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Analysing the spatial impacts of retail accessibility for e-shoppers' groups

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Abstract

Amidst the growing interest in enhancing the academic understanding of the relationships between e-shopping and transport, a key element remains underexplored – the impact of e-shopping on spatial accessibility to in-store retail. The paper studies variations in multimodal accessibility to in-store retail between e-shopper groups and the associated spatial effects. The research is based on a face-to-face questionnaire, administered in the city of Alcalá de Henares (Madrid Metropolitan Area, Spain), which provides data on socio-economic characteristics, e-shopping habits, and travel time preferences to reach in-store retail. Clustering techniques serve to identify three e-shopper groups: occasional e-shoppers with a car, infrequent e-shoppers with a car, and frequent e-shoppers without a car. A comparison of e-shopper distance-decay functions to reach in-store retail is made, revealing significant differences between the three e-shopper groups for car and public transport for any time interval. However, for walking such differences are limited to time intervals between 10 and 40 minutes. Distance-decay functions are processed through a gravity-based model, identifying three main multimodal accessibility places: highly resistant places to e-shopping, moderately resistant places, and vulnerable places. Places that are highly resistant to e-shopping are mainly located in the city centre, while vulnerable places are mostly found in the city's periphery. The paper closes with concluding remarks on policymaking and a few pathways for future research.

Keywords: Online shopping; internet; transport; mobility; clusters

1. Introduction

These are challenging times for in-store retail activity at the city level. The unprecedented growth of e-shopping rates is generating both competing and complementing dynamics between e-shopping and in-store retail, with a strong

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impact on shopping trips (Pettersson et al., 2018; Zhen et al., 2016; Lee et al., 2017; Rotem- Mindali & Weltevreden, 2013). The COVID-19 pandemic has further intensified this trend (EU, 2020). While the situation remains dynamic and in flux, there is a potential push to adapt in-store spaces into other functions, altering traditional urban landscape and neighbourhood functionalities (Kelobonye et al., 2019; Maat & Konings, 2018). Furthermore, it also originates spatial accessibility variations for reaching in-store retail (Farag et al., 2007; Zhen et al., 2018), which negatively affect population groups less-familiar with e-shopping (Ariza-Álvarez et al., 2019; Olsson et al., 2019).

An e-shopper group is conceived as a set of individuals with similar socio-economic characteristics and e-shopping habits. The particularities of each e-shopper group depend on their individual priorities, needs, and circumstances (Jaller & Pahwa, 2020; Rotem-Mindali and Weltevreden, 2013). The scientific approach of multimodal relative accessibility seems appropriate for gaining insight into how spatial accessibility to in-store retail varies between e-shopper groups as well as the associated effects (Chang and Liao, 2011; Kelobonye et al., 2019; Páez et al., 2010b, 2010a). Multimodal relative accessibility is specifically defined as "a set of opportunities available to an individual with defined characteristics at a selected location, relative to an individual from a reference group at the same location" (Páez et al., 2010, p.3).

The academic literature has paid limited attention to research the interface between e-shopping and multimodal spatial accessibility. While a majority of existing studies focus on the impact of e-shopping on the number of shopping trips (Edrisi and Ganjipour, 2016; Lee et al., 2017; Rotem-Mindali and Weltevreden, 2013; Shi et al., 2019), little is known about how variations in trip duration affect spatial accessibility and the subsequent link with types of e-shoppers (Van Wee, 2016). Gaining insight into the e-shoppers' accessibility patterns to retail may provide guidelines for addressing potential conflicts between e-shopping and in-store retail. There are also a persistent interest in academic studies in knowing how e-shoppers' behaviour impacts on motorized modes and trips, rather than on addressing research designs that follow a multimodal approach (Arranz-López et al., 2019b; Etminani-Ghasrodashti and Hamidi, 2020; Lee et al., 2017). Building on these important issues, this paper explores the following research questions: Which are the time intervals that indicate shifts in spatial multimodal accessibility to reach in-store retail between e-shopper groups, and which are the spatial and social effects of such multimodal accessibility levels?

The remainder of the paper is structured as follows. Section 2 reviews the literature on the impacts of e-shopping on transport and relative accessibility. Section 3 presents the data gathering process and sample characteristics and Section 4 details the research design, including the study area. The key results are presented in Section 5, while Section 6 shares concluding remarks and highlights issues for further research.

2. Literature review

2.1. E-shopper profiles, e-shopping activity, and the need for an accessibility-based approach

Previous research traditionally has paid attention to characterize e-shoppers from a socio-economic viewpoint. Age is a controversial variable; some studies show a decrease of e-shopping frequency among older people (Crocco et al., 2013; Farag et al., 2007; Maat and Konings, 2018b; Zudhy Irawan and Wirza, 2015), but other studies did not find a significant relationship between age and e-shopping (Lee et al., 2017). Having a car is another notable variable (Lee et al., 2017). For example, Irawan and Wirza (2015) and Zhen et al. (2016) show that owning a car and driver license coincides with higher online shopping frequency. However, Etminani-Ghasrodashti and Hamidi (2020) find that people who use a car as their primary transport mode for shopping tend to e-shop less frequently.

There is a vast body of literature that examines to what extent e-shopping complements, substitutes, modifies, or has no effect on shopping trip frequency. Limitations emerge when the effects of e-shopping on shopping trip frequency are evaluated via the lens of the complementing vs substituting dichotomy. The main hindrance is based on the need to move towards an accessibility-based approach, rather than addressing e-shopping effects on mobility indicators, such as trip frequency (Edrisi and Ganjipour, 2016; Etminani-Ghasrodashti and Hamidi, 2020; Lyons et al., 2008; Shi et al., 2019). Adopting an accessibility-based approach means recognizing that e-shopping has a spatial dimension, emanating from the reciprocal relationships between land use and transport (LUT), which would shift the research focus towards types of e-shoppers (e.g., higher/lower e-shopping frequencies) and types of places (e.g., retail more/less vulnerable to e-shopping) (Ozbilen et al., 2021).

2.2. The approach of multimodal relative accessibility

The approach of multimodal relative accessibility operates on the identification of population groups that experience significant variations of accessibility levels to destinations, finding accessibility-related advantages and disadvantages in the identified groups. The approach is appropriate for addressing the research questions of this study, facilitating the understanding of how multimodal accessibility varies between e-shopper groups and which spatial effects are being originated at the city level.

3. Study area and dataset

3.1. Data gathering and sample characteristics

The data was collected via a face-to-face questionnaire, administered during January and February 2020, just before the outbreak of the COVID-19 pandemic. In total, 252 respondents living in Alcalá de Henares took part. The questionnaire was structured in three main blocks: (1) socio-economic characteristics; (2) e-shopping habits and perceptions; and (3) transportation habits, focused on capturing the spent time to reach in-store retail by car, public transport, and on foot.

Regarding socio-economic characteristics, a little over half of the sample were women (51.98%) and the most numerous age group (34.12%) was between 41 and 60 years old, closely followed by individuals 26 to 40 years old (29.76%). A majority of participants had a high educational level, with 44.05% of respondents having a bachelor's degree. Almost two-thirds of participants had a job (60.71%), usually as employees (82.35%) with a minority being self-employed (17.65%). The majority (83.01%) were full-time, while 16.99% were part-time workers. A total of 13.09% of respondents were university students. Household's net income €2,000–€2,999 was most common (38.89%), followed by monthly earning's of €1,000–€1,999 (29.76%). Most lived in a family unit (63.89%), and 23.81% had children under 12 years old. Finally, 78.97% of respondents had at least one car available in the household, and almost three-fourths had a driver's license (73.81%).

Within the block of e-shopping habits, 17.86% of participants never buy online and 19.85% rarely. The occasional e-shoppers were 24.21%, while 38.09% bought online often and quite often. Almost half (43.25%) of respondents did their last online purchase the same week they filled out the questionnaire, preferring home deliveries (65.08%). One-quarter (26.19%) perceived e-shopping as easier and faster. E-shopping was also seen as a time saver (21.82%). Only 15.08% show preference for e-shopping because they considered that in-store retail is too far away from their usual daily places. Within the share of respondents that buy online, approximately two-thirds saw e-shopping as secure, with clothing and fashion accessories (55.16%) as the most commonly purchased products, closely followed by plane and train tickets (50.40%), and tech products (48.41%).

The last block of the questionnaire focused on mobility habits. Participants were asked to indicate the travel time usually spent to reach in-store retail locations by car, public transport, and on foot. Almost 70% of the respondents travelled 10 min or less by car, with 11.11% spending 10 to 20 min and 12.30% driving more than 30 min. For public transport, the percentage of those travelling 10 min or less increased up to 80%; with 20 to 30 min standing at 4.63% and more than 30 min at 7.14%. Walking travel time's frequencies were substantially different compared to motorized modes. Almost two-thirds of the respondents walked up to 30 min to reach in-store retail. However, only 10.31% walked 40 to 50 min. Notably, one-quarter of respondents walked 60 min or more to reach in-store retail.

4. Research design

4.1. Identification of e-shopper groups

Clustering techniques were used to identify e-shopper groups, aiming to group individuals with similar socio-economic characteristics and e-shopping habits. Due to the high number of socioeconomic and e-shopping variables included in the questionnaire, Principal Component Analysis (PCA) was first implemented to reduce the number of variables finally used in the study, while maintaining the dataset's higher variance–covariance structure. PCA results indicated that age, car ownership, e-shopping frequency, and the perception of e-shopping as a time saver were the less correlated variables and that they simultaneously explained the highest variance. These four variables were selected to identify e-shopper groups. Considering the categorical data of those variables, the k-modes algorithm was used for clustering (Chaturvedi et al., 2001). Three e-shopper groups were established based on the Silhouette coefficient value.

4.2. Analysis of distance-decay functions to reach in-store retail

Distance-decay functions show the time spent to reach in-store retail locations. Such distance-decay functions were empirically obtained from the travel time declared in the questionnaire. In total, nine functions were obtained, including three distance-decay functions representing each transportation mode (car, public transport, walking) for each e-shopper group. Analyses were based on determining statistical differences between the e-shoppers' distance-decay functions for car, public transport, and walking. The Kruskal-Wallis test served to simultaneously compare the distance-decay functions between e-shopper groups, considering all time intervals simultaneously. Significant differences would imply that at least one e-shopper distance-decay function was different at any travel time interval. When no significant differences were found, distance-decay functions for each e-shopper group were then simultaneously compared according to time intervals percentiles. The Kruskal-Wallis test was again used for this purpose, to facilitate the identification of travel time thresholds for which at least one e-shopper group had a different distance-decay function. Finally, the Mann-Whitney test served to compare the distance-decay functions between pairs of e-shopper groups for both time intervals as a whole and for percentiles of time interval.

4.3. Evaluating and mapping spatial effects of multimodal accessibility for e-shopper groups

A gravity-based model, which is regularly used in transport research (Arranz-López et al., 2021; Papa and Coppola, 2012; Vale et al., 2015), was applied to calculate spatial accessibility to reach in-store retail locations by car, public transport, and on foot for the three e-shopper groups. The R statistical computing environment and ArcGIS 10.8 were used to calculate and map multimodal accessibility levels of each modal choice. The following formula was used:

$$A_i = \frac{\sum_{j \neq i} E_j e^{\beta X_{ij}}}{E}$$

Where A_i is the accessibility for zone i; E_j is the number of in-store retail at destination j; β is the parameter of the distance-decay function described in Section 4,2, and X_{ij} is the time between origin and destination. E represents the total amount of retail stores and served to normalize the accessibility values for car, public transport, and walking, thus enabling the comparison of accessibility values between the three transport modes for each e-shopper group.

The qualitative combination of the three types of accessibility for each e-shopper group served to identify multimodal accessibility places. A multimodal benchmarking cube was designed (Silva, 2013), identifying five potential multimodal accessibility categories. Then, the multimodal accessibility categories were compared between e-shopper groups, identifying whether they had the same multimodal accessibility category at a specific place.

4.4. Alcalá de Henares

The city of Alcalá de Henares (197,562 inhabitants), located in the eastern part of the Madrid Metropolitan Area, Spain, served as the case study. This city is part of a relevant industrial and logistics area, with a privileged location next to both Madrid (35 Km.) and a crossroad of national transport corridors.

5. Results

5.1. Identification of e-shopper groups

Three e-shopper groups were identified along the main distinguishing characteristics: age, car ownership, e-shopping frequency, and perception of e-shopping as a time saver.

(i) *Group #1: Occasional e-shoppers with a car.* Formed by 168 people, they are between 25 and 65 years old, own a car, occasionally buy online and perceive e-shopping as a time saver.
(ii) *Group #2: Infrequent e-shoppers with a car.* Made up of 45 people, they are between 40 and 75 years old, own a car, rarely or never buy online and perceive that e-shopping does not save time.
(iii) *Group #3: Frequent e-shoppers without a car.* Consisting of 39 people, they are between 18 and 40 years old, without a car, frequently buy online and perceive e-shopping as a time saver.

5.2. Analysis of distance-decay functions to reach in-store retail locations

The results show a significant difference between the car functions for the three e-shopper groups. For public transport functions, the results show that the distance-decay function for Group #3 is significantly different from Group #1. However, no other significant differences are seen between other pairs of e-shopper groups. The Mann-Whitney results for walking functions show that Group #1 and Group #2 are statistically different in the range between 15 and 40 min. However, Group #1 and Group #3 are statistically different in all the time intervals analysed. Finally, the distance-decay functions for Group #2 and Group #3 are different for the 40 min interval.

5.3. The spatial effects of multimodal relative accessibility for e-shopper groups

The first MAP analysed (Figure 1) is of places that are “highly resistant to e-shopping”, covering a total of 34.12% of the hexagonal cells. It includes the city centre (e.g., Casco Histórico, Juan de Austria, Val) and the centre of some neighbourhoods located in the periphery (e.g., La Garena, Ensanche, Espartales, Rinconada). Due to the ease of reaching in-store retail in these places by car, public transport, and on foot, no significant advantages or disadvantages are noted between e-shopper groups. Nevertheless, Group #2 would be the most favoured group, as it contains the larger number of older people. For this reason, it seems appropriate to foster high level of public transport and walking accessibility to retail in this MAP, as older people tend to reduce their car use, are less ICT-savvy, and walk longer distances as age increases. For Group #1, who live in places that are “highly resistant to eshopping”, e-shopping would complement in-store shopping. This peculiarity is relevant for younger residents and women within Group #1, since they declared to both buy online more frequently and spend longer time travelling by public transport and on foot to reach in-store locations. In the case of Group #3, two main issues must be highlighted. First, this group has a limited car access, resulting in the occasional use of a shared car (e.g., parents, friends). Second, the youngest people within Group #3 usually live with their parents and have limited shopping responsibilities.

The second MAP to be considered is places that are “moderately resistant to eshopping”, covering a total of 10.27% of the hexagonal cells. Although such places present medium-high multimodal accessibility levels, they usually have low accessibility levels by car and public transport, making retail in these locations relatively vulnerable to e-shopping for specific population groups. Group #3 experience the lowest car accessibility levels. However, they may not perceive this situation as a disadvantage for at least two reasons. On the one hand, Group #3 is made up of the youngest people of the sample, who probably both do not own a car and prefer public transport and walking. On the other hand, people from this group exhibit high e-shopping frequency and, thereby, also meet their main shopping demand without having to travel. Group #1 might be the most disadvantaged group in MAP cells with low public transport accessibility, as they tend to spend the shortest travel time by public transport, compared to other groups. Specifically, Group #1 older people and low-income families with residences in these cells can be disadvantaged because they tend to spend less time travelling by public transport.

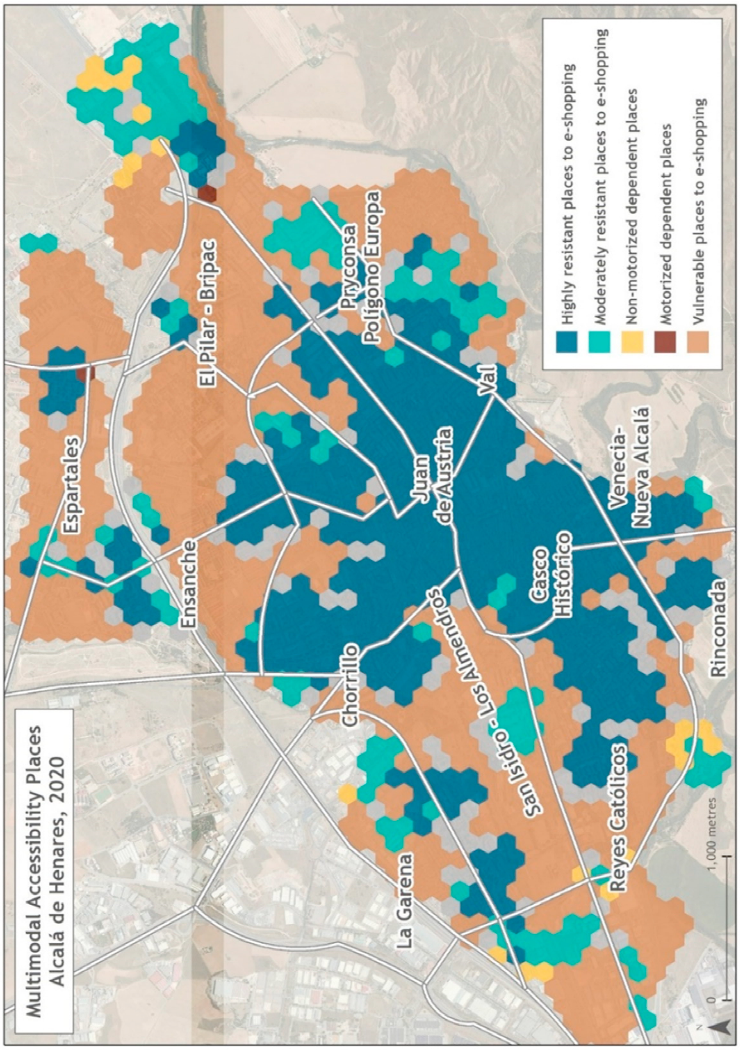

Fig. 1. Multimodal accessibility categories for each e-shopper group and multimodal accessibility places (MAPs).

Places that are "vulnerable to e-shopping" was the third MAP to be evaluated. It covers the biggest area in the case study, 44.77% of the hexagonal cells. These places are characterized by low accessibility values by car, public transport, and walking. These MAPs are mainly located around places that are "highly resistant to e-shopping", extending to the outskirts of the city. Neighbourhoods such as Espartales, El Pilar- Bripac, and Reyes Católicos have the highest number of cells within this MAP category. The Group #2 who live in these locations are the most disadvantaged group, as they sporadically or never buy online. People over 60 years old, who are heavily represented in Group #2, are also strongly disadvantaged due to both their less-developed ICT skills and the poor physical access to in-store retail. Group #1 is the second most disadvantaged group. In this case, special attention must be paid to low-income individuals, as they spend more time to reach retail by public transport, instead of using a car or walking, and certain public transport stops in this MAP are difficult to reach (e.g., El Pilar-Bripac, the western area of Reyes Católicos). Finally, Group #3 is seen as the most advantaged; demonstrating the highest level of e-shopping frequency, they can reach retail virtually without having to deal with the challenges of physical accessibility.

6. Conclusion and discussion

The first tier of findings highlights the need to move towards an accessibility-based approach. Most of the consulted studies focus on unravelling the relationships between e-shopping and shopping trip frequency. This mobility-oriented approach does not adequately address the interaction between land use and transport, which is key from a sustainable and inclusive planning perspective (Bertolini, 2017; Kenyon, 2010). This approach has two relevant limitations. First, variations in mobility standards (e.g. trip frequency) are hardly translated into specific planning concepts based on accessibility levels (Handy, 2005). Second, the spatial effect of the relationships between land use and transport is not captured (Handy, 2020; Hull et al., 2012). The identification of MAPs can be also seen as a contribution to incorporating online activities in accessibility gravity models, which traditionally have difficulties to process the spatial effects of the mentioned online activities (Suel and Polak, 2018). MAPs provide policy-makers with a framework to extend planning criteria to online activities and better manage shopping and urban mobility – a particularly useful contribution to the post-COVID- 19 recovery.

The second tier of findings highlights the need to understand and address social inequalities linked to spatial accessibility and online activities (Banister, 2018; Hong et al., 2020). Online activities could potentially reduce accessibility-related inequalities by providing virtual access to major destinations, such as jobs, in-store retail, and leisure (Lachapelle and Jean-Germain, 2019; Ozbilen et al., 2021). However, other inequalities emerge in an internet-based society, especially related to the digital divide and the capacity to access electronic devices and the internet (Van Deursen and Mossberger, 2018; Velaga et al., 2012). Under this context, the relative multimodal accessibility approach implemented in this research can be valuable to bridge equity issues, transport planning, and the impact of internet on society (Arranz-López et al., 2019; Kelobonye et al., 2019; Páez et al., 2010a). A relevant aspect of using a relative accessibility approach is the identification of accessibility thresholds, which identify breaking points of accessibility levels between population groups.

Further research could focus on at least two relevant issues. First, gaining insights into the influence of e-shopping on those time thresholds that trigger significant shifts in multimodal accessibility to in-store retail. Second, MAPs should be customized for different types of products, due to the noted variations in penetration of e-shopping for certain products.

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