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Research Article

Spatiotemporal patterns of commercial activities in Exarchia-Neapoli area.

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Keywords

*Commercial uses,
Spatiotemporal analysis,
Clustering,
Avoidance,
Spatial centrality,
Athens*

Abstract

The focus of this paper is the analysis of spatio-temporal patterns of commercial activities in the area of Exarchia-Neapoli, in Athens, during the last decade. A significant downturn during the financial crisis has left its mark on commerce along with all other sectors of the economy in Greece. However, there is poor geographical analysis up to this date, depicting the changes in spatial concentration and dispersion of shops, flourishing and decaying sectors and their spatial footprint. The main purpose of this study is to reveal these transformations in a central mixed-use neighborhood of Athens. The type of commercial activity of ground floor stores and offices in the area is recorded at three different points in time (2009, 2014, 2019). After the collection and categorization of data, spatial analysis was carried out using geostatistical indicators such as mean center and standard deviational ellipse and spatial patterns were determined through nearest neighbor analysis. The analysis over space and time reveals trends and patterns of clustering and avoidance respectively, both within commercial uses and between different ones. Furthermore, their correlation with the centrality of the network (space syntax analysis) reveals not only proximity relationships, but also their strength and resilience over time. Finally, we discuss our findings in relation to the dynamics of commerce in the Exarchia area and propose scaled-up research opportunities.

Highlights:

- The effect of educational attractors on bookshops and publishing houses spatial patterns.
- The effect of financial crisis on commercial sectors as captured in the center of Athens.
- Spatial patterns of supra-local and local commercial uses.



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1. INTRODUCTION

Commercial activities have always been at the core of urban development and the way they evolve through time is a reliable indicator of a city's prosperity, economic expansion or shrinkage levels. Hence, spatial analysis of urban commercial activities is valuable in terms of planning strategies and decision-making processes, both at the collective (formal and institutional) and individual (entrepreneurial) level. On the one hand, prospective merchants and retailers consider location to be one of the most important factors of their business success and profitability (Pradhan, 2007). Depending on the nature of their business, the centrality of the area and the type of prospective customers, some may choose to locate next to similar shops while others will definitely try to avoid that. On the other hand, spatio-temporal analysis of commercial activities can be a valuable tool for policy making. Adding the dimension of time can provide a thorough understanding of the dynamics and trends of commerce during specific periods and helps link them to broader socio-economic conditions and transformations underway. In this way, it can contribute in interpreting commercial development and at the same time anticipating and planning future strategies and measures in a bigger scale. Business location and spatial patterns constitute an important field of study of geography that has been extensively studied since the first decades of the 20th century, producing a large volume of theoretical approaches and empirical research. The retail literature has evolved around the main theories of Hotelling (1929), Christaller (1933) and Reilly's business behavior (1931).

1.1 Focus of study/space

This study explores spatiotemporal patterns of commercial activities in the area of Exarchia-Neapoli in Athens, during the last decade. The study area demonstrates great research interest as it is situated in the wider central area of the city of Athens, bordering the so-called commercial triangle (main commercial, administrative and financial center of Athens) and constitutes a lively, mixed-use neighborhood. Exarchia-Neapoli is specifically chosen as it is situated next to a number of important educational facilities and other non-commercial attractors and the study aims at exploring the influence of those both in the type of commercial activities and their resilience over time. Additionally, the area demonstrates a great variety of commercial sectors and services and hence is ideal for developing a commercial analysis method over space and time.

1.2 Focus of study/time

The last decade (2009-2019) has been marked by the global financial crisis that has had vast implications in economies, societies and applied policies throughout the world. Greece has been the epicenter of the European financial crisis since 2008 and has one of the weakest economies that is still struggling to recover from its impacts. In parallel, deep transformations in fiscal policies have been applied that have affected all sectors of economic life, not always in a positive way (Hadjimichalis, 2011). In particular, the center of the Greek capital constitutes the field of profound changes and transformations, driven both by local and global forces, in terms of land uses, real estate and property ownership (Maloutas, Siatitsa & Balampanidis, 2020). These changes and transformations and their effects in commerce are yet to be explored and crystallized, as some consider the crisis to be an ongoing situation that intensifies and declines respectively over time.

1.3 Focus of study/commercial sectors

The aim of the spatio-temporal analysis is to reflect on the specific area's commercial character and its transformation over the last decade. The analysis categorizes ground floor

uses into five main commercial sectors in order to trace clustering and avoidance patterns of similar stores or services (Krider & Pudler, 2013), as well as relations of competition or complementarity between the different sectors and subsectors (Fik, 1991). It intends to offer a better understanding of how the last decade of austerity has affected the commercial sectors in a central area that acts as an educational pole, which sectors have shrunk, which ones have flourished and how they have rearranged in space.

1.4 Scope and structure

However, even though the numbers of growth or shrinkage in commercial sectors are more or less known and easily accessible, their reflections in space have not been properly studied. This research proposes a methodological approach of monitoring and assessing these transformations using spatial analysis tools and methods and Geographical Information Systems. It explores patterns of clustering and avoidance of commercial sectors, their spatial dispersion and the changes they undergo throughout the study period, using three time points (2009, 2014 and 2019) for a total number of one thousand, one hundred and sixty-seven ground-floor (1167) shops and offices. These three time points were chosen as they represent the beginning of the crisis, the middle period and the latest period close to the present time.

The paper begins by addressing the methodology developed during the research and the tools that were used to gather, catalog and analyze the recordings. It goes on by presenting findings concerning the share, dispersion and spatial patterns of main commercial sectors that were observed and their respective subcategories. Subsequently, predominant subcategories and combinations of them are further analyzed and discussed with a special emphasis on attractors related ones (education related ones). The focus then moves to permanently closed and permanently open shops to explore the factors of resilience and decline respectively. Finally, the syntax analysis applied to the wider area is presented and linked to the rest of the findings, to correlate them with the centrality of the network. In conclusions, findings are critically presented and discussed, while further research possibilities and scale-up studies are proposed.

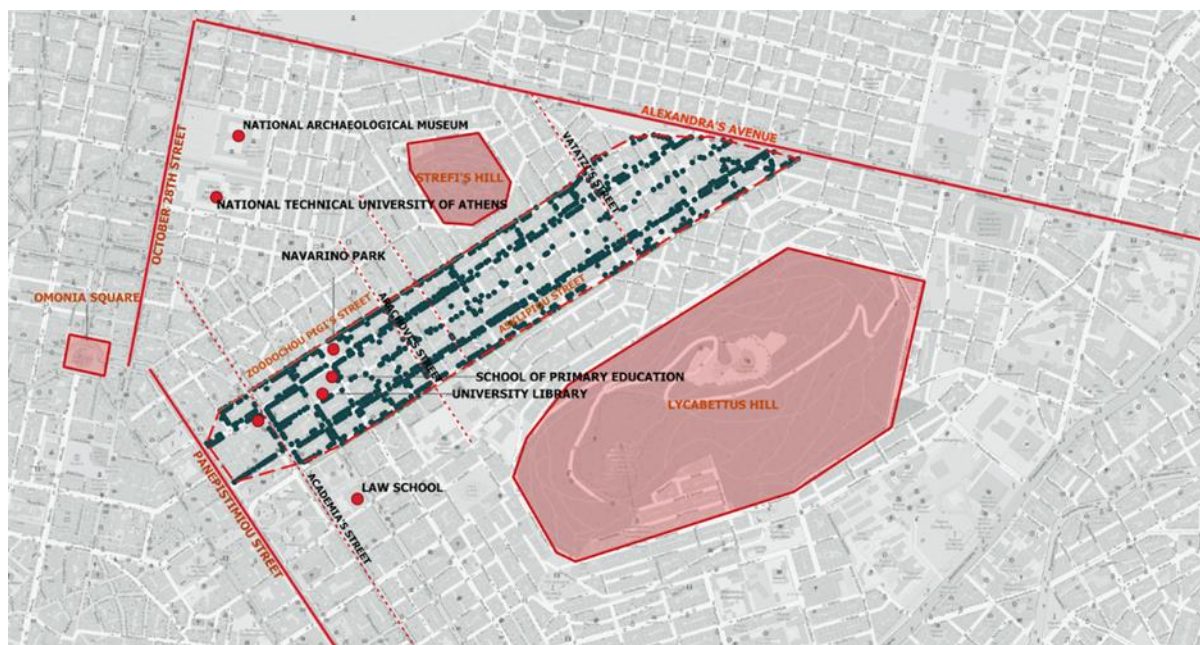
2. METHOD

2.1 Study Area

The study area is located in the wider area of the center of Athens, between main arteries and commercial axes of the city. It borders two major arteries in the north and southwestern part, Alexandra's Avenue and Panepistimiou Street respectively, that connect various neighborhoods of the city and Zoodochou Pigi's Street in the northwestern part and Asklipiou in the Southeastern one. The area is characterized by its close proximity to universities, important administrative and cultural entities as well as the famous hill of Lycabettus. Neapoli-Exarchia is a mixed-use area with residencies and offices in the upper floors and various kinds of shops and services found in the ground floors. Certain points of interest in between the boundaries of the study area, that can act as circulation and activity attractors, were taken into consideration in the course of the study, such as neighboring university facilities and the municipal theater (Figure 1).

In addition to that, attractors in the wider area of Exarchia, outside the exact boundaries of our study area, were taken into consideration as there is a significant number of supra-local uses in the area (universities, museums) and a number of stops of the metropolitan railway. As a result, we expected a big variety of shop types as well as a significant number of specialized bookshops.

Figure 1. Focus area, points of data collection and points of interest/ attractors



2.2 Data collection and analysis tools

Ground floor shops and offices were recorded for the years 2009, 2014 and 2019 using Google Maps Street View. Consequently they were categorized in the following main types: Retail-“EMP”, Services/Offices-“GR”, Healthcare-“YG”, Food and Beverage /Entertainment-“EST”, Clothing-“END”, Parking spaces-“PARK”. The code of the main use is followed by a number indicating the subcategory of use (e.g. “EMP1” = bookshops, “EMP2” = publishing houses, etc.). Each ground floor store was represented by a dot-point on the map. In case of an inactive store(out of business at that moment) the term “closed” was assigned, while “0” was assigned to describe shops or offices that belonged to buildings that were built after that particular point of recording(e.g. in an empty plot a building was erected in 2018 and hosted a ground floor bakery since then. It’s entry would be the following: 2009-0, 2014-0, 2019-EMP18.) All spatial processing was carried out in QGIS environment.

After data collection and categorization, spatial analysis was conducted using geostatistical indicators, namely mean center and standard deviational ellipse and methods like Nearest Neighbor Analysis, to determine the centrality, dispersion and spatial pattern of each category and subcategory. Each commercial category consists of several points on the map, dispersed throughout the study area, in different vertical or horizontal streets. Hence in order to determine the density and concentration patterns of these categories Nearest Neighbor Index was used. The study area is very small and given the relative homogeneity of the building blocks, the unequal probability of existence is considered to be eliminated. Thus NNI was considered an appropriate method, as it fundamentally takes into account the distance and compares the mean of the distance observed between each point and its nearest neighbour with the expected mean distance that would occur if the distribution were random (O’Sullivan & Unwin, 2003 p. 100). The space was not treated as a road network or a set of city blocks because the aim was not to identify densities in each square or road as a line, but the interaction of the points of each category that are scattered in space and different axes (vertical and horizontal).

In order to define spatial patterns of clustering and avoidance we applied corrective adjustments to the Nearest Neighbor Index given by Nearest Neighbor Analysis tool in QGIS. This was necessary because, in order to calculate the average distance of the points, QGIS would take into account the area (Bounding Box), shown in Figure 2, which would not

correspond to the actual surface occupied by our recordings. NNIndex compares the mean of the distance observed between each point and its nearest neighbor with the expected mean distance that would occur if the distribution was random (O'Sullivan, Unwin, 2003).

So, in order to adjust the NNI to the actual surface of our study area (Figure 3), the following ratio was used:

$$NNI = \frac{\text{Average Nearest Neighbor Distance}}{\text{Expected Average Nearest Neighbor Distance}} = \frac{\bar{d}}{E(\bar{d})},$$

where

$$\bar{d} = \frac{\sum_{i=1}^n d_i}{n} \text{ and}$$

$$E(\bar{d}) = 0.5 \sqrt{\frac{A}{n}}, \text{ (Briggs, 2007)}$$

where

n: the number of recordings and

A: the actual surface

The average distance (d) was calculated by QGIS through the Nearest Neighbor Analysis tool. The actual surface (A) was estimated to be 345.456 m².

Figure 2. QGIS Bounding Box



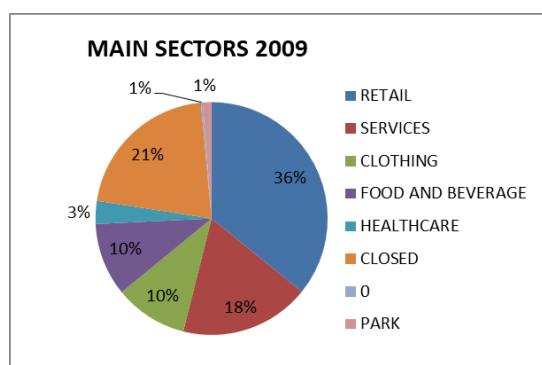
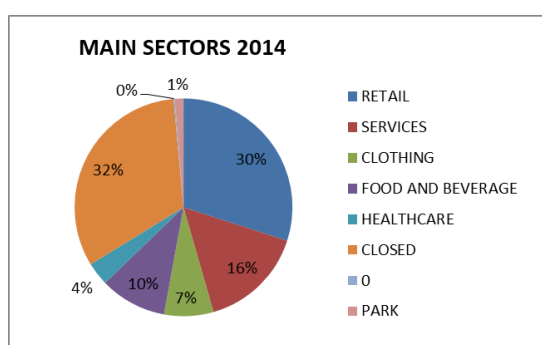
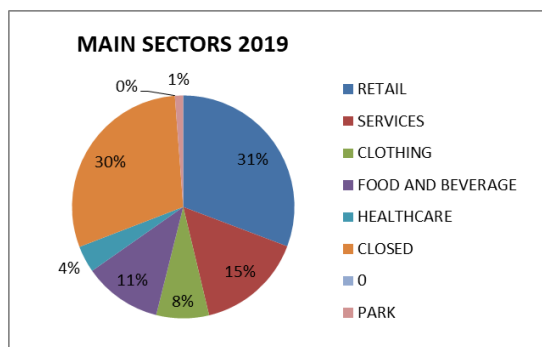
Figure 3. Actual surface (A)

Finally, in order to describe points spatial distributions, we used the measures of Mean Center and Standard Deviation Ellipse. The mean center is located at the geographic center (centroid) of concentration of the points. The centroid of a polygon is computed (by definition) by weighting the mean center with area. Thus, for the calculation of each mean center, a new polygon is formed each time, which encloses the referenced points. In combination to that, we used Standard Deviation Ellipse, in order to assess the level of dispersion of each commercial category and thus minimize potential bias by spatial extremes.

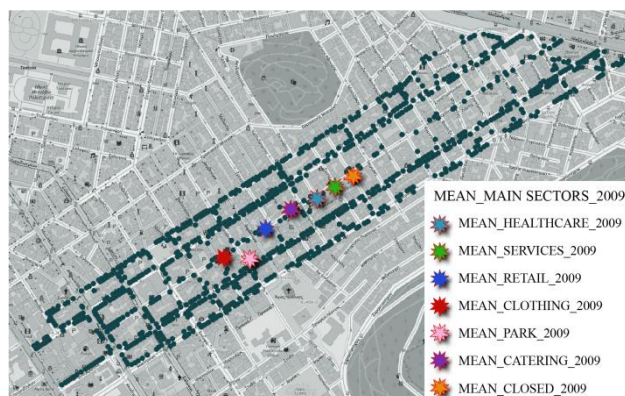
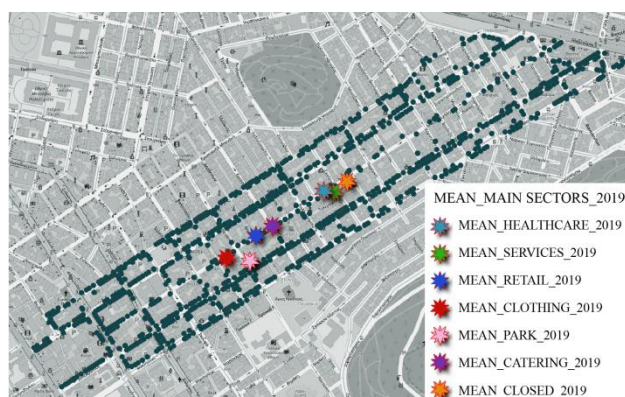
3. SHARE, DISPERSION AND SPATIAL PATTERN OF MAIN TYPES AND SUBCATEGORIES OF GROUND FLOOR SHOPS

3.1 Main commercial sectors

From 2009 to 2019, there is an overall declining trend in commercial activity, with about one fifth (21%) of stores closed/out of business in 2009 and increasing to about one third (30%) in 2019 (Figure 3). The biggest impact of the financial crisis seems to be reflected in 2014, where the percentage of closed stores reached a maximum (32%) to decrease slightly in 2019. Most major uses show a declining trend, with retail falling by 5% overall during the study period, while a small increase of 1% is observed in food and beverage and healthcare sectors.

Table 1. Share of main sectors in all shops in 2009**Table 2.** Share of main sectors in all shops in 2014**Table 3.** Share of main sectors in all shops in 2019

The mean centers of most main sectors (Figure 4) are located along Mavromichali Street (the road that is found in the middle of the five parallel streets examined) with some of them tending towards the direction of Panepistimiou Street and some towards the direction of Alexandra's Avenue. Clothing is the use that is found closest to Panepistimiou Street, the more commercial part of the study area, as mentioned above, followed by parking lots and retail. Healthcare, services but also closed/out of business shops are gathered spatially from the vertical street of Kallidromiou (approximately the center of the study area) and towards Alexandra's avenue, while food and beverage is located approximately in the center, near Kallidromiou Street. Throughout the study period (2009-2019), the sectors that demonstrate a noticeable shift in space are retail and food and beverage, that move towards Panepistimiou Street and healthcare, that moves slightly towards Alexandra's avenue. All other sectors remain relatively stable in the area.

Figure 4. Mean centers of main commercial sectors in 2009**Figure 5.** Mean centers of main commercial sectors in 2014**Figure 6.** Mean centers of main commercial sectors in 2019

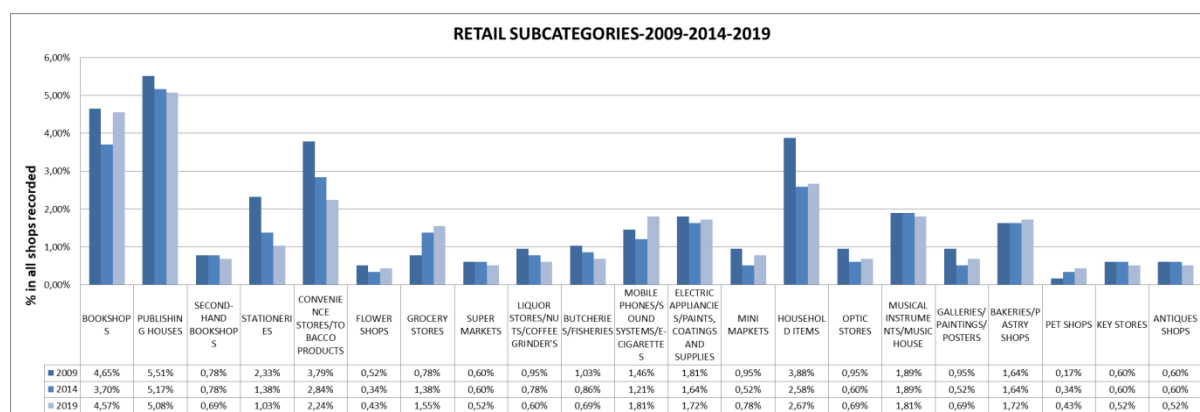
3.2 Subcategories of main sectors

3.2.1 Retail.

As already mentioned, the area demonstrates a variety of different uses, with each main use being divided into subcategories. The widest range is observed in retail (Figure 5), with a big number of sub-categories, from neighborhood services (e.g. florists, butchers, convenience stores) to equipment (mobiles/audio systems, paints/electric appliances, household items) and even more specialized subcategories that are observed in significant shares and give a special character to the area (bookshops, publishing houses, second-hand bookshops,

handmade musical instruments and music houses). The most numerous subcategory is that of publishing houses (in 5.5% of all shops of the study area in 2009), with bookshops, convenience stores and household items following next. Overall, from 2009 to 2019 a downturn is evident in most subcategories and in the most numerous ones (bookshops, publications, convenience stores, household items). At the same time, a few subcategories slightly gain ground such as groceries and electronic commerce (audio, mobiles and electronic cigarettes).

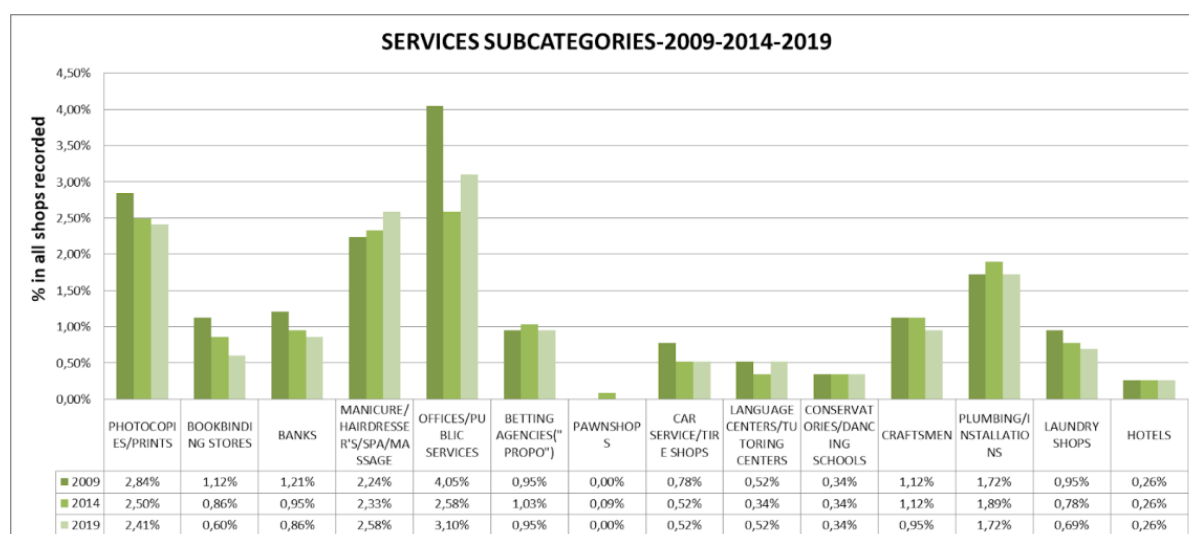
Figure 7. Share of retail subcategories in all shops recorded throughout the study period



3.2.2 Services.

The next most numerous sector is that of services and offices (Figure 6). The most common subcategory is the one that includes offices and public services and mainly consists of accounting/tax offices and lawyers' offices while there are some few public services establishments in the area. Immediately next is the subcategory of photocopies and prints stores, which we examine in combination with that of bookbinding stores and consider them to be related to the poles of interest of the area (universities, library) as well as the retail uses of bookstores and publishing houses. Finally, the only subcategory that demonstrates an increase from 2009 to 2019 is that of beauty salons, hairdressers, spas and massage centers.

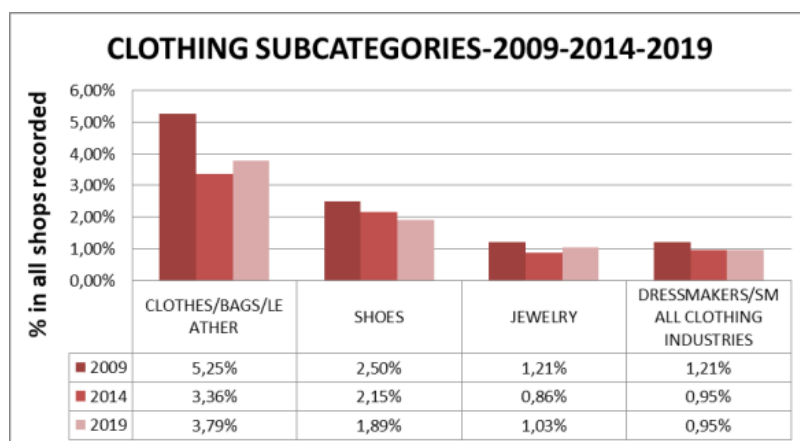
Figure 8. Share of services subcategories in all shops recorded throughout the study period



3.2.3 Clothing.

The main use of clothing includes all uses related to clothing and accessory items sell and manufacturing and contains the following subcategories: clothes / bags / leather goods, shoes, jewelry and dressmakers/small clothing manufacturing/industries (Figure 9). The subcategory of clothes / bags / leather is the predominant one in Clothing as well as one of the most numerous uses generally in the area for 2009. However, following the general trend, its share is significantly reduced until 2019. A decrease is also observed in all other subcategories of Clothing.

Figure 9. Share of clothing subcategories in all shops recorded throughout the study period



3.2.4 Food and Beverage.

The main sector of Food and Beverage and entertainment activities (Figure 10) includes the following subcategories: cafes / bars, coffeehouses (the type of old/traditional cafes, frequented mostly by men), restaurants, take away (crepes, sandwiches, snacks etc.) and cinemas/theaters. The predominant subcategory is that of cafes / bars that in 2019 held a share of 4.7% in all stores in the area, being one of the most numerous subcategories in all uses and one of the few that flourished and increased throughout the study period. Coffeehouses and take away remain stable, theaters and cinemas decline, while restaurants increase slightly.

3.2.5 Healthcare.

The main use of Healthcare (Figure 11) includes: pharmacies, gyms/martial arts schools and clinics/hospitals/ infirmaries. Interestingly, the two subcategories of gyms/martial arts schools and clinics/hospitals/infirmaries have increased steadily from 2009 to 2019. On the other hand pharmacies remained completely steady

3.3 Spatial Patterns (Nearest Neighbor Analysis)

Nearest Neighbor Index is used as an indicator to determine clustering, avoidance or random spatial patterns in subcategories of use. For random pattern, $NNI = 1$, for clustered pattern, $NNI = 0$, for dispersed pattern, $NNI = 2.149$ (O'Sullivan & Unwin, 2003). A tendency towards uniform spatial patterns, hence avoidance, is mainly observed in neighborhood scale services and retail stores (Table 4). Such are flower shops, grocery stores, supermarkets, pet shops, locksmiths, betting agencies ("propo" agencies in Greek), craftsmen, pharmacies, extra-curricular tutoring centers. We assume that these uses are

likely to operate competitively at the neighborhood level and are spatially distributed in such a way as to ensure a minimum coverage radius of service to residents. Some of them may also be bound by some overall uniform design of dispersion such as “propo” agencies.

Figure 10. Share of Food and Beverage subcategories in all shops recorded throughout the study period

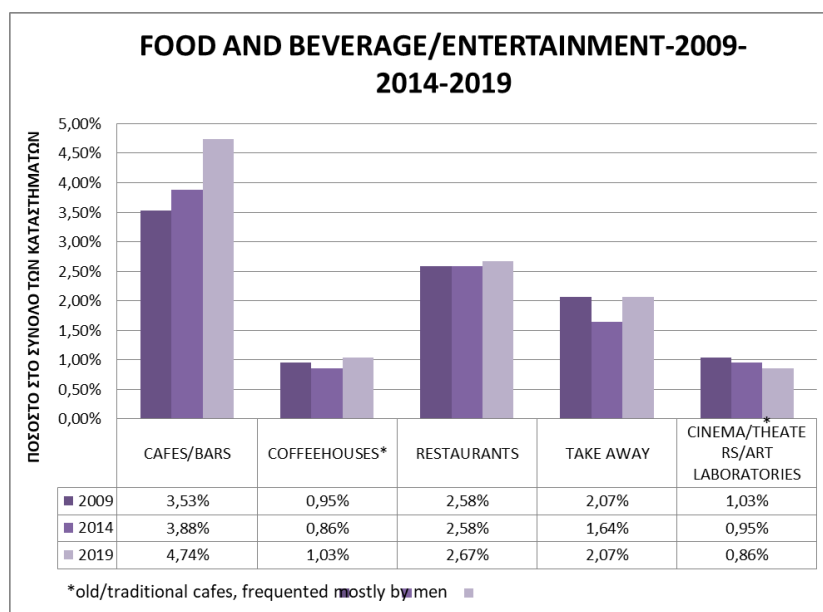
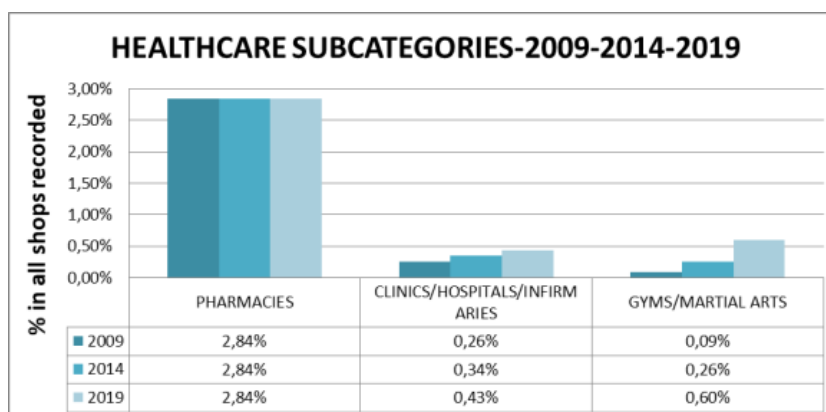


Figure 11. Share of healthcare subcategories in all shops throughout the study period



On the other hand, some subcategories demonstrate a tendency towards a clustered spatial pattern (Figure 10, blue outline). Such are bookstores, shoes, optic stores (for 2009 and 2014) and banks. In the case of bookstores clustering can be attributed, among other things, to the existence of attractors/points of interest in the area, which create the need for a diversified market around them. Shoes, which demonstrate the highest degree of clustering, are gathered around and on Akadimia's Street and on Charilaou Trikoupi Street respectively. We assume that these subcategories (namely shoes and bookstores) specifically create a kind of special market in the area where they are concentrated and operate in a supra-local level (beyond the boundaries of the area we are examining and the wider area of Exarchia-

Neapoli), trying to attract customers and promote consumption by offering diversity and variety.

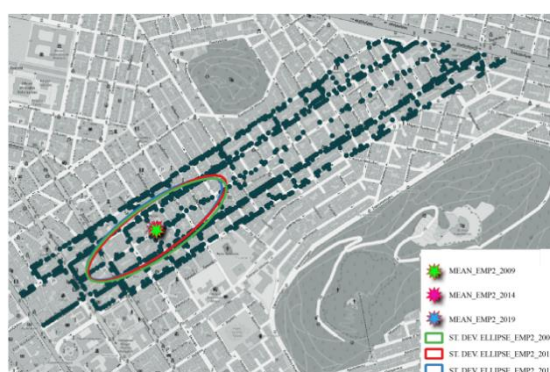
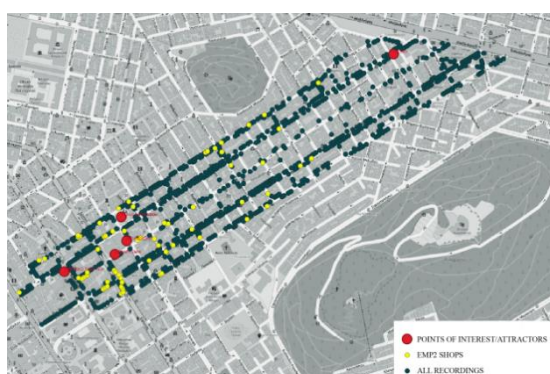
Table 4. Nearest neighbor index of all sectors and subcategories

MAIN SECTORS					SERVICES				
EMP	RETAIL	0,75	0,80	0,81	GR1	PHOTOCOPIES/PRINTS	0,90	0,95	0,91
GR	SERVICES	0,90	0,95	0,91	GR2	BOOKBINDING STORES	0,94	0,90	0,49
END	CLOTHING	0,72	0,78	0,90	GR3	BANKS	0,89	0,62	0,64
EST	CATERING	0,99	1,01	0,96	GR4	MANICURE/HAIRDRESSER'S/SPA /MASSAGE	1,14	1,07	0,95
YG	HEALTHCARE	1,21	1,40	1,35	GR5	OFFICES/PUBLIC SERVICES	1,10	0,88	0,97
CLOSED	CLOSED	0,77	0,71	0,68	GR6	BETTING AGENCIES("PROPO")	1,54	1,21	1,52
0	NON EXISTENT AT THE MOMENT	0,24	0,48	-	GR7	PAWN SHOPS			
PARK	PARK	1,07	1,06	1,07	GR8	CAR SERVICE/TIRE SHOPS	1,15	1,75	1,75
RETAIL					GR9	LANGUAGE CENTERS/TUTORING CENTERS	1,62	2,07	1,93
EMP1	BOOKSHOPS	0,69	0,75	0,63	GR10	CONSERVATORIES/DANCING SCHOOLS	2,34	2,34	2,34
EMP2	PUBLISHING HOUSES	0,75	0,84	1,00	GR11	CRAFTSMEN	1,46	1,09	1,11
EMP3	SECOND-HAND BOOKSHOPS	1,30	1,13	1,18	GR12	PLUMBING/INSTALLATIONS	0,87	0,87	0,87
EMP4	STATIONARIES	0,95	1,24	1,32	GR13	LAUNDRY SHOPS	1,06	1,22	1,39
EMP5	CONVENIENCE STORES/TOBACCO PRODUCTS	1,29	1,13	1,22	GR14	HOTELS	2,67	2,67	2,67
EMP6	FLOWER SHOPS	1,62	2,18	1,62	CLOTHING				
EMP7	GROCERY STORES	1,99	1,44	1,34	END1	CLOTHES/BAGS/LEATHER	0,85	1,11	0,90
EMP8	SUPER MARKETS	1,29	1,29	1,58	END2	SHOES	0,30	0,45	0,51
EMP9	LIQUOR STORES/NUTS/COFFEE GRINDER'S	0,99	0,89	1,22	END3	JEWELRY	0,82	1,52	1,25
EMP10	BUTCHERIES/FISHERIES	0,72	1,30	0,85	END4	DRESSMAKERS/SMALL CLOTHING INDUSTRIES	1,07	0,61	0,83
EMP11	MOBILE PHONES/SOUND SYSTEMS/E-CIGARETTES	0,90	0,71	0,91	CATERING				
EMP12	ELECTRIC APPLIANCES/PAINTS, COATINGS AND SUPPLIES	0,88	0,84	1,15	EST1	CAFES/BARS	1,05	1,08	1,02
EMP13	MINI MAPKETS	1,36	0,80	0,89	EST2	COFFEEHOUSES	1,46	1,72	1,54
EMP14	HOUSEHOLD ITEMS	0,85	0,79	0,90	EST3	RESTAURANTS	1,20	0,89	0,91
EMP15	OPTIC STORES	0,43	0,51	1,31	EST4	TAKE AWAY	1,10	1,31	1,17
EMP16	MUSICAL INSTRUMENTS/MUSIC HOUSE	0,82	0,96	0,77	EST5	CINEMA/THEATERS/ART LABORATORIES	1,17	1,32	1,34
EMP17	GALLERIES/PAINTINGS/POSTERS	1,47	0,89	0,55	HEALTHCARE				
EMP18	BAKERIES/PASTRY SHOPS	1,08	1,17	1,08	YG1	PHARMACIES	1,28	1,43	1,37
EMP19	PET SHOPS	1,44	1,73	0,90	YG2	CLINICS/HOSPITALS/INFIRMARIES	1,55	2,12	1,81
EMP20	KEY STORES	1,70	1,27	1,22	YG3	GYMS/MARTIAL ARTS	0,00	1,05	1,31
EMP21	ANTIQUES SHOPS	1,24	1,06	1,43					

4. ANALYSIS OF PREDOMINANT SUBCATEGORIES AND COMBINATIONS OF SUBCATEGORIES

4.1 Publishing Houses/Scientific Bookshops (EMP2)

Publishing houses and scientific bookstores form the most numerous subcategory of the whole study area. The sum of both was given under the code EMP2 as a subcategory of trade. Table 5 shows the count and NNI of the subcategory for each year. A small decrease in the count of stores is observed throughout the years, while the NNI (Table 5) increases, approaching the number 1, transforming their spatial pattern closer to randomness. Additionally we recorded changes from one time point to the other concerning shops closing or changing their use, from this subcategory to another and vice versa. In general, we observe a small, but quite stable change from EMP2 to other uses and the opposite (Table 6). The standard deviational ellipses (Figure 12) for all 3 years/time points remain almost the same, which reveals a similar spatial dispersion. At the same time, the mean centers for all three time points almost coincide, allowing us to assume that these shops were always clustered in this part of the area, approximately at the height of the Academia's Street, close to the boundary of Panepistimiou Street. Figure 13 also demonstrates the dispersion of publishing houses in the area in 2009 related to the education attractors (University school , Law School Library).

Figure 12. Mean centers and standard deviational ellipses of EMP2 for the years 2009, 2014, 2019**Figure 13.** Dispersion of EMP2 in relation to attractors for the year 2009**Table 5.** Count and NNI of EMP2 throughout the study period

PUBLISHING HOUSES AND SCIENTIFIC BOOKSHOPS(EMP2)					
count	nnindex	count	nnindex	count	nnindex
2009	2009	2014	2014	2019	2019
64	0,74	60	0,84	59	0,96

Table 6. Inflows and outflows from EMP2 throughout the study period

CHANGED FROM EMP2 TO ANOTHER SUBCATEGORY			
2009-14			2014-2019
5			5
11 WITH CLOSED			10 WITH CLOSED
CHANGED FROM ANOTHER SUBCATEGORY TO EMP2			
2009-14			2014-2019
5			3
7 WITH CLOSED			9 WITH CLOSED

4.2 Bookshops of all subcategories (EMP1+EMP2+EMP3+EMP4)

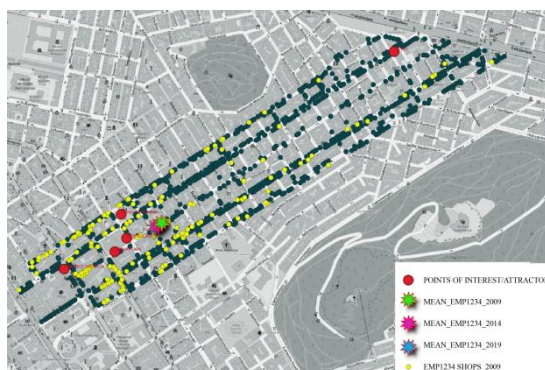
Subsequently, we analyzed the sum of the bookshops of all subcategories (bookshops + publishing houses + second-hand bookshops + stationeries= EMP1 + EMP2 + EMP3 +

EMP4), as they form a group of shops that are important for the study area and act as a supra local market of bookshops for the city of Athens. Similar to the previously examined case, standard deviational ellipses and mean centers for the three time points (2009, 2014 and 2019) almost coincide and are found at the same location as EMP2 corresponding indicators (Figure 14). Overall, the number of bookstores has decreased since 2009 (table 8) and the standard deviational ellipse of that year has a bigger length than the others, revealing a greater degree of dispersion in the area, which slightly decreases throughout the years. Again, a significant degree of correlation to the educational attractors is observed, with most shops clustering around the School of Primary Education and Law School Library (Figure 15).

Figure 14. Mean centers and standard deviational ellipses of EMP1+2+3+4 for the years 2009, 2014, 2019



Figure 15. Dispersion of EMP1+2+3+4 in relation to the attractors for the years 2009, 2014, 2019



The years from 2009 until 2014 seem to have been the most challenging for the bookstores sector as more than a third of shops either closed or changed to another use through that period, while a much smaller number changed from another use or from being out of business to a bookstore. On the contrary, from 2014 to 2019 only 16% of shops closed or changed to another use while almost 20% of 2019 recordings were new shops (turned to bookstores either from being out of business or from another use, Table 8), which also reflects the slight recovery of the sector in 2019 compared to 2014.

Table 7. Count and NNI of EMP1+2+3+4 throughout the study period

BOOKSHOPS+PUBLISHING HOUSES+SECOND-HAND BOOKSHOPS+STATIONARIES(EMP1+EMP2+EMP3+EMP4)					
count 2009	nnindex 2009	count 2014	nnindex 2014	count 2019	nnindex 2019
154	0,77	128	0,90	132	0,84

Table 8. Inflows and outflows from EMP1+2+3+4 throughout the study period

CHANGED FROM EMP1+2+3+4 TO ANOTHER SUBCATEGORY			
2009-14			2014-2019
29			8
55 WITH CLOSED			21 WITH CLOSED
CHANGED FROM ANOTHER SUBCATEGORY TO EMP1+2+3+4			
2009-14			2014-2019
12			7
16 WITH CLOSED			25 WITH CLOSED

4.3 Cafes / Bars+Cafes (EST1+EST2)

Examining the two subcategories of catering, coffeehouses and cafes/bars, that combined form the dominant broader subcategory in the study area, we observe a shift of the mean center towards Panepistimiou Street during the study period (Figure 16,17,18). As already mentioned catering is the only sector, along with healthcare, which shows an overall increase from 2009 to 2019. Between 2009 and 2014 there is no significant increase in the total number of shops, but there are inflows and outflows of shops of about 20% to and from other subcategories. From 2014 to 2019 another 20% (table 10) changes from this subcategory to another while 30% (table 12) is added to it, hence there is a large increase from 55 to 67 shops (table 9). Overall, it can be characterized as a resilient and growing sector, as it is the only subcategory which showed an increase in the number of stores (from 55 to 67) even during the deep recession, in 2014. The inputs and outputs that were observed can be attributed to the particular flexibility and mobility of the sector. It is worth mentioning that the food and beverage sector, particularly in Greece, is a commercial sector of great mobility and constant alternations, with shops opening and closing on a regular basis.

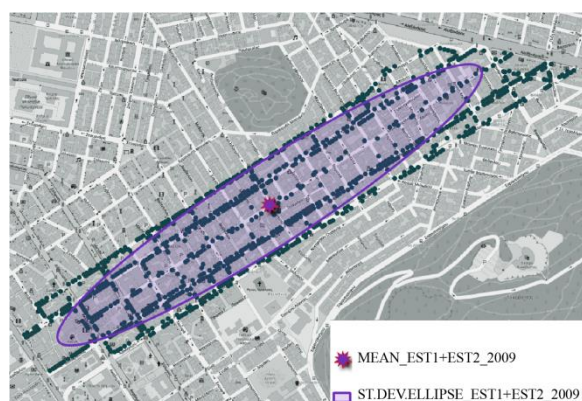
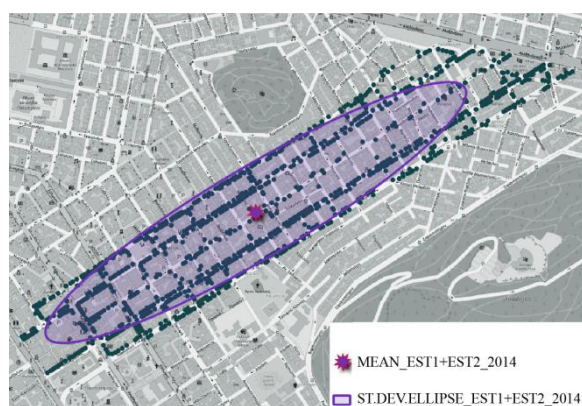
Figure 16. Mean center and standard deviational ellipse of EST1 + EST2 for 2009

Figure 17. Mean center and standard deviational ellipse of EST1+ EST2 for 2014**Figure 18.** Mean center and standard deviational ellipse of EST1+EST2 for 2019**Table 9.** Count and NNI of stores (EST1+EST2) throughout the study period

CAFES/BARS AND COFFEHOUSES(EST1+EST2)					
count 2009	nnindex 2009	count 2014	nnindex 2014	count 2019	nnindex 2019
52	1,02	55	1,01	67	1,07

Table 10. Inflows and outflows from EST1+ EST2 throughout the study period

CHANGED FROM EST1 AND EST2 TO ANOTHER SUBCATEGORY			
2009-2014			2014-2019
9			8
10 WITH CLOSED			10 WITH CLOSED
CHANGED FROM ANOTHER SUBCATEGORY TO EST1 AND EST2			
2009-2014			2014-2019
8			11
13 WITH CLOSED			22 WITH CLOSED

4.4 Clothes/bags/leather goods+Shoes (END1+END2)

Clothing and footwear, combined, account for one of the most numerous sectors and remain consistently concentrated at approximately the same point over the study period as a whole. There is a shift towards Panepistimiou Street in 2014(Figure 19), however the mean center reverts back again in 2019, as shown in Figure 23. There is a particular drop here in the number of shops after 2009, which indicates a particular influence of the economic crisis on this commercial sector. Up to 2014 40% (table 12) of the shops had changed subcategory and only 11% changed from other subcategories to clothing and footwear. Strong changes were also observed from 2014 to 2019, with around a third of shops (1/3) changing subcategory and another third entering this one, thus not significantly changing the total number of shops, which slightly increased from 64 to 66(table 11). In general, this sector can be characterized as declining, with numerous inflows and outflows while the large downturn after 2009 did not seem to be significantly reversed after 2014.

Figure 19. Mean center and standard deviational ellipse of END1+END2 in 2009

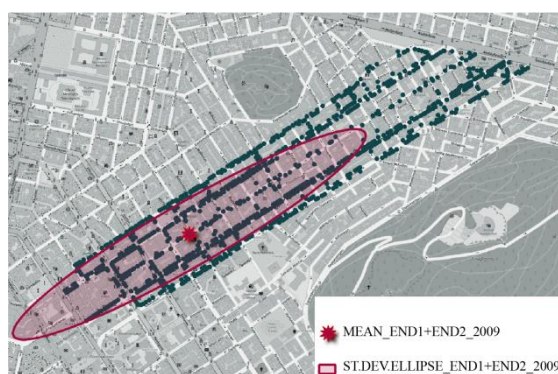
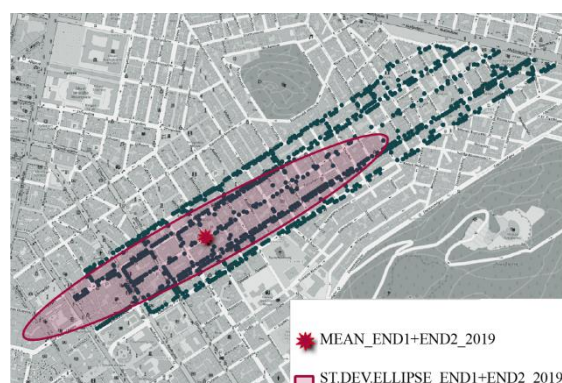


Figure 20. Mean center and standard deviational ellipse of END1 +END2 in 2014



Figure 21. Mean center and standard deviational ellipse of END1+END2 in 2019**Table 11.** Count and NNI of END1+END2 throughout the study period

CLOTHES/BAGS/LEATHER AND SHOES(END1+END2)					
count 2009	nnindex 2009	count 2014	nnindex 2014	count 2019	nnindex 2019
90	0,69	64	0,91	66	0,88

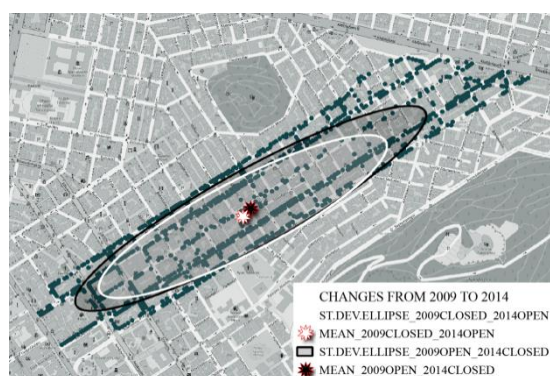
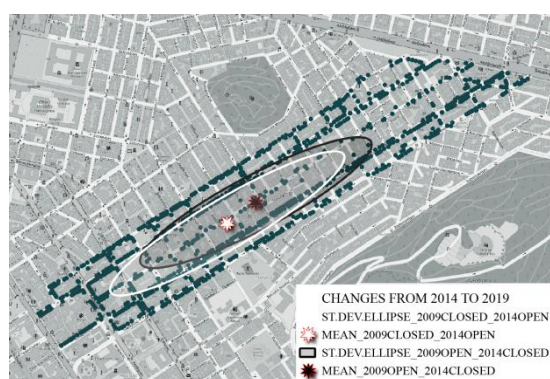
Table 12. Inflows and outflows of END1+END2 throughout the study period

CHANGED FROM END1 AND END2 TO ANOTHER SUBCATEGORY			
2009-2014			2014-2019
19			13
36 WITH CLOSED			20 WITH CLOSED
CHANGED FROM ANOTHER SUBCATEGORY TO END1+END2			
2009-2014			2014-2019
9			11
10 WITH CLOSED			22 WITH CLOSED

5. SPATIAL PATTERNS OF OPEN AND CLOSED SHOPS

5.1 Changes in open and closed stores

Figures 22 and 23 demonstrate the mean centers and standard deviation ellipses of stores that open or close from one time to the next respectively. From 2009 to 2014 (Figure 22) the mean centers are quite close to each other and towards the center of the study area, while the ellipse of shops changing from open to closed is longer, meaning that the shops that close have a larger spread in space than those that open, and the number of shops is much larger (177 shops closed and only 47 opened from 2009 until 2014). In contrast, from 2014 to 2019 the trend is reversed, with 75 stores closing in the area and 105 opening, bringing about a slight recovery, as discussed above. The mean centers (figure 23) move away from each other significantly, mainly due to the shift in the average number of shops opening in this period towards Panepistimiou Street and the slight shift in the average number of stores closing towards Alexandra's Avenue. Here, the ellipse of shops that open has grown significantly in length, which demonstrates a greater dispersion of these shops in space and, conversely, the ellipse of shops that change to closed is slightly shortened in length.

Figure 22. Changes in open and closed stores from 2009 to 2014**Figure 23.** Changes in open and closed stores from 2014 to 2019

5.2 Centrality and dispersion of permanently open and permanently closed stores

From the below figures (24, 25) the significant distance between the mean centers of permanently open and permanently closed shops is evident. In the first image, the mean center of the permanently open shops is located near the middle of our area, below Kallidromiou Street. Furthermore, these shops demonstrate a wide dispersion along the study area. In contrast, the mean center of the permanently closed shops is displaced very high up, towards Alexandra's Avenue, while these shops demonstrate a limited dispersion, almost exclusively in this part of the study area.

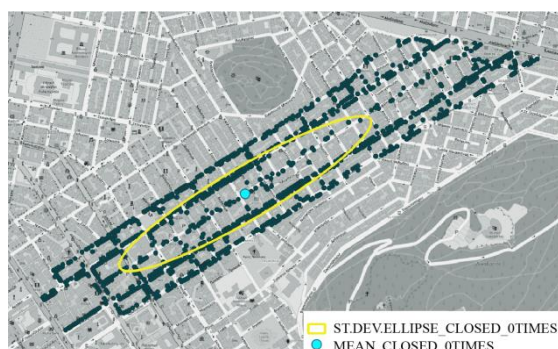
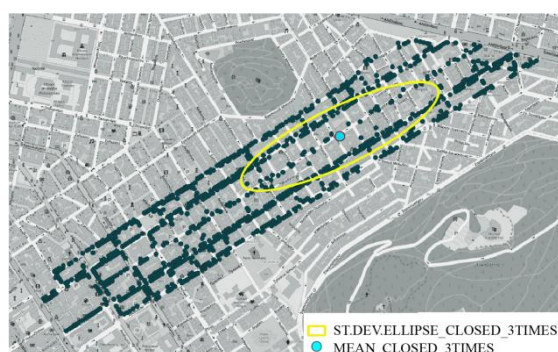
Figure 24. Mean center of permanently open stores

Figure 25. Mean center of permanently closed stores

5.3 Changes in closed shops throughout the study period

Figure 26 demonstrates the mean centers and standard deviational ellipses of closed shops for each time point in the survey. The mean centers are close to the middle of the study area, but the 2014 one tends more towards Panepistimiou Street. On top of that, the standard deviational ellipse appears to be larger in 2014, indicating that there was a greater dispersion of closed shops in the area, which is justified by the general economic downturn, peaking around that year. In contrast, 2009 demonstrates the smallest ellipse with the center of distribution heading towards Alexandra's Avenue.

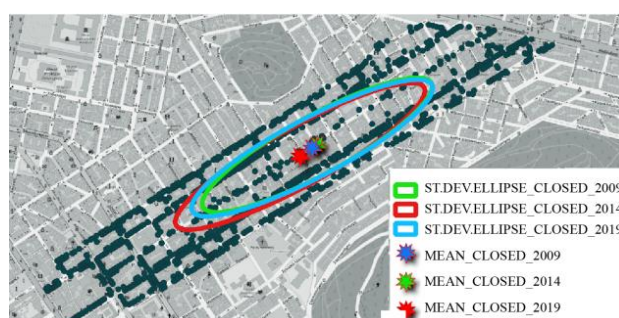
Figure 26. Mean centers and standard deviational ellipses of closed stores in 2009, 2014, 2019

Table 13 also verifies the fact that in the year 2014 the greatest number of closed shops was recorded (N=375), while in 2019 their number slightly decreased and their spatial pattern was closer to clustering (NNI= 0.68).

Table 13. Count and NNI of closed stores over time

	2009	2014	2019
CLOSED	245	375	344
NNI corr.	0,76	0,71	0,68

5.4 Shops closed for 1, 2 or 3 times.

Most of the shops (N=675) in the area turned out to remain permanently open at the time of the surveys. The most crowded category of closed shops (N=177) (Table 14) is the one

that remained closed only once out of the three time points. The mean center of shops that remained closed once(Figure 28), is located very close to the one of the permanently open shops. The mean center of those that were closed once is situated very close to the one of the permanently open shops(Figure 27). Additionally, the mean center of those that remained closed for two time-points (Figure 29) moved up slightly higher towards Alexandra's Avenue, with the mean of permanently closed shops (Figure 30) being moved, as already mentioned, below Strefi's Hill (Figure 1). In the case of the permanently closed shops (Figure 30), their standard deviational ellipse is also strongly differentiated , showing a limited dispersion of the phenomenon in this part of the area.

Figure 27. Mean center and standard deviational ellipse of permanently open stores

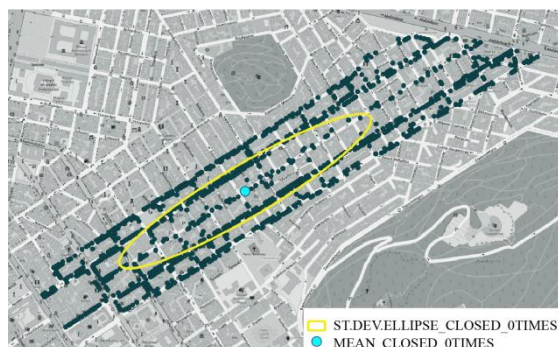


Figure 28. Mean center and standard deviational ellipse of closed stores for one time

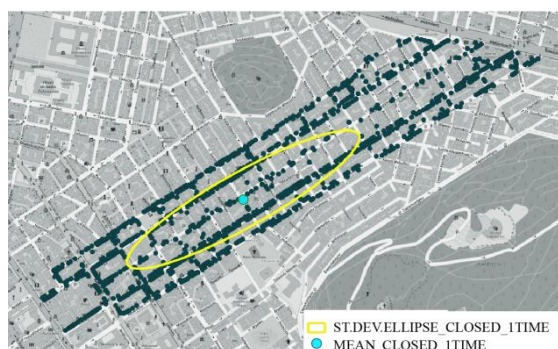


Figure 29. Mean center and standard deviational ellipse of closed stores for two times

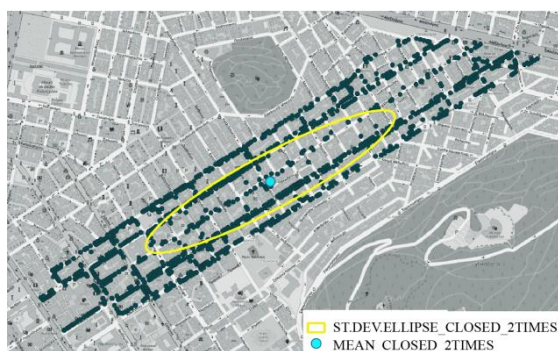
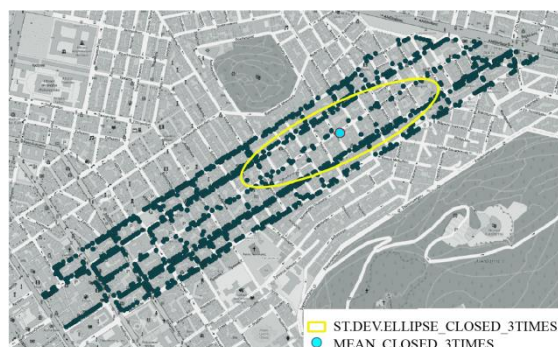


Figure 30. Mean center and standard deviational ellipse of permanently closed stores for three times**Table 14.** Count of closed stores for 0, 1, 2 or 3 time points

CLOSED SHOPS				
TIMES	0	1	2	3
COUNT	675	177	158	157

6. SYNTAX ANALYSIS OF THE STUDY AREA

In order to correlate the syntax structure of the study area with the rest of our findings, we proceeded to syntax analysis (space syntax). Space syntax offers an explanation of how spatial configuration affects land use and human activity in a city (Hillier et al., 1993; Penn et al., 1998). It encompasses a set of theories and techniques developed by Bill Hillier and Julienne Hanson and their colleagues at the University of London to analyze the geometry and connectivity of the urban network and its relationship to human movement within it (Hillier & Hanson, 1984; Hillier, et al., 1993; Hillier, 1996; Hillier, et al., 1998; Hillier, 1999). At its core, it approaches the city as a spatial system-configuration, defined not simply from network connections, in order to identify the relationship between space and society (Hillier, 2014).

In this research we used the 'angular segment analysis' because movement patterns have shown that people move through space by 'reading' the angular geometry of the network rather than simply physical distances (Hillier & Vaughan, 2007) and also in accordance with Hillier and Iida (2005) *angular analysis is highly responsive to spatial navigation and orientation, as users are likely to minimize cognitive distance when moving through an unfamiliar environment*.

The measures used are segment angular choice and segment angular integration with a metric radius, as they are considered the best tools for identifying potential traffic and important routes of the urban network (Al-Sayed, et al., 2014; Vaughan, 2015; Hillier, 2014). Segment Angular Choice expresses how likely an axis is to be used as a pass-through and is ultimately a quantification of the choice of street use, (how often it is chosen by users) in relation to the urban system to which it belongs. Choice highlights important commercial axes. Segment Angular Integration calculates how close to all others each road segment is, based on the total angular variations introduced in each path within a selected distance (radius) (Vaughan, 2015). In essence, Integration expresses the closeness of a space to the system, and ultimately quantifies the accessibility of a space in relation to the urban system to which it belongs. Acts as an indicator for the 'destination' in the whole area, highlighting the main roads and indicating the areas it connects.

Specifically, we used normalized syntax measures, normalized angular Integration (NAIN) and normalized angular Choice (NACH). These two new measures have been developed as an evolution of the previous two by Hillier, Yang, & Turner (2012) to allow comparison between systems of different sizes. Normalized angular integration normalizes angular total depth by comparing the system to the urban average and Normalized angular choice is calculated by dividing the total choice by the total depth for each segment in the system (Yamu et al, 2021).

A metric radius was applied to angular analysis. A radius of 800 meters was chosen, which corresponds to a 10- 20 minute walk. So, the normalized segment angular choice (NACH) at 800 meters (Figure 31), which includes mainly pedestrian and rarely vehicular traffic, highlighted the subsystems created within the system by the commercial axes, thus indicating the neighborhoods within our area and the wider area around it. We could therefore divide the study area, based on choice into four (4) subsystems. The two most commercial ones are located at the two edges of the area, which get the highest choice values (bright dark red), one between Panepistimiou Street and Academia's Street and the other between Vatatzi's Street and Alexandra's Avenue. The other two lower choice subsystems are located in the intermediate area, one between Solonos Street and Arachovi's Street and the other between Arachovi's Street and Vatatzi's Street, with the last one being the least commercial part.

Figure 31. Normalized angular choice (NACH) at 800 meters



Finally, the measure of integration demonstrated its highest values (Figure 32) along Alexandra's Avenue and its verticals and thus these are highlighted as the main roads in the study area. It is noteworthy that Panepistimiou Street has not received the same high values, although the Choice measure highlighted it as a very commercial street (it is also next to the commercial triangle- one of the most commercial areas in Athens). In general, however, the area is characterized by a very well integrated network.

Figure 32. Normalized Angular Integration (NAIN) at 800 meters



7. CENTRALITY AND PROXIMITY OF SECTORS

Figure 33 pictures the mean centers of all subcategories for 2019. We first note that many of the neighborhood-scale shops and services are concentrated in the center of the study area and towards Alexandra's Avenue Street. These include, for example, shops that serve residents on a daily basis such as butchers, supermarkets, dry cleaners, and other ones such as craftsmen, plumbing and electrical services, conservatories, and dancing schools. Undoubtedly, one reason for this is the residential character of the area towards Alexandra's Avenue, which is altered towards Panepistimiou Street, where the predominant use of upper floor spaces is offices. On the other hand, a concentration of supra-local commercial activities is observed towards Panepistimiou Street, such as bookshops and publishing houses, clothes and shoes shops, as well as more specialized commercial subcategories that characterize the area such as musical instruments and music houses.

Subsequently, concerning the food and beverage sector, it is noteworthy that while restaurants, cafes and cafes/bars are concentrated towards the center of the study area, in close proximity to each other, the takeaway category is located quite far away, towards Panepistimiou Street, adjacent to the more commercial part of clothing, shoes and bookshops. This can be explained by the fact that, especially during daytime, this part of the area is particularly busy, with a supra-local market character, and also hosts a significant number of offices on the upper floors of the buildings. Thus there is a greater need for this kind of shops to serve the continuous crowds coming in and out of the area.

Figure 33. Mean centers of commercial activities in 2009

8. CONCLUSIONS

Overall, the study revealed an area with a special commercial character and vitality and a variety of different commercial activities and services. The study period, from 2009 to 2019, coincides with a period of great economic recession experienced in the country. The first years of the decade (2009-15) were the most challenging ones for the Greek economy, with the scenario of a possible “Grexit” causing great liquidity issues and financial instability, resulting in the recessionary capital controls in the summer of 2015. This situation is indeed reflected in our findings. Overall, there is a downward trend and an increase in the number of closed shops, a phenomenon that peaked in 2014 and subsided in 2019, without however returning to the original situation of 2009. The only commercial sectors that show a very slight upward trend during the decade are catering and healthcare.

Our findings suggest that there are various commercial and non-commercial factors that affect how commerce is developed and distributed in the area and different elements that act as attractors or repulsors of certain sectors and phenomena. On the one hand, many commercial sectors that serve residents of adjacent areas and even beyond, tend to concentrate towards the southwestern boundary of Panepistimiou Street, close to a highly commercial triangle, that is highlighted also by the syntax analysis (Figure 31), and are apparently drawn by the supra-local poles/attractors that are situated in that part of the area (mainly educational and cultural facilities). These poles help shape a particular market of education/university related shops, bookshops of various kinds and publishing houses (the most populous category in the study area), that acts as a supra-local market for a big part of the city and its inhabitants. Apart from books related categories, other uses are also concentrated towards Panepistimiou Street such as shoes and optic stores. It is noteworthy that some of these categories (bookshops, shoes and optics) demonstrate a clustering spatial pattern for all of the three years of recordings or most of them and we argue that if studied in a wider area, all other books related sectors would demonstrate a strong clustering pattern, as they seem to be decidedly drawn by the educational poles.

On the other hand, another small-scale neighborhood kind of market seems to be formed in the northeastern part, close to Alexandra’s avenue, a quiet, mostly residential area. Neighborhood scale shops and services tend to be more concentrated to the center of the

area and towards Alexandra's Avenue, more specifically to the part where the lowest values of angular choice were measured by syntax analysis, that is above Arachovi's Street up to Vatatzi's Street. Such commercial subcategories are for example butcheries, liquor stores, craftsmen, laundry shops, plumbers, electricians, traditional coffeehouses, super markets and others. Many of them tend to form a spatial pattern of avoidance, which leads us to conclude that they aim at a specific share of customers from their adjacent neighboring area and wish to avoid locating too close to competitors.

The long distance between the mean centers of the permanently open shops and the permanently closed shops (figure 27 & 30), is representative of the results of the vector angular choice and indicative of the differentiation of the area at its two edge points. On the one hand, the purely commercial part of the study area is concentrated around the Academia's and Panepistimiou Street attracting prominent commercial activities and on the other hand, Alexandra's Avenue, which is bordered by another purely residential neighborhood, Gyzi's neighborhood, gathers around it mainly small shops and hairdressers. Additionally, the phenomenon of permanently closed shops (in all three time points) is also concentrated towards Alexandra's Avenue, a fact that implies an already existing declining trend in commerce in that part of the study area (Figure 31). The mean center of the permanently open shops approaches Arachovi's Street, towards the center of the study area, which demonstrates higher values of angular choice and defines from that point and below a more commercial neighborhood.

In the light of the recent unprecedented developments caused by the global pandemic of Covid 19, a renewed interest in the study and analysis of commercial activities is evident. The sector of commerce is one of the most hardly hit by the pandemic and its consequent effects such as long-term lockdowns and the growing global inflation. These, combined with the rise of online commerce are expected to drastically affect consumer models and trends, thus rearranging physical aspects of commerce and its spatial materialization.

The study area under review in this paper would be ideal to further examine the impacts of the pandemic in commerce, as it includes various different shops and services, some of which were directly affected by the measures implemented to combat the virus spread. More specifically, the food and beverage sector, one of the most prominent sectors in the area, is still struggling from these measures and it is uncertain when restrictions will be permanently lifted (limited opening hours, distance protocols, customers' number restrictions etc). It would also be of great research value to monitor the evolution of another important commercial activity in the area, bookshops and publishing houses, which depend greatly on the nearby educational institutions, the function of which has been disrupted by periodical lock-downs, leading to a hybrid temporary online-offline system.

Which sectors will shrink and which new unprecedented ones will flourish during and after the pandemic? Will the role of attractors be strengthened or weakened, and in what ways? Finally, in order to approach new methodologies to answer these questions and get a clearer view of clustering and avoidance patterns, we propose the broadening of the study area, to include the whole area of Exarchia, which is included between the boundaries of Alexandra's Avenue, October 28th Street, Solonos Street and the foot of Lycabettus hill.

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