Effects of a new on-street parking management scheme on park-and-ride facility demand: a preliminary before – after analysis

Konstantinos Kepaptsoglou, Researcher- PhD Candidate, kkepap@central.ntua.gr
Matthew Karlaftis, Assistant Professor, mgk@central.ntua.gr
George Yannis, Assistant Professor, geyannis@central.ntua.gr

School of Civil Engineering, National Technical University of Athens
5 Iroon Polytechniou str, 15773, Athens, Greece,

ABSTRACT

This paper investigates the effects of parking policies in central urban areas to the demand for commuter park-and-ride facilities. In particular, the impact of the introduction of the new parking management scheme in the Athens central area, to the demand for parking at the Fix park-and-ride facility located at the city outskirts is investigated. Demand data for the periods before and after the introduction of the parking management scheme are analyzed, any other trend not related to the impact of the new parking scheme is removed and a non-parametric statistical test (Man – Whitney *U* test) is applied. These preliminary results provide evidence of the positive impacts of the new parking policy to the demand for commuter park-and-ride facilities.

KEY WORDS: Parking policy, Park-and-ride facility, before-after analysis, non-parametric statistical test

1. INTRODUCTION

In an era of car dominance, parking policies and management are critical for discouraging traffic from entering city centers, ensuring parking space availability and shifting passengers to other travel modes. On-street parking control and the establishment of park-and-ride facilities are among those measures undertaken for that purpose. Control of on-street parking implies limited parking duration and charge of a parking fee, increases parking capacity and is disincentive for drivers willing to drive and park in city centers. As for park-and-ride facilities, these are of major importance to the attractiveness and operation of public transportation systems; especially commuters tend to prefer driving to transit stations and use rapid transit to reach their final destination.

While the impacts of the aforementioned measures to traffic and city operations have been extensively investigated, research on the effect of the implementation of a parking measure to another is equally interesting. These effects can be critical upon deciding changes in policy measures or infrastructure operations; for example, enforcement of controlled parking in an area would lead parking station owners into changing their policy, in an effort to attract more passengers. In that context, the impact of parking control policies to the operations of park-and-ride areas is examined. In particular, the effects of the introduction of the Athens new parking management scheme on the Fix park-and-ride facility, located at the outskirts of the Athens central area are investigated.

The remainder of this paper is organized as follows. In the second section, a brief literature review of related studies is provided and next, the problem at hand is described in the third section. The fourth and fifth sections include the methodological approach and results and the study's conclusions are presented in the sixth section.

2. BACKGROUND

The literature on parking management and policies is vast; during the last decade numerous studies have examined and analyzed parking policies and their effects both to traffic and the operation of other elements of the transportation system. Among those studies, Bolanowska and Hemily (2001) , Willson (2005) provide critical reviews of transit supportive parking policies, while overall critiques of parking policies and management are given by Marsden (2006) and Litman (2007). Shiftan and Burd-Eder (2001) attempt to model driver response to these policies. The effects of parking policies on traffic flows in central urban areas of developing countries are examined by Khin *et al.* (2001). Petiot (2004) studies the relationship between parking enforcement and travel demand management. Wambalaba and Goodwill (2004) evaluate the impacts of shared park-and-ride garages and Shoup (2005) analyzes the differences in parking management between San Francisco and Los Angeles and highlights their differences. A comparison of the effects of parking policies versus congestion pricing is provided by Albert and

Mahalel (2006); the authors report that drivers are more sensitive to the increase of congestion tolls. Another study by Arnott (2006) analyzes the spatial competition between downtown parking policies and parking garages. The author indicates that spatial competition equilibrium is inefficient because parking garages have market power and therefore parking policies can alter that distortion. Morover, he examines underpricing of on-street parking and its effects towards the demand for off-parking. In recent studies, Li *et al.* (2007) model park-and-ride services of multimodal networks, Rye and Ison (2007) investigate impacts of maximum parking standards in Scotland and Willson and Menotti (2007) compare commuter parking versus transit oriented development. Overall, the review revealed only one study assessing the effects of parking policies to off-street parking and vice versa; however that case considered on and off-street parking in the same area on not the effect of parking management to commuter parking garages while only the relationship between commuter parking garages and transit oriented development has already been examined.

3. PROBLEM OVERVIEW AND PRELIMINARY ANALYSIS

The objective of this study is to analyze the potential effects of a specific parking policy (parking restrictions and/or on-street parking charging) to the operation of a commuter parking facility located at the outskirts of the Athens central area. The large, shared-use park-and-ride facility for the Athens metro system is located at the boundaries of the Athens central area – it is the "Fix" parking station (Figure 1).

Figure 1. Location of the "Fix" park-and-ride station (source: www.driveme.gr)

The Athens metro system had already a number of facilities of that type near stations in the suburbs of Athens, mainly serving metro users. However, this six-level station with a capacity of over 640 vehicles had specific characteristics that differentiated it from the rest of the park-and-ride lots such as its shared use by metro and other users, its proximitity to the Athens central area,

its densely populated surrounding area with limited on and off street parking availability and the fact that it is located at the limits of the Athens traffic restriction area (Athens ring).

The “Fix” parking station commenced operations in late 2005; in November 2006 a new parking management scheme was introduced in the Athens central area. Basic characteristics of the scheme involve pre-specified on-street parking areas for the central area residents and government usages and only a limited number of parking spaces for visitors. Visitors are charged a fee for on-street parking of a maximum duration of a few hours; the management scheme practically aims at prohibiting commuters from parking their vehicles to the central area for long periods. This paper intends to examine whether the establishment of the parking management scheme had any effect to the demand for parking at the Fix parking station. That demand (in weekly terms) is presented in Figure 2:

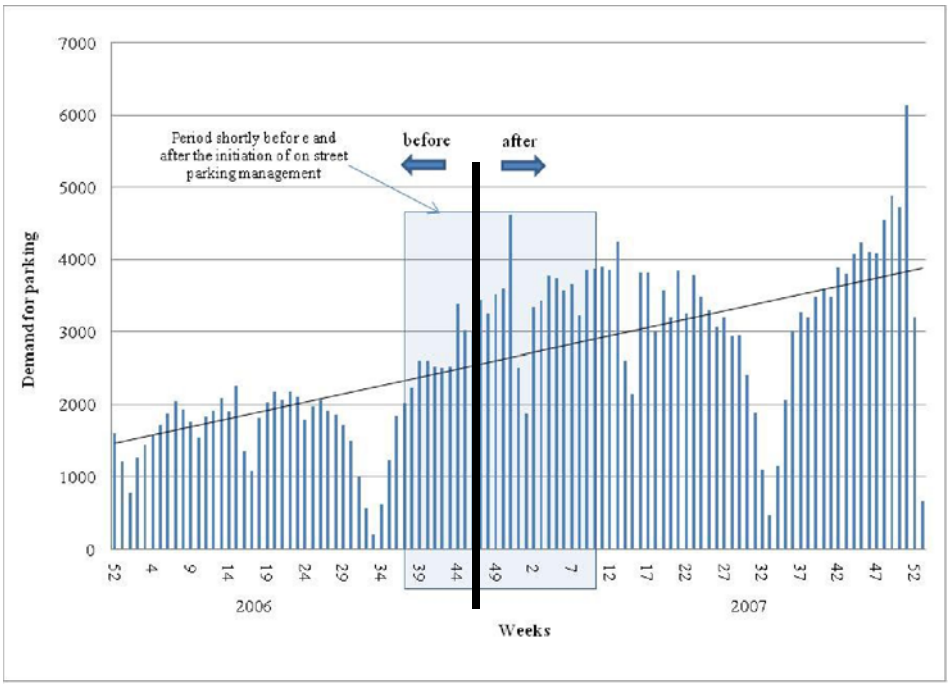

Figure 2. Weekly demand for parking at the Fix station (Dec 2005 - Dec 2007)

By inspecting Figure 2, the following can be observed:

1. Demand is constantly increasing since the operation of the parking station was introduced.
2. There is a seasonal variation of demand; valleys are observed in the periods of Christmas, Easter and summer vacations.
3. A preliminary view of the demand trend, before and after the implementation of the parking management scheme (week 46) implies a sudden rise in demand at that time – this is highlighted by a box on Figure 2.

A formal statistical analysis would imply checking whether differences in demand before and after the implementation of the parking management scheme are (a) statistically significant and (b) attributed to the parking management scheme or not.

4. METHODOLOGY

From a methodological perspective, the main interest focuses in explaining differences in demand between various time periods. In that sense, it is examined whether weekly demand values of different time periods of the operation of the parking scheme belong to the same or different statistical population. A non-parametric statistical test is applied for that purpose, the Mann-Whitney – Wilcoxon *U* (MWW-U) Test (Washington *et al.*, 2003). The strength of non parametric tests is that they do not rely on underlying assumptions regarding the distribution of the analyzed data. The null and alternative hypotheses of the test are the following:

H_0: The two sample distributions are drawn from the same population.
H_1: The two sample distributions are drawn from two different populations.

In order to obtain the test statistic, the two samples are combined and the set is ranked from smallest to largest. In cases of ties, an average rank of tied observations is assigned. The smallest observation is denoted as 1 and the largest as n. The sum of ranks for the first sample is R_1 and for the second sample is R_2. If n_1 and n_2 are the sizes of the two populations, the test statistic is calculated as follows:

$$U = n_1 \cdot n_2 + \frac{n_1 \cdot (n_1 + 1)}{2} - R_1 \tag{1}$$

The U statistic is a measure of the difference between the ranks of the two samples. The assumption that only location differences (mean or median) exist between the two populations and a large or small value of the statistic provides evidence of the difference in the location of the two populations. If samples are large (n_1,$n_2 \geq 10$), the U statistic can be approximated by a normal distribution. In that case, its mean value and standard deviation are given by:

$$E(U) = \frac{n_1 \cdot n_2}{2} \tag{2}$$

$$\sigma_U = \sqrt{\frac{n_1 \cdot n_2 \cdot (n_1 + n_2 + 1)}{12}} \tag{3}$$

and the large sample test statistic is given by:

$$Z^* = \frac{U - E(U)}{\sigma_U} \tag{4}$$

However, before implementing the test, there is need for removing any other trend not related to the impact of the new parking scheme and especially in this case the trend of increasing demand of the park-and-ride facility and take care of any seasonal inconsistencies. For that reason, the following periods for the analysis were selected – these periods exclude any particularly low demand periods such as long holidays:

- January 23st – April 9th, 2006 (weeks 4-14)
- May 18th –June 26th, 2006 (weeks 18-26)
- September 4th – November 12th, 2006 (Weeks 36-45)
- January 21st – March 31st, 2007 (weeks 4-13)
- April 30th – June 25th, 2007 (weeks 18-26)
- September 4th – November 24th, 2007 (weeks 36-47)

Additionally, the trend of increasing demand of the park-and-ride facility is removed by subtracting a linear estimation of the trend from the original data-set. The MWW-*U* test to the de-trended dataset is applied.

5. METHODOLOGY IMPLEMENTATION AND RESULTS

The data set is first divided into the "before" part (prior to Nov 16th, 2006) and the "after" part (after Nov 16th, 2006) and accordingly exclude low demand periods, as mentioned earlier. For "before" periods, there was an average weekly demand for parking equal to 2131±410 clients, while for the "after" period that average was increased to 3621±825 clients. By applying simple linear regression to the remaining data set, obtain a trend line of the following form is obtained:

$$\hat{Y} = 1591 + 42.08 \cdot X,\ R^2 = 0.78 \tag{5}$$

where $\hat{Y}$ is the estimate for the weekly demand and X is the week since the commencement of the parking station operations. If Y is the observed demand for parking, the trend of increasing demand of the park-and-ride facility is removed by calculating $Y - \hat{Y}$ values. These are depicted in Figure 3:

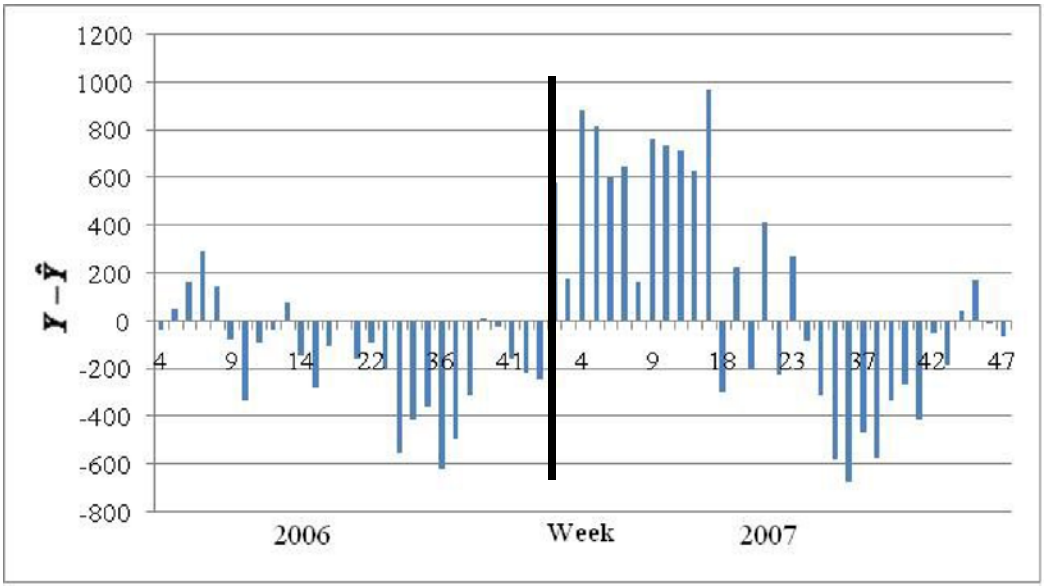

Figure 3: $Y - \hat{Y}$ values

Then the MWW-*U* test is applied for the $Y - \hat{Y}$ samples before and after the parking management scheme introduction date. Test results are shown in Table 1 (SPSS v.15 is used):

Table 1. Results for the MWW-*U* test

	Samples	N	Mean Rank	Sum of Ranks
$Y - \hat{Y}$	Before	30	27,47	824,00
	After	31	34,42	1067,00
	Total	61		

	Statistic
Mann-Whitney U	359,000
Wilcoxon W	824,000
Z	-1,529
Asymp. Sig. (2-tailed)	,126

Table 1 results indicate that the null hypothesis of the same population for the “before” and “after” cases can be rejected; this implies that location differences exist for samples before and after the implementation of the parking management scheme. Therefore, there is evidence that the parking management scheme of the Athens central areahad an effect to the demand for the “Fix” parking station.

6. CONCLUSIONS

The aim of this paper was to provide preliminary evidence of the effect of parking policies to the demand for commuter park-and-ride facilities. The statistical analysis, based on de-trended

demand data obtained for the periods before and after the implementation of the new parking policy, revealed that that policy positively affected demand for the park-and-ride station. A more detailed analysis would also indicate any particular seasonal effects that policy might have had to the station's demand for parking; this is set forth as potential future research when additional data will be available.

REFERENCES

Albert, G; Mahalel, D (2006). Congestion Tolls and Parking Fees: A Comparison of the Potential Effect on Travel Behavior. *Transport Policy*, 13(6), 496-502.

Arnott, R. (2006). Spatial Competition Between Parking Garages and Downtown Parking Policy, *Transport Policy*, 13(6), 58-469.

Bolanowska, M; Hemily, B (2001). Developing transit-supportive parking policies: A synthesis of key concepts from the literature. *Report*, Canadian Urban Transit Association, Canada

Khin, E.C., Sakamoto, K., Kubota, H. (2001). Parking policy and its effects on traffic flow in CBD areas in developing countries, *Selected Proceedings of the 9th World Conference on Transport Research*, Elsevier UK.

Li, Zhi-Chun, Lam, W., Wong, S.C., Zhu, D.L., Huang, H-J. (2007). Modeling Park-and-Ride Services in a Multimodal Transport Network with Elastic Demand. *Transportation Research Record: Journal of the Transportation Research Board*, 1994, 101-109

Litman, T. (2007). Evaluating Parking Management Benefits. *Proceedings of the Transportation Research Board 86th Annual Meeting*, Washington DC, U.S.A.

Marsden, G. (2006). The Evidence Base for Parking Policies-A Review. *Transport Policy*, 13(6), 447-457

Petiot, R. (2004). Parking Enforcement and Travel Demand Management. *Transport Policy*, 11(4), 399-411.

Rye, Tom; Ison, Stephen (2007). Use and Impact of Maximum Parking Standards in Scotland. *Proceedings of the Transportation Research Board 86th Annual Meeting*, Washington DC, U.S.A.

Shiftan, Y., Burd-Eden, R. (2001). Modeling Response to Parking Policy. *Transportation Research Record: Journal of the Transportation Research Board*, 1765, 27-34.

Shoup, D. (2005). San Francisco and L.A.: Parking makes the difference. *Planning*, 71(1), 36-37.

Wambalaba, F., Goodwill, J. (2004). Evaluation of shared use park and ride impact on properties. *Report*, National Center for Transit Research and Florida Department of Transportation, U.S.A.

Washington, S.P., Karlaftis, M.G., *Mannering, F.L.Statistical and Econometric Methods for Transportation Data Analysis*, Chapman & Hall / CRC Press, Boca Raton, FL.

Willson, R. (2005). Parking Policy for Transit-Oriented Development: Lessons for Cities, Transit Agencies, and Developers, *Journal of Public Transportation*, 8(5), 79-94.

Willson, R., Menotti, V. (2007). Commuter Parking Versus Transit-Oriented Development: Evaluation Methodology. *Transportation Research Record: Journal of the Transportation Research Board*, 2021, 118-125