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## Space-Time Human Behaviour and Models of Locomotion: the Case of Students in the City of Volos, Greece

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# **SPACE - TIME HUMAN BEHAVIOR AND MODELS OF LOCOMOTION: THE CASE OF STUDENTS IN THE CITY OF VOLOS, GREECE**

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## **ABSTRACT**

The problem of space-time human behaviour is currently a very active subject of research in the geography and transport literature. The main objective of this study is the investigation of the factors that configure the dynamics of in-the-city individual locomotion through the tracing of daily movements and with respect to a specific set of destination alternatives, originated by the place of residence. According to the proposed methodological framework, an activity-based model of daily locomotion of a specific socio-economic group can be defined through the combined utilisation of methods and techniques from the scientific fields of Use of Time and Spatial Analysis. In this respect, the application deals with the spatio-temporal analysis of diachronic daily locomotion and the definition of the space of activity through the determination of space-time intensity and concentrations and is based on questionnaire data obtained by students in the city of Volos, Greece.

## **INTRODUCTION**

The analysis of Spatial Human Behaviour and more specifically its locomotion aspects can constitute a decisive factor for infrastructure planning in modern cities. In this respect, the analysis of spatial dissemination of locomotion to specific places can reveal the structure of activities in space and the underlying behavioural model, as well. A direct consequence of individual mobility to daily activities is the configuration of Activity Space. Accordingly, the size of Activity Space can determine the utilisation of transport infrastructures by individual.

The focus in an analysis of travel based on the activity can convert the system of transports in a direction that could be viable in the long run, coinciding with the investment in infrastructure for the satisfaction of new demand. At this significance the planning of transports is called to evaluate present and future urban structures from the prospect of viable policy of transports. It is investigated that, at the duration of one day and taking into consideration the dynamics of creation of activity, it can

be located the structure of locomotion in connection with the basic choice of mobility, that is to say the residence.

The study of spatial human behaviour covers a wide range of choices and decisions, that concern the way of locomotion, in human immigration, as well as in spatial knowledge and in environmental perception. The study of spatial human behaviour is an important sector of research for geography, psychology and the economic sciences (Golledge and Stimson, 1997). From the mid 70s, with the focus of researchers in the analysis of locomotion by the attendance of activity (activity-based travel) became perceptible that human behavioural models lead to the locomotion. The up to day applications are focused mainly in researches of accessibility of households and different social teams to their daily activities (Hanson and Pratt 1990). These researches have similar methodological frames. At the stage of collection of elements of activity are used Recall and Activity Diaries or modern methods GPS that record the different places of individuals at their attendance in the activities. In the stage of analysis, methods of spatial analysis and the technology of Geographic Information Systems are combined to visualise information and to assist in the export of final conclusions.

The main objective of this article is to investigate whether, at the duration of one day and taking into consideration the dynamics of creation of activity, the structure of locomotion can be located in connection with the basic choice of mobility, that is to say the residence. Taking for granted is the bidirectional relation of residence and activities. Specifically, the choice of place of residence depends on the adjacency on daily activities, as is in effect also reverse. Accordingly, that relation produces an intermediary space which is the activity space that is translated in travel or locomotion from the place of residence to the daily activities.

The paper is a fusion of methods of research of time use and spatial analysis for the localisation of daily models of locomotion. It is focused in the analysis of daily locomotion of individual from the residence to the activities, locating the spatial intensity and concentration, and investigating, on one side the spatial behaviour and on other the daily activity space of students. Timetables of retraction are used and the localisation of space of locomotion is realised in a G.I.S environment with the reduction of the problem to the analysis of point patterns that result from the visualization of different temporally places of students in the city of Volos.

Thereafter, the assessment of dynamics of each activity, in the located diachronic specific model, determines the corresponding daily space of locomotion.

More specifically, the following methodological steps were followed. Initially, current and previous residences of students were geocoded in the topological informed road network of Volos and their distribution was analysed. Then the preliminary spatial analysis of activities and locomotion in a 24-hour basis was performed. It was determined the temporally weighted spatial median of student places per activity and with the use of the method of kernel density, the intensity and the spatial concentration of locomotion as well as the diachronic space of action and locomotion of students were defined. Finally, the different formations of activity space based on the produced breadth area (bandwidth) of cores of density were evaluated.

## **1. HUMAN SPATIAL BEHAVIOUR AND SPACE-TIME ACTIVITY**

The time localisation of spatial dimension of individual activities is included in the more general frame of spatial human behaviour. The spatial human behaviour and the mechanisms of choice of activity space are important question in the geography and the planning of transports. During of last 50 years, researchers and public institutions are interested “for how the individuals take the spatial behavioural decisions and how those can be summarized from models and generalisations in order to interpret total actions” (Fellman, Getis and Getis, 1999). It has been applied mainly in researches for accessibility the households, and the different social teams to their daily activities (Hanson and Pratt 1990) and for the forecast of locomotion through the examination of daily models of activity.

First to deal with the study of spatial human behaviour were Hagerstrand (1970) and Chapin (1974). Hagerstrand was focused in human models of locomotion in a space- time frame of restrictions that emanates from a number of personal and social elements. The theory of Chapin examines models of locomotion in space and time for the satisfaction of needs of person. At the decade of '90s the models of locomotion are drawn away from the strict space-time frame. This approach is supported in the significance of domestic completion and the emphasis is not more in the locomotion, but in the attendance in the activities and the cohesiveness

between these, so much for an individual and so for teams of persons (McNally, 2000).

The analysis of spatial human behaviour can create the condition for the better evaluation of urban structure. Specifically, the analysis of dissemination to concrete places of activity reveals the structure of offer of occasions of activity in the space and the behaviour moved. The dissemination of activities, respectively, shapes the activity space, the size of which determines the use of services of transport. With this significance the planning of transports evaluates present and future urban structures from the prospect of viable policy of transports (Schofnelder, 2003).

## 1.2 ACTIVITY ANALYSIS

The analysis of activity according to Jones (1990) “*is a frame in which the travel is analyzed in daily or diachronic models of behaviour, that emanate from the differences in the way of life and are related with the attendance of population in activities*”. This definition contains two substantives revolutionary ideas. The supremacy of activities against locomotion and persons against vehicles (Kurani, Lee-Gosselin, 2000). Specifically, was stated that until then it has not been possible to comprehend “*how the models of locomotion will be influenced by the changes in the system of transports, without deeper comprehension of individual everyday routine and activities*” (Behrens, 2001).

From very early the analysis of activity turned the attention of researchers of transports in the dimension of time. The time was determined as homogenous and constant in its flow, with the significance that it is not possible to stop or to be reversed. Consequently, the time constitutes as a different beginning of organisation for a significant part of human activity and it is used in order to arrange the activities at the duration of time intervals (Miller, 1999).

Hagerstrand (1970) is the first who spoke for the space-time frame, which is directed in the measurement of accessibility, recognizing that attendance of activity has spatial and time dimensions, as it is presented in concrete places and in finite time durations (Miller, 1999). Respectively, Time-Geography it determines the factors that limit the choice of individual separating them in restrictions of faculty (for example the time that it needs for sleep and diet), familial and authorities (schedule of operation of services and commercial activities).

In order to analyze the status of the individual, the time should be incorporated in the spatial studies as means of segregation of statistical populations (Behrens, 2001). The individual through space prism can be moved in different localities, in different time intervals conceiving the duration and the cost of travel (Jovicic, 2001). The particular frame dictates consequently essential but not satisfactory terms on the human interaction (Miller, 1999).

### **1.3 STUDIES OF USE OF TIME - TIMETABLE OF ACTIVITY**

An important analysis tool of individual activity in the space during the time, are the researches of use-time. The researches of use - time are focused mainly in an approach: in the study of frequency and the duration of human activities. The research of use-time is unique in the analysis of social sciences. Szalai (1972) presented results from the first world study that was based on elements that were collected in 12 countries at the 1960. The results developed a system of classification of activities which up to today influences the corresponding researches (Stinson, 1999).

The methods for the collection of data were through telephone and electronic post and were used recall activity diaries. Those particular methods require from the individuals to remember and to expose their activities for certain period of time, but also those are considered problematic for them asked with selective memory or tendency of false statement. In corresponding cases are applied methods based on (GPS) that allow the recording in detail space-time orbits (Miller, 2000).

For the planning of timetable of activity, it should be answered the following critical questions which substantially determine its synthetic parts (Behrens, 2001).

- ❖ If the descriptions of activity are open or are coded
- ❖ If are required all descriptions for the activities except residence or simply their place
- ❖ If the time intervals are open or regularly
- ❖ If the activities are recorded for the previous day, at the duration of day, or for concrete days of week
- ❖ If the timetable is supplemented with interview or with the use of other methods.

The formal variables that can structure a timetable of activity are (Axhausen, 2002):

- ❖ the type of activity
- ❖ the locality
- ❖ the time
- ❖ the duration
- ❖ the size and the composition of team and
- ❖ the cost

It is explicit that there does not exist any guarantee for the possibility of use of such techniques in each population. It is also obvious that demographic, cultural, economic, political and technological developments lead to increased complexity to the behavioural dynamics. The modern methods of creation of such models produce relatively holistic descriptions for how the persons conceive time, spatial dimensions of activities and for how interact with other in order to organise them (McCray, Lee-Gosselin, 2003).

In the present application became the use of all variables with the exception of the cost and the size of team. Determining the distribution of time are exported conclusions on the spatial and geographic dimension of activities in the network of city and are located the activity space.

#### **1.4 ACTIVITY SPACE**

Result of human spatial behaviour is the determination of activity space as part of daily environment that is used from moved. Moved select the ways in the time and in the space in order to they satisfy the obligations, the needs and their wishes. They try to select these ways optimally, but they are limited from the knowledge of space and the possibilities of complicated reasoning. Relative significances are the space of awareness, the perceptible places, the intellectual maps, space prisms that describe individual possibilities of locomotion based upon spatial knowledge.

The geometry, the size and the structure of activity space are determined by three factors (Schfnfelder and Axhausen, 2003):

- ❖ the residence, as place from where begin the locomotion,
- ❖ the mobility, from and to the places of visiting activities,
- ❖ the locomotion, between the centres of daily life

At the same time, the activity space gives answers in critical questions as the urban poverty and the deprivation of urban regions in infrastructures and transports. As supported by the Kenyon, Lyons and Rafferty (2002) *"to size and the structure of space of activity can act as a indicator of social justice and the efficiency of political creation of infrastructures combined itself with social needs"* (Schofnelder, 2003). The determination of activity space is supported in three techniques of analysis of dissemination of specific incidents (Schofnelder and Axhausen, 2003):

- a) The standard ellipse rounded suitably in selectively points that show the direction of dissemination of activities
- b) The kernel density that provide information on the frequency of use of space and the model of visiting places
- c) Also network of shortest paths networks, that is to say the minimal distance between the visiting places.

In the present article and according to the proposed methodological frame were developed the standard ellipse and the kernel density for the determination of direction of dissemination of diachronic distributions and activity space of students, taking into consideration the intensity of visiting of activities.

## **2. SPATIAL ANALYSIS**

As point pattern analysis can be determined a total of points which is distributed in a concrete geographic unit. It is result of some spatial process which presents concrete spatial characteristics, as the dissemination of illnesses and pollution in the space, as well as the distribution of crimes, of ecology of plants and archaeological discoveries.

In order to determine an event as specific model will be supposed to be portrayed in the level and to have suitable geometric characteristics (point, place, distance). The region of study should not be accidental but be selected objectively, avoiding erroneous results in the analysis, additionally it will be existed cross-correlation between region of study and precise place of points in the space (the Sallivan and Unwin, 2003).

### **2.1. POINT PATTERN ANALYSIS**

Point Pattern Analysis was introduced in late 1950s. The methods that were defined were based on techniques that were used in the ecology of plants (Gatrell, 1996), in



the distribution of residences (Dacey, 1962) and in the arrangement of commercial activities in urban area (Rogers, 1965).

Point Pattern Analysis measures according to the place of events and the distribution of point, the existence assembled, accidental or uniform model and depends immediately from the determination of region of study, after a regularly distributed model can appear assembled attributing bigger limits in the region of study (Pfeiffer, 1996).

The Point Pattern Analysis techniques that are used have been separated in two categories. First includes the indicators of spatial central position and tendency that is similar with statistical indicators that are used in not geographic data and are: centroid, spatial mean, standard ellipse and the standard distance. In the second category belong those that investigate the spatial dissemination of model in the space, and determine the rate of differentiation from the statistically likely values of variable (Koutsopoulos, 2002). The acquaintances are nearest neighbour analysis, quadrat analysis, kernel density, spatial autocorrelation, as well as the geostatistical and spatial econometric analysis (Xue and Brown, 2002). In that particular work a critical role play the methods of standard ellipse and kernel density.

## 2.2. SPATIAL MEAN

Spatial mean is the median place of distribution of a spatial phenomenon, which even if it does not have no significance as numerical value presents important advantages. It can be used in order to observe a diachronic spatial distribution as measure of comparison of distribution of different phenomena in the space. It is calculated by the types:

$$\bar{x} = \frac{\sum_{i=1}^n w_i x_i}{n} \quad (1)$$

$$\bar{y} = \frac{\sum_{i=1}^n w_i y_i}{n} \quad (2)$$

Often it acquires a "synthetic" character or it can be located except the geographic frame of study, when, for example, are studied coastal points and are determined in the sea, or when two different distributions have the same spatial means

(Koutsopoulos, 2002). In that particular work different diachronic spatial median sites of students were calculated, according to the individual daily timetable of movement with aim to be recorded the space-time change of their mean place in the 24-hour and the delimitation of activity space.

### 2.3. STANDARD ELLIPSES

The standard distance is a measure of dissemination of events round the mean centre which, however, does not conceive any directional tendency or the form of spatial distribution. On the other side, the standard deviational ellipse gives the spatial distribution in two dimensions and is determined by three parameters:

- The corner of rotation
- The spatial distribution at length of main axis
- The spatial distribution at length of secondary axis

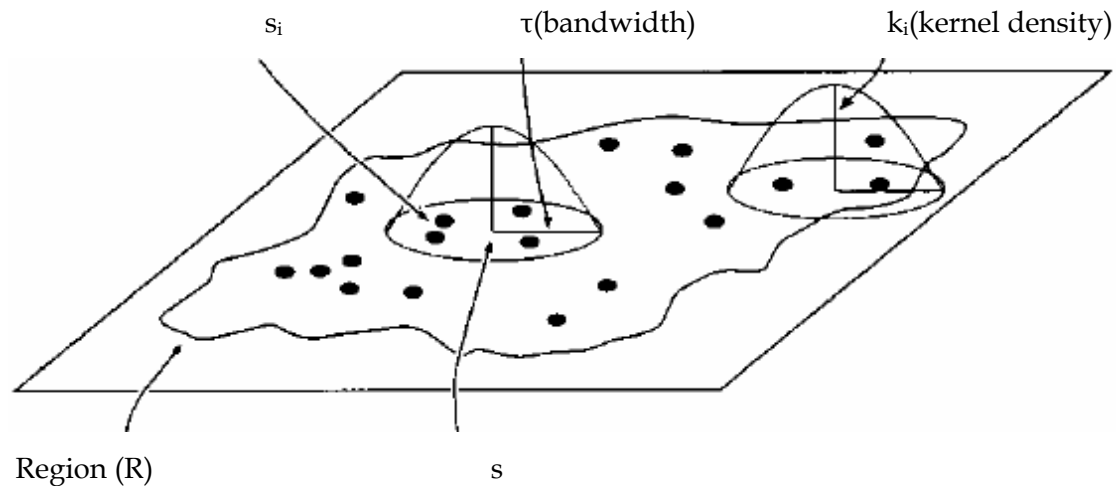
The main axis determines the direction of biggest dissemination of distribution. The secondary axis is vertical, and corresponds in the minimal dissemination. In that work the standard deviational ellipse represents the direction of spatial distribution of diachronic places of students' residences.

### 2.4. KERNEL DENSITY

The models of densities aim at locating the spatial concentration and intensity of models of locomotion through the transformation of total points in continuous values of density of wider region. The method of kernel density is technique of generalisation that via interjection attributes values in wider departments of region of study. The mathematic expression is given by the relation:

$$\lambda(s) = \sum_{d_i < \tau} k\left(\frac{d_i}{\tau}\right) \quad (3)$$

Where k the operation of evaluation of cores, t the breadth of area (bandwidth) or parameter of regularisation, and d the distance between the points of grid s and observed.



**Form 2.4.1.** Visualization of density of cores

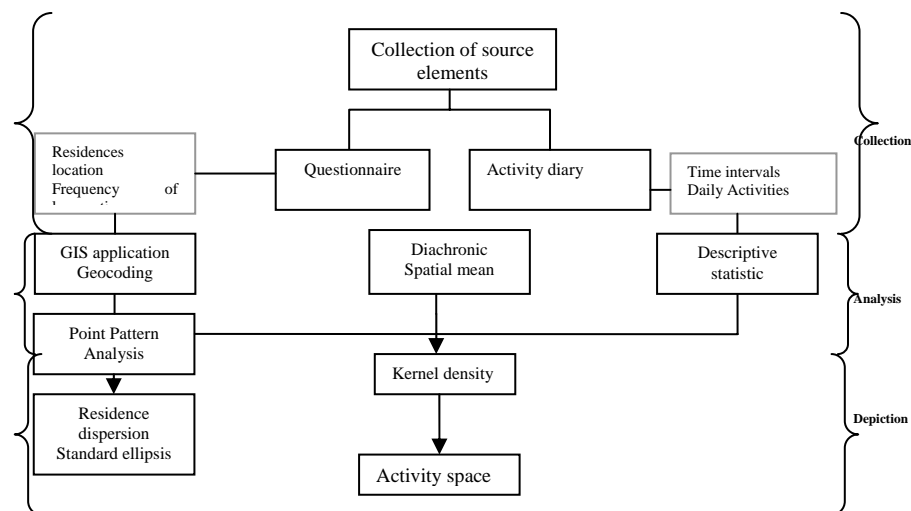
The kernel density is sensitive in the choice of breadth of area (bandwidth) which substantially, portrays a biggest distance of spatial interdependence between the places of activities. Specifically, while its increase smoothes out the intensity of spatial change, particularly its increased values do not facilitate the discernible of the patterns. Thus, the final determination can contribute in a conceptual approach of proximity and neighbourhood.

The proposed approach, it represents the sub-centres of individual activity space. According to the methodology, the biggest distance of locomotion between residence of each different activity was fixed as the from definition value (default) that determines the density according to the number of points per square unit (Schofnfelder and Axhausen, 2002), creating different sizes of distance which were then evaluated.

The more important advantage of this method is its faculty to examine the spatial relations between the different surfaces in concrete geographic frame. Moreover, from the perspective of forecast and planning, it appears useful, are exported quantitative conclusions that are reported in orientation and in choice (Schofnfelder and Axhausen, 2002). The G.I.S. calculate the kernel density as means of depiction of specific pattern, localisation of regions of intensity (hot spots) and determination of local concentrations (Sullivan and Unwin, 2003).

### 3. METHODOLOGY

For the determination of activity space the methodology which following is portrayed to the below diagram (Schema 3.1). Particularly, that case is investigated by following three steps. At first, in the collection step, the source elements were collecting with activity diaries and questionnaires. The activities diaries recorded daily activities and the time intervals of a day. Additionally, in questionnaires recorded the location of student residence with the diachronic change of it. Thereafter, in the second step the elements are being analyzed by basic descriptive statistic and by the point pattern analysis. At that stage is imported the application of GIS. GIS is implemented mostly in that case with the geocoding and techniques of the point pattern analysis. Lastly, at the third stage depicted spatially the extent of activity space of student locomotion from their residence to their daily activities.

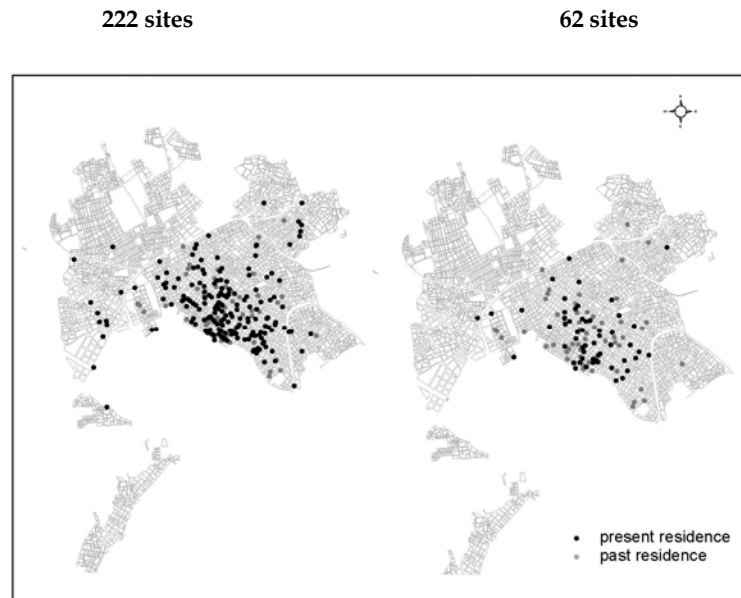


Schema 3.1. Flow diagram

#### 3.1. PATTERNS OF LOCOMOTION OF STUDENTS IN CITY OF VOLOS

In the city of Volos is accommodated eleven (11) Academic Departments with 4.104 active students (2002-2003). For that research was selected a sample of 5,5%, particularly 229 students, and the site of that research was the five different locations of university. From a sum of 229 responded students, 222 answered for the precise place of their present residence and only for 62 students were existed diachronic

change of their residence. With the use of method of geocoding determined precisely the site of residences as a node on the road network. Through the analysis of the point spatial pattern of two different distributions the determination of activity space is diachronically approached.



**Chart 3.1.1.** The diachronic sites of residence of students

The standard ellipses were used for the spatial localisation of the direction of main diachronic distributions. More specifically, for the case of 222 sites it was realised that so much the extent and the direction of main dissemination are not altered. However, important difference appears to exist in the distribution of 62 sites. The main dissemination of past residences has bigger extent than current and proportionally its direction is very different. At the same time, the present residences appear that are assembled in bigger degree round their median place compared to past. That particular analysis portrays spatially the total extent of activity space of students. The activity space will be investigated extensively with the use of kernel density.

222 sites

62 sites



**Chart 3.1.2.** Standard ellipsis for the diachronic distributions

### 3.2. DATA COLLECTION

For the collection of data were used questionnaires as the most classic and relatively more reliable method for the reception of necessary information. Aim of the creation of questionnaire is to be investigated the behaviour of student in the city of Volos and the relations between residence of student and daily activities. Simultaneously, were located the past and present sites of student residence with its corresponding characteristics and were recorded the daily locomotion between residence and daily activities. Specifically, with the use of timetable of daily activities, located their way of locomotion, the time that is spending in order to approach their activities, the frequency of locomotion to destinations. The layout of the timetable became with the following way. Initially, were defined five general categories of activities.

- ❖ faculty/department,
- ❖ entertainment,
- ❖ market,

- ❖ student union and
- ❖ services

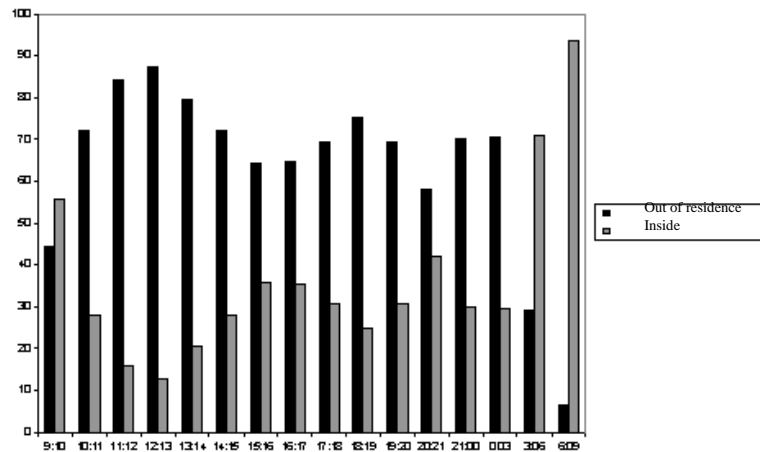
Continuity was selected one formal 24-hour in the week and became per hour the separation of time intervals of that day, with the exception of the 9 m.m. up to 9 p.m. which was separated in three hour intervals (table 3.2.1).

**Table 3.2.1.** The activity timetable

Time interval	Activities
	(1)school (2) entertainment (3)market (4) student union (5) services
09:00 – 10:00	
10:00 – 11:00	
11:00 – 12:00	
12:00 – 13:00	
13:00 – 14:00	
14:00 – 15:00	
15:00 – 16:00	
16:00 – 17:00	
17:00 – 18:00	
18:00 – 19:00	
19:00 – 20:00	
20:00 – 21:00	
21:00 – 00:00	
00:00 – 03:00	
03:00 – 06:00	
06:00 – 09:00	

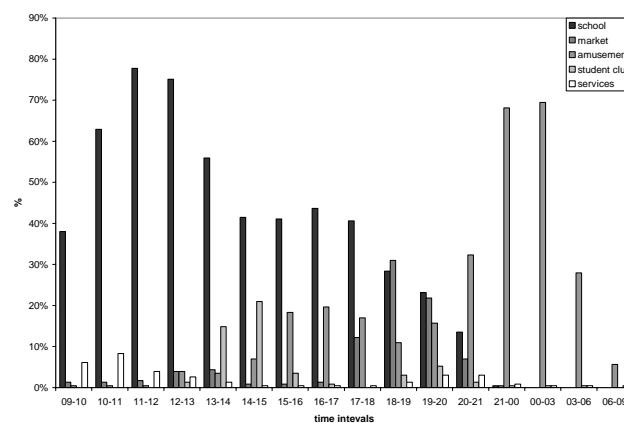
### 3.3. ANALYSIS OF USE OF TIME DAILY- EXCEPT RESIDENCE STUDENT ACTIVITIES

Through the collection of daily individual activity daily student choices are reviewed and daily intensity and concentration of locomotion between residence and activities are investigated spatially. In Diagram 3.3.1, the 90% of the daily activities except residence begin in the 10p.m and complete in the 3m.m and occupy the 63% of day of student.



**Diagram 3.3.1.** In and out of residence activities

Accordingly, in Diagram 3.3.2 is portrayed the fluctuation of the activities except residence in a 24-hour. More specifically, from the 9 pm up to the 6 am the bigger department of students finds itself in the university. After the six and up to late evening main activities are market and entertainment. Generally, it is realised that the faculty constitutes the more important activity in a day while is observed small dissemination of students to the student union in the midday, in the afternoon the markets with the entertainment strengthens their percentage, contrary to the services that maintain minimal percentages in the 24hour. That particular fluctuation will be used for the determination of median site of student residence per activity in a day aiming at the localisation of activity space.

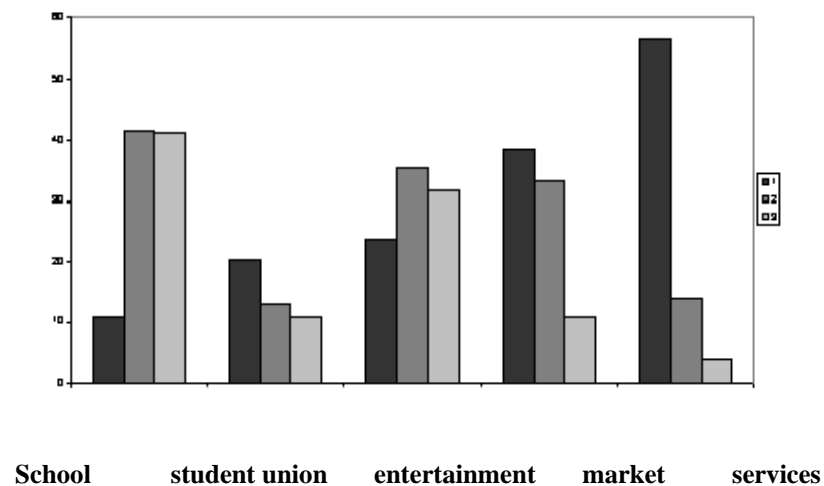


**Diagram 3.3.2.** The attendance of activities

With regard to the frequency of locomotion at the duration of day from the residence to the five activities, it is realised that the 80% asking realise two with three



locomotions (Diagram 3.3.3). Respectively, a percentage of order the 70% moved to the entertainment maintain the same level of locomotion. While, the 75% of locomotion to the market referred to two locomotions. Finally, the 55% of locomotion to the services concern in one only locomotion in the duration of day. The frequencies are used then in order to weigh the spatial mean for the determination of diachronic locomotion of students to their daily activities at the duration of one day.



**Diagram 3.3.3.** Frequency of locomotion in a 24-hour basis

### 3.4. A model of students' daily activity patterns

For the localisation of spatial concentration and intensity of locomotion for each activity were used the total diachronic distribution of 222 places of student residences and the method of kernel density. With this method it was achieved are impressed in the space the intensity and the extent of locomotion to the daily student activities. Simultaneously, with the produced cores were located the relation of spatial means, that is to say the median place of students to each activity in each time interval, with the produced cores.

In order to locate the intensity of daily locomotion to each activity separately, it should determined different spatial mean of the place of corresponding students in the predetermined temporally intervals of day and they are weighting by the frequency of locomotion in the day. Thus, through the comparison of produced cores is determined the diachronic pattern of locomotion of students for each activity and consequently is located their space activity.

In order to determine the dissemination of student locomotion receiving as

main destination the place of market, were created two different temporally maps that portray the intensity, their spatial concentration and the diachronic change of mean places of students concerning the activity of market. Observing their resulting density of core for each time period is realised important various but also resemblances. Important resemblance between the precedents and the current locomotion is that the central core of these has the same intensity in the space and is assembled in a relatively common department of city. Differentiation exists as for the intensity of total density of previous locomotion which presents significant dissemination. On the contrary the current and previous locomotion of students are more assembled. Consequently, the daily locomotion by the place of residence to the place of market presents a concentration in central part of city, while at the past this concentration was extended. The diachronic locomotion of residence concerning a constant diachronic daily program of visiting markets led to the conclusion that the student decreased the extent of his daily travel to the regions of markets (Chart 3.4.1.).

Respectively, for the locomotion to places of education a common central core is realised, with the main intensity of current movement more directional contrary to the precedents. At the past, existed teams of spatial means that intensified the coiling something that is verified according to the current depiction of locomotion. Consequently, the diachronic locomotion of residence concerning the constant diachronic daily program of visiting school leads to the conclusion that the size of daily travel of student to the places of education presented minimal change (Chart 3.4.2.).

The locomotion of students to the places of entertainment has not been altered at the byway of time. Observing the two different maps of locomotion, is temporally realised the existence of common central core in the region of beach that collects the bigger intensity of these and Accordingly the movement of spatial means of places of students becomes with the same relatively way with concentration in the central department of city. Consequently, the diachronic locomotion of residence concerning the constant diachronic daily visiting program of place of entertainment leads to the conclusion that the size of daily travel of student to the entertainment remained constant (Chart 3.4.3).

With regard to the intensity of locomotion to the space of student union it appears that the more important part of current locomotion limits itself in a small

region of centre, contrary to the core of previous locomotion. While, spatial mean that fix the particular core for the current locomotion are assembled coastally, contrary to the precedents they deviate considerably. This result shows that the behaviour of main volume of students that daily presents the particular activity has been altered with the byway of time. In general lines, the locomotion at the past were more extensive in the space from proportional current, but also their total volume was bigger. Finally, the new places of residences of students decrease the size of locomotion to the student union (Chart 3.4.4.).

For the case of locomotion that has as destination the places of services the existence of differences between the two different temporally periods is realised. By produced densities of current locomotion is defined the existence of two intensely separated cores in different and spatially apart units, while the previous locomotion communicates to a large extent presenting tendencies of significant dissemination. Additional difference appears also in the locomotion of spatial means and particularly what fixes the cores, while those that they fix utmost the dissemination remain constant. Consequently, the cores of density portray the degree of extent and the intensity of locomotion from the residence so much current as long as past with destination the total of services (Chart 3.4.5.).

### **3.5 Conclusions of analysis**

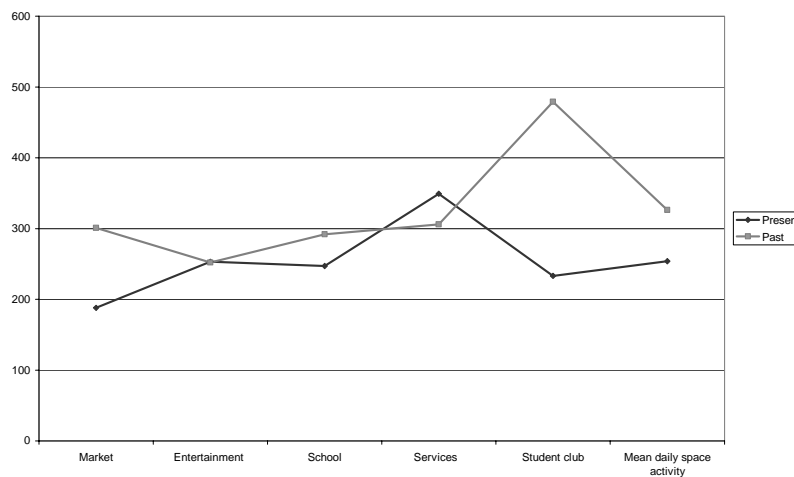
For the locomotion to the places of students activities are realised the existence of concentrations in central points of city. The locomotion by the current places of students in their total, differ from corresponding the previous places. More specifically, in almost all the cases the previous places contrary to current presented bigger dissemination of their intensity in the network of city.

Accordingly, wanting this space to acquire a metric dimension will become analysis of produced breadth area of cores of density, so it will be determined the biggest distance between residence and activities. Table 3.4.1 shows the breadth area that is to say the biggest distance of locomotion between destinations and specifically between the residence and each activity separately. The above interpretation is verified by the produced breadth area, or the biggest distance of locomotion between the activities.

**Table 3.4.1.** Diachronic change of activity space of students

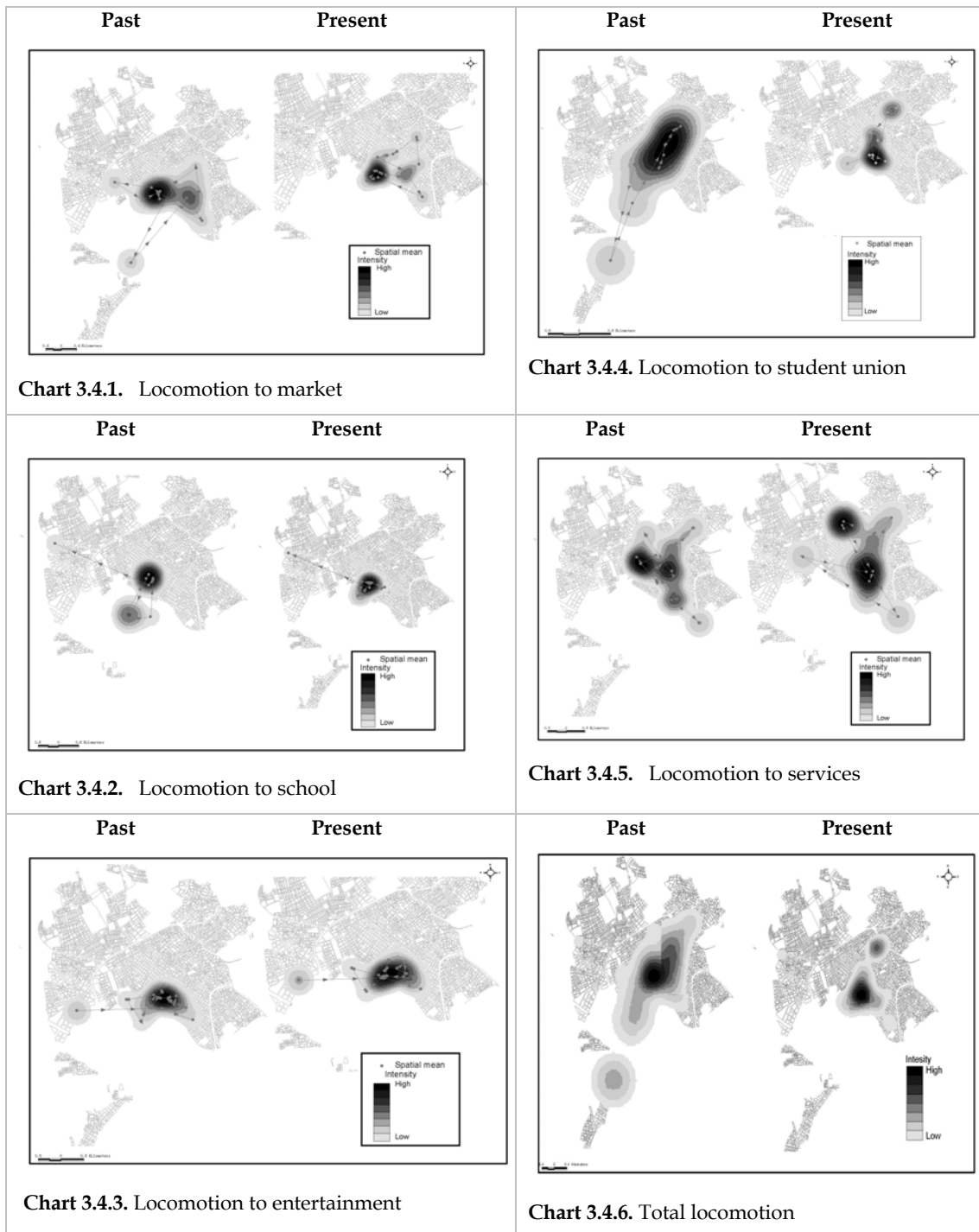
Breadth area (m)	Present	Past
Market	188	301
Entertainment	253	252
School	247	292
Services	349	306
Student union	233	479
Mean daily activity space	254	326

Is verified, the fact that the locomotion of students in the frame of their daily activities at the past occupy a relatively wider region. However, the same students after a time interval appear to have delimited the choices of their locomotion in a relatively more limited area of action (diagram 3.4.1).



**Diagram 3.4.1.** Change of activity space based on the definition of breadth area

The diachronic densities that were produced for each activity separately in the GIS environment determined the activity space of students for the complete set of their activities. In this respect, a raster overlapping was performed creating a different mosaic. The outcome of the above process is two diachronic maps that portray the intensity and the concentration of generalized activity space. Consequently is verified the fact that, at the past, the students covered bigger distance for the realisation of their daily needs. Change of place of residence it aimed in the reduction of the statistically weighed median cost (Chart 3.4.6).



## 4. CONCLUDING REMARKS

The methodological approach that was presented aimed at analyzing and determining the structure of daily activity space of a group of individuals through the fusion of research of use of time and quantitative spatial analysis. The individual possibility of activity was defined through the analysis of recall and activity diaries that contained a detailed description the daily student activities in the city of Volos.

Even if, such an approach can provide holistic descriptions for the way that persons conceive space-time dimensions of activities, it succeeds in the decoding and clarification of the complex behaviour of the specific study group.

The investigation of daily locomotion is realised in a G.I.S. environment with the assistance of methods of point pattern analysis. Through this analysis it is realised that the need of spatial determination of individual activity space is achieved mainly through the use of specific patterns and particularly through the pattern of density. The pattern of density and more specifically the use of kernel density proved to be a reliable indicator for the spatial determination of place of locomotion and action. However, it must be underlined the fact that the particular method determines the seeking activity space in connection with the predetermined breadth of area. Alternatively, in the particular work the biggest distance is not delimited, but constitutes one from the objectives of analysis. At the same time, placed to further investigation is the question of use of kernel as metre of assessment of concentration of individual activity space. In the same manner, we could question whether the produced activity space should exceed daily basis and consequently a final question refers to change of activity space for the different days of week as well as between holidays.

For the analysis we adopted the spatial mean of different temporally places and we determined the different temporally place of students in the city in the frame of realisation of their daily activities. The incorporation of choices of individuals and their time restrictions in each spatial distribution produces a detail regard of possibility of locomotion.

Finally, the research of investigation of human locomotions, based on the activities, constitutes essential parameter analysis of demand of travel which can lead to a long-term viability through the planning for the investment to infrastructure for the satisfaction of new demand. This new tendencies can coincide with the idea of 24-hour cities changing the behaviour of movement in order to achieve positive consequences in the overall performance of transportation systems.

## 5. BIBLIOGRAPHY

- Axhausen, K.** (2002) "A dynamic understanding of travel demand: A sketch", Arbeitsberichte Verkehrs- und Raumplanung, 119, Institut für Verkehrsplanung und Transportsysteme, ETH Zürich, Zürich.
- Behrens, R.** (2001) "Looking beyond commuter travel in Cape Town: Methodological lessons from the application of an activity-based travel survey", International Conference on Transport Survey Quality and Innovation: How to Recognise It and How to Achieve It, 5-11 August,  
(available in [www.its.usyd.edu.au/.../South\\_Africa\\_Papers/Behrens %20-ictsqi.doc](http://www.its.usyd.edu.au/.../South_Africa_Papers/Behrens%20-ictsqi.doc)) (accessed 3/6/04).
- Dacey, M.** (1962) "Analysis of central place and point patterns by a nearest neighbour method", Lund Studies in Geography, Series B, Human Geography 24 55-75.
- Fellman, J. D., A. Getis and J. Getis** (1999) *Human Geography*, WCB/McGraw-Hill, Boston.
- Gatrell, A.** (1996) "Spatial point pattern analysis and its application in geographical epidemiology", *Transport British Geography*, 21, 256-274,  
(available in [www.dpi.inpe.br/cursos/ser301/referencias/gattrel\\_paper.pdf](http://www.dpi.inpe.br/cursos/ser301/referencias/gattrel_paper.pdf))  
(accessed 3/6/04).
- Golledge, R., Stimson, R.** (1997) *Spatial behavior: A geographical perspective*, Guilford: New York.
- Jovicic, G.** (2001) Dissertation: *An Activity based travel demand modelling*, Danmarks TransportForskning.  
(available in [www.rft.dk/upload documents/not0801.pdf](http://www.rft.dk/upload_documents/not0801.pdf)) (accessed 3/6/04).
- Hanson, S. and G. Pratt** (1990). "Geographic perspectives on the occupational segregation of women". *National Geographic Research* 6(4), 376-99.
- Koutsopoulos, K.** (2002) *Geographic Information Systems and spatial analysis*, Athens:Papasotiriou.
- Kurani, K. Lee-Gosselin,** (2000) "synthesis of past activity analysis applications".
- McCray, T. Lee-Gosselin, M.** (2003) "Netting action and activity space/time: are our methods keeping pace with evolving behaviour patterns?", 10th International Conference on Travel Behaviour Research Lucerne, 10-15. August 2003
- McNally, M.** (2000) "The Activity-Based Approach", Institute of Transportation Studies, University of California,  
(available in <http://repositories.cdlib.org/itsirvine/casa/UCI-ITS-AS-WP-00-4>)  
(accessed 3/6/04).
- Miller, H.** (2000) "Activities in space and time", *Handbook of transport 5: Transport Geography and Spatial Systems*, Pergamon/Elsevier Science

(available in [www.geog.utah.edu/~hmler/papers/Activities\\_Space\\_Time.pdf](http://www.geog.utah.edu/~hmler/papers/Activities_Space_Time.pdf) )  
(accessed 3/6/04).

**Miller, H.** (1999) "Measuring space-time accessibility benefits within transportation networks: basic theory and computational procedures", *Geographical Analysis*, volume 31, pp. 187-212

**O' Sullivan, D. Unwin, D.** (2003) *Geographical information analysis*. Canada: Wiley & Sons.

**Pfeiffer, D.** (1996) "Issues related to handling of spatial data", Massey University, Second Pan Pacific Veterinary Conference, Christchurch, 23-28 June,  
(available in [www.vetschools.co.uk/EpiVetNet/epidivision/Pfeiffer/files/spacedp2.pdf](http://www.vetschools.co.uk/EpiVetNet/epidivision/Pfeiffer/files/spacedp2.pdf)) (accessed 3/6/04).

**Rogers, A.** (1965) "A stochastic analysis of the spatial clustering of retail establishments", *Journal of the American Statistical Association* 60 1094-1102.

**Schönfelder, S.** (2003) "Between routines and variety seeking: The characteristics of locational choice in daily travel", 10th International Conference on Travel Behaviour Research Lucerne, 10-15 August,  
(available in [www.ivt.baum.ethz.ch/allgemein/pdf/schoenfelder.pdf](http://www.ivt.baum.ethz.ch/allgemein/pdf/schoenfelder.pdf)) (accessed 3/6/04)

**Schönfelder, S. , Axhausen, K. W.** (2002) "Measuring the size and structure of human activity places the longitudinal perspective", *Arbeitsbericht Verkehrs- und Raumplanung*, 135, Institut für Verkehrsplanung und Transportsysteme (IVT), ETH Zürich, Zürich,  
(available in [http://e-collection.ethbib.ethz.ch/ecol-pool/incoll/incoll\\_700.pdf](http://e-collection.ethbib.ethz.ch/ecol-pool/incoll/incoll_700.pdf)) (accessed 3/6/04).

**Schönfelder and Axhausen,** (2003) "Activity places: Measures of social exclusion?" *Arbeitsbericht Verkehrs- und Raumplanung*, 140, Institut für Verkehrsplanung und Transportsysteme (IVT), ETH Zürich, Zürich.

**Stinson, L.** (1999) "Measuring how people spend their time: a time- use survey design. *Monthly Labor Review*", vol 122, 12-19.

**Xue, Y. , Brown, D.** (2002) "Decision based spatial pattern analysis Department of Systems and Information",  
(available in <http://www.sys.virginia.edu/techreps/2002/sie-020009.pdf>) (accessed 3/6/04).