Master Thesis

The Effects of Paid Parking

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Abstract:

There is growing recognition that the imbalance resulting from poorly conceived parking policies is a major obstacle to the establishment of an effective and balanced system of urban transport, and it is also an important cause of high traffic and air pollution (Weinberger et al., 2010). This recognition led to large attention to the importance of paid parking policy. This paper comprehensively studies the effects of paid parking, which, more precisely, investigates whether paid parking affects urban car travel demand or not and evaluates the relationship between them by controlling variables of population, urban density, private car ownership, personal income on PPP[1] (Purchasing Power Parity), urban GDP[2] (Gross Domestic Product), employment rate and educational level. The preferred OLS regression model indeed provides some support for the view above.

A dataset of 53 cities in Europe were searched from various websites and related journals, annual reports. After testing the correlations between explanatory variables and their distributions via Stata, we remove variable of urban GDP and set up two models with on-street and off-street parking price separately, which will be explained specifically in the section of Data Collection and Analysis. The final regression model turns out that parking price for both on-street and off-street shows no significant influence on car travel demand at 5% level. The major reason is that car use percentage data used in our model is searched by EPOMM, which is mostly based on commuters

[1] PPP: https://en.wikipedia.org/wiki/Purchasing_power_parity
[2] GDP: https://en.wikipedia.org/wiki/Gross_domestic_product

because it is easier to collect information from commuters than temporary parkers. Commuters, on the one hand, are more likely to park longer time. Therefore, commuters may subscribe for parking and pay once a month or even longer, namely, long-term parking contracts, and in this case, the change of parking price will not affect car travel demand a lot. On the other hand, subsidy from employers play an important role to affect its relationship between car travel demand. And there is always a special offer for the long time parking. However, on the other hand, variables of private car ownership, employment rate and educational level do show significant effects on citizens' car travel demand, namely car use percentage, at 5% level. Policy implications, limitations and further researches are also presented in this paper.

Acknowledgement

First of all, I would like to express my greatest gratitude to Giuliano Mingardo Jan-Jelle Witte for their great supervision and helpful feedback, without which the whole analysis could not have been carried out. Moreover, I would like to say thank you to my parents who supported my two years of study in Erasmus University Rotterdam both emotionally and financially. Many thanks also go to my friends in Rotterdam and at home for always being there and supporting me through hard times.

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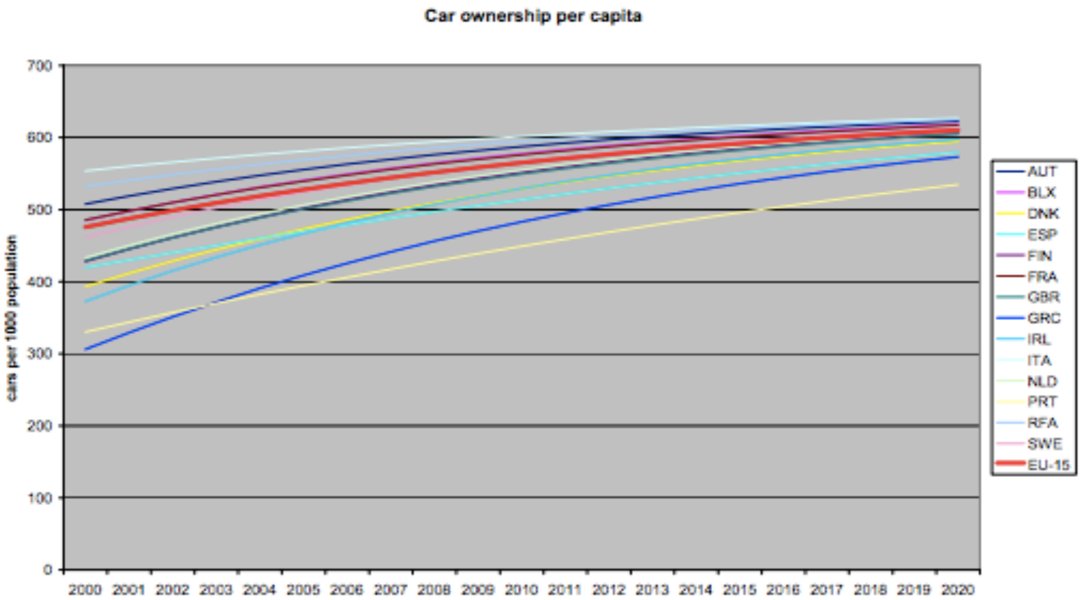
1. Introduction

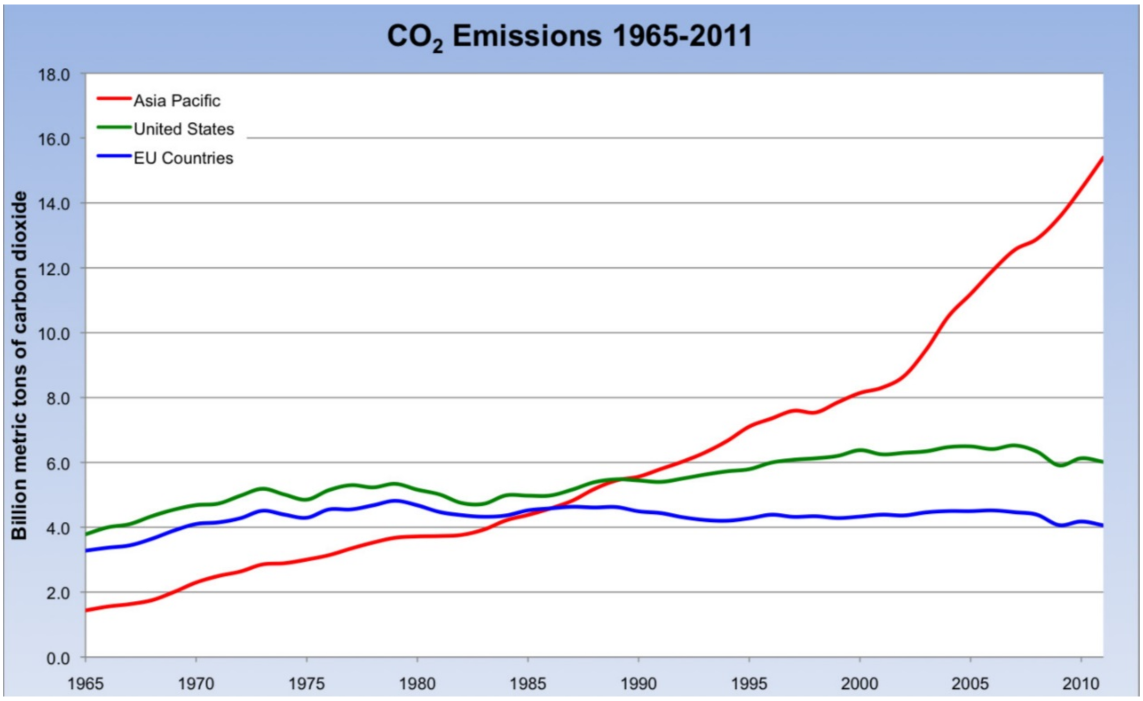
With the development of population, urban economy and citizens' living standard, private car ownership has a dramatic growth over the past decades and will continue increasing in the future (See Figure 1-1). It is also a truism that this phenomenon gives rise to new, greater pressures on city life. Various problems such as highly traffic congestion, unbalanced model split, poorly land use, increasing environmental disruption (including air pollution, noise annoyance and road insecurity) occurs, especially the dramatic CO_2 emissions growth (See Figure 1-2). Therefore, it may pose a serious threat on local economic growth and livability of urban regions as well.

Figure 1-1: Projected Car Ownership Per Capita in EU-15



Source: Trends in Vehicle and Fuel Technologies - Scenarios for Future Trends

Figure 1-2: The World CO_2 Emissions 1965-2011



Source: 2012 BP Statistical Review of World Energy

During recent years, transportation planners have become further aware of the importance of car parking because of its relation to different activities, land use, pedestrian movement, public transportation stations, road networks and even local economic development (Al-Fouzan, 2009). Some municipalities have noticed that inappropriate parking policies might address a host of negative impacts resulting from private automobile use and smart parking management can benefit consumers and business in time and money savings (Weilinberger and Kaehny, 2010). However, when it comes to reducing traffic congestion, various ways are alternative, such as congestion tolls, carpooling and integrated public transport system. And for the majority of cities and countries, road pricing and road space rationing are preferable than that of parking pricing and supply management. Because road pricing can be used to influence a wider range of trip characteristics than parking policies can, such as ''trip length, time of driving, route followed and vehicle used'' and can therefore more adequately be used to tackle the full range of externalities (Verhoef et al., 1995). As a result, parking policy has received comparatively little study even though the application of parking pricing and supply restrictions is ''the most widely and readily accepted method'' of limiting car use (IHT, 2005) .

Nonetheless, virtually every car has to be parked at the end of a trip, parking policies, especially parking price, can indeed offer a potentially strong instrument for influencing traffic demand (Marsden, 2006). An appropriate transportation policy decision can have a large effect on the development of the urban system. Many cities and countries have applied parking policy to manage their transport system. Take UK and USA for examples, they use parking policies, especially the application of car parking standards, along with other planning and transport measures to promote sustainable transport choices (Al-Fouzan, 2009). In 2001, the Department for Communities and Local Government (DCLG) issued Planning Policy Guidance 13 (PPG 13): Transport. The objectives of the guidance are to integrate transportation and planning at the national, regional, strategic and local levels, and to encourage more sustainable transport alternatives both for moving freight and for transporting people (DCLG, 2001). The application of the requirements for car parking to the development of new projects or to the expansion of existing projects is a key tool for reducing the levels of traffic (Essex Planning Officers Association (EPOA), 2001). Moreover, a well-designed parking policy, in various ways, contributes to the promotion of a more efficient use of the transport network, lower emissions, higher densities and better, more inclusive urban design (IHT, 2005; Shoup, 2005a; Stubbs, 2002; Valleley et al., 1997). Poorly designed policies, on the other hand, can act in the opposite direction (Shoup , 2005b).

Therefore, we expect that paid parking policy indeed has effects on citizens' car travel demand. The aim of this paper is to evaluate the effects of paid parking on car travel demand. In other words, the research question is whether and how paid parking policy affect citizens' car travel demand (urban car use percentage). At the meantime, we control variables of population, urban density, private car ownership, personal income on PPP, urban GDP, employment rate and educational level.

In this paper, both qualitative and quantitative methods are used to investigate the topic of the effects of paid parking. More specifically, on the one hand, a wide variety of existing literatures support our theoretical parts, including definitions of dependent variable (C), independent variables (On-street Parking Price and Off-street Parking Price) and control variables (Population, Urban Density, Private Car Ownership, Personal Income in PPP, Urban GDP, Employment Rate and Educational Level). On the other hand, cross section data for 53 cities in Europe ranges from 2010-2016 are searched and filtered via websites like Eurostat, Knoema, Wikipedia and other related annual reports, journals.

The remainder of this paper is organized as follows: The second section provides an extensive review of the literature touched upon our topic and some additional researches. The third section presents our data collection. The fourth section shows the analysis of our model. It is again subdivided into one subsection on description of the applied methodology and our OLS regression model. Another subsection focuses on the results and discussions of our model. Thereafter, the fifth section gives our conclusions. In this section, one subsection answers our research question and give some advices for policy making, and another one comes up with limitations and further research.

2. Literature review

As mentioned above, previous study on the effects of parking policy is comparatively scarce. The economic literature looked at parking almost exclusively as a fixed fee added on at the end of an auto trip decade years ago and road pricing draws more attention than parking policies do as the tool to manage travel demand and traffic congestion. However, urban population shoots up, private car ownership surges, the consequent social problems become more and more severe, and with the realization of the inability of cities to cope with unrestrained car traffic increase, those management goals have emerged into a consideration of the degree to which parking policy contributes to the wider economic, environmental and social policies of towns and cities (Valleley et al., 1997).

Therefore, empirical literatures on parking policy emerge and the pace of research on the economics of parking has increased dramatically since the early nineties. Studies have shown that the most important factor in reducing car usage is the parking price (Higgins, 1992). Arnott and Inci (2006) pointed out that by increasing the full price of an auto trip, parking fees can affect car travel demand and modal choice. One early example is that Westin and Gillen (2006) incorporated parking charges into an empirical model of modal choice in Toronto. Arnott, de Palma, and Lindsey (1998) examined the temporal-spatial equilibrium of parking and congestion under a variety of pricing regimes when all drivers have the same desired arrival time at a common downtown destination and walk from their parking locations to the common destination. Parking policies are considered as a powerful tool for solving parking problems as well as problems of the transportation system in general (traffic congestion, modal split, etc.). Parking policy can be the most effective policy for achieving the desired modal split (Victorian Competition and Efficiency Commission (VCEC), 2006). The main objective of parking management is to balance the parking supply with the parking demand (Simićević et al., 2012). Rye et al. proposed that there is a demonstrable link between parking availability, price and mode choice, and parking policy has been shown to be a powerful demand management tool. Take Dutch government for example, it confirms that regulatory parking policies are an "indispensable part of an integral transport policy aimed at reducing the growth of road traffic" (Tweede et al., 1991-1992). Calthrop, Proost and van Dender (2000) gave a more recent study that examined the second-best level of the parking fee when congestion tolls cannot be imposed on city streets. The parking charge is considered to be the second best measure for solving traffic congestion after congestion charging (Albert and Mahalel, 2006; Kelly and Clinch, 2006), but it is used far more often because of its relatively simple implementation (Marsden, 2006; Verhoef et al., 1995). Also, previous publications showed that parking policies (Glazer and Niskanen, 1992) and fuel taxes are alternatives to road pricing while road pricing is recognized as the first-best instrument to reduce car travel demand and relieve traffic congestion.

Parking policy has a strong impact not only on the operation of the parking subsystem but also on the entire transportation system and the city in general (Simićevićet al., 2012). Despite of the reduction in car travel demand and traffic congestion, land use is another province that parking policy can have an influence on. According to Marsden (2006), parking policy is one of the key links between transport and land-use policy, in other words, he indicated that parking policy acts as glue between the implementation of land-use and transport policies. Marsden and May (2006) also mentioned that parking policy should not be developed in isolation but as part of local and regional spatial and transport planning processes. Well-designed parking policies, in various ways, contribute to the promotion of a more efficient use of the transport network, lower emissions, higher densities and better, more inclusive urban design (IHT, 2005; Shoup, 2005a; Stubbs, 2002; Valleley et al., 1997).

On the other hand, there is a concern that parking policy can jeopardize the competitiveness and business efficiency of a zone (D'Acierno et al., 2006). Valleley (1997) and Waerden (2009) argued that there are major conflicts in parking policy implementation: using it to manage demand for traffic may reduce revenue generation, or (be perceived to) damage the local economy. A well-designed parking policy may benefit urban a lot, but poorly designed policies can act in the opposite direction. For example, many major cities in the KSA(Kingdom of Saudi Arabia) suffer from the problem of car parking provisions, not only resulting from a high private car ownership ratio but also the fact that car parking planning is not done in line with land-use planning

(Al-Fouzan, 2009). After analyzing 16 studies from 11 international cities, Shoup (1997) showed that approximately 30% of the traffic volume are vehicles cruising for parking, i.e., result of poor parking management. Glazer and Niskanen (1992) also considered a sequence of partial models to illustrate possible perverse results from the naive application of parking policy. According to Simicevic et al. (1997), one of the measures for achieving as favorable a modal split as possible, together with improvement of the quality of public transport service, is the introduction of parking charges in the Central Business Districts (CBDs) and other zones of high attractiveness. By using this approach, the attractiveness of these zones will decreases because of the costs of travelling by car increases (TBRP, 2005). Furthermore, Glazer (1992) came up with a viewpoint that, indeed, an increase in the price of parking induces each person to park for a shorter time, allows more persons to use parking spaces each day, and can thereby increase traffic. There are some arguments that parking policy lacks sensitivity when compared with road pricing and may vary with the duration and location of parking, not necessarily reflecting travel conditions (Sulli-van, 1990; Verhoef et al. 1995).

Lately, more and more researchers are interested in the topic of parking policy effects. However, due to the vast fields that the implementation of parking policy may involve, different perspectives with regards to parking policy exist. In a review paper on parking policy, Marsden (2006) noted that “We do not understand nearly enough about how individuals respond to parking policy interventions nor how these responses interact with local circumstances, the availability of alternative transport modes or alternative destinations," and among parking topics that require further research, he highlighted "the importance of out-of-vehicle costs and in particular walk-times on parking behaviour". Simićević et al. (1997) argued that possible driver responses to parking policy (primarily to the parking charge and time limitation) are complex and varied. These include a change in the parking type, parking location, transportation mode, car occupancy, destination, travel frequency, travel time (with possible consequences on the parking duration) and route (Scholefield et al., 1997). Hess, Shiftan, Burd-Eden, Tsamboulas, Shiftan, Golani, Albert, Mahalel, Khodaii et al. and Simićević et al. also showed that, when we are going to investigate the parameters of significance for parking decision making, some of the socio-economic and trip characteristics needs to be identified.

Therefore, the point of views on the effects of paid parking policy in literature reviews can be classified into three main categories as follow:

1. **Different target groups:**

Kelly and Clinch (2003, 2006, 2009) also pointed out that conventional models were later replaced by disaggregate models because it was recognized that the individual impact must be examined and included.

For commuters: According to Simićević et al. (1997)**,** a positive finding for policy makers is that commuters are more sensitive to parking measures than other user. This is a desirable finding for policy makers to pay more attentions on managing user categories when it comes to city central areas. Marsden (2006) stated that one of the objectives of commuter parking policy is to reduce the amount of single car commute trips to the problem area to achieve both environmental and congestion benefits. And a common response to parking restrictions in the US context, charges or cash-out initiatives is a switch to car pool. Moreover, take a survey of Shoup of the implementation of parking cash-out at eight firms (where commuters are offered the option of a cash alternative instead of their parking subsidy) for example, it found that ‘‘the number of solo drivers to work fell by 17% after cashing out. The number of carpoolers increased by 64%, the number of transit riders increased by 50% and the number of who walk or bike to work increased by 39%. Vehicle–miles from commuting to the eight firms fell by 12%’’ (Shoup, 1997).

However, there is another argument that commuters are less sensitive to parking price than other groups because they need longer parking time. Subsidy from companies and long-term parking contract are the determinants of this phenomenon.

For commercial and leisure travelers: Drivers making leisure and shopping trips have a far greater range of options available to them to respond to parking restraint policies than commuters. These include reducing frequency of visits and changing destination as well as altering how and how long they visit a center for if they still decide to go (Marsden, 2006).

For residents: Balcombe and York indicated that, with regards to residents, more effects of parking policy on their behavior is the constraints on availability of parking spaces. First, the distance that vehicles were parked from the home appears to deter the purchase of better vehicles with between 22% and 54% of residents saying they did not buy a better vehicle due to fear of vandalism (Balcombe and York, 1993). Concerns over losing a parking space and the inconvenience of finding another also appears to deter car owners from making some trips, particularly shorter trips by car with ''over 50% of owners at the six older sites stating that they occasionally walked instead of using their car, in order to reserve their parking space''. Some substitution of car trips by public transport trips was also recorded although to a lesser extent (Balcombe and York, 1993).

2. On-street and off-street parking price

Arnott and Rowse (1999) focused on optimal on-street parking search strategy on an isotropic circular road with unsaturated parking. Calthrop and Proost (2002) presented a spatially homogeneous model characterizing the steady-state equilibrium of on- and off-street parking, in which the search cost for on-street parking balances the higher fee associated with off-street parking, but did not consider traffic congestion per se. Arnott and Inci (2006) proposed two views. One is that, whether or not the amount of on-street parking is optimal, it is efficient to raise the on-street parking fee to the point where cruising for parking is eliminated without parking becoming unsaturated. The other is that, if the parking fee is fixed at a sub-optimal level, it is second-best optimal to increase the amount of curbside allocated to parking until cruising for parking is eliminated without parking becoming unsaturated.

Influences of public resource and private ownership will show up when it comes to the on-street and off-street. Recent European Union (EU) research on parking (COST342, 2005) confirms that in all EU countries, curbside parking is a public good whose management (although not necessarily enforcement) is the responsibility of the local authority (municipality). Anderson and Palma (2004) noted that, in the case of on-street parking, private ownership is not usually viable; but in the case of off-street parking we can compare private ownership with public provision of unpriced parking lots, and the higher the price charged, the lower the equilibrium congestion level.

3. **Paid policy with regards to other elements:**

Parking space and parking duration: Milosavljevic et al. (2010) showed that maximum standards contribute to sustainable urban development without negative effect on local economy, where maximum standards of parking policy mean the limitation of parking space. Maximum vehicle parking standards indicate the typical reduction in the amount of parking required for 10–30% (Litman, 2010). Local authorities are expected to adopt maximum parking standards as an incentive measure to support sustainability through limitation of the number of parking spaces when new developments, extensions or change in use of the already existing developments are in question (International Association of Public Transport 2000). As Al-Fouzan (2012) mentioned that, in the UK, a study by the Department for Communities and Local Government (DCLG) found that the availability of car parking has a large influence on people’s transportation mode. This effect can also be found in places that are well served by public transport. Furthermore, car parking is costly to business, occupies a huge space in urban development and decreases urban densities. In a new development, it is necessary to reduce the number of parking spaces to promote sustainable travel options as part of the planning and transport measures (Department for Communities, 2001).

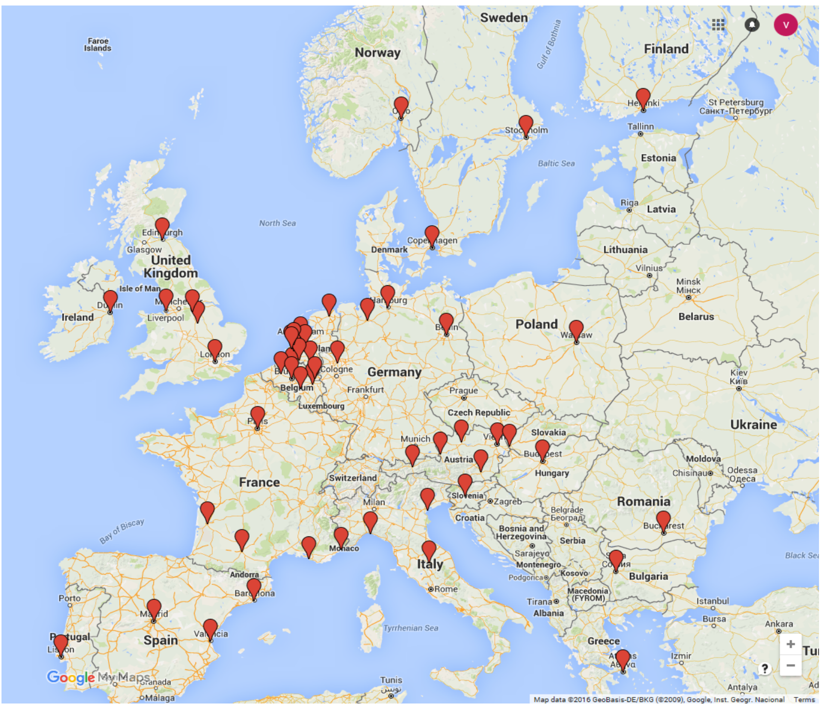
Simićević et al. (1997) indicated that parking prices affect car usage, while time limitations determine the type of parking used (on-street or off-street). (Transit Cooperative Research Programme (TCRP), 2005). The evidence suggests that the imposition of a curtailment of parking hours at specific locations under existing tariffs will lead to a relocation of parking and some small switch to public transport.

Public transport accessibility level and area attractiveness: As stated by Milosavljevic et al. (1997), if Public Transport Accessibility Level (PTAL) of a zone the subject development belongs to is high, the number of parking spaces to be provided is restricted and customers are encouraged to shift to alternative transport modes. Besides introducing PTAL, defining parking standards based on the degree of attractiveness of the zone the subject development belongs to is also suggested (COST Secretariat 2001; Valley et al. 1997), the degree of attractiveness refers to the degree of traffic congestion in CBD and economic sustainability.

3. Data collection

The primary purpose of this paper is to explore the effects of paid parking policy. We would like to set up an OLS regression model to investigate the relationship between paid parking and citizens' car travel demand while controlling several variables (population, urban density, private car ownership, personal income on PPP, urban GDP, employment rate and educational level), where dependent variable (car travel demand) is represented by car use percentage in model split of each city. This paper investigates 53 European cities (See Figure 3-1) and our model is estimated on the basis of pooled time-series (2010-2016) and cross section data.

Figure 3-1[3]: The Spatial Distribution of Investigated Cities in Europe

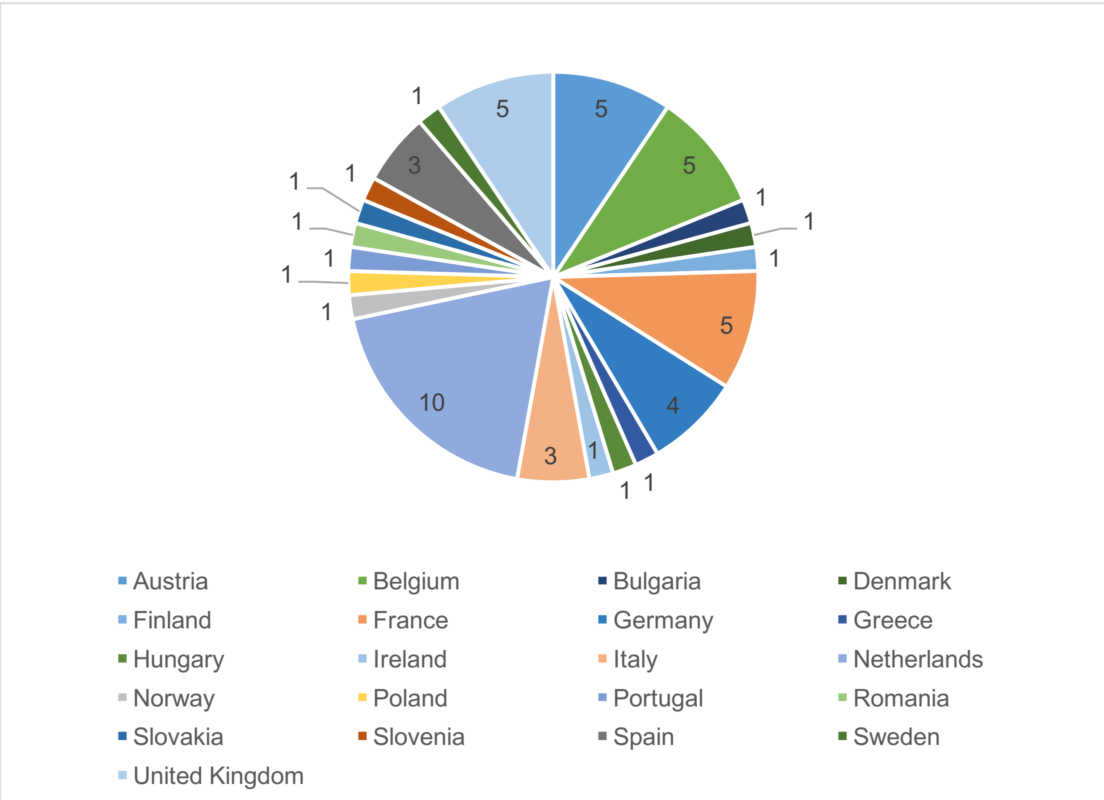


Source: Google Map, 6/22/2016

[3] https://www.google.nl/maps

Figure 3-1 shows the distribution of the cities investigated in Europe, which is depicted by Google Map. In this map, it is obvious that our observations distribute almost uniformly in Europe, but with more observations in South and East Europe than North and West Europe. Figure 3-2 presents us the numbers of cities in each country that we studied. The pie chart shows that the Netherlands has the most cities (10) studied, Austria, Belgium, France and United Kingdom rank second with 5 cities investigated. Then it comes to Germany, Italy and Spain, which has 4, 3 and 3 cities researched separately. Finally, only one city is observed in Bulgaria, Denmark, Finland, Norway, Poland, Portugal, Romania, Slovakia, Slovenia and Sweden. Concerning the time series of this dataset, it will be described in details hereinafter.

Figure 3-2: Numbers of Cities Investigated in Each Country



Dependent variable: In this paper, we explore the effects of paid parking on citizens' car travel demand and the car use percentage in model split is used to represent it. For these data, we search information from EPOMM (European Platform on Mobility Management)[4] , which provides use percentage of model split in each city, namely the use percentage of Bike, PT (Public Transport), Walk and Car via TEMS.

Independent variables: With regards to paid parking, parking price of on-street and off-street are both used to investigate our goal-focused relationship. Because of the variances of parking price, different cities have different parking price and parking price also varies with different time periods during a day or a week. Parking zones also determine parking price, for example, parking price in CBD (Central Business District) is usually higher than that of edge zone. For most of the cities' parking price (both on-street and off-street), we search information from the website Car-parking (See Reference). However, this website only provides dataset for part of European countries, therefore, website Parkopedia (2016) (See Reference) is used to collect parking price for all cities in UK and other European cities (Dublin, Sofia, Oslo, Warszawa, Lisbon, Bucharest, Bratislava and Ljubljana).

Particularly worth mentioning is that we make assumptions about independent variables (on-street and off-street parking price) because of their complexity and make baseline regression model as simple as possible.

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[4] European Platform on Mobility Management is an international partnership aiming to promote and further develop Mobility Management in Europe and fine tune the implementation of Mobility Management in the EU

Assumption 1: There are different zones with different parking price (both for on-street and off-street), citizens are assumed to park in CBD where has the most attractiveness for both commuting, commercial and leisure, i.e., the parking price in CBD is chosen as our independent variable.

Assumption 2: Differences between weekday and weekend parking price exists, as most of the time of a week is covered by weekdays, parking price during that time is preferable. Likewise, parking price during daytime is not the same as that at night, and parking price of special night offers is disregarded.

Assumption 3: It is normal that in many cities there are cheaper offers for the first minute or even a "first X minutes free" policy. In this paper, we ignore these special parking offers and choose the parking price for longest parking duration.

Figure 3-3-1 and Figure 3-3-2 depict the range of our on-street and off-street parking price separately. In general, as we can see from these two graphs, on-street parking price in each city is lower than its off-street parking price. Average parking price for on-street is 3.06 €/hour while average parking price for off-street is 3.56 €/hour. Moreover, it is obvious that parking price in UK is much higher than that in other countries, for both on-street and off-street. One important reason is that the price level is higher in UK than other countries that have been investigated, which determines our control variable selection. When we consider the effects of personal income on citizens' car use percentage, we should also take local price level into consideration. Because it is normally that higher price level is with higher personal income. Thus, personal income on PPP (Purchasing Power Parity) is more appropriate for evaluating the effects on car travel demand.

Figure 3-3-1 On-street Parking Price of Investigated Cities in Europe (€/hour)

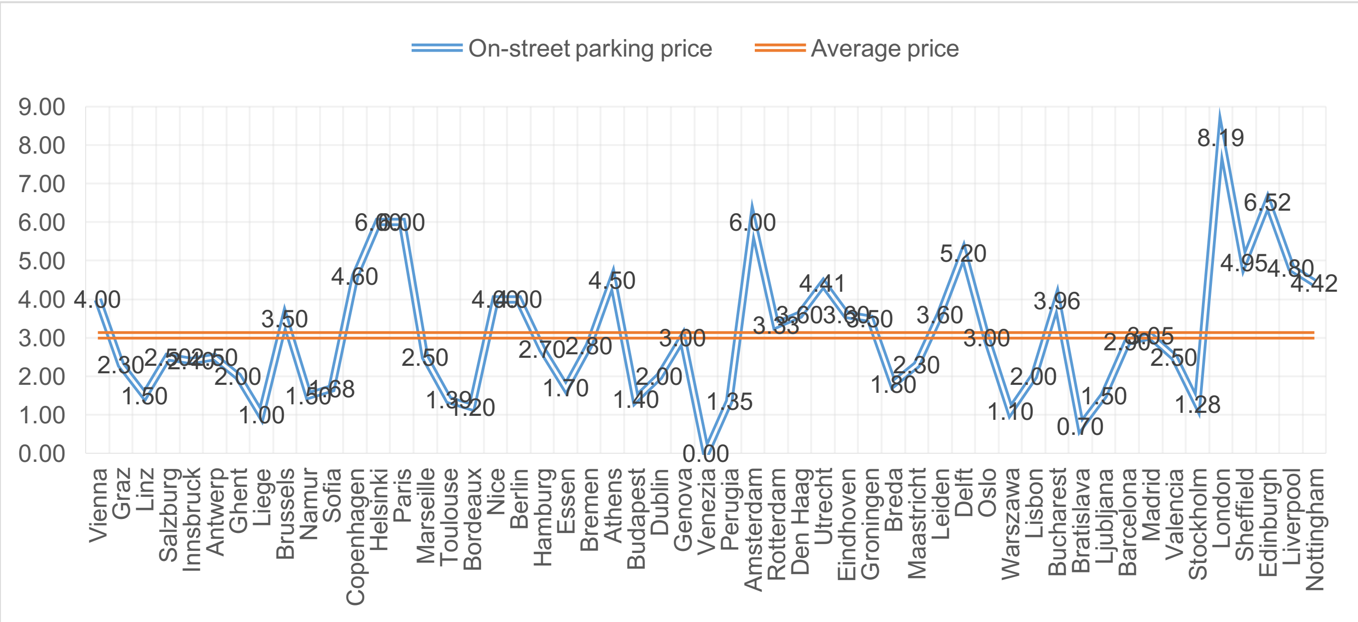
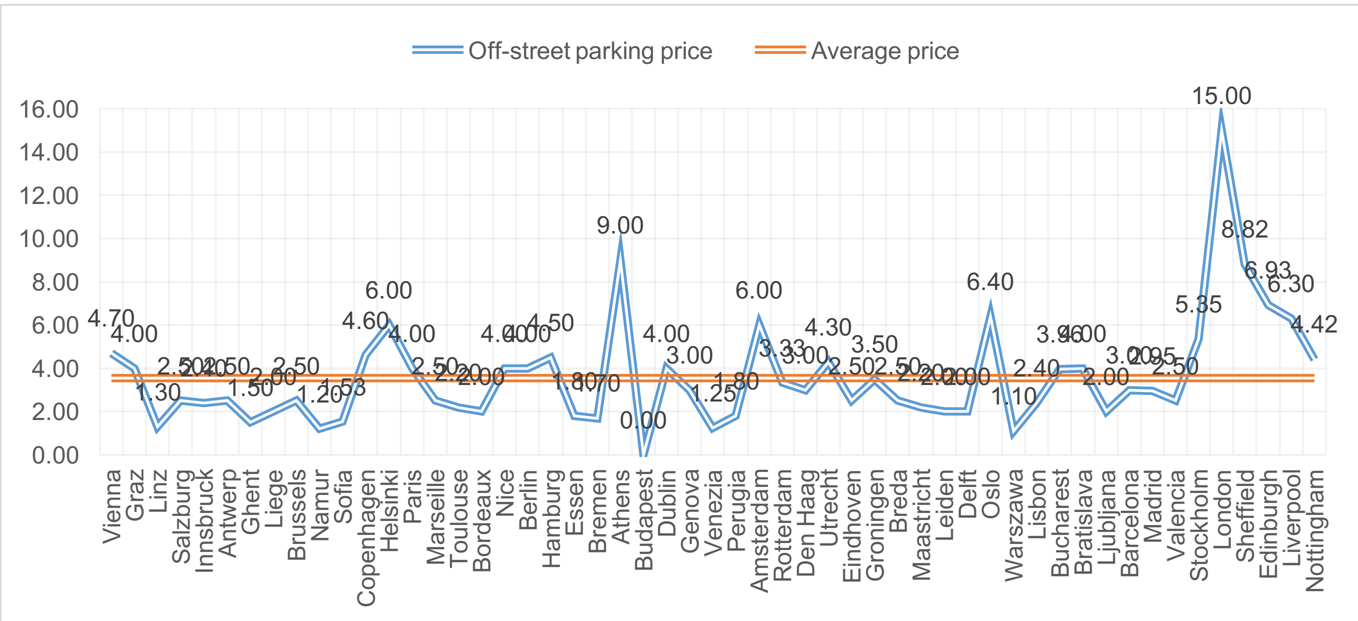


Figure 3-3-2 Off-street Parking Price of Investigated Cities in Europe (€/hour)



Control variables: Based on sufficient literature reviews, we control variables including Population, Urban density, Private car ownership, Personal income on PPP, Urban GDP, Employment rate and Educational level. For population and urban density, website of Wikipedia (See Reference) povides us the latest data.

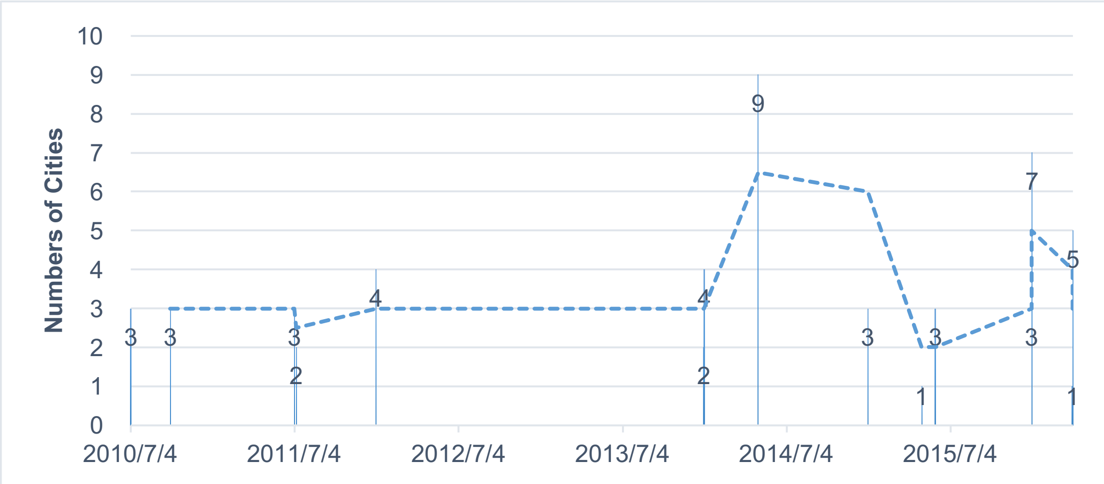
Population size is used to represent city size and searched from website Wikipedia (See Reference). Data related to private car ownership was searched from Website Knoema and Chartsbin (See Reference), where it shows us the passenger cars per 100 habitants. In addition, passenger car ownership of Vienna in Austria is cited in Vienna in Figure 2015 (See Reference).

Figures of personal income on PPP, urban GDP and employment rate were quoted from websites Knoema. However, some of the cities cannot be found. Personal income on PPP and urban GDP of Dublin and Edinburg were found from Wikipedia and Fred Economic Data and World Cities Culture Form (See Reference) separately. With regards to employment rate of Barcelona and Madrid, 2012 figure report provides us the information; for Valencia, we searched for the data at website Statista (2016).

Educational level data was collected from Eurostat. However, these data were only based on regions and details of some of the cities was not available. Therefore, we replenished the data from website Knoema and also used the regional educational level to represent urban level.

With regards to our data, as we searched different countries in different years, therefore, it ranges from 2010 to 2016. And we take collection time of population for example (See Figure From 3-4).

Figure 3-4 Population Time Series of Investigated Cities



During the data collection process, despite issues of parking price, we encountered other issues which could potentially lead to some small bias in our OLS regression model and we imposed corresponding assumptions for them.

Assumption 4: All parking spaces are assumed to be identical and that demand is uniform over time. We thus do not address the role of parking fees in allocating more and less desirable parking spaces to users.

Assumption 5: We suppose there is a fixed number of parking spaces per unit distance and avoid the disruption of walking time to drivers' destination.

Assumption 6: Interaction between on-street and off-street parking are allowed, i.e., we are here interested in parking that is both unassigned and assigned. Longer parking duration will induce some drivers to drive directly to a parking garage without cruising for parking, for example, commuters can have long-term parking contracts.

Assumption 7: To avoid complications associated with scheduling, interaction between individuals is ignored and all trips are single-purpose (Gillen, 1978).

Assumption 8: We assume that all the parking prices are at the same standard by ignoring differences among daily, weekly and monthly. Special cheap offers are also disregarded, which is stated in assumptions 1, 2 and 3 specifically.

4. Analysis

i. The applied methodology

As previously indicated, our baseline model is a simple OLS regression model. More concretely, it is of the following form at the beginning:

Y (Car Travel Demand) = β0 + β1* On-street Parking Price + β2 * Off-street Parking Price + β3 * Population + β4 * Urban Density + β5 * Private Car Ownership + β6 * Personal Income on PPP + β7 * Urban GDP + β8 * Employment Rate + β9 * Educational Level + u

where Y indicates citizens' car travel demand and is represented by urban car use percentage. β0 is the intercept of our model and u represents unobserved variables that will also influence our dependent variable.

Figure 4-1 Model 1 with All Variables

Source	SS	df	MS
Model	6642.01564	9	738.001737
Residual	2315.00323	43	53.8372845
Total	8957.01887	52	172.250363

Number of obs	= 53
F(9, 43)	= 13.71
Prob > F	= 0.0000
R-squared	= 0.7415
Adj R-squared	= 0.6874
Root MSE	= 7.3374

traveldemand	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
onstreet	-2.166203	1.115806	-1.94	0.059	-4.416439	.0840339
offstreet	.8128242	.8581778	0.95	0.349	-.9178562	2.543505
population	-1.61e-06	1.30e-06	-1.24	0.222	-4.24e-06	1.01e-06
density	-.0000977	.0004389	-0.22	0.825	-.0009827	.0007874
ownership	.5633246	.1325163	4.25	0.000	.2960801	.8305691
personalincome	-.0001602	.0001196	-1.34	0.187	-.0004014	.0000809
GDP	.0000515	.0000281	1.83	0.074	-5.14e-06	.0001081
employmentrate	-.3404703	.1232248	-2.76	0.008	-.5889767	-.0919639
educationlevel	-.0000661	.0000176	-3.75	0.001	-.0001017	-.0000306
_cons	51.16094	10.29672	4.97	0.000	30.39562	71.92625

Thereafter, we use Stata to run our regression model. During the process, we modified and improved our OLS model by testing both correlations and distributions of our variables. Finally, we set up two OLS regression models with On-street and Off-Street Parking Price separately. And for both models we control variables of ln (Population), Density, Private Car Ownership, Personal Income on PPP, Employment Rate and Educational Level.

First of all, we use Stata to regress our model with all variables (See Figure 4-1). Then we test the correlations between explanatory variables of interest and their significance (See Figure 4-2) to see whether there exists multicollinearity or not.

Figure 4-2 Correlations between Explanatory Variables of Interest and Significance

	onstreet	offstr~t	popula~n	density	owners~p	person~e	GDP
onstreet	1.0000						
offstreet	0.7314	1.0000					
	0.0000						
population	0.4370	0.6273	1.0000				
	0.0011	0.0000					
density	0.2224	0.1860	0.3286	1.0000			
	0.1095	0.1824	0.0163				
ownership	-0.4694	-0.3342	-0.3959	-0.1335	1.0000		
	0.0004	0.0145	0.0033	0.3407			
personalin~e	0.1113	0.2583	0.0484	-0.1977	-0.1268	1.0000	
	0.4276	0.0619	0.7305	0.1559	0.3656		
GDP	0.4885	0.6488	0.7334	0.1859	-0.1987	0.1526	1.0000
			|.0000	0.1826	0.1538	0.2753	
employment~e			|.0330	0.1344	-0.1584	0.1872	0.1345
			|.8143	0.3373	0.2571	0.1795	0.3368
educationl~l			|.2759	0.2220	-0.2893	-0.1650	0.0429
			|.0455	0.1101	0.0356	0.2377	0.7606

	employ~e	educat~l
employment~e	1.0000	
educationl~l	0.0885	1.0000
	0.5287	

From the correlations and significance showed above, we can see that there is no obvious multicollinearity in our model except parking price of on-street and off-street, whose correlation is 0.7314 and correlation between urban population and urban GDP is 0.7334. Because the data of GDP in our model is based on the whole city, it is actually representing the city size, which has similar effects with variable urban population. And in terms of economic effect on our dependent variable, we have already included variable personal income on PPP. Therefore, variable urban GDP is removed from baseline model-Model 2 (See Appendix 2). Moreover, multicollinearity also exists between on-street and off-street parking price and correlations between car travel demand and parking price of on-street and off-street are -0.4326 and -0.1440 (See Appendix 1), we thus set up two OLS regression models with on-street parking price and off-street parking price separately to explore the effects of parking price on car travel demand more specifically.

Secondly, distribution histogram graphs of each variable are showed in Appendix.

The distributions of car travel demand and parking price for both on-street and off-street are almost normally (See Appendix 3).

With regards to population, its distribution is much too right skewed and we transform it into logarithm so as to make it normally distributed (See Appendix 4). There is right-skewed distribution of urban density and logarithm of urban density becomes more normally but is still left-skewed (See Appendix 5). When it comes to the distribution of private car ownership, it is obvious right skewed and there is not a large change in its normality after transforming (See Appendix 6). The distribution normality of personal income on PPP and ln (personal income on PPP) only changes from right-skewed into left-skewed (See Appendix 7). For educational level, even though its distribution become more normally after transforming it, the Adjusted R-squared in models goes down (See Appendix 9). All the changes after transforming variables for models with on-street and off-street parking price separately can be seen in Appendix 10 and Appendix 11. As we can see the results from these changes, both R-squared and Adj R-squared decrease, therefore we keep variables population, density, ownership, personal income, employment rate and education level for Model 3-1 with on-street and Model 3-2 with off-street parking price (See Appendix 12).

Finally, normality of estimators is also tested for our two baseline models with on-street and off-street parking price separately (See Appendix 13). As we can see from the distribution graphs and P values (0.55191 for Model 3-1 and 0.94876 for Model 3-2) in swilk test, it is obvious that the estimators are normally distributed for both models.

To sum up, we use two OLS regression models with on-street and off-street parking price separately to investigate the effects of paid parking on car travel demand specifically. And our improved OLS regression models are as follows:

Model 3-1 and Model 3-2:

Y (Car Travel Demand) = $\beta 0 + \beta 1 *$ On-street Parking Price + $\beta 2 *$ (Population) +

$\beta 3 *$ Density + $\beta 4 *$ Personal Income on PPP+

$\beta 5 *$ Employment Rate + $\beta 6 *$ Educational Level + u

Y (Car Travel Demand) = β0 + β1* Off-street Parking Price + β2 * (Population) +

β3 * Density + β4 * Personal Income on PPP+

β5 * Employment Rate + β6 * Educational Level + u

Figure 4-3 Results of model analysis

Dependent variable: Car travel demand (Car use percentage)(%)				
Variables	Model 1	Model 2	Model 3-1	Model 3-2
Onstreet parking price	**-2.166203**	**-2.052223**	**-1.028701**	
(€ / hour)	(1.115806)	(1.143582)	(0.8350585)	
Offstreet parking price	**0.8128242**	**1.121907**		**0.05383**
(€ / hour)	(0.8581778)	(0.8637467)		(0.6412157)
Urban Population	**-1.61e-06**	**-1.83e-07**	**5.81e-07**	**1.09e-07**
	(1.30e-06)	(1.07e-06)	(8.99e-07)	(1.08e-06)
Urban Density	**-0.0000977**	**-0.0001901**	**-0.0001643**	**-0.0002084**
(persons per sq. km)	(0.0004389)	(0.0004475)	(0.0004505)	(0.0004583)
Urban GDP	**0.0000515**			
(million euro)	(0.0000281)			
Private car ownership	**0.5633246****	**0.6214334**	**0.6393106****	**0.7017699****
(per 100 inhabitants)	(0.1325163)	(0.1320789)	(0.1323589)	(0.1272897)
Personal income on PPP	**-0.0001602**	**-0.0001545**	**-0.0001019**	**-0.0000979**
(euro per inhabitant)	(0.0001196)	(0.0001227)	(0.0001167)	(0.0001215)
Employment rate (%)	**-0.3404703****	**-0.2875392***	**-0.3368948****	**-0.390416****
	(0.1232248)	(0.1229685)	0.1178398	(0.1114398)
Educational level	**-0.0000661****	**-0.0000687****	**-0.000076****	**-0.0000695****
(ISCED level 5-6)	(0.0000176)	(0.000018)	(0.0000173)	(0.0000185)
Constant	**51.16094****	**46.32623****	**47.9035****	**45.1683****
	(10.29672)	(10.21701)	(10.22174)	(10.44515)
Number of observations	**53**	**53**	**53**	**53**

P-value:+:p<0.10; *p<0.05; **p<0.01

All models have the same dependent variable which is the car travel demand

Standard errors are reported in parentheses.

ii. Results and discussions

After improving and optimizing our regression model, Model 3-1 and Model 3-2 are (See Figure 4-4 and Figure 4-5) our final models, which is used to analyze goal-focused relationship.

<u>Figure 4-4 Model 3-1 with on-street parking price</u>

```
. reg traveldemand onstreet population density ownership personalincome employmentrate ed
> ucationlevel
```

Source	SS	df	MS
Model	6365.32124	7	909.331606
Residual	2591.69762	45	57.5932805
Total	8957.01887	52	172.250363

Number of obs	53
F(7, 45)	15.79
Prob > F	0.0000
R-squared	0.7107
Adj R-squared	0.6656
Root MSE	7.589

traveldemand	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
onstreet	-1.028701	.8350585	-1.23	0.224	-2.710596	.6531926
population	5.81e-07	8.99e-07	0.65	0.522	-1.23e-06	2.39e-06
density	-.0001643	.0004505	-0.36	0.717	-.0010716	.000743
ownership	.6393106	.1323589	4.83	0.000	.3727262	.905895
personalincome	-.0001019	.0001167	-0.87	0.387	-.000337	.0001331
employmentrate	-.3368948	.1178398	-2.86	0.006	-.5742363	-.0995533
educationlevel	-.000076	.0000173	-4.40	0.000	-.0001108	-.0000412
_cons	47.9035	10.22174	4.69	0.000	27.31585	68.49115

<u>Figure 4-5 Model 3-2 with off-street parking price</u>

```
. reg traveldemand offstreet population density ownership personalincome employmentrate e
> ducationlevel
```

Source	SS	df	MS
Model	6278.33968	7	896.905669
Residual	2678.67918	45	59.5262041
Total	8957.01887	52	172.250363

Number of obs	53
F(7, 45)	15.07
Prob > F	0.0000
R-squared	0.7009
Adj R-squared	0.6544
Root MSE	7.7153

traveldemand	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
offstreet	.05383	.6412157	0.08	0.933	-1.237645	1.345305
population	1.09e-07	1.08e-06	0.10	0.920	-2.07e-06	2.29e-06
density	-.0002084	.0004583	-0.45	0.651	-.0011315	.0007146
ownership	.7017699	.1272897	5.51	0.000	.4453953	.9581445
personalincome	-.0000979	.0001215	-0.81	0.424	-.0003425	.0001467
employmentrate	-.390416	.1114398	-3.50	0.001	-.6148673	-.1659647
educationlevel	-.0000695	.0000185	-3.76	0.000	-.0001067	-.0000323
_cons	45.1683	10.44515	4.32	0.000	24.13069	66.20591

In this regard, the OLS regression models are fitted to predict the effects of introducing or changing the parking price. The parameters included in the models are, in addition to the parking price, population, urban density, private car ownership, personal income on PPP, employment rate and educational level. All relations of the independent variables to the dependent variable are logical and expected. All statistics show that the model is good at fitting the data.

The Adjusted R-squared of Model 3-1 with on-street parking price and Model 3-2 with off-street parking price are 0.6656 and 0.6544 separately. R-squared is 0.7107 in Model 3-1 and 0.7009 in Model 3-2, which means that 71.07% of the variance is accounted for by our regression model 3-1 and 70.09% of the variance is accounted for by our regression Model 3-2. However, the model results confirm that the parking price for both on-street and off-street do not affect car travel demand at 5% significance level. There are significant relationships between car travel demand and private car ownership, employment rate and educational level at 5% level. Relationships between car travel demand and population, personal income on PPP and urban density are not significant at 5% level.

First of all, there is no significant relationship between parking price and car travel demand for both on-street and off-street, which is contrary our expectation that parking price will decrease car travel demand. The possible reasons for this results are as follows. First of all, car use percentage data used in our model is searched by EPOMM, which is mostly based on commuters because it is easier to collect information from commuters than temporary parkers. Commuters, on the one hand, are more likely to park longer time. Temporal parkers such as tourists, shoppers, their demands for parking are less regular, typically less predictable, and for shorter time periods. Therefore, commuters may subscribe for parking and pay once a month or even longer, namely, long-term parking contracts, and in this case, the change of parking price will not affect car travel demand a lot. On the other hand, subsidy from employers play an important role to affect its relationship between car travel demand. And there is always a special offer for the long time parking. For example, the daily maximum parking price for off-street in Brussels is around €12.5-€20 and €30-€50 in Amsterdam. Moreover, the change of daily maximum off-street parking price does not fluctuate a lot. Namely, even though parking price is raised, commuters are not going to change their parking behavior. Therefore, it is logical and expected that parking price for both on-street and off-street shows no significant relationship with car travel demand.

Relationship between population and car travel demand is not significant at 5% level in both models. Firstly, dramatic increase of population leads to severe traffic congestion in the crowded cities, spatial space for car reduces a lot because of the protection of pedestrian movement. Therefore, usage of private car is not encouraged. For example, there are limitations for car usage in CBDs and congestion tolls, which also reduces large amount use of passenger cars. Secondly, integral public transport, such as tram, bus, metro and train, urges people to choose more sustainable model split. Finally, with the increase awareness of environmental protection and the support of government, people are consciously replacing car with cycling, walking and public transport.

Urban density shows no significant relationship with parking price at 5% level. This is contrary to our expectation that urban density may affect car travel demand. As Hu and Lu (2007) have proved that different urban densities have certain effect on different travel demand, and within certain threshold, there is an obvious monotonous relationship between urban density and travel demand. City shape and road density have been concluded to have a significant effect on annual household vehicle miles (VMTs) traveled (Bento et al., 2005). Several reasons may explain our insignificant regression results. Firstly, significant relationships between urban density and car travel demand mentioned above are based in China and United States, which have large land area while countries in Europe are rather small. Secondly, commuters are the majority objects of car use percentage data survey, therefore the different urban density has little effect on their travel demand due to their special features (long term parking contract, parking subsidy from employers, etc.)

Private car ownership has a positive and significant relationship with citizens' car travel demand according to both Model 3-1 and Model 3-2. The P-values are almost 0 in two models, which are much smaller than 0.05. When there is one more person own a passenger car per 100 inhabitants, car travel demand will increase 0.639% in Model 3-1 and increase 0.702% in Model 3-2. It is obvious that if the car ownership increases, citizens have more chance to use their car for its convenience as people are more willing to spend time in car instead of out of the vehicles. Furthermore, people will also treat car as a symbol of their position and wealthy, namely, citizens use car not only with instrumental motives but also symbolic and affective motives (Steg, 2005).

Moreover, the relationship between personal income on PPP is not significant related with car travel demand at 5% level. On the one hand, according to Cervero (1989), nowadays, most citizen members reduce car usage, and many appear to be leasing vehicles in lieu of walking and biking. Car-share vehicles are used more for personal business and social-recreational travel than for nondiscretionary, routine travel such as to work or school. Shared cars are generally not used during peak periods or to dense settings well served by transit, such as downtown. In this sense, appearance of car sharing might be beneficial for stimulating a resourceful form of judicious auto mobility. Users are accruing substantial travel-time savings and willingly pay market prices for these benefits (Robert Cervero,1989).

With respect to employment rate and educational level, both negative and significant relationships are shown between them and car travel demand. When employment rate increases 1%, the car use percentage will decrease 0.337% in Model 3-1 and decrease 0.390% in Model 3-2; when there is one more person in higher educational level (ISCED level 5-6)[5], citizens' car travel demand will decrease 0.000076% in Model 3-1

[5] The International Standard Classification of Education (ISCED) is a statistical framework for organizing information on education maintained by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and was designed in the early 1970s to serve 'as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries and internationally'.

and 0.0000695% in Model 3-2. When there are more and more commuters, company shuttle bus for their employees can be an important reason for the decline of car travel demand. And on the other hand, most of the commuters have jobs in the city center or the locations with integral transport system, thus, commuters will shift to alternatives rather than driving, which will add both time cost during peak time. In terms of educational level, the higher level of education, the more awareness of protecting environment. Therefore, the more people graduated from high education (ISCED level 5-6), the more they realize the importance of private car usage and CO_2 emissions reduction. Hence, citizens will choose sustainable models like cycling, walking and public transport. Naturally, car travel demand namely, car use percentage will decrease.

ISCED level 5 indicates short-cycle tertiary education and ISCED level 6 indicates bachelor or equivalent.

5. Conclusions

i. Summary and policy implications

At the beginning of this study, we asked ourselves if parking price (including both on-street and off-street) have effects on citizens' car travel demand, which is indicated by car use percentage in model split in each city. Now, after having presented and discussed the results of our OLS regression model, we do explain the effects of paid parking. According to the results of baseline model, R-squared is 0.7107 in Model 3-1 and 0.7009 in Model 3-2, which means that 71.07% of the variance is accounted for by our regression model 3-1 and 70.09% of the variance is accounted for by our regression Model 3-2. However, the model results confirm that the parking price for both on-street and off-street do not affect car travel demand at 5% significance level. The possible reasons for this results are as follows. First of all, car use percentage data used in our model is searched by EPOMM, which is mostly based on commuters because it is easier to collect information from commuters than temporary parkers. Commuters, on the one hand, are more likely to park longer time. Temporal parkers such as tourists, shoppers, their demands for parking are less regular, typically less predictable, and for shorter time periods. Therefore, commuters may subscribe for parking and pay once a month or even longer, namely, long-term parking contracts, and in this case, the change of parking price will not affect car travel demand a lot. On the other hand, subsidy from employers play an important role to affect its relationship between car travel demand. And there is always a special offer for the long time parking. For example, the daily maximum parking price for off-street in Brussels is around €12.5-€20 and €30-€50 in Amsterdam. Moreover, the change of daily maximum off-street parking price does not fluctuate a lot. Namely, even though parking price is raised, commuters are not going to change their parking behavior. Therefore, it is logical and expected that parking price for both on-street and off-street shows no significant relationship with car travel demand.

On the other hand, there shows positive and significant relationships between car travel demand and private car ownership. Negative and significant relationships also present between employment rate and educational level.

In this regard, implications for transport policy decisions and urban development can be recommended to both urban residents and local government.

1. Special parking policy should be conducted on different driver groups. From our regression model analysis, commuters may be less sensitive to parking price when compared with other groups (relationship between off-street parking price and car travel demand is insignificant) as there is no significant relationship between parking price and car travel demand. Therefore, in order to encourage reduction of commuter driving and promote carpooling, limiting parking subsidy is one efficient way on the one hand, as Willison (1991) noted that fewer automobiles are driven to work when workers have to pay to park, as compared to when they park free or with parking subsidy. And on the other hand, public transport system should be improved in the location where commuters work. In other words, accessibility of the

workforce (and potential workforce) to the site of employment should be improved (Marsden, 2006). Moreover, daily shuttle bus can be developed by companies to pick up employees.

2. Limited passenger car ownership principle can be implemented by government. For example, tariffs can be levied on the second passenger car for one household family to reduce the ownership of private cars. As with the development of GDP and residents' living standard, households are going to own one more passenger cars for more symbolic and affective motives than instrumental one (Steg, 2005). Carpooling should also be encouraged not only for commuters but also for tourists and shoppers.

3. Local government also has to act within a framework of good governance and be fiscally responsible. The objectives of parking policy are, as Shoup (1999, 2005a) mentioned, the desire to use parking measures as a means of regenerating a specific part of the urban area such as the town center (i.e., providing more parking to attract business); the desire to use parking controls as a means of restraining vehicle traffic and improving environmental quality, or to encourage the use of non-car modes; and the need to secure sufficient revenue from the parking operation to cover costs or to make a surplus to fund other activities (IHT, 2005, p. 64). Thus, government should pay more attention on applying paid parking policy.

4. Moreover, parking policy should not be developed in isolation but as part of local and regional spatial and transport planning processes (Marsden and May, 2005).

Milosavljevic et al. (2011) argued that in the course of producing vehicle parking standards, the level of parking restrictions is to be depending on the Public Transport Accessibility Level. If Public Transport Accessibility Level of a zone the subject development belongs to is high, the number of parking spaces to be provided is restricted and customers are encouraged to shift to alternative transport modes. Therefore, the promotion of public transport along with efficient paid parking policy is better.

5. Intangible infrastructure of a city should be strengthened as well. Urban education system can improve citizens' awareness to reduce car usage. Abundant advertisements on the threat of CO_2 emissions and benefits of sustainable model choice are helpful.

ii. Limitations and further research

Even though our regression model shows logical and expected results, limitations still exit during our investigation process. And further researches are needed for improving the estimation of paid parking effects.

Limitations:

1. There are only 53 investigated European cities, which are shown in details in section Data Collection. Majority investigated cities locate in the South and East Europe than North and West Europe. And numbers of cities evaluated in different countries

are different. However, parking price varies little within the same countries, therefore, this will lead to some bias in our regression model. Moreover, our cross section data ranges from 2010 to 2016, which means that we searched data for different cities with different years.

2. During data collection process, different data sources for one variable may result in bias. Take urban GDP for example, we search data for most of the cities in website Knoema, but for some cities, information is cited from Wikipedia.

3. As Albert and Mahalel (2006) pointed out that even though parking pricing is a potentially powerful tool for regulating traffic congestion, it is intrinsically difficult to determine the appropriate parking fee. There are many aspects of parking price that have been assumed away in this analysis. On the one hand, dynamic pricing is disregarded. Namely, parking price varies with different time periods of a day, a week and also changes with different zones in one city. But we only take the parking price of weekday daytime in CBDs. On the one hand, special offers like free parking for the first minute or first X minutes are also ignored.

4. Different drivers have different parking behaviors. As we can see from the model analysis above, commuters are less sensitive to parking price than temporal parkers such as tourists and shoppers. Specific evaluations are needed for behaviors of different parking groups.

5. As we use the data of car use percentage from EPOMM, and the methods for data collection of EPOMM are not uniform for different cities in different countries. Thus, bias and mistakes might exist.

6. Paid parking policy may also differ a lot due to different cities or different countries. Government specific event and personal preference can also be important determinants for paid parking policy decision.

7. Other unobserved elements can also affect car travel demand. For example, interaction between employment rate and educational level may influence car travel demand. The more people get high educational level; the more people can be employed. Furthermore, the higher intelligence people have; the higher educational level people can get, therefore, variable can also be included in our baseline model.

Further research:

First of all, a parking fee, lacks sensitivity and may vary with the duration and location of parking, not necessarily reflecting travel conditions (Sulli-van, 1990; Verhoef et al. 1995). And it is not appropriate to estimate the impacts of the measures (the time limitation and parking price of on-street parking and the parking price of off-street parking) individually because of their synergistic effect; instead, this should be performed simultaneously (Ibeas et al., 2011). Namely, paid parking is only one aspect of parking policy, parking duration and parking quantity should also be included in our regression model to avoid potential bias.

Secondly, several areas requiring further research have been identified: the importance of out-of-vehicle costs and in particular walk-times on parking behavior. Within this, greater attention should be paid to the segmentation of the parking market; understanding the zones of influence of parking restraint policies, particularly for commuter traffic; the importance of the quality of the retail offer, public transport accessibility and parking policies in determining retail destination choice at a disaggregate level; the impacts of restricted residential parking on short- term transport adaptations and long-term housing location decisions; evaluation of the impacts of residential new-build parking standards on mode choice (Marsden, 2006).

Moreover, according to Yao and Morikawa, induced travel is also an important component of car travel demand, including short run effects (e.g., route switches, mode switches, changes of destination, and new trip generation) and long term effects (e.g., change in household auto ownership, and spatial real- location of activities).

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Appendix

Appendix 1. Correlations among All Variables

	travel~d	onstreet	offstr~t	popula~n	density	owners~p	person~e
traveldemand	1.0000						
onstreet	-0.4326	1.0000					
	0.0012						
offstreet	-0.1440	0.7314	1.0000				
	0.3037	0.0000					
population	-0.2967	0.4370	0.6273	1.0000			
	0.0310	0.0011	0.0000				
density	-0.2133	0.2224	0.1860	0.3286	1.0000		
	0.1251	0.1095	0.1824	0.0163			
ownership	0.6826	-0.4694	-0.3342	-0.3959	-0.1335	1.0000	
	0.0000	0.0004	0.0145	0.0033	0.3407		

	GDP	employ~e	educat~l
GDP	1.0000		
employment~e	0.1345	1.0000	
	0.3368		

Appendix 2. Model 2 without variable GDP

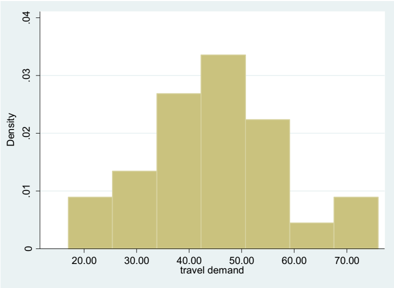
```
. reg traveldemand onstreet offstreet population density ownership personalincome employm
> entrate educationlevel
```

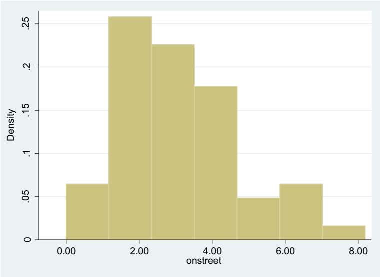
Source	SS	df	MS
Model	6461.02564	8	807.628205
Residual	2495.99323	44	56.7271189
Total	8957.01887	52	172.250363

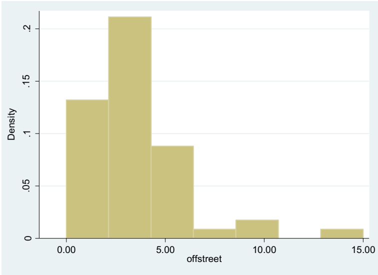
Number of obs =	53
F(8, 44) =	14.24
Prob > F =	0.0000
R-squared =	0.7213
Adj R-squared =	0.6707
Root MSE =	7.5317

traveldemand	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
onstreet	-2.052223	1.143582	-1.79	0.080	-4.356961	.2525152
offstreet	1.121907	.8637467	1.30	0.201	-.6188598	2.862674
population	-1.83e-07	1.07e-06	-0.17	0.865	-2.34e-06	1.97e-06
density	-.0001901	.0004475	-0.42	0.673	-.001092	.0007118
ownership	.6214334	.1320789	4.71	0.000	.3552459	.8876209
personalincome	-.0001545	.0001227	-1.26	0.214	-.0004018	.0000927
employmentrate	-.2875392	.1229685	-2.34	0.024	-.535366	-.0397124
educationlevel	-.0000687	.000018	-3.80	0.000	-.000105	-.0000323
_cons	46.32623	10.21701	4.53	0.000	25.7352	66.91726

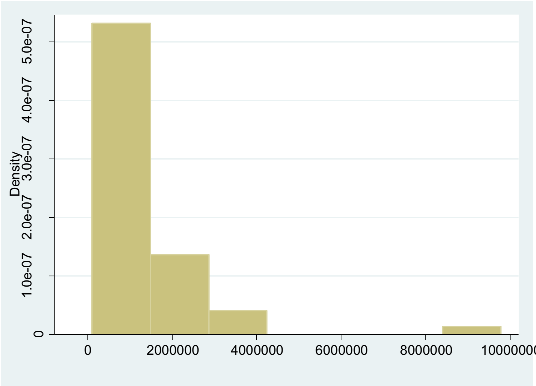
Appendix 3. Distribution Histogram of Car Travel Demand, On-street Parking Price and Off-street Parking Price

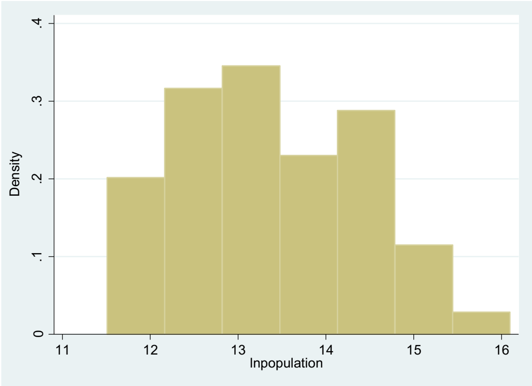




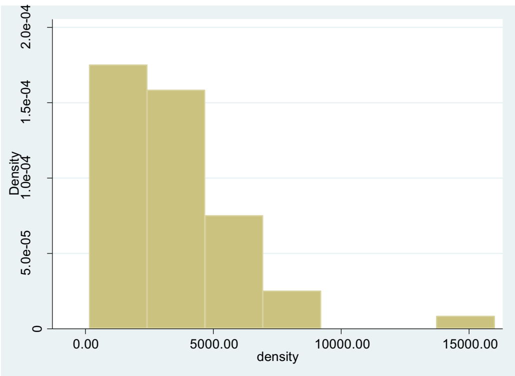


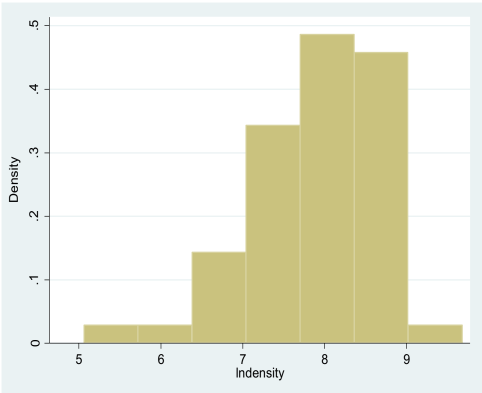
Appendix 4. Distribution Histograms of Population and ln(Population)



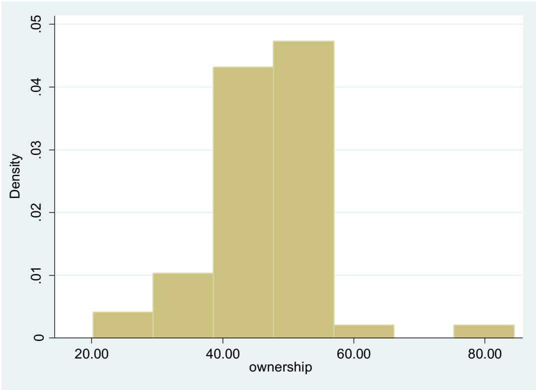


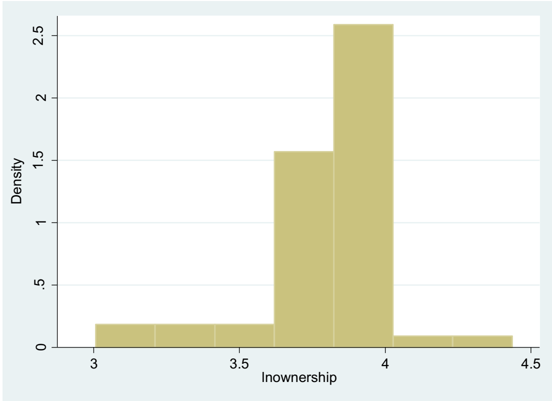
Appendix 5. Distribution Histograms of Density and ln(Density)



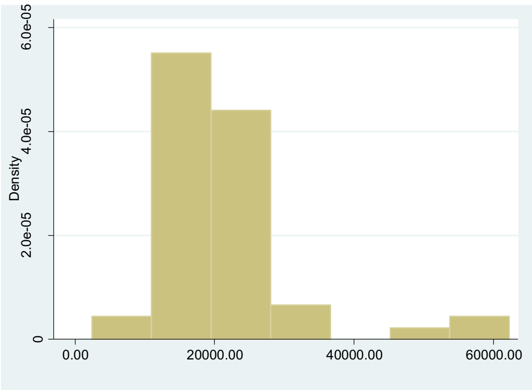


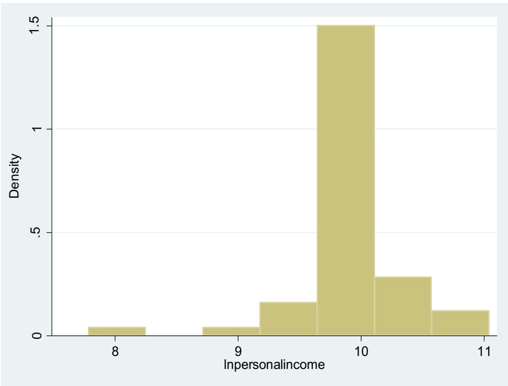
Appendix 6. Distribution Histograms of Ownership and ln(Ownership)



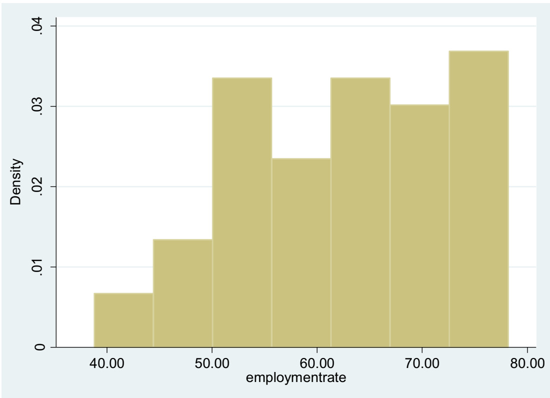


Appendix 7. Distribution Histograms of Personal Income and ln (Personal Income)

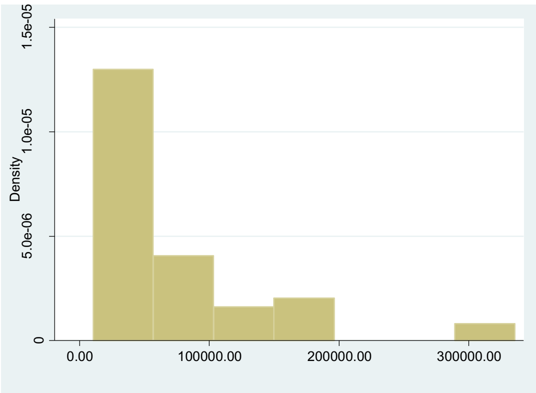


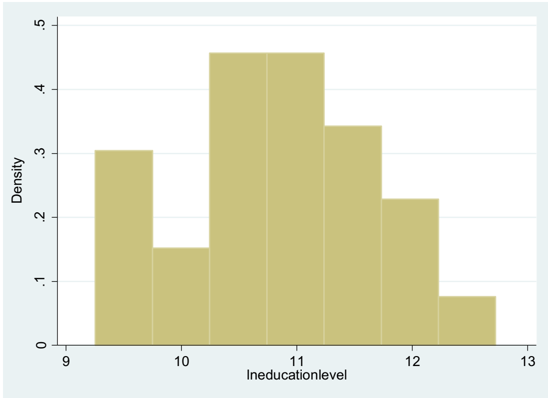


Appendix 8. Distribution Histogram of Employment Rate



Appendix 9. Distribution Histograms of Educational Level and ln (Educational Level)





Appendix 10. Model changes with on-street parking price

Model with ln (urban population)

```
. reg traveldemand onstreet lnpopulation density ownership personalincome employmentrate
> educationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   15.68
       Model |  6352.12098     7  907.445854           Prob > F      =  0.0000
    Residual |  2604.89789    45  57.8866198           R-squared     =  0.7092
-------------+------------------------------           Adj R-squared =  0.6639
       Total |  8957.01887    52  172.250363           Root MSE      =  7.6083

------------------------------------------------------------------------------
traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    onstreet |  -.9182868   .8046221    -1.14   0.260    -2.538879    .7023053
lnpopulation |   .6640898   1.534654     0.43   0.667    -2.426862    3.755042
     density |  -.0001806   .0004856    -0.37   0.712    -.0011587    .0007975
   ownership |   .6372788   .1335124     4.77   0.000     .3683711    .9061865
personalincome | -.0001065  .0001209    -0.88   0.383    -.0003501    .0001371
employmentrate | -.3427041  .1191758    -2.88   0.006    -.5827365   -.1026717
educationlevel | -.0000781  .0000202    -3.87   0.000    -.0001187   -.0000375
       _cons |   40.08533   23.34456     1.72   0.093    -6.933023    87.10368
------------------------------------------------------------------------------
```

Model with ln(urban population) and ln(urban density)

```
. reg traveldemand onstreet lnpopulation lndensity ownership personalincome employmentrat
> e educationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   15.66
       Model |  6349.6794     7  907.097057           Prob > F      =  0.0000
    Residual |  2607.33947    45   57.940877           R-squared     =  0.7089
-------------+------------------------------           Adj R-squared =  0.6636
       Total |  8957.01887    52  172.250363           Root MSE      =  7.6119

------------------------------------------------------------------------------
traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    onstreet |  -.9462702   .8050701    -1.18   0.246    -2.567765    .6752243
lnpopulation |   .2244157    1.50507     0.15   0.882     -2.80695    3.255781
   lndensity |   .4769518   1.539527     0.31   0.758    -2.623815    3.577719
   ownership |   .6340182   .1331003     4.76   0.000     .3659404     .902096
personalincome |  -.0000829   .0001196    -0.69   0.492    -.0003237    .0001579
employmentrate |  -.3636836   .1224566    -2.97   0.005    -.6103239   -.1170434
educationlevel |  -.0000763   .0000203    -3.76   0.000    -.0001171   -.0000354
       _cons |   42.48446   21.85318     1.94   0.058    -1.530105    86.49903
------------------------------------------------------------------------------
```

Model with ln (urban population), ln(urban density) and ln(ownership)

```
. reg traveldemand onstreet lnpopulation lndensity lnownership personalincome employmentr
> ate educationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   14.58
       Model |  6216.37746     7  888.053922           Prob > F      =  0.0000
    Residual |  2740.64141    45  60.9031425           R-squared     =  0.6940
-------------+------------------------------           Adj R-squared =  0.6464
       Total |  8957.01887    52  172.250363           Root MSE      =   7.804

------------------------------------------------------------------------------
traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    onstreet |  -.7800609   .8483609    -0.92   0.363    -2.488747    .9286257
lnpopulation |  -.1007884   1.535763    -0.07   0.948    -3.193975    2.992398
   lndensity |    .114699   1.578209     0.07   0.942    -3.063977    3.293375
 lnownership |     25.777   5.852643     4.40   0.000     13.98917    37.56483
personalincome |  -.0000868   .0001226    -0.71   0.483    -.0003337    .0001601
employmentrate |  -.4225586   .1265923    -3.34   0.002    -.6775286   -.1675886
educationlevel |  -.0000666   .0000214    -3.12   0.003    -.0001097   -.0000236
       _cons |  -16.67221   31.66159    -0.53   0.601    -80.44194    47.09751
------------------------------------------------------------------------------
```

Model with ln (urban population), ln(urban density) , ln(ownership) and ln(personal income)

```
. reg traveldemand onstreet lnpopulation lndensity lnownership lnpersonalincome employmen
> trate educationlevel
```

Source	SS	df	MS
Model	6187.6247	7	883.946386
Residual	2769.39417	45	61.5420926
Total	8957.01887	52	172.250363

Number of obs	53
F(7, 45)	14.36
Prob > F	0.0000
R-squared	0.6908
Adj R-squared	0.6427
Root MSE	7.8449

traveldemand	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
onstreet	-.7350996	.8503434	-0.86	0.392	-2.447779	.9775799
lnpopulation	-.3582028	1.502009	-0.24	0.813	-3.383403	2.666998
lndensity	.3411884	1.578319	0.22	0.830	-2.83771	3.520087
lnownership	26.10301	5.951979	4.39	0.000	14.11511	38.09091
lnpersonalincome	-.4615242	2.724776	-0.17	0.866	-5.949504	5.026455
employmentrate	-.4430407	.1267243	-3.50	0.001	-.6982765	-.1878049
educationlevel	-.000063	.0000216	-2.92	0.005	-.0001066	-.0000195
_cons	-12.66994	43.54204	-0.29	0.772	-100.3681	75.02824

Model with ln (urban population), ln(urban density) , ln(ownership), ln(personal income) and ln(educationlevel)

```
. reg traveldemand onstreet lnpopulation lndensity lnownership lnpersonalincome employmen
> trate lneducationlevel
```

Source	SS	df	MS
Model	6072.86318	7	867.551883
Residual	2884.15569	45	64.0923486
Total	8957.01887	52	172.250363

Number of obs	53
F(7, 45)	13.54
Prob > F	0.0000
R-squared	0.6780
Adj R-squared	0.6279
Root MSE	8.0058

traveldemand	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
onstreet	-.6851374	.873771	-0.78	0.437	-2.445002	1.074728
lnpopulation	-.3139462	1.602457	-0.20	0.846	-3.54146	2.913568
lndensity	.8437397	1.596506	0.53	0.600	-2.371787	4.059267
lnownership	28.12286	5.92229	4.75	0.000	16.19476	40.05097
lnpersonalincome	.901099	2.67211	0.34	0.738	-4.480807	6.283005
employmentrate	-.5020198	.1249379	-4.02	0.000	-.7536578	-.2503819
lneducationlevel	-4.607404	1.822898	-2.53	0.015	-8.278909	-.9358992
_cons	10.48329	47.15431	0.22	0.825	-84.49038	105.457

Appendix 11. Model changes with off-street parking price

Model with ln (urban population)

```
. reg traveldemand offstreet lnpopulation density ownership personalincome employmentrate
> educationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   15.06
       Model |  6277.86995     7  896.838565           Prob > F      =  0.0000
    Residual |  2679.14891    45  59.5366425           R-squared     =  0.7009
-------------+------------------------------           Adj R-squared =  0.6544
       Total |  8957.01887    52  172.250363           Root MSE      =   7.716

------------------------------------------------------------------------------
traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   offstreet |   .0803169   .5790471     0.14   0.890    -1.085944    1.246578
lnpopulation |   .0820079   1.730746     0.05   0.962    -3.403894     3.56791
     density |   -.000209   .0004919    -0.42   0.673    -.0011997    .0007818
   ownership |   .7009819    .127782     5.49   0.000     .4436157    .9583482
personalincome | -.0000994  .0001234    -0.81   0.425    -.0003478    .0001491
employmentrate |  -.390863  .1132781    -3.45   0.001    -.6190168   -.1627091
educationlevel | -.0000695  .0000221    -3.14   0.003    -.0001141   -.0000249
       _cons |   44.19339   24.84389     1.78   0.082    -5.844769    94.23155
------------------------------------------------------------------------------
```

Model with ln(urban population) and ln(urban density)

```
. reg traveldemand offstreet lnpopulation lndensity ownership personalincome employmentra
> te educationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   15.00
       Model |  6270.52641     7  895.789487           Prob > F      =  0.0000
    Residual |  2686.49246    45  59.6998325           R-squared     =  0.7001
-------------+------------------------------           Adj R-squared =  0.6534
       Total |  8957.01887    52  172.250363           Root MSE      =  7.7266

------------------------------------------------------------------------------
traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   offstreet |   .0710724   .5806151     0.12   0.903    -1.098346    1.240491
lnpopulation |  -.3575519   1.691661    -0.21   0.834    -3.764731    3.049627
   lndensity |   .3729448   1.562748     0.24   0.812    -2.774591    3.520481
   ownership |   .6981023   .1276944     5.47   0.000     .4409127     .955292
personalincome | -.0000752  .0001223    -0.61   0.542    -.0003214    .0001711
employmentrate | -.4121821   .117125    -3.52   0.001    -.6480839   -.1762803
educationlevel | -.0000677  .0000222    -3.04   0.004    -.0001125   -.0000229
       _cons |    47.2525   23.43036     2.02   0.050     .0613265    94.44368
------------------------------------------------------------------------------
```

Model with ln (urban population), ln(urban density) and ln(ownership)

```
. reg traveldemand offstreet lnpopulation lndensity lnownership personalincome employment
> rate educationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   14.22
       Model |  6168.26035     7  881.18005            Prob > F      =  0.0000
    Residual |  2788.75852    45  61.9724115           R-squared     =  0.6887
-------------+------------------------------           Adj R-squared =  0.6402
       Total |  8957.01887    52  172.250363           Root MSE      =  7.8723

------------------------------------------------------------------------------
traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   offstreet |   .1389641   .5955315     0.23   0.817    -1.060498    1.338426
lnpopulation |   -.687013   1.717519    -0.40   0.691    -4.146273    2.772247
   lndensity |  -.0115636   1.591037    -0.01   0.994    -3.216077     3.19295
 lnownership |   28.47294   5.465303     5.21   0.000     17.46526    39.48063
personalincome | -.0000822   .0001245    -0.66   0.512    -.0003329    .0001685
employmentrate |  -.466855   .1185915    -3.94   0.000    -.7057105   -.2279996
educationlevel | -.0000571   .0000231    -2.47   0.017    -.0001037   -.0000105
       _cons |  -18.97659   32.07396    -0.59   0.557    -83.57686    45.62368
------------------------------------------------------------------------------
```

Model with ln (urban population), ln(urban density), ln(ownership) and ln(personal income)

```
. reg traveldemand offstreet lnpopulation lndensity lnownership lnpersonalincome employme
> ntrate educationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   14.04
       Model |  6143.42098     7  877.631569           Prob > F      =  0.0000
    Residual |  2813.59788    45  62.5243974           R-squared     =  0.6859
-------------+------------------------------           Adj R-squared =  0.6370
       Total |  8957.01887    52  172.250363           Root MSE      =  7.9072

--------------------------------------------------------------------------------
  traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
---------------+----------------------------------------------------------------
     offstreet |   .1012926   .5990537     0.17   0.866    -1.105264    1.307849
  lnpopulation |  -.8472347   1.706342    -0.50   0.622    -4.283983    2.589514
     lndensity |   .2011981   1.587322     0.13   0.900    -2.995833    3.398229
   lnownership |    28.5283    5.56243     5.13   0.000     17.32499    39.73161
lnpersonalincome | -.5200941  2.776997    -0.19   0.852    -6.113253    5.073065
employmentrate |  -.4823777   .1195355    -4.04   0.000    -.7231346   -.2416208
educationlevel |   -.000055   .0000234    -2.35   0.023    -.0001021   -7.92e-06
         _cons |  -14.38989     44.663    -0.32   0.749    -104.3458      75.566
--------------------------------------------------------------------------------
```

Model with ln (urban population), ln(urban density), ln(ownership), ln(personal income and ln(education level)

```
. reg traveldemand offstreet lnpopulation lndensity lnownership lnpersonalincome employme
> ntrate lneducationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   13.32
       Model |  6041.45337     7  863.064768           Prob > F      =  0.0000
    Residual |  2915.56549    45  64.7903443           R-squared     =  0.6745
-------------+------------------------------           Adj R-squared =  0.6239
       Total |  8957.01887    52  172.250363           Root MSE      =  8.0492

------------------------------------------------------------------------------
traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   offstreet |   .2138032   .6085806     0.35   0.727    -1.011941    1.439548
lnpopulation |  -1.007594   1.813486    -0.56   0.581    -4.660141    2.644954
   lndensity |   .6225873   1.603276     0.39   0.700    -2.606576     3.85175
 lnownership |   30.38289   5.511188     5.51   0.000     19.28279      41.483
lnpersonalincome | .589426  2.757901     0.21   0.832    -4.965271    6.144123
employmentrate | -.5312001  .1191788    -4.46   0.000    -.7712386   -.2911617
lneducationlevel | -3.787725 1.951128    -1.94   0.058    -7.717499     .142049
       _cons |   6.097411   46.99898     0.13   0.897    -88.56339    100.7582
------------------------------------------------------------------------------
```

Appendix 12. Model 3-1 with on-street parking price and Model 3-2 with off-street parking price

Model 3-1 with on-street parking price

```
. reg traveldemand onstreet population density ownership personalincome employmentrate ed
> ucationlevel

      Source |       SS       df       MS              Number of obs =      53
-------------+------------------------------           F(  7,    45) =   15.79
       Model |  6365.32124     7  909.331606           Prob > F      =  0.0000
    Residual |  2591.69762    45  57.5932805           R-squared     =  0.7107
-------------+------------------------------           Adj R-squared =  0.6656
       Total |  8957.01887    52  172.250363           Root MSE      =   7.589

------------------------------------------------------------------------------
traveldemand |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    onstreet |  -1.028701   .8350585    -1.23   0.224    -2.710596    .6531926
  population |   5.81e-07   8.99e-07     0.65   0.522    -1.23e-06    2.39e-06
     density |  -.0001643   .0004505    -0.36   0.717    -.0010716     .000743
   ownership |   .6393106   .1323589     4.83   0.000     .3727262     .905895
personalincome | -.0001019  .0001167    -0.87   0.387     -.000337    .0001331
employmentrate | -.3368948  .1178398    -2.86   0.006    -.5742363   -.0995533
educationlevel |  -.000076  .0000173    -4.40   0.000    -.0001108   -.0000412
       _cons |    47.9035   10.22174     4.69   0.000     27.31585    68.49115
------------------------------------------------------------------------------
```

Model 3-2 with off-street parking price

```
. reg traveldemand offstreet population density ownership personalincome employmentrate e
> ducationlevel
```

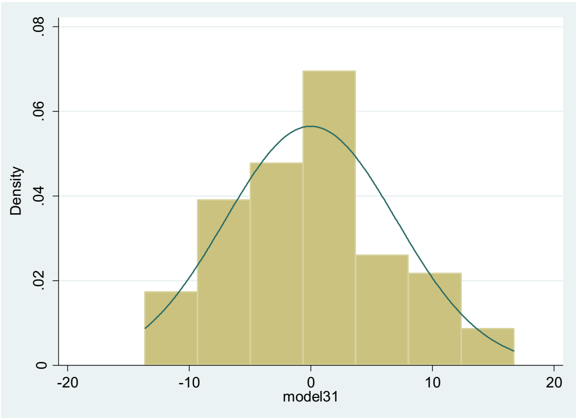
Source	SS	df	MS
Model	6278.33968	7	896.905669
Residual	2678.67918	45	59.5262041
Total	8957.01887	52	172.250363

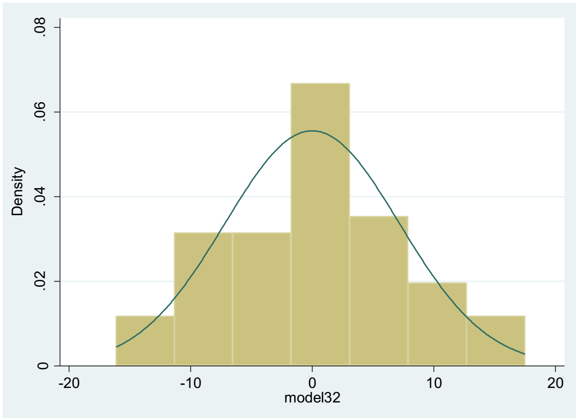
Number of obs	53
F(7, 45)	15.07
Prob > F	0.0000
R-squared	0.7009
Adj R-squared	0.6544
Root MSE	7.7153

traveldemand	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
offstreet	.05383	.6412157	0.08	0.933	-1.237645	1.345305
population	1.09e-07	1.08e-06	0.10	0.920	-2.07e-06	2.29e-06
density	-.0002084	.0004583	-0.45	0.651	-.0011315	.0007146
ownership	.7017699	.1272897	5.51	0.000	.4453953	.9581445
personalincome	-.0000979	.0001215	-0.81	0.424	-.0003425	.0001467
employmentrate	-.390416	.1114398	-3.50	0.001	-.6148673	-.1659647
educationlevel	-.0000695	.0000185	-3.76	0.000	-.0001067	-.0000323
_cons	45.1683	10.44515	4.32	0.000	24.13069	66.20591

Appendix 13. Normality of Estimators for Model 3-1 and Model 3-2

Estimator distribution graphs for Model 3-1 and Model 3-2





Swilk test for Model 3-1 and Model 3-2

```
. swilk model31
```

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
model31	53	0.98089	0.941	-0.130	0.55191

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
model32	53	0.99053	0.466	-1.633	0.94876