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Impacts of a metro station to the land use and transport system: the Thessaloniki Metro case

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Abstract

The paper deals with the interaction between the transport and land use system in an urban area having as a case study the Thessaloniki Metro (which is an on-going project) and especially one of its main stations (the Papafi station) which is located outside the city centre. The Thessaloniki basic metro line will have a length of 9.6 km, with 13 stations. The construction phase initiated in June 2006. The only experience in the country so far about the impacts of a metro station to the transport and land use system comes from the city of Athens where there is an extensive metro network. The research presented in this paper is based on analytical recording of the land use system characteristics within a buffer zone of 500 m. around the Papafi station and also on a Stated Preference (SP) survey addressed to the residents and visitors in the study area. The connection of the study area with the inner ring road of the city, which is a critical issue for the integrated transport planning process, is also examined within the paper. Appropriate maps with the transport and land use data were produced using the Geographical Information System technology. The interpretation of the inter-relationships among the selected data from the SP survey took place using the method of Principal Components Analysis for Categorical Data. It is estimated the methodology followed and the research results can contribute to the enrichment of the existing experience concerning the way a metro station affects the land use system as well as the trip characteristics in its near area.

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1. Introduction

Land use and transportation interaction is a dynamic process that includes spatial and temporal changes between the two systems. Changes in land use system can cause modifications in the travel demand patterns and induce changes in transportation systems while transportation system evolution, increases accessibility levels and thus stimulate changes in land use patterns (Aravantinos, 2000 and Zhao et al., 2003).

There have been numerous studies the objective of which was to identify the interaction between the two systems in spatial level and in terms of the degree of impact. An important number of them have focused on how transportation systems' innovations can have an impact on land value.

In the USA many studies which have examined the effect of new rail transit provision on property prices have generally found positive effects, presenting significant statistical evidence of land value price increases (reaching or surpassing the 25% in many cases), which have been associated with new rail transit provision, even though with some mixed results (Landis et al., 1994; Riley, 2001; Cervero and Landis, 1993; Bowes and Ihlanfeldt, 2001; Cervero and Duncan, 2002; Hess and Almeida, 2007).

Hass – Klau et al. (2004) examined the effect of trams and light rail stations on residential property prices, office rents and retailing, in 15 cities in France, Germany, UK and Canada, covering developments since the late 1970s.

This study revealed that proximity to rail infrastructure has a positive impact on land value in the vast majority of case studies. Moreover, Gibbons and Machin, 2011, identified considerable increase in house prices after Jubilee's line extension in London in areas that are located within the line's influence zone. Similar results were found by other research studies that have been undertaken with case studies cities located in northern Europe (Du and Malley, 2007; Ghebregiabiher et al., 2007; Ahlfeldt and Feddersen, 2010; Smith et al., 2010).

A relevant research in Greece, having as a case study Athens, has been undertaken in 2007. It focused on the impact of 7 Athens metro stations within a buffer zone of 250 m. aiming to identify the relation between commercial land use and rail transit innovations.

An increase of the retail activity was reported at the non – domestic properties located within 100 m. of the stations, while other positive results involve a growth of the pedestrians flow and the enhancement of employees' mobility, as well as a general upgrade of the area's urban environment (Tzouvadakis et al., 2007).

Thessaloniki is the second biggest city in Greece. The Thessaloniki's Prefecture has a population of 1.057.825 inhabitants, according to 2001 census (EL. STAT., 2011) spread in an area of 3.683 km². Thessaloniki is among very few European cities with such large population without any track based public transportation system (ATTIKO METRO S.A., 2009). This situation is expected to change with the construction of a contemporary metro system (both operationally and technologically), which is the largest on - going transport project in the country.

The Thessaloniki basic metro line will have a length of 9.6 km, with 13 stations, starting from the north - western part of the city and reaching the south east. The construction phase initiated in June 2006 and it is on – going until now (October 2011). It is estimated that after its completion, the line is going to carry 18,000 passengers/hour/direction (ATTIKO METRO S.A., 2011).

2. The research in Papafi area: choice of the area, data collection and methodology

The criteria that were taken into account for the choice of the Papafi station as the case study of this research were the location of the station within the urban network of Thessaloniki, the existing transport connections of the area, as well as its general urban profile. The station is situated in the area of East Thessaloniki, within a distance of approximately 500 m. from the so – called “historic centre” of the city. It is the 7th station of the metro line. The buffer zone of the research is defined as the area included in a radius of 500 m around the location of the station’s future infrastructure (Figure 1).

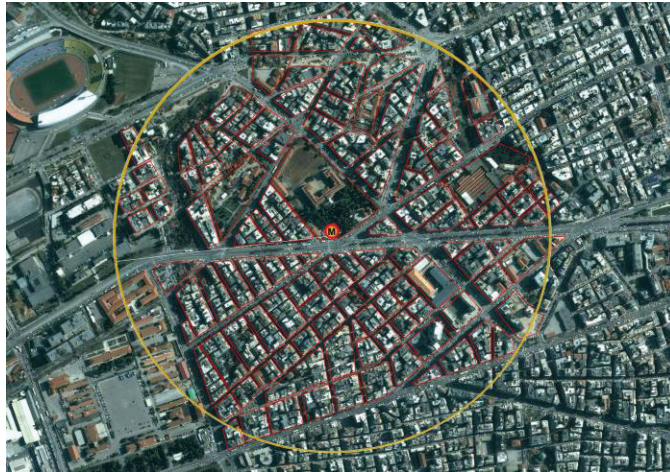


Fig. 1. Research buffer zone of 500 m. around Papafi station (Google Earth, 2010)

For the purposes of this research, only the blocks of flats that are totally included in the buffer zone are considered, due to the fact that there was no point in examining some blocks only partially. Therefore, the limits of the buffer zone are defined by the surrounding streets. The expected impact of the new Thessaloniki’s metro on land use was examined through detailed field work (Roukouni, 2010). Initially, the existing situation was described by gathering, elaboration and display of a significant volume of primary information concerning the nature and characteristics of the land use system. Moreover, a Stated Preference (SP) survey addressed to the residents and visitors of the study area with the aim of understanding and analysing the expected changes in the area after the completion and operation of the underground station was conducted. This survey involved the preparation and distribution of questionnaires under the objective of examining the stated preferences of the residents and visitors of the area (pedestrians within the buffer zone). The land use recording covers the total examined area, whilst the questionnaire research is based on sampling. The completion of the questionnaires took place by the use of the method of personal interview. Totally, 290 questionnaires were collected.

The advantage of this method is that the interviewers and the person who is responsible to record the answers communicate directly; this way, misunderstandings that might lead to false answering and thus to results that do not reflect the reality can be avoided. This happens due to the fact that in case the interviewee is not sure about the exact meaning of one or more questions he/she can ask for clarifications. Moreover, the research can be enriched with additional information and comments “outside the box” which can be also recorded and used in the analysis.

The stated preference questionnaire that is addressed to pedestrians consists of 3 different parts. The first part includes the socio – economic characteristics of the interviewee such as his/her age, occupation,

educational level, range of monthly salary, number of personal vehicles in the household etc. The second part attempts to describe the characteristics of the specific trip; the origin, destination and purpose of the movement, as well as the means of transport and the frequency of their use. Finally, with the last part it is attempted to capture the stated preferences of the interviewee, concerning the intention to use or not the new metro line, and Papafi station in particular, the main reason(s) leading to that choice, and estimation on the enhancement or not of the commercial activity and the general upgrade of the area's urban environment.

The questions have in their vast majority, predefined answer boxes that in some cases cover a range of potential answers (e.g. the question about the salary), in other cases, especially in the second SP part of the questionnaires, they indicate the degree of agreement with the statement. The questions that had "open type" answers were coded afterwards during office elaboration.

Both the land use recording and the questionnaire survey took place between February and March 2010. The total number of questionnaires completed, as mentioned previously, was 290. The collected data were introduced in digital databases. Initially, the descriptive statistical analysis of all the variables took place in order to calculate the frequencies with which each variable appears in the sample. Pie charts and bar charts were formed in order to reach certain basic conclusions of the survey. Moreover, in order to achieve the effective interpretation of the inter – relationships that appear among the variables used at the questionnaires, the method of Principal Components Analysis for Categorical Data was used. This method revealed interesting correlations and contrasts that were not visible by the simple descriptive analysis.

The Principal Components Analysis for Categorical Data is a non – linear technique of analysis in components; the relationships among the variables are represented by a small group of uncorrelated structures, usually two or three. Therefore, with the use of this method, a group of variables can be tested in order to find the principal dimensions of their variance. The initial variables are replaced with a lower number of new, uncorrelated variables, interpreting at the same time the highest possible percentage of the variance of the initial group of variables. The diagrammatic representation of the analysis' results is done using scatter plots that can either refer to the variables, the groups of variables or the objective items of the research (in this case the questionnaires) (Siardos, 2004). The next section includes the main results of the data analysis; the land use recording results and the corresponding GIS mapping representation of them, as well as the categorical analysis results.

3. Results of the land use recording and production of thematic maps

The detailed recording of the ground floor land use showed that within the buffer zone the existing land use patterns include 1342 properties, with most of them comprising the category "commercial use", as 353 such properties were recorded (26.30 % of the total), followed by the category which corresponds to "empty properties" (21.24%). This high percentage of empty properties should not be examined independently from the current financial circumstances caused by the economic crisis. Approximately 13.00% of land use consists of residential properties while the entertainment uses cover a lower 5.00%. The ground floor land use allocation is illustrated in the map of Figure 2a. Predominate land use (commercial properties and empty properties) is indicated with red and purple color respectively. Commercial activity is mostly concentrated alongside the main road networks. The majority of the recorded buildings are of medium height, those which have 5 floors reach the 31.36%, followed by those with 4 floors (24.00%). No particular groups of very high or very low buildings were recorded, even in the same block of flats big differentiations in height can be found.

While the aforementioned map presents the ground floor land use of the area on building level, Figure 2b shows a map, in which the grouped land use of the area (all building storeys) is presented, on blocks level this time. The yellow color that dominates indicates that the area can be characterized as residential as the vast majority of blocks belong to this category. In the area there are two large hospitals and one children care institution which although comprising only 3% of the total land use, they occupy significant space and in addition to that, they are main trip generators. There are also 13 buildings that accommodate educational activities.

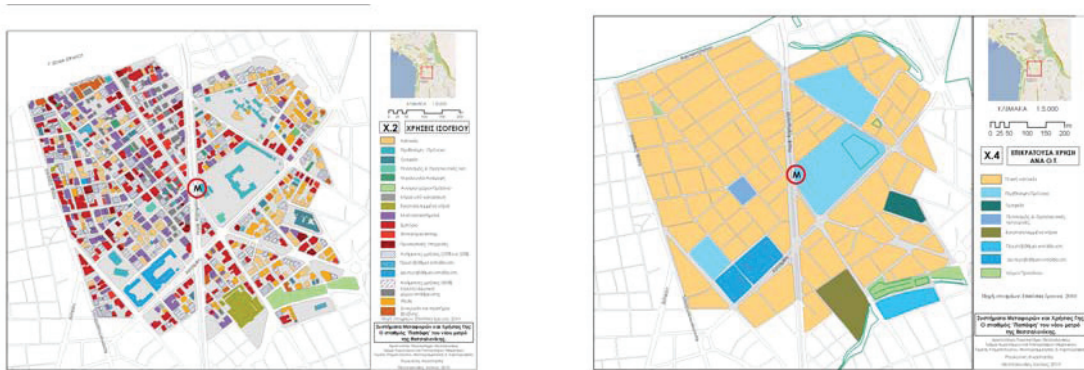


Fig.2. GIS map showing (a) the ground floor's land use allocation and (b) predominant use by block

4. Results of the Stated Preference Survey and Categorical Data Analysis

From the 290 questionnaires addressed to pedestrians that were collected, only 270 were considered valid. The rest 20 were rejected after the rational testing, due to the fact that they contained uncompleted or not very clear answers.

The answers of the stated preference part of the pedestrians' questionnaires revealed a very positive behaviour towards the new Thessaloniki metro line and Papafi's station in particular. Over 70% of the interviewees claimed that they would use the station for their trip (therefore they would take the metro alternatively to the transport mode they usually use), with the increase in speed appearing to be the main reason (40%) for that choice, followed by the growth in accessibility of the area. The great majority (85%) of the people participated in the survey think that the enterprises of the area will experience an increase in their clients after the operation of the metro line, while they consider it very possible that they will visit the area more frequently. The positive opinions at the question which discusses the general upgrade and development of the area's urban environment reach the extra high percentage of 90%.

In order to apply the method of Principal Components Analysis for Categorical Data, the variables of the questionnaires were divided in different groups. Each group was tested for the existence or not of correlation among its variables. The method was applied several times, using different combinations of variables each time, in order to find relationships of similarity or contrast that were not visible by the simple descriptive statistical analysis. In this paper, the main results of these applications of the method

are presented, and a representative example of a scatter plot that illustrates the results is presented below to provide an indication of the interpretation of the analysis.

The present application of the pedestrians' questionnaire involves considering the variables: Home Area (A6), Work Area (A7), Origin (B1), Destination (B2), Mode of Transport (B4). The analysis shows the existence of strong correlation between the area where the interviewee's job is located and between the interviewee's home area and his/her trip destination while the mode choice is not highly correlated with any other variable. This is confirmed by the scatter plot of Figure 3. In particular, as for the first component (horizontal axis), two separate groups of variables can be clearly observed; the first one includes the categories: residents of the buffer zone, those whose trip is done completely on foot, trips that their origin is either the buffer zone or the centre of the city. The second group consists of the categories: residents of the centre of the city, those who have as transport mode their personal vehicle (as drivers), bus or motorcycle, residents of the eastern and western part of the city, those who choose taxi or

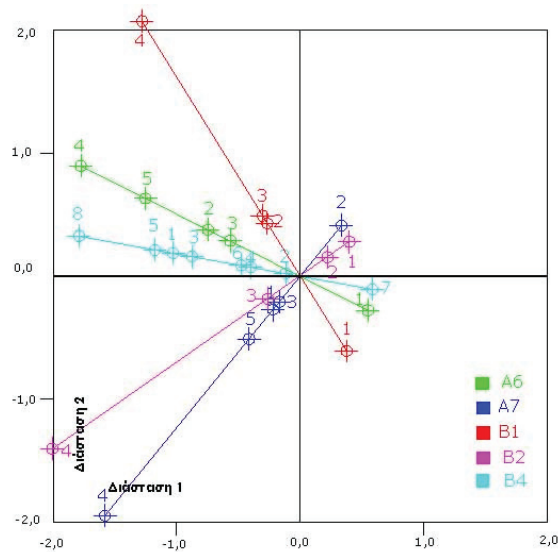


Fig.3. Scatter plot for a group of variables of pedestrians' questionnaires

cycling as transport mode or were co – drivers of personal vehicles, used more than one means of transport for their trip or their destination was Eastern Thessaloniki. As for the second component (vertical axis), the category that includes people who work somewhere in the centre of the city is appeared to be related with the categories whose trip origin is the centre or the eastern part of the city, whereas the category of those who work in the buffer zone of the research area or in Eastern Thessaloniki is appeared to be highly correlated with the category which involves trips that origin from the buffer zone.

Other worth mentioning results from the rest of applications include that people of middle or high education level and of middle or high salary appear to be more positive to the idea that the new metro station will bring additional development to the area in contrast with those of lower educational levels and who receive lower salaries; the negative views and the majority of “I do not know/I do not answer” answers are related with the latter group of interviewees. Moreover, the variables related with the potential increase of the area's visitors, the frequency of the future visits and the potential upgrade of the area, appear to be highly correlated, while the variable that describes the intention to use or not the metro station appears to be uncorrelated with the rest. The application that attempted to find the underlying

relationship among the age, salary and most frequently used transport mode, showed that although the age and salary are strongly correlated (as it would rationally be expected), when it comes to the most frequently transport mode, the correlation is considerably weaker. Furthermore, the age groups: 18 – 24, 25 – 54, 55 – 64, ≥ 65 years old and salary groups: 801 – 1600, 1601 – 2400 and ≥ 2400 euros per month are correlated in a low degree with the transport modes: personal vehicle (as a driver or co – driver), bus, taxi and motorcycle while the categories: cycling, pedestrians and combination of modes are partially correlated with the youngest age group (18 or less) and zero income.

5. Connection of the study area with the inner ring road of the city

Egnatia Odos S.A. is responsible for all the transport projects of the Master Plan (MP) of Thessaloniki. The first phase of the MP (until 2015) includes the construction of the metro line, the upgrade of the inner ring road etc. One of the MP's objectives is to facilitate the commuters' trips by upgrading the transverse inbound/outbound roads of the traffic from the urban road network to the ring road network.

One inner ring road's junction of significant importance that is located in the wider area of the research is K8 (direction: Triandria). The traffic queues that are currently formed during critical parts of the day at the traffic lights that is located at the intersection of the vertical road axis (Katsimidou street) and the horizontal road axis (Ag. Dimitriou street) and connects the urban road network with the ring road, can be avoided by the tunneling of the through traffic.

The tunneling is considered feasible due to the suitable gradient of the vertical alignment of Katsimidou street. This way, at the aforementioned traffic lights, only the turning movements would remain; the queues would therefore be avoided. The underground part of Katsimidou street will reach the surface next to the Papafi's station. Hence, the project could be integrated with the construction of the metro station due to the fact that there are certain common attributes and relations (such as excavations, drainages etc.) that could form (small) economies of scale.

When the upgrade described previously takes place, it will have as a consequence that a portion of the traffic of Leoforos Karamanli (principal horizontal road access mentioned previously in the paper), the importance of which is beyond the limits of the study area, will be able to access the ring road and conversely. It is worth mentioning that according to integrated traffic measurements in the area, it was proved that approximately 50.00% of the turning traffic of Leoforos Karamanli heads to the ring road and conversely.

Therefore, it is estimated that the impact on the land use system of the area will be dual:

1. The role of Papafi's metro station will be upgraded, due to the highly increased accessibility from the ring road of the city. This means that either the passengers of personal vehicles would prefer to alight and take the metro from that point or that, supposing that sufficient parking spaces are provided, they would prefer to leave their vehicles there and continue their trip to Thessaloniki by metro. Moreover, the increase of the station's importance is likely to increase the commercial activity of the area and there is the possibility of the creation of small private parking spaces as a potential new business activity.
2. The fact that on the surface of Katsimidou street, only the local traffic will remain after the completion of the project, could mean the promotion and development of compatible land use such as restaurants and cafes.

6. Conclusions

In this paper, the objective was to examine the expected impact of the new metro line of Thessaloniki, and Papafi station in particular, on the land use of the area. This was achieved through analytical

recording of the land use system as well as through a Stated Preference survey. The collected data were analyzed quantitatively by the technique of Principal Components Analysis for Categorical Data which revealed interesting inter – relationships which were described previously.

This paper brings on surface the importance of identifying and analyzing the range of impact the construction of new transport infrastructure can have on land use in this country. Furthermore it proposes an approach in order to fulfill this objective by combining recording of the existing land use, SP survey as well as multivariable analysis. In addition to that, it emphasizes the necessity of taking into account parameters such as the future modifications of the city's street network towards the principles of the integrated transport planning. More studies would be necessary to be undertaken after the opening and operation of the metro station in order to capture the exact situation under those future circumstances and thus to be able to confirm the generalizability of the presented results qualitatively and quantitatively.

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