# PARKING TRAGEDY OF THE COMMONS: THE CASE OF ISTANBUL

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**ABSTRACT**

A car needs two types of parking space. The first one is permanent, where it is parked after all daily errands or activities are carried out, near the place of residence most of the time, and generally restricted to night-times. The second one is temporary while carrying out daily errands or pursuing activities of various types. Carried out in a fast motorizing city, Istanbul, the study highlights perplexities of parking behavior when streets are regarded as de facto free parking spaces for privately owned vehicles too. Two descriptive models of parking behavior are developed in the study. The first model is a Multinomial Logit model for night-time (permanent) parking location choice among three alternatives: On-Street Parking, Off-Street Private Parking, and Paid Parking. The other model uses structural relationships for temporary parking location in the case of discretionary activities. When controlled for other variables, increasing paid parking supply in districts attracts demand for night time paid-parking. Assuming that income elasticity of discretionary activities in terms of time, destination and trip mode points to their flexibility, together with the results affirming that supply of paid parking affects different aspects of activity participation, pricing and supply of paid parking are good policy directions that deserve further research.

## INTRODUCTION

Istanbul, which is the largest city in Turkey, encompasses nearly 15 Million people along with a high rate of motorization lately. Between 2004 and 2009, the number of passenger cars registered in Istanbul increased by 95 per cent—yet their number is still below 150 per thousand people in 2013. A steady increase in GDP per capita in the last decade and projected single digit positive figures into the next gives a strong message that the car ownership in Turkey as well as in Istanbul will rise without no doubt. If business as usual practices continues, accompanying parking problems of this motorization trend will reach to domains of no solution, especially in the case of Istanbul.

Hopefully, in a typical developing country like Turkey, Istanbul still enjoys a high rate of public transit usage, which is still around 70 per cent for the past 30 years (*1*); this means car usage and its direct consequence, parking demand are below their potentials (for the time being). Reasons of this high transit usage rate might be found in the heavy traffic conditions, especially in the city center, on the one hand, and in heavy investment in public transit systems by the metropolitan administration and the central government, on the other—congestion and transit investments create push-pull forces on travel behavior that support high transit usage (*2*, *3*).

While metropolitan area transportation network is expanding and improving in many ways, parking demand is said to be below its potential due to trips avoiding private car usage during specific hours of a day and to certain destinations of the city. Nevertheless, one can easily observe that parking problem has risen to unbearable levels, especially in the inner city areas in the last five years. Therefore, one might say that parking problem contributes to high transit usage. However there is no guarantee that the steady increase of car ownership will never ignite (high rates of) car usage in the near future. Thereby, increasing traffic will demand more space for cars at rest, not to mention space for moving cars; indeed, the real problem is the lack of space. According to a survey conducted in 1999—Millennium Cities Database for Sustainable Transport compiled by International Union of Public Transport (UITP), road length per thousand people in Istanbul is 554 km, which is nearly half of the average of the cities in developing country, which is 1156 km. (cities in developed countries has 4182 km of road length per thousand people). Therefore, even if expectations foresee improvements in the transport system infrastructure, by new tunnels, bridges, or rail systems, in the near future, one has to consider how the expected increase in parking demand by ever increasing private car ownership and motorized private traffic will be met in terms of parking supply.

In order to pave way into the future, the current situation of parking demand should be made clear in terms of different aspects. Accordingly, this paper deals with the demand-side parking problems in Istanbul in a descriptive way. The paper approaches parking behavior by differentiating night-time parking which is related to private car ownership and day-time parking behavior which is related to private car usage. One can easily deduce that private car ownership and its usage have different behavioral backgrounds. While night-time parking behavior is directly related to car ownership and in-home activities, day-time parking behavior, on the other hand, is intrinsically very complicated and diverse in nature due to numerous prospective activities connected by daily activity-travel behavior of households and individuals.

We rely on the household-person database collected in Istanbul in 2006. Database includes both car-ownership level and night-time parking location of cars owned by each household. Besides, from person-trip behavior, day-time parking of cars can be followed by tracing private car trips. To work out the task defined, this paper is organized in six parts. The second part reviews historical evolution of parking policies in the world, not in an exhaustive way, but by certain approaches adopted globally. The third part sets the backdrop by summarizing the motorization in Turkey and the causes of severe parking problems in Istanbul. The fourth and fifth parts deal with night-time and day-time parking behavior respectively. Conclusions, but more discussion, are to follow in the last part.

## EVOLUTION OF PARKING: FROM TRAGEDY OF THE COMMONS TO EFFECTIVE AND MARKET SOLUTIONS

Policies and regulations regarding parking go back to the mass introduction of private cars in urban areas. Earliest examples can be found in the U.S. For example, park metering were first introduced in Oklohama City in 1935 (*4*). Parking minimums set by zoning were also instituted in the U.S. firstly In Europe, motorization and the introduction cars to the historic cities fueled important revisions in planning approaches too. The most famous is the Athens Charter which ushered European cities into

motorized ways of life, especially during the post-war (and welfare state) years, through suburbanization and hierarchical road systems (*5*).

Heretofore, two different parking approaches developed in the industrialized world. While in North America, cars are allowed and permitted in city centers (*6*), in Europe, on the other hand, cars are not allowed into (the historical) city centers. The second approach relied mainly on public transit and pedestrianization of the city centers (*7, 8*). However, no city was able to meet the (further aggravating) parking demand after the war, fueled by welfare state, fast motorization, and suburbanization. Especially, suburbanization and motorization interacting with each other positively have caused urban sprawl in the industrialized world consistently.

Parking minimums annexed to zoning and gauging demand with supply by metering parking began to change after enactment of The Clean Air Act in U.S in 1970s. Cities in the U.S. began to take effective actions in order to meet air quality standards especially in the city centers. These efforts were contemporaneous with the oil shocks that changed the public view toward private transportation. Instead of parking minimums, city governments began to institute parking maximums and caps, and began to diversify parking policies in relation to public transit accessibility as well. Nowadays, parking management and parking supply are regarded as effective and integrative tools of transportation demand management. A history that depends on an evolutionary path (interacting with the greater forces such as motorization, suburbanization, and air quality and energy considerations) enables us to define three different spheres of parking supply approaches (*9, 10*):

1. Conventional approach,
2. Parking management approach,
3. Market-based approach.

According to conventional approach, there is no consideration of taming parking demand; instead, parking supply is gauged to meet parking demand. The basic tenet of this lies in meeting the demand wherever it emerges; its basic instruments are parking minimums and zoning. Conventional approach may be further diversified into two sub-approaches, (i) Auto-centric approach, and (ii) Demand-realistic approach (*9, 10*). The difference between these two sub-approaches lies in their approach to sensitivity to the demand. Auto-centric approach assumes a homogenous parking supply by establishing parking minimums without considering variations in the demand. Demand-realistic approach assumes more realistic outlook by trying to find how parking demand fluctuates and to meet the demand according to its intensity.

However, parking management approach signifies divergence from conventional approach by adopting strategies in order to tame parking demand. To do so, travel behavior has to be understood and its sensitivity to certain parking policies has to be evaluated. Accordingly, public transit system and parking strategies has to be coordinated. Either a focus area which has to be cleared of motorized traffic or more generic management strategies may be considered under parking management approach. A significant improvement over conventional approach comes with broadening outlook into the parking problem, by putting areal policies ahead of parking policies focusing on individual buildings, which makes parking policies shortsighted and insensitive to broader policies.

Although examples of market-based approach has been there from 1930s, there were limited in scope indeed, either limited to downtown areas where parking metering was used to increase turn over, thereby parking supply. As a separate approach from both of the previous ones, market-based approach here endorses a uniform application of full cost accounting of parking at market rates. From conventional to market based approaches, one can see a significant shift from supply side policies to demand side policies.

Indeed, parking problem resembles traits of tragedy of the commons in many respects. As motorization increases, parking problem not only encroaches on public space (i.e., streets), it supersedes pedestrians and public transit as a direct outcome of insatiable car use. Policies that are used to control parking in certain areas makes parking a serious problem in adjoining areas. Therefore, broader outlook and market solutions have gained upper hand all over the world in terms of parking policies.

## PARKING IN ISTANBUL

Recently, passenger car ownership in Turkey has increased tremendously. In 17 years from January, 1995 to January, 2012 number of cars owned has increased from 2,876,616 to 8,185,556 which equals to a mere 2.8 times increase, while population increased only 1.33 times from 1990 to 2012.

Although the actual figures have increased a lot, passenger car ownership is still in its infancy when one considers that the increase has been from nearly 45 passenger cars to around 110 passenger cars per thousand people from 1995 to 2012. The increase in passenger car ownership has first gained momentum in provinces such as Istanbul and Ankara, where per thousand people passenger car ownership levels has reached 138 and 198 as of 2011, respectively. When these figures are compared with those in Europe of in North America, one can notice that private car ownership in Turkey is still in its infancy. Considering the economic growth and increase in household incomes in the near future, according to projections made worldwide (*11*) one may estimate that the low levels of passenger car ownership is on the verge of fast increase in Turkey in general, especially in Istanbul. Then, our concern focuses on whether Istanbul is ready for this surge or not. In terms of current traffic and parking problems, one can say that Istanbul is not ready for a predominant private motorized ways of life.

In fact, parking regulations in Turkey, which are auto-centric conventional unequivocally, go back to 1966. The first parking regulation in 1966 instituted strict parking requirements for all types of housing. However, public opposition caused replacement of the regulation by a new one in 1968, which revoked all parking minimums (*12*). Parking regulation in 1976 replacing 1968 regulation set minimums for residential apartment houses (one parking space for four apartments). This minimum standard has reached 1990s unchanged.

In the meantime, urban form of Istanbul has undergone densification by intermittent demolish-build cycles and incessant urban infill. The result was a significant shortage of parking space, which encouraged de facto use of public spaces, mainly roads, as parking areas. Off-street private parking was generally reserved in front or rear set-back areas in building parcels. Urban sprawl, on the other hand, was generally based on squatter housing and supported by privately operated paratransit minibuses—in these areas, there was no respect for modern planning standards; thereby, the built environment in squatter areas came with no parking area and road structure suitable for modern means of transport. Later, after development pardons mainly in 1980s, squatter houses were also included into demolish-build cycles, which further increased urban densities.

As regards day-time parking, on-street free parking is generally is the norm. However, localities with severe parking shortages have attracted (public and private) paid parking supply overlooked by the municipality, e.g., school gardens on the weekends, holidays or after school hours. Lately, municipality reacted to parking shortages in central areas, regulated street space where suitable (mainly on main streets) and established paid parking structures, both on-street or off-street.

ISPARK, semi-private establishment of Istanbul metropolitan municipality, has been established in 2005 to maintain and operate these parking structures. By instituting both on-street (most of which are operated during day times, generally between 09:00 AM–5:00 PM—there are exceptions to this in certain areas where heavy traffic continues through late night) and off-street paid parking areas, ISPARK has reached a total of more than 140,000 paid parking space for passenger cars, most of which are in the inner city areas.

Although municipality, through ISPARK, has become improved its effectiveness in parking management, parking supply is well behind the demand. The shortage for both day-time and night-time parking has created a profitable environment for private investments too. Especially, densely built, high income, central neighborhoods have attracted off-street parking investments by the private sector, which offer various types of subscription models to nearby residents and businesses too.

Although there is a consensus that parking supply should be controlled to control demand for parking, this seems over-optimistic as parking regulations are enacted by the central government as an attachment to planning law, local government is only entitled to increase parking minimums, which restricts municipalities to demand realistic conventional approach.

## NIGHT-TIME PARKING IN ISTANBUL

Night-time parking in Istanbul is closely related to car ownership and its distribution. As opposed to cities in the developed world, car ownership increases in the central areas. There are lower levels of car ownership in the inner city areas too. However these regions are generally densely populated, lower income built areas generally confined to the European side of the city and in the immediate vicinity of CBD areas. These areas have been mainly subjected to intermittent densification through demolish-build cycles.

An interesting relationship in Istanbul can be found between levels of car ownership and on-street parking. Districts with lower levels of car ownership exceed those with higher car ownership levels in terms of on-street parking behavior. Districts with highest levels of on-street parking and lowest levels of car ownership are all in the European side, neighboring central districts. This makes quite a sense in terms of urban development as all of these districts are subjected intensive densification in the last 40 years. This partially supports the conjecture that a significant portion of the (night-time) parking shortage in Istanbul lies in districts converted from squatter areas. Wealthier districts of Istanbul with lower rates of on-street parking are generally in the Anatolian side, where urban development had based on larger parcels historically. This enabled high rise apartment buildings or complexes with lower footprint ratios and longer set-backs distances from neighboring plots suitable for off-street parking (even parking supply in these districts fall short of parking demand).

As regards temporal aspects of night-time parking in residential districts, according to person-trip data (compiled from Household Travel Surveys conducted in 2006), 75 per cent of all cars are parked after 17:30; at 19:00, 50 per cent of cars have yet to be parked, which reduced to 25 per cent at 20:30, 5 per cent at 22:30. Private cars are parked for an average of 14 hours—the standard deviation of average parking duration is 3:30 hours—note that Computation of average night time parkings base on an important assumption as person-trip data only have one-day data; according to this assumption, departure from home in the morning is assumed to be same for the next day.

Considering night-time parking durations with respect to districts, it is seen that central districts and outlying districts display longer night-time parking durations—city center districts have night-time parking durations 40 minutes longer than the average, while outlying districts have 90 minutes longer night-time parking durations. One of the reasons for longer night-time durations in these districts might be shorter trip durations in these districts. 50 per cent of all passenger cars end night-time parking at 8:00 AM, another 25 per cent is to start engines in an hour. At 2:00 PM, only 5 per cent of all parked cars can be found parked from the previous day.

## Multinomial Logit Model of Night-Time Parking Choice

In terms of night-time parking, parking behavior of households for three alternative parking types, i.e., On-Street Parking, Off-Street Private Parking, and Paid Parking, are modeled using Multinomial Logit Model. On-Street Parking is the predominant form of parking in Istanbul (62.9 per cent). Only in three districts, on-street parking ratios are between 35 and 50 per cents. Off-street private parking is generally distributed in reverse order with respect to on-street parking: in districts where off-street private parking is high, on-street parking is low, and vice versa. Households resorting to paid parking are below 10 % in all districts, except Fatih, Eminönü and Sisli districts where paid-parking are 19, 15, and 14 per cents, respectively. Fatih and Eminonu together both constitute the historical peninsula, the Constantinople proper area. These districts have the highest paid parking capacity in Istanbul: 226 out of 971 open, 51 out of 171 closed parking structures congregates in Fatih and Eminonu districts. Sisli is a mixed land use district in the CBD area; luxury commercial shops and offices congregate along with residential units. Three of the districts are popular destinations for day-time trips, therefore paid parking investments in these districts are expected to be profitable.

As regards the independent variables that are hypothesized to have pertinent effects on night-time parking location, housing type seems to be closely related to night time parking location choice. Three house types are differentiated so far: i.e., apartment house (80.1 per cent), single-family house (8.5 per cent), and apartment complex (11.4 per cent)). Mostly, apartment houses are without suitable parking supply in densely built (or demolish-build cycle created) neighborhoods. Therefore, apartment houses are expected to inflate on-street parking more than other housing types. Although there is variation in terms of parking capacity, apartment complexes usually provide off-street private parking space for residents. Lately single-family houses come with reserved parking spaces, especially those for the higher end of the market; but those single-family (cooperative) houses built in 1980s, were generally without additional space for parking that incur additional land cost.

A car parked on-street is open to thefts, not to mention other dangers they are posed to, if not closely monitored. Although many households have little choice but to park on-street, they may be more inclined to park a newer car, either at a private parking or at a paid parking. 35.3 per cent of cars in the sample can be labeled as new (0−4 years), another 34 per cent constitute the moderately new cars (5−9 years), while the rest are labeled as old cars.

On the other hand, income is another source inducing change in parking behavior. A consistent decrease of on-street parking comes with increasing income: while 70 per cent of low-income households (48.2 per cent of the sampled households) prefer on-street parking, the ratio monotonously decreases to 39 per cent for high income households (6.2 per cent of the sample households)—low income households have less than 750 USD monthly income per month, which is 2,500 USD for high income households.

Buying a house is a decision arrived by considering broader set of criteria than renting a house (70.6 per cent of the sampled households are owner-occupiers). Consideration inevitably includes parking convenience. For example, Guo (2013) reports on positive effects of parking convenience on residential location choice (*14*). Further, Stubbs (2002) based on data collected in U.K. reports that if households move, a considerable share prefers more parking space (*15*). Then, our expectations favor garage parking in cases when households own the house they live in.

In terms of location, a stark difference between European and Anatolian sides of Istanbul surfaces when it comes to parking supply. Because of the reasons explained above, we expect more on-street parking in the European side.

The last three variables used in the model are Population Density (population per hectare), Automobile Density (number of cars per 1000 square mt.), and Cars per Paid Parking Space (number of cars per paid parking capacity). All of these variables are good proxies for on-street parking. As We expect that as population Density (average: 20.87, std.dev: 12.57) in a district increases, open space for off-street private parking decreases. When Population Density is controlled, increasing Automobile Density (average:1.88, std.dev. 1.64) may stand for tight conditions for both off-street private and on-street parking. Another density variable concerning private cars is measured by Cars per Paid Parking Space (average: 81.77, std. dev.: 194.46), which represents availability of paid parking space for night-time parking.

Estimation is carried out by SPSS 21 software. Model is estimated by setting Paid Parking alternative as the reference category, which sets the relative zero utility point for all other alternatives. Table 1 gives estimates of the coefficient values for all of the variables included into the model. The model with only alternative specific variables is significantly improved by the inclusion of the model variables (-2*L*=5,106.38 with 26 degrees of problem).

*TABLE 1 AROUND HERE*

According to estimates of the constant variables for two of the categories, households refrain from Paid Parking as it comes with monetary costs, and they are more inclined towards Off-Street Private Parking, which secures the private car at a (relatively) secure parking space. On-Street Parking seems to be a compensated version of off-street private parking if the private car can be closely monitored and accessed from the house.

Housing type gives different results for both On-Street Parking and Off-Street Private Parking. It seems that apartment complexes are equipped with off-street private parking, as households are more inclined to use off-street private parking at apartment complexes. On the other hand, in densely built Istanbul, apartments along with single family houses lend themselves to On-Street Parking. Intuitively, newer cars compared to older cars are more inclined to be safeguarded at secure parking locations. Generally, households opt for Paid-Parking (more than Off-Street Private Parking). When one switches to household income, the estimates turn out to be insignificant for Off-Street Private Parking. But for On-Street Parking, household income holds significant effects, which favor low income households going for On-Street Parking more than higher income households.

Owning and renting a house produce asymmetric results in terms of parking behavior: a rented house supports On-Street parking, while owned house goes for Off-Street Private Parking. This asymmetric behavior might bear information regarding non-included variables of housing choice. Quite normally, households reckon on a broader area of consideration when owning a house rather than renting one. Decision regarding buying a house draws on on a longer term, this term normally includes prospects of owning a private car too. Therefore, households might be more inclined to rate housing with an exclusive parking area higher into their buying decisions. Renting a house, on the other hand, is relatively a shorter term decision. Therefore, households may conform to deficiencies of the house and services supplied in the environment given the temporary nature of house.

Locational variables are included in order to control for high degrees of variation in terms of parking behavior in the metropolitan area. The first locational variable specifies location of the

residential district with respect to the Bosporus. European side is consistently denser in terms of population density, besides most of there are more work locations in the European side. Two sides of Istanbul, seems to have different paths of urban development in the last 150 years. Anatolian side has a history of urban development on larger plots of 19th Century Villas, demolish-build cycle of which has produced more spaces for Off-Street Private Parking per individual parcels. European side did not have such kind of villas in their populated areas, where demolish-build cycles produced smaller parcels for buildings (*13*). However, these developments occur in formally built areas of Istanbul. If we turn to squatter areas, which are informally built by masses of migrants from all over Turkey, there is little variation across both sides of the Bosporus. After development pardons, urban transformation in squatter areas had produced very dense urban areas, which generally neglected basic infrastructure and the commons—parking is part of the commons according to Development Law.

The second locational variable represents districts with high paid-parking capacity; namely, these districts are Eminonu, Fatih, and Sisli, which are mentioned above. Lastly, altogether, seven districts out of 33 are specified as city center districts—two districts are on the Anatolian coastline. City center districts constitute dense, mixed land uses; therefore night-time behavior is expected to be different in the city center. We believe that after controlling for locational variables, parking behavior of households regarding remaining non-locational variables might truly represent their behavior-inducing power.

Anatolian side is more supportive for parking other than paid parking. Two reasons might be given for this. Relatively higher household car ownership and low level of paid parking in the Anatolian side districts supports this result. In districts where paid parking capacity is relatively higher, it is found that households choose paid parking. This finding is also supported by city center districts, where paid parking is preferred with respect to other parking types by households.

As regards spatial variables regarding densities, we find that high population density which means less open space for free or reserved parking, drives the demand for Paid Parking. Automobile Density, a proxy for cars searching for parking areas in a delimited area turns out to be significant and positive for both non-paid parking type choices. Interpretation of this result can be given along with the distribution of car ownership per thousand people which increases as one gets closer to the Bosporus on both sides. This is mostly because of traditional location of high income groups in or around the Bosporus. We already know that central areas have less open space for car parking; therefore as demolish-build cycle proceeds, development becomes more sensitive to supply of off-street private parking space. Alas, parking supply is well behind parking demand in all districts, which supports on-street parking consistently.

## DAY-TIME PARKING IN ISTANBUL

During day-time, on the other hand, parking behavior diversifies and complexity prevails. Besides long-duration parking at work places (compulsory activity), there is short term parking behavior at various activity centers. Compulsory activities such as paid work and school are activities generally associated with fixed durations, which are significantly longer than the rest in terms of duration. 50 per cent of parking durations for paid work and school activities are shorter than 9:15 and 5:25 hours, respectively (Table 2).

*TABLE 2 AROUND HERE*

Apart from paid work and school, shorter durations prevail for other activities, thereby, one hour parking duration prevails (in terms of median statistics). When we turn our focus to locality of the trips, out-of districts trips do not pose any extension in terms of compulsory activities, but there is a clear increase for non-compulsory ones. For example, parking for both shopping and medical care (maintenance activities) increases nearly 35 minutes in districts other than the residential district—non-local car trips for maintenance activities constitute 66 per cent of all. However, it should be noted that non-locality is expected to increase as one gets closer to the city center—districts size decreases in the city center.

Parking durations are not that important unless parking behavior is entangled in terms of day-of time behavior. All activities show a clear downward trend in parking durations in the afternoon, however with divergent characteristics. For only compulsory activities, parking has reached its 75 per cent before noon (9:35 and 11:10 for work and school, respectively). The rest of the activities reasonably seem to be pursued in the afternoon as 50 percent of parking for these activities wait for

afternoon. While parking duration for paid work decreases monotonously, for school and shopping activities, parking durations have bumps at noon.

Although night-time parking in Istanbul consistently reduces to a single location around residence, day-time distribution of parking behavior among different activities and localities display a fragmented pattern with respect to the distribution of activities pursued. However, as destinations of day-time activities are predominantly in the inner city districts, one can easily conclude that the parking supply will be in dire straits in terms of parking demand in these districts. For example, let us take Kadikoy—the inner most district on the Anatolian side, neighboring the southern tip of Bosporus, day-time activities other than paid work attract nearly 35,000 car trips daily, which overwhelm limited number of parking space and overtake pedestrian areas, conflict with public transit and flowing traffic.

## Structural Equations Model of Day-Time Parking Behavior for Discretionary Activities

Day-time parking is embedded into or an integral part of daily activity-trip behavior of car users. Previous section gives a clear indication that parking durations, thereby activity durations, change with respect to time of day. More precisely, durations are longer in the morning consistently. Parking duration is longer for non-local activities too. Given the time and money costs incurred to reach an activity at a non-local location, activity pursuer might be more inclined to invest longer duration in the non-local activity. However, parking availability is the first aspect for a decent activity participation—by parking availability, we may refer to parking space that is made available to park legally. But any instituted parking space might be of no use for an activity that is supposed to take longer than limited parking duration. Therefore, duration of parking is another aspect for a decent parking. If all these are satisfied, parking will satisfy the activity in consideration in terms of duration.

However, we have not mentioned about the distance that is supposed to be walked to the final destination, unless there is faster means of access than walking. Even if available parking space that matches activity duration is found, it might be ruled out because it calls for walking beyond the activity pursuer may bear. Any available parking space that fits to the activity duration is worth searching with respect to activity characteristics.

Generally for compulsory activities, parking supply is miscellaneous. Generally employer supplied parking rules out effects of paid parking. In extreme cases where there is severe parking shortage, employees generally resort to public transit or employer supplied shared buses. Among remaining activities that are associated directly with a facility, e.g., hospital or supermarket shopping, other than discretionary activities generally comes with free parking. Although there are some elasticity in terms of activity location and timing for these activities, we believe that paid parking is more effective on Discretionary activities (social, sports and entertainment) which are more elastic than all other activities in terms of day-time parking behavior given the diversity of associated facilities.

A discretionary activity that has many substitutes elsewhere might be less pursued by people with car if it is in dire straits in terms of parking availability. A popular activity that does not have any substitutes at the same dire-straits location might provoke transit usage. Therefore parking becomes an important leverage for discretionary activity participation if there is a parking shortage or not (and if it comes free or not as well). This might be translated into different behavioral adjustments in an environment where parking is regarded as a free of charge by the general public.

A simple structural equations model is devised in order to peek into these considerations, however very limitedly. We skip providing standard equations here thanks to the extensive literature in structural equations literature (*16-20*). For trips by private car, a destination choice is associated with paid parking supply, time of day and activity duration (or which is a proxy for parking duration in our case). In Istanbul, destination choice set in terms of discretionary activities increases in the European Side. In an ordinary activity participation model, destination choice might be affected by activity type. On the other hand, activity duration, which is assumed to be a proxy for parking duration, is affected by destination choice. Both are assumed to be affected by parking supply (Figure 1).

Considering activity type, it is nearly straight forward that mandatory (work and school) and discretionary activities differ in durations, with the latter shorter than the former. Type of activity and their flexibility in time and space means that a flexible activity might be pursued somewhere else, which explains variation in destination choice and time of day. Moreover, degree of flexibility of an activity has effects on activity duration, thereby on parking duration.

Two variable groups are used in the model: continuous and dichotomous variables, simultaneity of which is addressed by ADF-WLS estimation method used (*16-20*). However, one drawback of the estimation method might be the missing value problem; we have excluded cases which include missing values in the original data source, which leaves us with a sample size of 10,335 private car trips. In terms of dichotomous variables, most of the trips begin in the morning hours (71.6 per cent before 12:00 AM); most of them are contained in the European Side (66.6 per cent). A tiny fraction of the trips choose destinations locally (9.7 per cent), in the neighborhood. 20.2 percent of trips fall into discretionary activities. As regards the continuous variables, on the average, activity duration is 6.26 hours (std.dev.: 4.34). Average paid parking capacity in districts is 493 spaces with standard deviation at 406 spaces—note that the variables is multiplied by 0.01 for model estimation. Model results of both direct and total effects are presented in Figure 1.

In a city like Istanbul, where the public parking is regarded as a right per se (and free thereby), one may obtain a counter intuitive result that has negative effects on activity duration (for the district where parking capacity is maximum, the negative effects means 25 minutes shorter discretionary activity participation). Other negative results are obtained for the effects of paid parking and activity type on time of day decision. This should also be assessed in the context of Istanbul, a city in a developing country. People are used to free parking as in the past; especially for longer durations of parking. Normally, this kind of parking is generally also associated with discretionary activities that incur shorter parking durations. Together with the result obtained for the effect of paid parking capacity on discretionary activities, paid parking is associated with shorter activities.

One another result that has a reflection in the case of Istanbul is obtained in the case of local trips. Neighborhood is regarded as the sole area where car parking is seen as a right by residents for at least two reasons. The first one derives itself from the familiarity of the neighborhood where one lives. Even in the center city areas, where there are severe parking shortages, resident is more aware of free parking strips or areas where to park. The second reason derives itself from parking regulation that requires local governments to provide local free parking for resident populations. These results indicate the paradoxical nature of the parking behavior in a developing economy. Regulation falls short of the motorization trend and it is not effective to change general understanding of parking as free public good. Acceptance of free parking, wherever possible, gives rise to the result of parking tragedy of the commons. Another positive effect of parking capacity is obtained for destinations on the European Side. European side hosts most of the trips as well as the population and employments. European side also suffers from parking shortage. Wherever available in Europe, paid parking is more attractive than Anatolian side.

## CONCLUSIONS REGARDING POLICY IMPLICATIONS

One of the most significant results obtained in terms of night-time parking is the supply of paid night-time parking demand. When controlled for other variables, increasing paid parking supply in districts attracts demand for night time paid-parking. This is mostly related to a peculiarity that private car ownership increases in central cities as opposed to other European cities, like European cities, city center in Istanbul is dense (e.g., *21*). During the years of fast urbanization between 1960 and 1990, Istanbul has witnessed a tremendous increase in the built environment, both horizontally and vertically. Demolish-build, infill and squatter developments had produced dense urban environments; virtually, the city imploded.

Up to this time, parking regulations have changed in a number ways, missing one point consistently: parking exemptions. A building if not suitable for parking can be excluded from parking requirement with in lieu payment, which is to be used for constructing general parking areas in a district. Parking exemption has been used extensively in all over Istanbul. This has inflated the parking problem by increasing on-street parking. This is more evident especially nowadays as private car ownership is on the surge. The advantage of secured parking comes at this point, when search cost for a suitable night-time parking is high. Given that most of the apartment complexes with adequate parking spaces are in the outlying areas, supply of paid parking or other models of secured parking for private car owners in the central areas opens multitudes of opportunities to contain parking shortage.

Together with other variables, policy endorsing paid night-time parking in districts should be gauged to fit different income levels in districts. Thereby, given that households are willing to pay for secured paid parking, variable pricing applied in different districts or establishment of pricing zones will be the most suitable policy option here. Selection of districts for paid parking supply might take

locational (Anatolian Side vs. European Side, City Center) and spatial characteristics of districts (various density variables).

More than 75 % of all private-car trips are headed non-local destinations, however locality of trips arises when one considers (administrative) districts, which is over 50 % for school, shopping, and social, sports and entertainment trips. Any parking policy that aims to decrease car use has to consider this, before instituting district based permits.

According to the results obtained by structural equations model, policies adopted should choose one of the approaches given in the second section of this study. Assuming that people continue to engage in discretionary activities even if they do not use private cars, possible policies might assume parking management and market-based approaches, though they may come along with contradictory policies. Assuming that income elasticity of discretionary activities in terms of time, destination and trip mode points to their flexibility, together with the results affirming that supply of paid parking affects different aspects of activity participation, pricing and supply of paid parking are good policy directions that deserve further research.

**REFERENCES**

1. Istanbul Metropolitan Municipality (IMM) *Transportation Master Plan Household Survey (OD HH 2006)*. IMM, Istanbul, 2008.
2. Istanbul Metropolitan Municipality (IMM) *Transportation Master Plan*. IMM, Istanbul, 2011.
3. Alpkolin, P., and M Ergun. Istanbul metrobüs: first intercontinental bus rapid transit, *Journal of Transport Geography*, 24, 2012, pp. 58–66.
4. Weinberger, R., J. Kaehny, and M. Rufo. *U.S. Parking Policies: An Overview of Management Strategies*. Institute for Transportation and Development Policy, New York, 2010.
5. Watson, D., A. Plattus, R. Shibley. *Time Saver Standards for Urban Design*. The Mc Graw Hill, New York, 2003.
6. Shoup, D. *The High Cost of Free Parking*. American Planning Association, Chicago, 2011.
7. Newman, P. W. G., and J. R. Kenworthy. The land use–transport connection: anoverview, *Land Use Policy*, 13,1996, pp. 1–22.
8. Knoflacher, H. (2007) Success and failures of urban transport planning in Europe—understanding the transport system. Sadhana, 32, 293–307.
9. Barter, P. A. (2010) Off-Street Parking Policy without Parking Requirements: A Need for Market Fostering and Regulation, Transport Reviews, 30, pp. 571–588.
10. Asian Development Bank (ADB) (2011) Parking Policy in Asian Cities. Asian Development Bank, The Philippines.
11. Dargay, J., and D. Gately (1999) Income's effect on car and vehicle ownership, worldwide: 1960–2015. Transportattion Research A, 33,101–138.
12. Tekeli, I (2013) İstanbul'un Planlanmasının ve Gelişmesinin Öyküsü (*Story of Planning and Development of Istanbul*). Tarih Vakfı-Yurt Yayınları, İstanbul (in Turkish).
13. Tekeli, I (2010) İstanbul ve Ankara için Kent İçi Ulaşım Tarihi Yazıları (*Essays on Urban Transportation History for Istanbul and Ankara*). Tarih Vakfı-Yurt Yayınları, İstanbul (in Turkish).
14. Guo, Z. (2013) Home parking convenience, household car usage, and implications to residential parking policies. *Transport Policy*, 29, pp. 97–106.
15. Stubbs, M. (2002) Car parking and residential development: sustainability, design and planning policy, and public perceptions of parking provision. Journal of Urban Design, 7, 213–237.
16. Hoyle, R.H.: *Structural Equation Modeling: Concepts, Issues, and Applications*. Sage Publications, Thousand Oaks, 1995.
17. Golob, T.F., and M.G. McNally. A model of activity participation and travel interactions between household heads. *Transportation Research B 31*, 1997, pp. 177–194.
18. Jöreskog, K.G., and D. Sörbom. LISREL8: User's Reference Guide. Scientific Software International, Chicago, 1993.
19. Sobel, M.E. Effect analysis and causation in linear structural equation models. *Psychometrika*, 55, 1990, pp. 495–515.
20. Bollen, K.A. *Structural Equations with Latent Variables*. Wiley, New York, 1989.
21. Naess, P. *Urban Structure Matters: Residential Location, Car dependence and Travel Behaviour*. Routledge, Oxfordshire, 2006.

**LIST OF TABLES AND FIGURES**

**Table 1 Multinomial Logit Model Results of Night-Time Parking Type Choice**

| Variables | | On-Street Parking | | Off-Street Private Parking | |
|---|---|---|---|---|---|
| | | Coefficient | *p* | Coefficient | *p* |
| Constant | | 2.958 | 0 | 4.668 | 0 |
| Housing Type | Aparment | 0.227 | 0.364 | -1.643 | 0 |
| | Singe Family House | 0.487 | 0.061 | -0.937 | 0.002 |
| | Apartment Complex | - | | - | |
| Car Age | New | -0.725 | 0 | -0.510 | 0 |
| | Moderately New | -0.474 | 0 | -0.285 | 0.017 |
| | Old | - | | - | |
| Household Income | Low | 0.987 | 0 | 0.210 | 0.205 |
| | Medium | 0.679 | 0 | 0.166 | 0.298 |
| | High | - | | - | |
| House Tenure | Rented | 0.179 | .007 | -0.247 | 0.009 |
| | Owned | - | | - | |
| District Location | Anatolian Side | 0.719 | 0 | 1.296 | 0 |
| | European Side | - | | - | |
| Districts with High Paid Parking | | -0.493 | 0.004 | -0.785 | 0 |
| City Center Districts | | -0.808 | 0 | -0.583 | 0 |
| Population Density | | -0.022 | 0 | -0.062 | 0 |
| Automobile Density | | 0.063 | .001 | 0.171 | 0 |
| Automobile per Paid Parking Space | | 0 | .553 | 0.001 | 0.541 |
| Sample Size (Households) | | | 17,036 | | |
| *LL* (Constants Only) | | | 8662,355 | | |
| *LL* Model (*d.f.*: 26) | | | 5106,380 | | |

**Table 2 Day Time Parking Duration of Out-Home Activities**

| Out-Home Activities | Parking Duration (Hours : Minutes) | | | | | |
|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | 25th % | Median | 75th % | 95th % |
| Paid Work | 8:08 | 3:44 | 5:43 | 9:15 | 10:45 | 12:50 |
| School | 5:24 | 2:51 | 4:15 | 5:25 | 7:20 | 10:00 |
| Work related | 1:54 | 2:20 | 0:30 | 1:00 | 2:15 | 7:30 |
| Shopping | 1:43 | 1:56 | 0:30 | 1:00 | 2:10 | 5:30 |
| *Social, sports and entertainment | *2:47 | *2:29 | *1:00 | *2:00 | *3:40 | *8:10 |
| Medical care | 2:09 | 2:09 | 0:45 | 1:20 | 3:00 | 6:50 |
| *Other | 2:23 | 2:54 | 0:20 | 1:05 | 3:25 | 10:00 |

* Discretionary activity

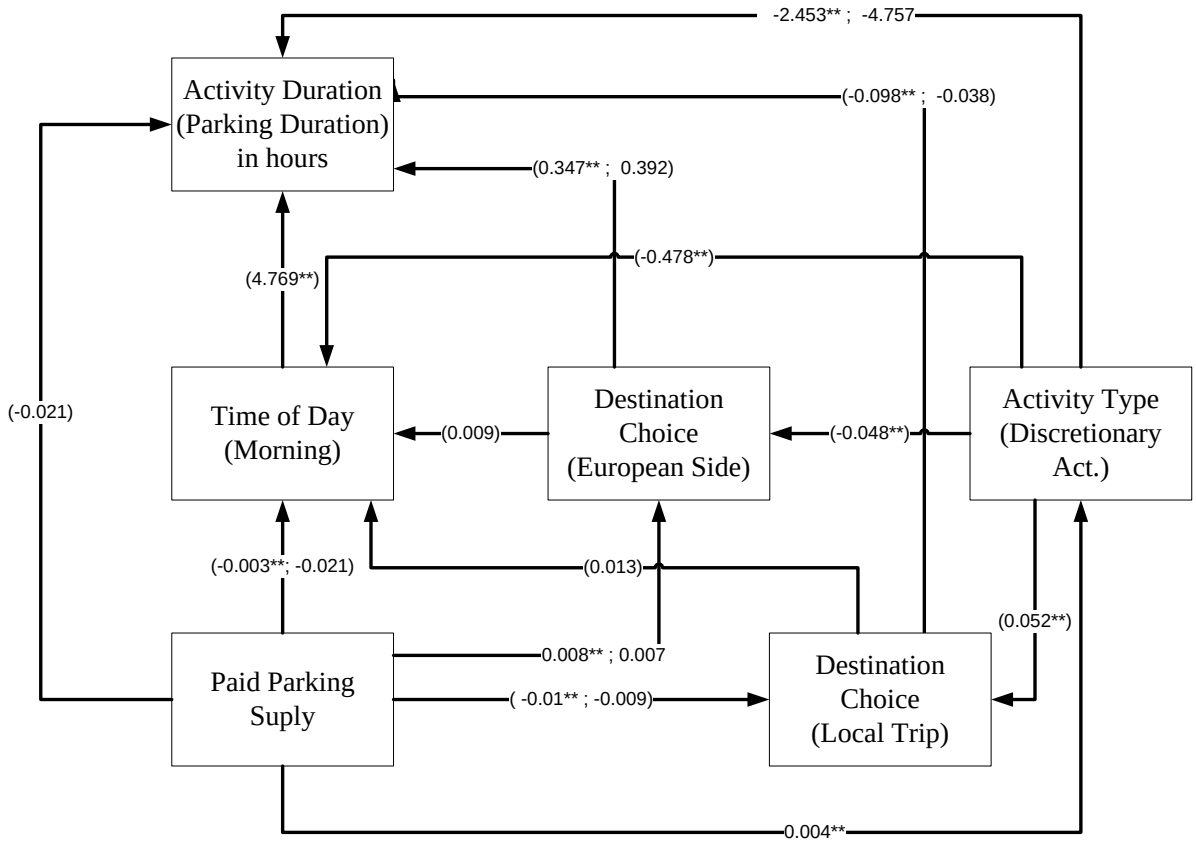


**Figure 1 Results of Structural Equations Model of day-time parking behavior for discretionary activities (** indicates *p* <0.01; the first effect in parantheses is the direct effect, single figures represent total effects indicating no direct relationship assumed).**