aggregate value is considered satisfactory.

The last point is the criteria that allows the match between demand and the supply.

Recalling Cardenas [7] and Weltevreden [8], the criteria chosen is the walking accessibility to network in 5 min: more than 5 min could discourage the user from considering pick-up points as a viable alternative; the use of car, even if 5 min, is not considered a viable alternative for sustainability reasons.

Consider i_p as the isochrone generated in a 5-min walking from point p. Being I_p the area that falls inside the isochrone i_p, there is the need to evaluate the population living inside Ip, POP_p. Population is often linked to the characteristics of data available; in this case, we are considering a common case, in which population POP_n is known for each zone n. Another assumption is POP_n uniformly distributed into zone n, characterized by surface A_n; this is possible due to the nature of data. Population data are often divided by census area, maximizing the homogeneity of urban and environmental characteristics.

Considering these assumptions, it is possible to define the population living inside the area $A_{n,p}$, intersection between A_p and I_p, as

$$POP_{n,p} = \frac{A_{n,p}}{A_n} POP_n \tag{3.1}$$

Given all these elements, the population living in the area I_p is given by

$$POP_p = \sum_{n=1}^{N} POP_{n,p} \tag{3.2}$$

This value represents the population living in a generic area. Aiming to represent an absolute value, it is possible to evaluate the share of population living in I_p as

$$POP_{p,\%} = \frac{POP_p}{POP} \tag{3.3}$$

It is more useful to consider this parameter given the entire system. Also, as suggested in Sect. 2, often pick-up points catching area overlaps, making necessary to study the union of areas instead of considering them separately. It is possible to define the global 5-min catching area I_{TOT} as

$$I_{TOT} = \bigcup_{p=1}^{P} I_p \tag{3.4}$$

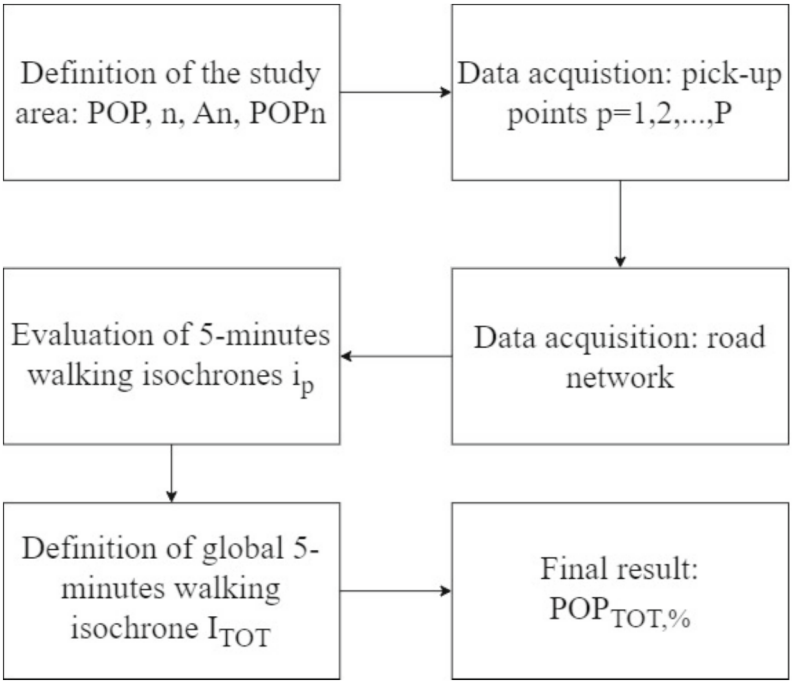

Fig. 3. Methodological steps

Equation (3.2) may be applied to I_{TOT}. Finally, considering the extension of Eq. (3.3) to I_{TOT}, it is possible to evaluate the value of $POP_{TOT,\%}$, the indicator who estimates the number of people who live in 5 min or less walk from nearest pick-up point in the study area.

$$POP_{TOT,\%} = \frac{POP_{TOT}}{POP} \tag{3.5}$$

The methodology discussed is schematically summarized in Fig. 3.

5 Results

The under-study area is described in Sect. 3 study and the operator considered for the study is Skroutz [35], the main e-commerce operator in Greece, having and operating a large network of pick-up points. For the case study under consideration, two kinds of points are considered:

- Points that fall inside the defined study area;
- Points that fall outside the defined study area but placed next to its boundaries.

This assumption is needed to better define the user perspective: people, even if living inside the study area, may consider the possibility to use a pick-up point placed outside the area, if it is very near. Due to the continuity of urban environment, especially in the Northern and South-Eastern side of the city, between Thessaloniki and neighboring municipalities, this approach allows a better approximation (Fig. 4).

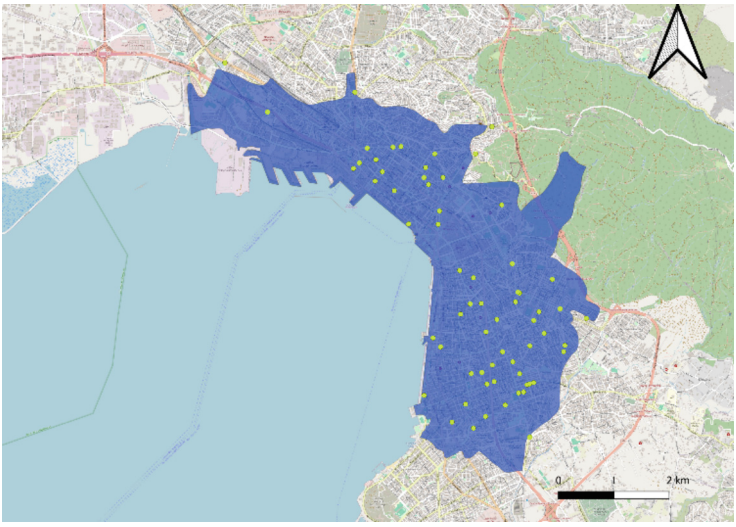

Fig. 4. Pick-up points considered (Source: authors' elaboration based on QGis [36] and Openstreetmap [37])

The points considered are in total 65, 60 of which are placed in Thessaloniki Municipality. The remaining 5 are placed in the Municipalities of Ampelokipoi – Menemeni, Neapoli – Sykies and Pylea – Chortiatis. The geographic distribution of points is shown in Fig. 5.

The evaluation of I_{TOT} is done. It is shown in Fig. 5.

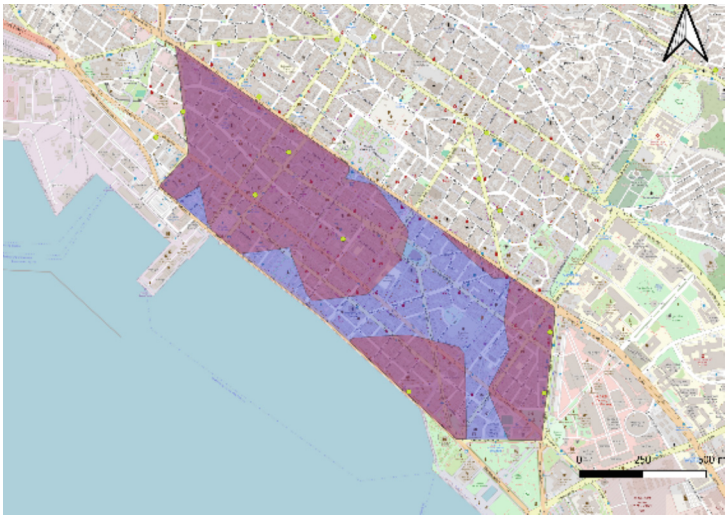

Fig. 6. Isochrone I_{TOT} for the Aggelaki-Egnatia-Dodekanisou-(Leoforos) Nikis Avenue area (Source: authors' elaboration based on QGis [28] and Openstreetmap [29])

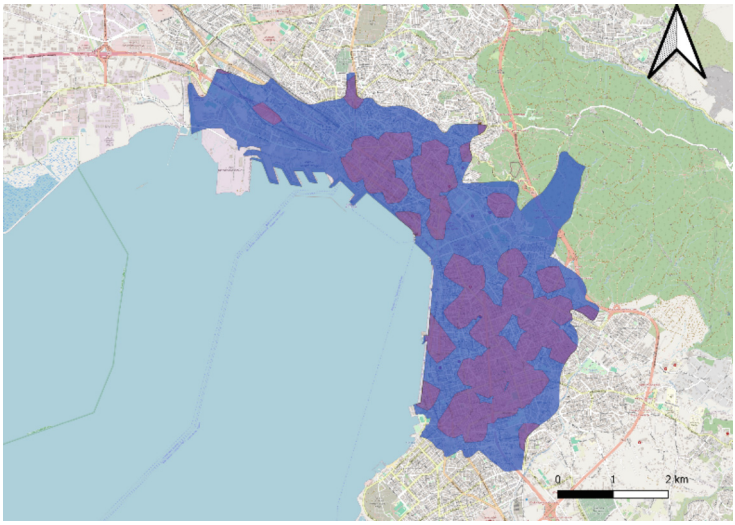

Fig. 5. Isochrone I_{TOT} for the study area (Source: authors' elaboration based on QGIS [36] and Openstreetmap [37])

Globally, the population covered by 5-min walking isochrone is 39,7% of the total. Within the basin considered, and once the criteria for choosing services have been identified, the operators who manage sea transport services are defined in Tab. X.

It is possible to see some inhomogeneities between different zones. Central area ("the body of butterfly") and South-Western area are generally well-covered. In Fig. 6 is proposed a focus on the Aggelaki-Egnatia-Dodekanisou-(Leoforos) Nikis Avenue.

In this case, the evaluation of population coverage is near to 70%, showing a value much higher than the global one.

6 Discussion and Conclusion

Different considerations are necessary. E-commerce has seen a great growth in last decades; even less developed regions, in the Western European context, like Greece or Southern Italy, have to deal with it. Traditional retail is not disappearing but has to coexists with e-commerce. Pick-up point is a tool that often explains how these two channels may coexists: several times, a retail store also offers the possibility to host a pick-up point for a national-scale logistics company. Also, it is important to recall that pick-up points may have in a sustainable logistics perspective; concentration of deliveries may lead to a reduction in emissions, but only if it is coupled with an improving in walking mobility.

The work illustrates a methodology for the evaluation of pick-up point accessibility, but also highlights the application of an interesting case study. Municipalities of Thessaloniki is the second Greek city by population, and it has several criticalities both from logistics and mobility point of view. Also, it is a big urban reality in a country mainly rural, with an economic development similar to several case studies analysed in other works [38].

Results showed a great distribution of pick-up points in the area considered, showing how this strategy is considered as important not only for international operators (like Amazon) but also for national scale operators (Skroutz). The population coverage is good, even if it is not equally distributed; as seen in previous sections, some parts of the city are characterized by clusters of points; in others, however, there is not a single pick-up point. The analysis has focused of the main central area of the Thessaloniki municipality, that showed a great coverage. The results highlight that pick-up point are a channel common in the city, but with several limits that have been experienced in other context. Mainly, the uneven distribution of points and the trend to form cluster confirms results from other cities. Points are mainly located in central area of the city; these points are mainly at the service of pedestrian mobility for the collection of parcels from users. However, some points are located in peripheral areas, close to main road axes of regional importance; this represents a first basis on which to develop subsequent analyzes for the feasibility of DRTL-type services [39, 40]. Among the future developments of the research, we intend to verify the feasibility of DRTL-type services that allow the parcel delivery service to be integrated starting from these peripheral points with passenger transport services to reach the main city center [41, 42]. These results allow another consideration: differences in distribution could reflect differences in accessibility to network, indicating variability in possibilities from people on the basis of place of residence. These aspects, that could led to more considerations on exclusion from logistics services, has to be further analyzed in future developments.

The main limitation of the study is related to the demand aspects. The only parameter considered is the population; this is useful for doing a preliminary study, but a focus on specific e-commerce users' categories is among the future developments of the research; knowing the demand generated for e-commerce in each zone of the city, it is possible to better understand the efficacy of pick-up points distribution, evaluated not in terms of population covered but in terms of e-commerce demand covered. Population is an indicator of potential demand that may be refined.

Also, the study may be extended to other municipalities of Thessaloniki greater area and of smaller cities and towns of Greece; this may be very interesting to see if the results for Thessaloniki are confirmed in smaller realities or if they are specific to its urban dimension.

Current work may be useful for several categories of stakeholders. Mainly, logistics operators in Greece and other European countries are interested; in this work, they can read a preliminary approach to analyze their system considering basic elements of demand. Public authorities are interested in this work too, to have a tool to evaluate quantitative elements that are not often considered in transportation planning.

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