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Research Article
2026 July - December
versión original aquí

E-commerce and residential density: A geospatial analysis of demand in Córdoba (Argentina) Comercio electrónico y densidad residencial: Un análisis geoespacial de la demanda en Córdoba (Argentina)

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ABSTRACT E-commerce has initiated a process of territorial restructuring of retail commercial activity. The trends of this process and its implications for the physical and functional structure of cities are currently a subject of debate. In this context, e-commerce parcel delivery destinations constitute key data, as they allow for the analysis of demand levels in different areas and the evaluation of their correlation with various socio-urban indicators. The objective of this article is to analyze the impact of residential density on the volume of B2C e-commerce purchases in different areas of the City of Córdoba (Argentina). The proposed methodology is based on the use of geographic information systems (GIS) to cross-reference geospatial data and is complemented by linear correlation calculations. The results reveal that areas with lower residential density tend to have a higher average number of purchases per household.

RESUMEN El comercio electrónico ha iniciado un proceso de reestructuración territorial de la actividad comercial minorista. Las tendencias de dicho proceso y sus implicancias en la estructura físico funcional de las ciudades son motivo actual de debate. En este contexto, los puntos de destino de la paquetería *e-commerce* constituyen un dato clave, ya que permiten analizar el nivel de demanda en diferentes áreas y evaluar su correlación con diversos indicadores socio urbanos. El objetivo de este artículo es analizar la incidencia de la densidad residencial en el volumen de compras *e-commerce* B2C en diferentes áreas de la Ciudad de Córdoba (Argentina). La metodología propuesta se basa en el uso de sistemas de información geográfica (SIG) para el cruzamiento de datos geoespaciales y se complementa con cálculos correlación lineal. Los resultados revelan que las áreas con menor densidad residencial tienden a un mayor promedio de compras por vivienda.

Received: 02/09/2025
Reviewed: 13/01/2026
Accepted: 28/01/2026
Published: 04/05/2026

KEYWORDS e-commerce, residential density, territorial restructuring, retail commerce, city of Córdoba

PALABRAS CLAVE comercio electrónico, densidad residencial, reestructuración territorial, comercio minorista, ciudad de Córdoba

Cómo citar este artículo/How to cite this article: Gamba, M. (2026). Comercio electrónico y densidad residencial: un análisis geospacial de la demanda en Córdoba (Argentina). *Estoa. Revista de la Facultad de Arquitectura y Urbanismo de la Universidad de Cuenca*, *15*(30), e6258. https://doi.org/10.18537/est.v015.n030.a06

ESTOA **30** / Vol 15 / 2026
e - ISSN: 1390 - 9274
ISSN: 1390 - 7263

1. Introduction

In recent decades, e-commerce has initiated a process of territorial restructuring of the retail sector as a whole (Brynhildsen, 2021). By combining digital platforms with specialized logistics systems, this process tends to fragment and disperse commercial activity across time and space (Couclelis, 2000, 2004, 2009; Mokhtarian, 2004). All stages of the product purchasing process (information gathering, product selection, payment, delivery, etc.)—which previously took place within a single, defined time and space where suppliers and consumers coexisted (the physical store)—now unfold at different times and in different places, mediated by digital devices (Couclelis, 2004). This phenomenon is part of a broader process of urban restructuring, driven by the emergence of platform economies and 4.0 technologies in our daily lives, redefining the relationships between activity (system of actions) and material space (system of objects) (Gamba, 2024). The resulting territoriality is diffuse, fluctuating, and complex to interpret. In Figure 1, we can compare the concentration of in-person commercial activity in the city of Córdoba with the dispersion of demand for e-commerce home deliveries, based on shipments made by the company Correo Argentino between July 4, 2023, and September 21, 2023.

Unlike traditional *retail, e-commerce* does not necessarily require a location in areas with high demand concentration to operate, allowing for more efficient management of supply, storage, and distribution costs (Anderson, 2008; Moliní, 2002). In light of this phenomenon, some authors note that the economic sustainability of physical stores may be compromised, at least in certain sectors, if they fail to adapt to broader market trends and a more competitive cost structure (Fabri and Valverde Márquez, 2020; Nahiduzzaman et al., 2021). As a consequence of this process, the role of current urban centers could be redefined, and their image and operational dynamics altered (Brynhildsen, 2021; Nahiduzzaman et al., 2019; Zimmermann and Burkholz, 2019). On the other hand, the way in which the new territoriality of retail interacts with other urban functions could even influence, in the medium and long term, the location demands of other urban functions such as housing, work, education, recreation, or leisure (Nahiduzzaman et al., 2019, 2021; Visser and Lanzendorf, 2004).

To date, urban transformations linked to the rise of e-commerce have been studied in depth primarily by examining their impact on urban goods distribution systems and urban mobility in general (Beckers et al., 2022; Behrends et al., 2008; Bosona, 2020; Comi and Nuzzolo, 2014, 2016; De Silva et al., 2020; Fried and Goodchild, 2023; Kumar and Chidambara, 2023; Sakai et al., 2020, 2024; Siegfried et al., 2021; Stinson et al., 2019; Xiao et al., 2021). While these studies are valuable in that they shed light on the implications and technical requirements of the activity in terms of logistics and its qualitative differences from traditional retail supply systems, they do not allow for conclusions regarding the territorial distribution of

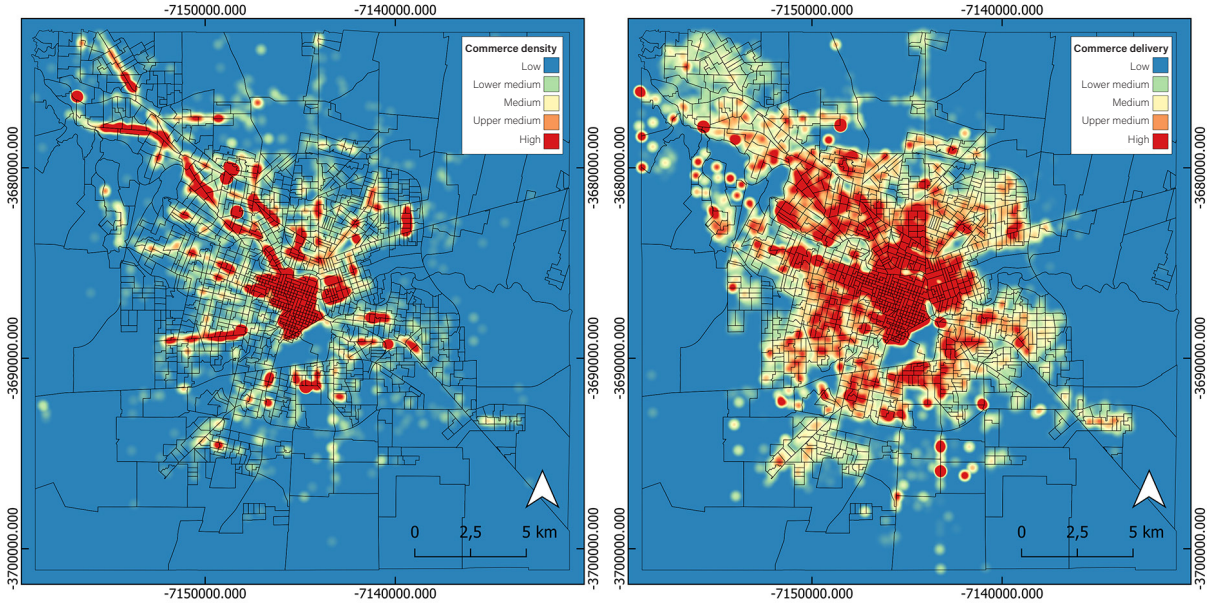

Figure 1: Heat map of brick-and-mortar stores vs. e-commerce deliveries. (2025)

the activity as a whole (e.g., the location of suppliers and consumers) or its consequences for the physical and functional structure of cities.

There are, on the other hand, studies that explore, at a theoretical level, the implications of e-commerce on citizens' lifestyle choices and its effects on the growth dynamics of cities. Visser and Lanzendorf (2004) anticipate the possible short-, medium-, and long-term effects of *e-commerce* use, predicting changes in citizens' daily routes and activities, in their chosen modes of transportation, and even in their preferences regarding where to live or work. Along these lines, Nahiduzzaman et al. (2019) posit that e-commerce catalyzes urban transformation, shifting from a monocentric to a polycentric structure in which the centripetal nature of the central area is weakened. According to the author, this process involves the division, fragmentation, reconceptualization, and relocation of retail stores, which tend to downsize and offer complementary services focused on recreation and socialization in response to the growth of e-commerce operations. In turn, he notes that changes in the efficiency principles governing store location are leading retailers to fragment their facilities and relocate storage and logistics areas away from traditional commercial zones to optimize costs (Nahiduzzaman et al., 2021). It is also worth mentioning the contributions of Brynhildsen (2021), who, based on surveys and interviews with various stakeholders, examines the effects of e-commerce on urban development and social interactions in the city of Malmö, Sweden. This study highlights the risk that e-commerce growth poses to the attractiveness of commercial centers and their role as social integrators, as well as the difficulties a lack of knowledge about this phenomenon creates for urban planning.

The contributions of Nanda et al. (2021) are also key to understanding the relationship between the home as a multifunctional hub of activity and the process of territorial restructuring of retail activity. The authors analyze the strategies implemented by various retailers in the United Kingdom alongside interviews with retail asset managers and property owners, using a mixed-methods approach. First, they note that digitalization and the implications of the COVID-19 pandemic have challenged (at least partially) the traditional role of commercial streets as hubs of economic activity and innovation, where people and businesses congregate and form markets. At the same time, they argue that the criteria for choosing residential locations have also been revised in the wake of the COVID-19 pandemic. Thus, changes in household location choices would, in turn, drive transformations in retail location choices. Since customer traffic is no longer concentrated on main streets or in urban centers due to remote work and e-commerce, the customer foot traffic relevant to retailers is declining. At the same time, the dispersion of workers' locations across the city also appears to be driving the emergence of satellite commercial centers around the working population. As a result, traditional businesses on main streets may be forced to relocate or expand their operations to these emerging satellite centers. The authors argue that this process of spatial reorganization will have significant implications for urban planning.

On the other hand, Coster (2019) examines, using correlation and multiple regression analyses, the effect of e-commerce on the demand for commercial real estate across various locations in the Netherlands between 2011 and 2016. There, we find empirical evidence that the increase in online shopping, especially for non-daily goods, is associated with a decline in demand for retail real estate. Along the same lines, Liu et al. (2022) quantify and evaluate the transformations e-commerce has generated in the value of retail store rents using geospatial big data. This study observes the emergence of small, dispersed, high-rent commercial hubs, indicating a diminishing influence of central place theory on the location of commercial activity, as well as the decline of some traditional locations with the highest commercial values in the face of new service centers emerging in suburban areas.

Finally, it is worth considering the contributions of Zimmermann and Burkholz (2019) in their study on changes in the spatial requirements of traditional retail businesses in Germany following the incorporation of digital sales channels. This study reveals a trend toward smaller retail spaces, where the *"showroom"* concept—focused on delivering a brand experience—prevails over the "point of sale" function, which is increasingly handled by e-commerce channels.

The literature cited above serves as a theoretical and methodological starting point to guide this research. However, to date, there are no empirical studies that investigate the factors governing the spatial distribution of retail demand in *e-commerce*—that is, that analyze the level of correlation between different socio-urban indicators and the location and level of participation of buyers**.** Identifying which areas of cities experience the highest retail e-commerce (B2C) consumption and analyzing the causes of this distribution is key to subsequently explaining the location and mobility demands arising from the phenomenon.

This study hypothesizes that the spatial distribution of retail demand in e-commerce is not homogeneous and can be explained by its correlation with various socio-urban indicators. Among the variables we consider relevant to analyze are: level of concentration of brick-and-mortar commercial activity, level of mixed-use development, type of urbanization, residential density, population density, land value, accessibility, socioeconomic status of the population, and its age composition. In this study, we will limit our analysis to the spatial distribution of demand relative to residential density within a

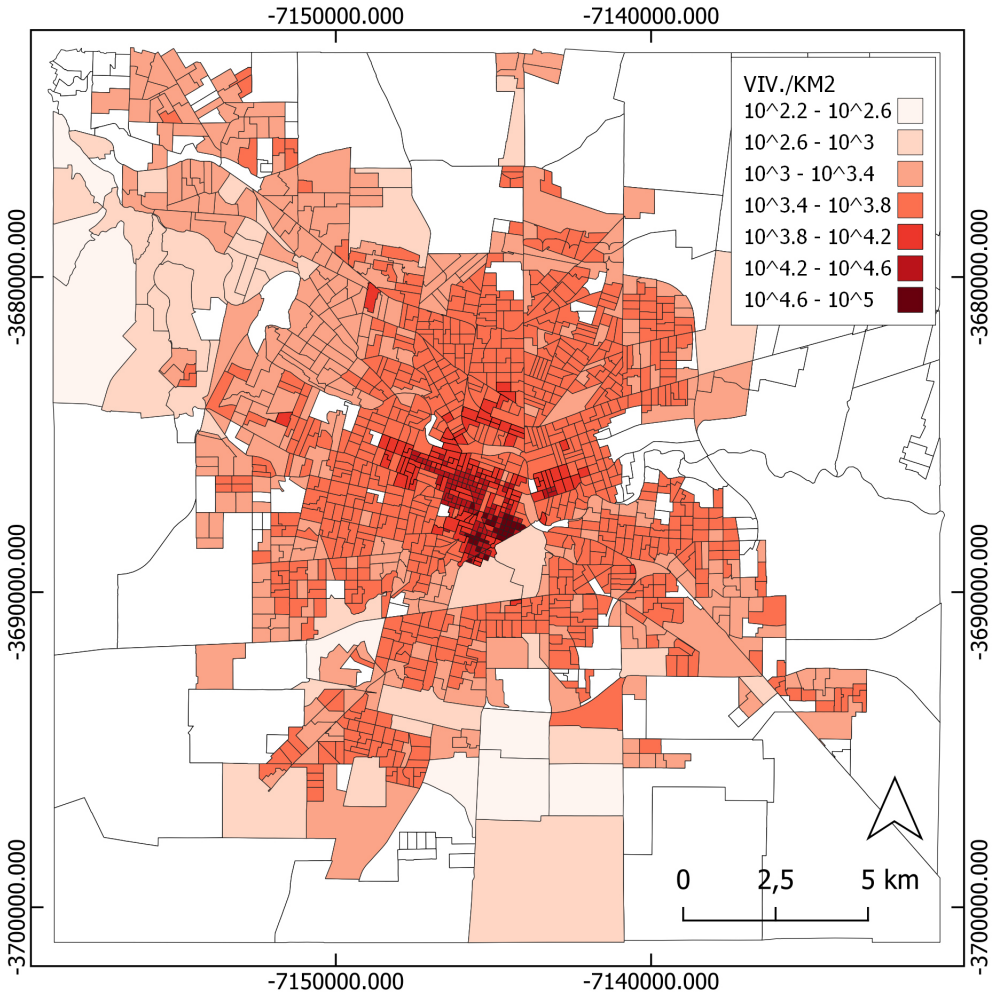

Figure 2: Residential density at the census tract level, City of Córdoba, Argentina (logarithmic segmentation). Household and Housing Census, INDEC (2021)

proposed urban case study area: the city of Córdoba, Argentina. We consider this initial approach relevant, as it will allow us to identify the general characteristics of neighborhoods with the highest prevalence of e-commerce, specifically the average number of purchase orders per household. The socioeconomic status (SES) of the population in the studied areas will be used as a control variable, since a priori, it has a significant impact on the volume of purchases in these areas.

2. Study area

The urban area of Córdoba, Argentina, is proposed as the study area. It is located in the central region of the country and is the second most populous city. Like many American cities, it has developed extensive radial growth over time, with a progressive decline in building and population density from the center to the periphery. These processes can be identified in a series of concentric rings of expansion, comprising a dense central area with mixed-use development, a peri-central area of medium-to-low density, and a peripheral area that is monofunctional, low-density, and characterized by significant socio-spatial contrasts. The proposed study area will be analyzed in sub-areas defined by 1,364 census tracts. These are spatial units created by the National

Institute of Statistics and Censuses (INDEC) for the collection of sociodemographic data, consisting of approximately 300 households each. The relevance of the chosen study area is based, on the one hand, on its socio-urban complexity, featuring a broad spectrum of urban fabrics with diverse residential densities and sociodemographic compositions. On the other hand, its radial-centric structure, marked by strong, extensive growth, allows the results obtained to be transferred to other cities with similar urban processes, with the caveats specific to each case.

3. Materials and methods

3.1. Materials

To analyze the distribution of e-commerce retail demand in the proposed study area, we will use the delivery destinations of non-daily goods as our data. For this purpose, this research relies on data from Correo Oficial de la República Argentina S.A., which currently handles approximately 60% of all e-commerce parcel deliveries nationwide. The information provided by the company corresponds to the total number of home deliveries made within the city of Córdoba's urban area from July 4, 2023, to September 21, 2023. It should be noted that although the company offers other delivery formats, such as pickup at branches and postal units, these account for only 19% and 9% of total deliveries, respectively. As indicated by the Argentine Chamber of Electronic Commerce (CACE) in its 2023 annual report, home delivery remains by far the most popular delivery option nationwide among consumers, accounting for 72% of total shipments (Kantar, 2023), a figure confirmed by the sample used in this study.

To define the socioeconomic status (SES) of the census tracts analyzed, we used the study by De Grande and Rodríguez (2022), which consists of a territorial stratification based on seven segments that take into account the material and infrastructure conditions of housing, as well as the socio-educational capital of adults and youth in each classified tract (Figure 3). Finally, to calculate residential densities at the census tract level, the 2020 Household and Housing Pre-Census conducted by INDEC (2021) was used.

3.2. Methods

We propose a linear correlation analysis of the average number of deliveries per dwelling in each census tract of the city of Córdoba (dependent variable) and residential density (independent variable), using different segmentation criteria. To this end, the socioeconomic level of the population was considered as a control variable, as it has a significant correlation with the average number of deliveries per household (Pearson's coefficient: 0.39). Geographic information systems were used to geocode and cross-reference the data to be analyzed.

Below, we describe the procedures performed and the criteria used for the analysis.

3.3. Data normalization

The sample provided by Correo Argentino comprises 99,122 home deliveries. To geocode the parcel delivery destinations, it was necessary to standardize the addresses, as they did not follow a consistent format. In turn, the presence of residential complexes and real estate developments within the study area that lack street names and/or street numbers poses an additional challenge when geolocating the sample in GIS and requires special procedures for their processing.

Of the data provided by the company, 2.03% corresponds to "unlocatable" addresses, as they lack sufficient information to be located, even approximately. These data are characterized by lacking a street name and/or number and, at the same time, any precision regarding the neighborhood to which they belong (e.g., "public street s/n", "Santa Fe Street s/n", "Public Street 453"). This group in the sample was discarded in its entirety. From the remaining 97.97%, two groups were created. On the one hand, the addresses we call "regular" have a precise, legible data structure that specifies the type of street, name, block number, and floor and apartment number (e.g., "969 Ambrósio Olmos Ave., 8th floor, apt. C"). On the other hand, the addresses we call "irregular", which do not have a traceable address but indicate the neighborhood, housing development, or settlement to which they belong, allowing for an approximate location. This is the case, for example, with gated communities or informal settlements that lack street names or numbers but are identifiable as defined areas within the urban area (e.g., "Barrio El Rocío s/n").

"Irregular" addresses account for 2.86% of the sample and were detected by applying keyword filters (e.g., "barrio", "mz", "manzana", "mzn", "lote", "lt", "km", "calle pública", "cp", "country", "sn", "s n"). These addresses were manually assigned the centroid coordinates of the polygon to which they belong (neighborhood, development, or settlement). The addresses we refer to as "regular" (95.11% of the sample), on the other hand, underwent a process of prefix standardization (e.g., "gral", "general", "gral.") and removal of unnecessary suffixes (floor and apartment numbers), following the guidelines proposed by the Argentine Geographic Data Standardization Service, to reduce the error rate in the subsequent geocoding.

3.4. Geocoding of the sample

For the geocoding of addresses defined as "regular", two different methodologies were combined: one based on the *OpenStreetMap* API, using the MMQGIS plugin in QGIS, and the other based on INDEC data, using the API of the Argentine Geographic Data Standardization Service.

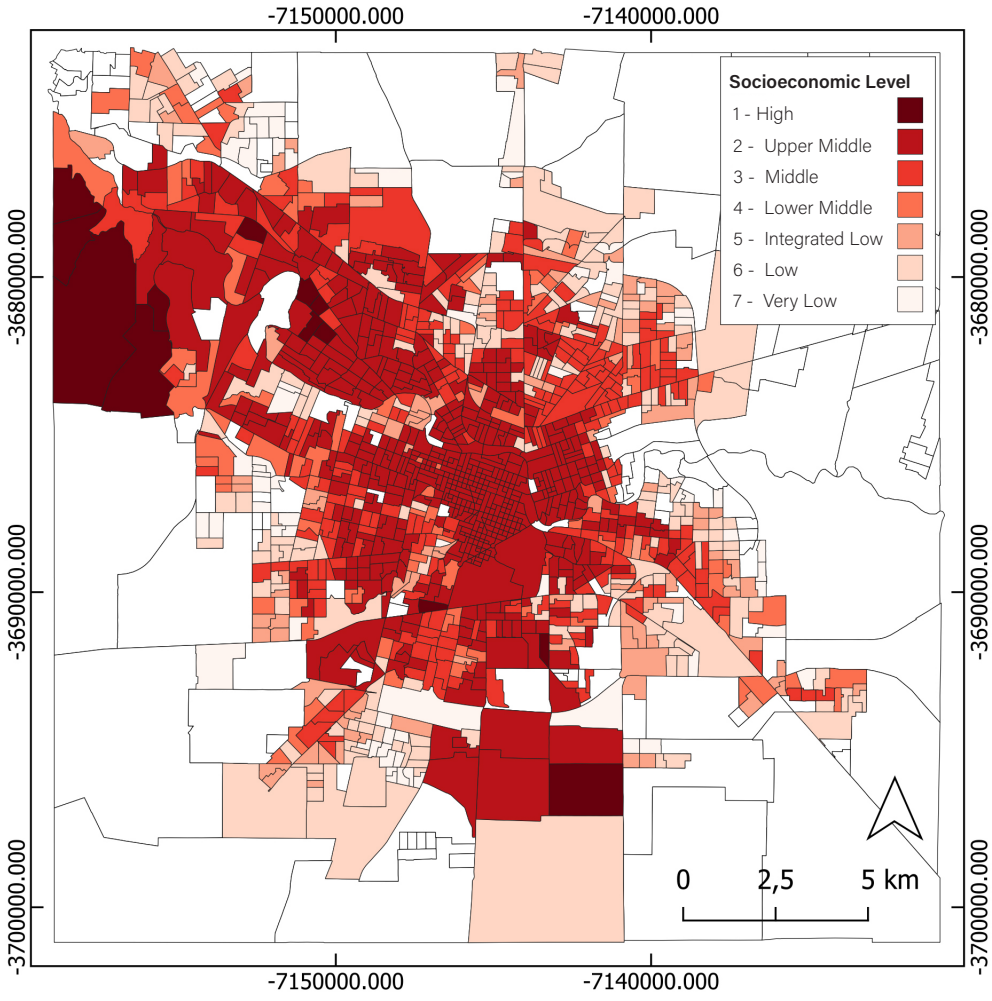

Figure 3: Socioeconomic stratification at the census tract level, City of Córdoba, Argentina. De Grande and Rodriguez (2022)

The first method yielded a success rate of 96.82% (91,408); however, of that percentage, only 74.13% constitutes reliable data, since for the remaining 28.87%, the application could not find the street elevation in the database, returning an approximate result with margins of error that are not acceptable for this research. The second method, based on the INDEC database, yielded a success rate of 84.47% (79,081), matching 91.70% of the addresses correctly located by the first method. For this reason, the reliable results from both samples were combined, achieving a success rate of 90.71% (85,644 entries) of the total "regular" addresses.

Thus, of the total locatable addresses—both regular and irregular—94.23% were successfully geocoded, totaling 91,508 deliveries, thereby avoiding systematic errors that would result in data loss concentrated in specific areas, such as gated communities or informal settlements.

3.5. Calculation of residential densities

To calculate the residential density for each census tract, the total number of dwellings obtained from INDEC's 2020 Household and Housing Census was used. Tracts that lacked data or where the number of dwellings was zero were excluded, resulting in a total of 1,364 tracts (97.42%). Furthermore, when defining the area for density calculations, certain considerations must be taken into account. Census tracts are, in this case, spatial units that randomly group different land uses such as green spaces, commercial and residential areas, public and private facilities of various scales, and industrial and rural uses. To avoid the distorting effect of large non-residential polygons in the calculation, areas larger than 2 ha corresponding to industrial, commercial, and rural uses, green spaces, areas designated for aggregate extraction and mining, urban facilities,

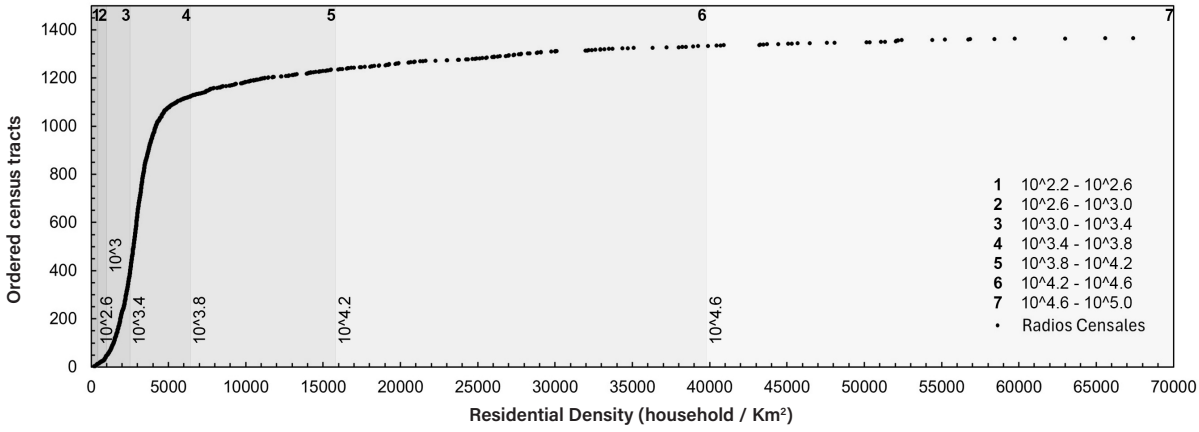

Figure 4: Residential density by census tract. Household and Housing Census, INDEC (2021)

and undeveloped vacant areas were subtracted from each census tract's total area. Figure 2 shows the residential density for each census tract, ordered from lowest to highest, expressed in dwellings/km². A logarithmic segmentation criterion was used for subsequent analysis (Figure 4).

3.6. Calculation of average deliveries per dwelling

The final indicator needed for cross-referencing and analyzing the data is the average deliveries per dwelling, calculated as the ratio of deliveries per census tract to the number of dwellings in that tract. Figure 6 illustrates this indicator, segmented by Jenks' natural breaks.

3.7. Segmentation criteria and data analysis

As stated earlier, when analyzing the impact of residential density on average deliveries per dwelling, it is essential to control for the socioeconomic level of the population (Figure 3). Applying the segmentation criteria of De Grande and Rodríguez (2022), this variable has shown a linear correlation with the average number of deliveries per dwelling of 0.40. For this reason, it is necessary to study each socioeconomic stratum separately, ensuring that this variable remains constant across analyses (Figure 5).

On the other hand, it is important to note that not all socioeconomic strata in the proposed case study cover the same range of residential densities. As we can see in Figure 5, only "SES 2 – Upper-Middle" has a density range of 217 to 67,421 dwellings/km², while the rest of the SES strata range from 314 to 7,659 dwellings/km². This observation highlights the need to analyze the data by grouping socioeconomic strata with similar density ranges. This will allow us to conclude the level of correlation obtained across different density ranges.

Based on the above, three criteria for segmentation and analysis are proposed:

- Segmentation by SES and residential density (logarithmic): we can analyze and compare the average number of deliveries per dwelling across the different density ranges within each socioeconomic stratum, and calculate the linear correlation coefficient for each.
- Segmentation by SES: where the linear correlation between the average deliveries per household and the residential density of all census tracts grouped according to the socioeconomic stratum to which they belong will be calculated.
- Segmentation by density ranges: where socioeconomic strata with similar density ranges are grouped, and the linear correlation between the average deliveries per household and residential density is calculated.

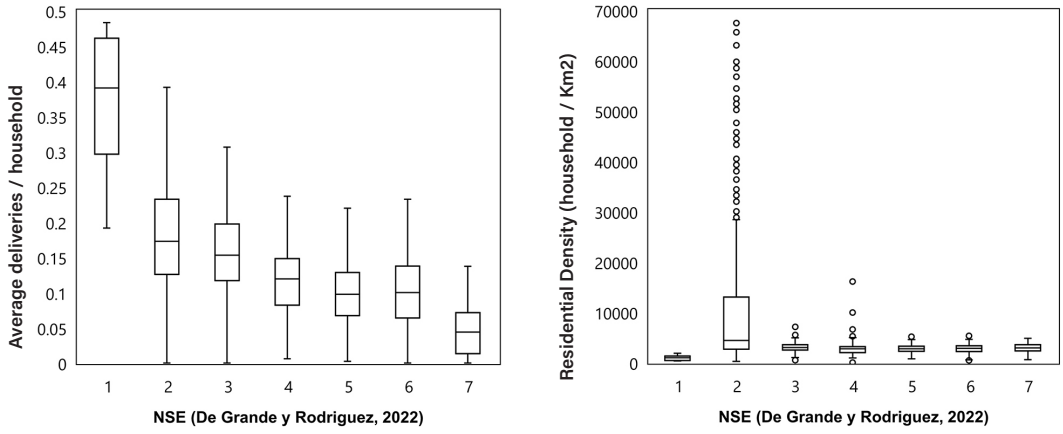

Figure 5: Average deliveries per household and residential density segmented by SES. (2025)

4. Results

4.1. Segmentation by SES and residential density

Figure 7 shows the trend in average deliveries per household by SES across the residential density segments outlined above. Across all SES groups, the average number of deliveries per household decreases as residential density increases. This trend is more pronounced in the "high", "upper-middle", and "middle" strata, while in the "lower-middle", "integrated-low", "low", and "very low" strata, the variation in the average number of deliveries per dwelling is smaller. Only in the "very low" stratum is a significant jump in delivery demand observed, corresponding to range 2 (398 to 1,000 homes/km^2). This segment of the sample consists of three census tracts, two of which are predominantly composed of small-scale industrial areas. This could explain the observed increase, as consumers located there are likely from higher-SES groups than those assigned to these census tracts. In the remaining segments, such situations are not significant, either because they do not concentrate small-scale industrial activities or because the number of analyzed census tracts reduces their impact on the segment's data.

In turn, the Pearson coefficients (see corr. coef. 3, Table 1) range from -0.93 to -0.99, indicating a significant inverse correlation between the average number of deliveries per household and residential density across the socioeconomic strata studied.

4.2. Segmentation by SES

Regarding the linear correlation coefficient between the average number of deliveries per household and residential density for each socioeconomic stratum (correl. coef. 1, Table 1), it is worth noting that it is negative in all cases, confirming the inverse relationship between deliveries per household and residential density noted above. On the other hand, all SES groups show a correlation between -0.20 and -0.50, except for SES 6, which shows a coefficient of -0.054. In the latter case, a significant percentage of census tracts with varying residential densities have very low or zero deliveries per dwelling, which explains the lower correlation coefficient compared to the other strata.

On the other hand, by excluding census radii with outlier data for their SES (-3 , +3), we found correlations ranging from -0.20 to -0.36 across all SES levels, except SES 6 (correlation coefficient 2; Table 1). Given that we understand the average number of e-commerce purchases per household to be a multicausal variable, we can consider the correlations obtained to be relevant.

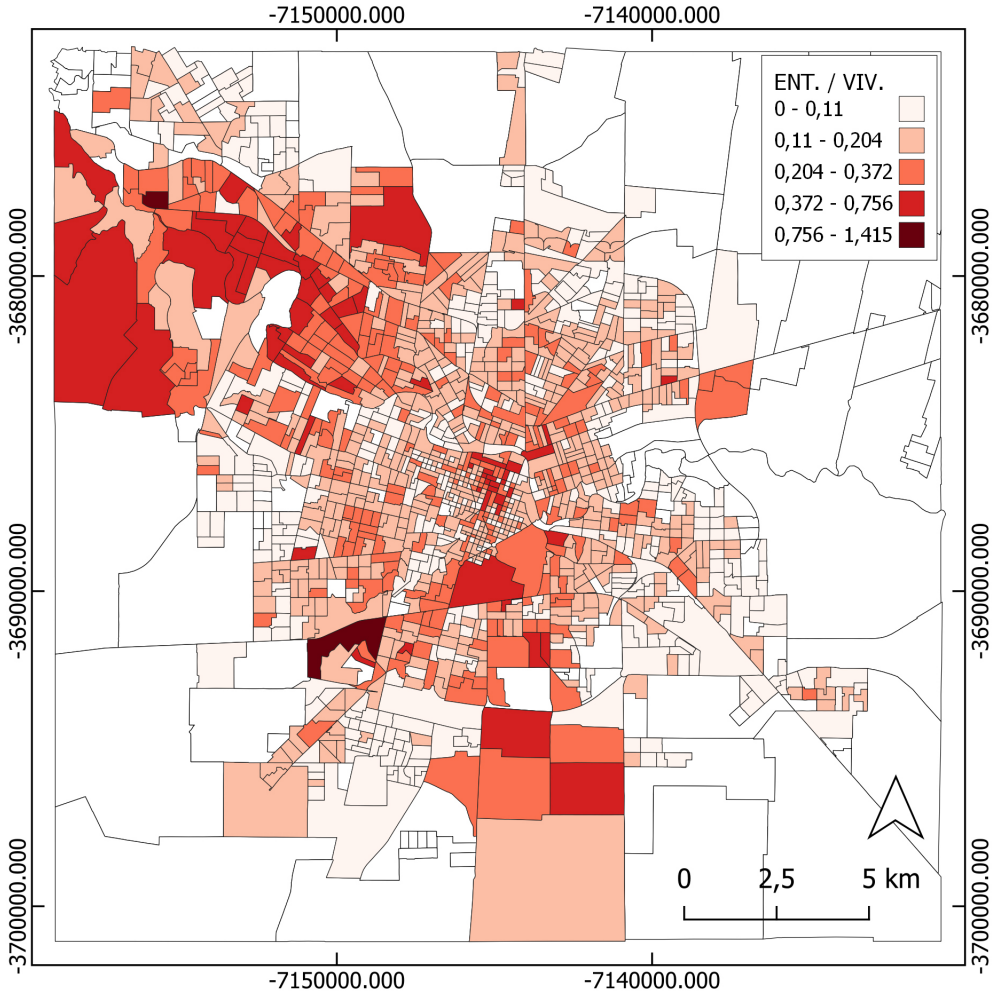

Figure 6: Average deliveries per household at the census tract level. Official Mail of the Argentine Republic (2023)

4.3. Segmentation by density range

Figure 8 shows the scatter plots for NSE 2, with a density range between 217 and 67,421 homes/km^2,and for the remaining NSEs combined, with a density range from 314 to 7,659 homes/km^2. The Pearson coefficient in these cases is -0.24 and -0.26, respectively, indicating a similar correlation across different density ranges. The trend line in both cases shows an acceleration in the demand for deliveries per dwelling as residential density decreases.

5. Discussion

5.1. Residential density as a relevant factor in e-commerce purchase volume

While the average number of e-commerce purchases per household in different areas of the city can be explained by multiple socio-urban factors, this research highlights the relevance of residential density in understanding the spatial distribution of the phenomenon. First, it was found that the number of purchases per household tends to be higher in low-density residential areas, a fact that holds across all socioeconomic strata. It was also found that the variation in purchase volumes by residential density is more pronounced in the high- and middle-socioeconomic strata. In contrast, in the lower strata, it is less significant. This is likely due to the limited purchasing power of the lower strata and programmatic differences in the composition of these neighborhoods compared to the higher strata, where residential mono-functionality predominates.

It is worth noting that when different socioeconomic strata with similar density ranges were analyzed together, the resulting correlation was similar to that obtained when analyzed separately. For this reason, we can infer that socioeconomic segmentation may

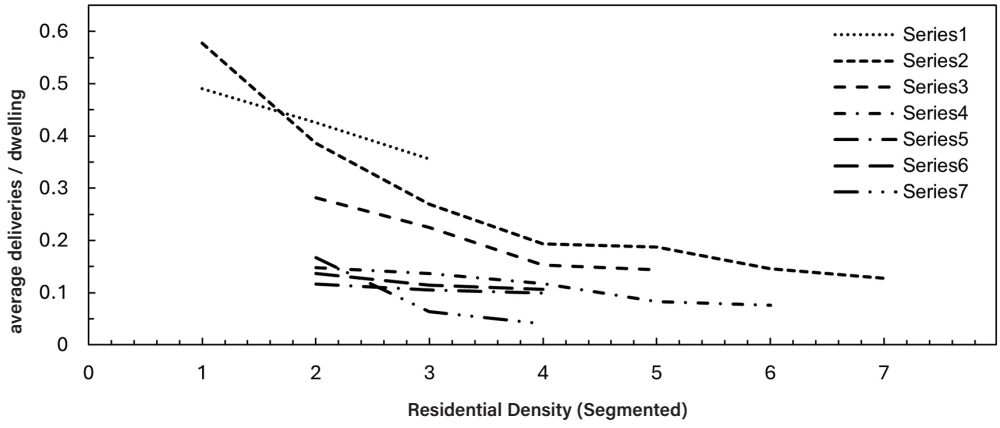

Figure 7: Average number of deliveries per dwelling, segmented by residential density and SES. (2025)

be indispensable for explaining the relationship between residential density and the average number of deliveries per dwelling if no significant differences are observed among these strata within the density range they cover. To confirm this hypothesis, it will be necessary to test the proposed procedure in additional case studies with narrower density ranges and to evaluate the results.

5.2. E-commerce as a phenomenon associated with low-density areas

Unlike other studies focused on the spatial analysis of retail supply, this study examined e-commerce by analyzing the spatial distribution of demand. However, the conclusions reached here complement the literature cited in this article. As discussed earlier, low-density residential areas exhibit the highest average household demand. These areas are located on the city's outskirts and have very low concentrations of commercial activity. It is in these areas where e-commerce emerges as an opportunity, reducing their operational dependence on the central business district, in line with the observations of Nahiduzzaman et al., (2019).

Furthermore, the emergence of new small, high-income, dispersed centers in suburban areas (Liu et al., 2022) appears to correlate with e-commerce consumption in those areas. This trend toward the dispersion of brick-and-mortar retail may complement the online shopping experience in peripheral areas, for example, through "showroom" formats, as proposed by Zimmermann and Burkholz (2019). Furthermore, the spatial distribution of demand also helps us understand the relocation of e-commerce-oriented warehousing and logistics facilities. The location of these infrastructures in peripheral areas (Nahiduzzaman et al., 2021) is explained not only by land value but also by proximity to areas of higher demand, thereby optimizing parcel logistics in terms of time and distance.

5.3. Methodological limitations and scope of the study

This study did not account for sociodemographic data, such as the number of residents per census tract or the age structure of the population. This is because the results of the 2022 National Population, Household, and Housing Census have not yet been published at the census tract level. The absence of this information prevents us from delving deeper into controlling variables in the demand distribution analysis, such as population density, the average number of inhabitants per household, the percentage of the economically active population, and the average age of the different areas analyzed.

This research highlights that residential density alone is far from sufficient to explain the territorial distribution of e-commerce demand. However, the conclusions presented serve as a starting point and guide for future research that systematically explores the correlation of this phenomenon with other socio-urban variables, such as the level of concentration of in-person commercial activity, the level of mixed-use development, the type of urbanization, land value, and relative accessibility. We understand that the proposed methodology is adaptable to different case studies, with the segmentation and analysis criteria adjustable to the specific conditions of each case. We consider it advisable to conduct the proposed study in other urban centers with varying densities to observe whether the impact of this variable on the distribution of e-commerce demand changes and, if so, in which direction.

Regarding the scope of the work, it is worth clarifying, on the other hand, that this article strives to differentiate the spatial concentration of e-commerce demand (higher in central areas) from the frequency of purchases per household (which tends to be inversely proportional to residential density), focusing on understanding consumer purchasing behavior in

SES	Residential density (Log. Seg.)	Deliveries/ household	No. of deli-veries	Σ	Correlation coefficient 1 (total)	Correlation coefficient 2 (σ3)	Correlation coefficient 3 (means)
1	1	0.4907	3	0.2351			
1	2	0.4257	4	0.2176	-0.4808	-0.2574	-0.9998
1	3	0.3556	6	0.0887			
2	1	0.5777	4	0.3549			
2	2	0.3856	15	0.1603			
2	3	0.2699	111	0.1655			
2	4	0.1938	243	0.1256	-0.2443	-0.3142	-0.9138
2	5	0.1876	110	0.1226			
2	6	0.1454	96	0.0861			
2	7	0.1280	34	0.0612			
3	2	0.2815	4	0.1536			
3	3	0.2253	66	0.1445	-0.3740	-0.3639	-0.9641
3	4	0.1526	204	0.0664			
3	5	0.1440	2	0.0345			
4	2	0.1477	2	0.0933			
4	3	0.1366	36	0.0643			
4	4	0.1177	46	0.0544	-0.2333	-0.2245	-0.9788
4	5	0.0829	2	0.0000			
4	6	0.0761	1	-			
5	2	0.1164	2	0.0313			
5	3	0.1055	32	0.0584	-0.2036	-0.2036	-0.9901
5	4	0.0989	69	0.0421			
6	2	0.1362	5	0.0611			
6	3	0.1141	65	0.0812	-0.0542	-0.0542	-0.9639
6	4	0.1063	131	0.0551			
7	2	0.1668	3	0.1092			
7	3	0.0639	23	0.0704	-0.2264	-0.2264	-0.9393
7	4	0.0407	46	0.0307			

Table 1: Linear correlation coefficients segmented by residential density and SES. (2025)

different urban environments. This highlights the effect of e-commerce as a catalyst for the city's extensive, fragmented, and dispersed urban growth, without denying the importance of the externalities generated by the concentration of online demand in central areas—for example, increased traffic and CO_2 emissions.

6. Conclusions

In this article, we have developed a methodology for studying the spatial distribution of retail demand via e-commerce. This methodology allows us to analyze the impact of socio-urban indicators on consumer purchase volume. The results of this study reveal that in the city of Córdoba, areas with lower residential density tend to have a higher average number of e-commerce purchases per household. These areas are primarily characterized by:

- Being located away from the city center,
- Predominantly residential land use (monofunctional),
- Low concentration of commercial uses,
- Greater socio-spatial fragmentation.

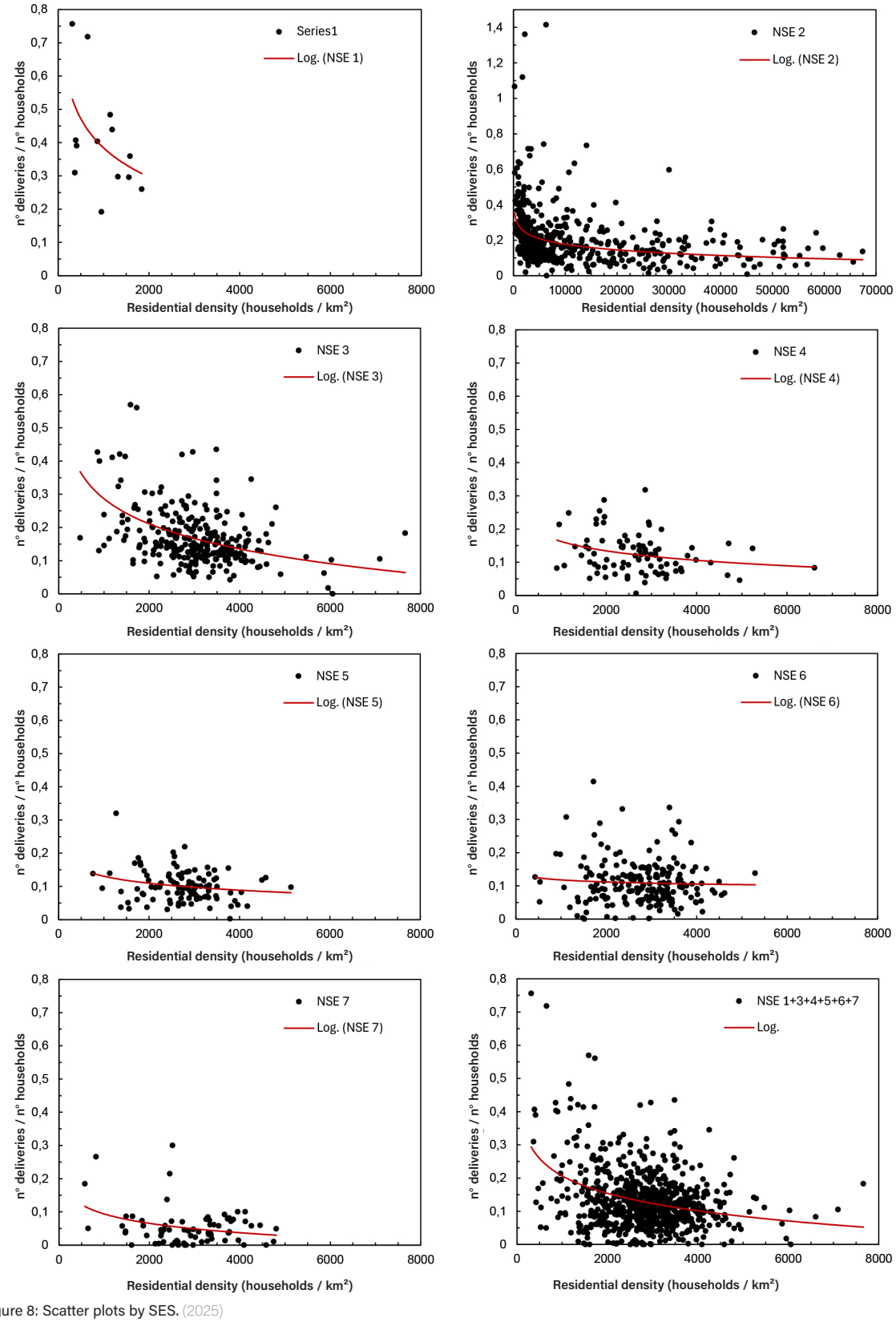

Figure 8: Scatter plots by SES. (2025)

In this case, e-commerce constitutes a commercial alternative that effectively adapts to the lifestyles typical of suburban areas with the aforementioned characteristics, as it significantly reduces travel costs, saving time and money (Kantar, 2023). It also reduces these areas' dependence on the city center for obtaining non-daily consumer goods (Coster, 2019), a phenomenon complemented by the development of new hubs with services geared toward social interaction and recreation. These observations align with Nahiduzzaman et al. (2019, 2021), who posit that e-commerce catalyzes urban transformation, in which the centripetal nature of the central area weakens, leading to a tendency toward dispersion and polycentricity (with the social and environmental costs that this entails).

In light of the results, it can be inferred that the territorial restructuring process experienced by the retail sector is associated with the dispersion in e-commerce demand. This trend contrasts with the logic of the "central place", whose effectiveness depends on certain levels of population concentration and land use. Physical stores that aim to offer a brand experience complementary to online sales (Zimmermann and Burkholz, 2019) tend to prioritize their connection to other social and recreational activities in suburban areas rather than their location in high-activity zones of the traditional downtown. Perhaps the main challenge for contemporary urban centers is reinventing their experiential (in-person) appeal by expanding the range of meaningful experiences that revitalize their dynamics. Under this hypothesis, we shift from a paradigm of "centrality of need" to one of "centrality of desire", where the sense of proximity and concentration fulfills a desire for social interaction rather than a purely functional or commercial demand (which is effectively met by e-commerce). Only in this way will the territoriality inherent in the process we call digital transformation find synergies that nourish central areas with the intensity that has historically characterized them.

Throughout this article, we have discussed the impact of residential density on e-commerce purchase volume as a first step in the analysis, enabling us to identify general characteristics of the urban fabric in which this phenomenon unfolds. Further study is needed to examine other socio-urban indicators such as the concentration of in-person commercial activity, the level of mixed-use development, the type of urbanization, population density, land value, accessibility, and the age structure of the population. The methodology developed in this study is useful for these purposes. Identifying the levels of correlation among these indicators will allow us to understand the logic governing the phenomenon's territoriality and strategically integrate it into the planning of urban centers.

Conflict of interest. The author declare no conflicts of interest.

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ESTOA 30 / Vol 15 / 2026
e - ISSN: 1390 - 9274
ISSN: 1390 - 7263