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A methodological debate on the measurement of the motorized passenger mobility in urban spaces: Towards a new methodological perspective

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Abstract

This paper discusses the methodological shortages in measurements of motorized urban mobility subsequent to a type of systematic literature review. In this sense, the research questions and the related methodologies of such studies have been criticized. According to the preliminary indications, firstly, it has been observed that in almost all these researches, the research question, which investigates the marginal effect of travel time on Vehicle Miles Traveled (VMT), has been adopted. Secondly, it has been asserted that such types of researches have not been able to isolate the generative part and redistributive part of the induced travel demand measurements up to now. Unlike any previous researches, dealing with the marginal effect of travel time on Vehicle Miles Traveled (VMT), this study firstly proposes a methodological focus specifically on the interrelation between the travel times of the individuals and the number of trips they exhibit in a day. For such a research question, the newest econometric model, namely, Generalized Simultaneous Equations Model (GSEM Path Analysis) will be convenient model structure, which refers to methodological contribution of this study for such similar future studies. The methodological proposal of this paper will be able to be integrated into a trip generation model, and will also be able to be used to assess the performance of any transportation project reference the discussions taking travel demand management policies into account.

Keywords
Induced motorized passenger mobility demand, Travel demand management policies, Urban mobility, Disaggregated travel demand models, Generalized simultaneous equations model.

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1. Introduction

Unlike any other researches, this study firstly proposes a research focusing on the interrelationship between the daily motorized travel time of the individuals and the number of daily motorized trips of the related individuals. The outcome of this paper is the methodological proposal of such a research question. Herein, the generalized simulatenous equations model structure has been proposed as the most attractive model.

In the light of the research framework asserted in this paper, two main dependent variables have been defined: 'number of daily motorized trips' and 'daily motorized travel time for each individual'. In this context, firstly, the dependent variable called number of daily motorized trips is a candidate for the family of nonlinear count variable, while the daily motorized travel time will be the one of a gaussian distributed continious variable. Secondly, the first dependent variable called number of daily motorized trips will most probably involve excess amount of zero observations. In other words, there will occur so many individuals that have not carried out any trip in any stated day. This type of data deserves a careful treatment, coping with the potential problem of excess amount of zero observations. Thirdly, these two dependent variables tend theoretically to exhibit a kind of relationship, which is called simultaneity in econometrics. In other words, the daily travel time of an individual will affect the daily number of trips of this individual, then this daily number of trips will also affect the daily travel time of the related individual indeed. Such a type of reciprocal relationship is called simultaneity in econometrics. Lastly, the daily travel time of the individual will refer to a kind of endogeneous variable, affecting the daily number of trips of this individual. In the light of these views, any single equation model and/or any traditional simultaneous equations model structure will fall short in coping with all these four technical problems, which necessitate further modeling approach. From this point of view, this paper is designed as an instigator one for such related future studies, aiming to fill such methodological gaps in measuring induced motorized passenger mobility demand in urban spaces. To that end, the study has been structured by five sections in addition to this introduction part, namely, literature review, methodological debates, discussions, and concluding remarks.

2. Literature review

The notion called induced motorized passenger mobility demand in urban spaces refers to two main frameworks: diversion of the existing demand and newly generated traffic. In addition, the concept of newly generated traffic refers to two sub-forms, namely release of the suppressed demand and newly generated traffic with regards to the urban development effects.

The literature of measuring induced motorized passenger mobility demand mostly refers to the interrelationship between the Vehicle Miles Traveled (VMT) and the total travel time. In other words, the most of the empirical studies of induced motorized passenger mobility demand have focused on measuring the marginal effect of travel time on VMT. On the other hand, such these researches exhibit some weaknesses.

The first weakness comes from the differences between the spatial resolutions of the related studies. At this juncture, the ones conducting the facility based (a neighbourhood unit with its surrounding) or corridor based (along a highway route) analysis produce partial urban equilibrium marginal elasticities instead of the ones of system-wide urban equilibriums. The second is about the aggregation in data structures. That is to say, the travel survey data, which disregards the behavioral units (individuals or households level), will produce biased results that are far away from the reality.

The examples for the facility or corridor based studies are the ones conducted by Pells (1989), Hansen et al. (1993), Kroes et al. (1996), Luk & Chung (1997), and Mokhtarian et al. (2000), while the area-wide studies are Hansen & Huang (1997), Noland & Cowart (2000), Fulton et al. (2000), Cervero & Hansen (2002), Cervero (2003), Silva & Costa (2007), Ozuysal & Tanyel (2008), Holcombe & Williams (2010), Hymel, Small & Dender (2010), Melo, Graham, & Canavan (2012), and Vos & Witlox (2013). The facility or corridor based studies generally adopt the methodological frameworks called growth comparison analysis and matched pair analysis so as to calculate the related marginal elasticities. On the other hand, the area-wide studies mostly involve the econometric models such as Ordinary Least Squares (OLS) regression models, auto-regressive models, and travel demand models so as to get the related marginal elasticity coefficients.

According to the results of facility or corridor based studies, the related marginal elasticity coefficients change between 0,15 and 0,30 for the four years time horizon; 0,30 and 0,40 for the ten years time horizon; 0,40 and 0,60 for the sixteen years time horizon (Pells ,1989; Hansen et al., 1993; Kroes et al., 1996; Luk & Chung, 1997; Mokhtarian et al., 2000). On the other hand, according to the findings of the area-wide studies, the related short-run marginal elasticity coefficient varies from 0,30 to 0,50 for the county level, while it falls between 0,54 and 0,61 for the metropolitan region scale (Cervero, 2002).

In addition to the differences in spatial resolution of the related studies, the related models of these studies are also grouped into two: aggregated models and disaggregated models. In this sense, the level of aggregation refers both to data gathering structure (household/individual scale field surveys or not) and to the related model structures. In almost all these studies, the VMT is defined as the main dependent variable. On the other hand, the related independent variables are defined as the lane-miles additions with several time lagged variables and geographical variables within the studies involving aggregated time-series econometric models, while within the disaggregated ones, the independent variables mostly refer to the total travel time and average travel speed in addition to the individuals based socio-economic variables. Besides, the functional form of log-linear model specification is generally selected. The findings of all the related studies with refers to both aggregated data and aggregated models will cause enourmously increasing aggregated estimation errors due to both data gathering processes and to generalized functional forms. In addition, such estimation errors will enormously increase as the study area expands. Thus, the behavioral units (individuals or households scale) based data gathering and modeling approaches are required to minimize the related estimation errors. In this respect, the study of Barr (2000) is an interesting example. In this study, the households based national scale field survey was conducted for the United States. The models of this study are designated via cross-sectional data analysis with refers to the logarithm of the VMT per household as the main dependent variable, while the households based socio-economic variables are defined as the independent variables (Barr, 2000). Furthermore, the related models are stratified according to the spatial sizes of the related metropolitan regions located in the United States. On the other hand, the related results of the study indicate that there is no statistically significant difference in the related marginal elasticity coefficient estimations with refers to these spatial size based stratifications (Barr, 2000).

In addition to the aggregated estimation errors of data & model structures, the third source of error is defined as disregard of the simultaneity effects between the dependent and main independent variables. In this sense, the main dependent variable called Vehicle Miles Traveled (VMT) will exhibit a kind of reciprocal relationship with one of the preliminary independent variables called lane miles additions. That is to say, an increase in the total length of lanes via the lane mile additions will make the measure of VMT increase and that increase in VMT will also induce the demand for the new lane miles additions indeed. Disregard of such a reciprocal relationship in formulation of the related models will make the level of estimation errors increase. Few studies -asserting such a related simultaneity effect- are exhibited by Noland & Cowart (2000) and Cervero & Hansen (2002). In the first example, the related simultaneity effect is coped with by the addition of instrumental variables, which theoretically justify the interrelationship between VMT and lane miles additions. In the second example, the problem of simultaneity is coped with by the Two-Stages Least Squares (2SLS) simultaneous equations model structure (Noland & Cowart, 2000; Cervero & Hansen, 2002).

There are also other examples in literature tackling with the problems of endogeneity and simultaneity within a deeper manner. To illustrate, the study of Cervero (2003) asserts four simultaneous equations in the models with regards to the dependent variables called urban development, lane miles growth, VMT, and travel speed (Cervero, 2003). Lastly, in some further studies, it is investigated that whether the level of traffic congestion constitutes a statistically significant variance on the estimated marginal elasticity coefficients with regards to the measures of induced travel demand or not. In this context, according to the findings of the study of Hymel, Small & Dender (2010), the level of traffic congestion creates a statistically significant variance on the induced travel demand estimations in a negative direction (as it is theoretically expected), which increases as the level of income of the passengers increases (Hymel, Small & Dender, 2010). On the other hand, according to the empirical findings of the study carried out by Noland & Cowart (2000), the variance on induced travel demand estimations, which is created by the level of traffic congestion, does not exhibit statistically significant measures (Noland & Cowart, 2000).

According to these views, the literature of induced motorized passenger mobility demand measurements will refer to three different methodological approaches: ones adopting aggregated data collection procedure versus disaggregated data collection procedure, ones based on facility or corridor based studies versus area-wide studies, and ones asserting single index model structures versus simultaneous equations model structures. These three approaches will be re-phrased as data collection approach, spatial resolution approach, and model structure approach, respectively.

3. Methodological debates

It is required to define the term passenger for the investigation on the effect of change in daily motorized travel time of an individual on her number of daily motorized trips. Herein, the passenger is defined as the person, who is at least 16 years old. In accordance with this definition, the potential sample of the passengers within the study area is to be constructed randomly via the methodological framework called stratified simple random sampling. The more detailed methodological and contents based discussuions for such field travel survey design and sample selection procedure deserve an another research paper and so it is out of the scope of this article. The main intention of this paper is just to give the preliminary guidelines for such notions before beginning for such field research.

In this article, it is assumed that the researcher has succeeded the preliminary requirements in constituting a convenient sampling procedure and has conducted the field survey efficiently via gathering the convenient disaggregated data so as to begin the related modeling procedure. For this reason, this paper purely focuses on the detailed discussions based on modeling procedure of such future studies rather than focusing on the data collection processes. In this sense, with reference to the research question asserted in the paper, the theoretically justified dependent and independent variables will be defined as in the followings:

- Y1 = motor_y: total number of motorized trips of an individual (passenger) in a given day.
- Y2 = motor_s: total amount of time spent in minutes by the related individual (passenger) during all his/her daily motorized trips within a given day.
- X1 = motor_di: daily amount of total distance (in kilometer) traveled by the individual (passenger) with motorized vehicle(s).
- X2 =male_d: dummy variable asserting whether the individual (passenger) is male or not. If male, it takes value of 1; if female:0.
- X3 =h_head_d: dummy variable asserting that whether the related individual (passenger) is household

head or not. If he/she is household head:1, otherwise:0.

- X4=hh_inc: household disposable income per month (in Turkish Lira).
- X5 =oto_s: number of the private cars owned by the family.
- X6 =hhsize: household size (number of people in the family).
- X7 =age: age of the individual.
- X8 =hbw_d: dummy variable asserting that whether the stated daily trips of the individual (passenger) involve at least one home-based work (hbw) trip or not. If there exists at least one hbw trip among all the daily trips, it takes the value of 1, otherwise it takes 0.
- X9 =hbs_d: dummy variable asserting that whether the stated daily trips of the individual (passenger) involve at least one home-based school (hbs) trip or not. If there exists at least one hbs trip among all the daily trips, it takes the value of 1, otherwise it takes 0.
- X10 =tahsil_y: number of years of schooling that the individual has attended.
- Z1 = motorfft: motorized free flow time (motorfft) as a traffic congestion parameter for the daily trips of the individual (passenger). In other words, this measure refers to the average amount of free flow travel time (in minutes) of the indiviual in the case that the motorized vehicle of the trip is the unique one between the related origin and destination within given a day reference to each motorized trip.
- Z2 = mot_y_s: dummy variable indicating that whether the individual (passenger) carries out at least one motorized trip in a given da yor not. If he/she carries out at least one motorized trip in a given day, it takes the value 1, otherwise 0.

It is essential to highlight that the travel behavior (and so number of trips) of a passenger mostly refers to his/her socio-economic characteristics that are represented by her income, number of automobiles owned, household size, age and number of years of schooling. Besides, the explanatory variable called total motorized travel times spent by an individual in motorized trips is both independent and endogeneous variable affecting number of daily motorized trips (simultaneity). Herein, the travel time variables are the key variables, and their elasticities with respect to total number of motorized trips are assumed to reflect the willingness to travel more depending on a reduction in daily travel times. The other explanatory variables are dummy variables specifying sex (male_d), specifying whether the individual is household head (h_head_d), and indicating whether the individual is working (hbw_d) or student (hbs_d), respectively. Furthermore, the variable called motorized travel distance (motor_di) measures the total lenght of the motorized daily trips. In addition, free flow time of motorized trips (motorfft) and dummy variable indicating that whether the individual has realized at least one motorized trip in the day or not (mot_y_s) are two instrumental variables that are included in the related models. Herein, the latter variable is intuitively used so as to eliminate the potential excess zero observations in the number of daily motorized trips. Lastly, the variable called free motorized flow time is asserted in the list of variables, because within the disaggregated data level, any individual selects psychologically to travel between any pair of Origin (O) & Destination (D) if the free flow time of that individual (between the related O/D) refers to a value that is less than or equal to the his/her psychological treshold level. On the other hand, the variable called daily travel time is the daily sum of the motorized travel times, which is an outcome of the transportation network. That is why the disaggregated variable called free motorized flow time (instead of daily motorized travel time) is generally preferred in the classical travel demand forecasting models.

In the light of these views, a modeling framework, which can cope with the followings, will be required;

- i. Non-linear nature of number of daily trips of an individual.
- ii. Potential excess-zero observations in number of daily trips of an individual (motor_y = Y1).
- iii. Endogeneity of the daily motorized travel time of the related individual.

- iv. Simultaneity between number of daily trips of an individual (motor_y) and daily motorized travel time (motor_s = Y2).

To begin with, according to the first requirement (i), non-linear model structures come into agenda. In this sense, Poisson Regression Model (PRM) and Negative Binomial Regression Model (NBRM) are the leading model structures (Green, 2007; A.Colin Cameron & Pravin K. Trivedi, 2005). To begin with, the PRM (Poisson Regression Model) is the most basic form of the count models. According to the poisson model, the random variable that will be called yi shows a poisson distribution, and mean of this distribution is λi as revealed in equation 1:

$$f\,(Y_i = y_i) = \frac{(e^{-\lambda_i})(\lambda_i^{y_i})}{(yi)!} \quad y_i = 0, 1, 2, ..;\ f\text{: probability distribution function (pdf)} \quad (1)$$

The mean of the distribution is λi, which is explained by a set of variables called xi. The formulation to estimating model parameters is the log-linear model (equation 2):

$$\ln(\lambda_i) = \beta' x_i \quad (2)$$

The basic assumption of this model is the equidispersion (equation 3), which refers to that conditional mean and conditional variance are equal:

$$E[y_i\,|x_i] = Var[y_i|x_i] = \lambda_i = e^{(\beta' x_i)} \quad (3)$$

The elasticity with respect to any given variable is nonlinear, and it can either be estimated at the variable means or as the mean of individual elasticities in the sample (equation 4):

$$\frac{\partial E[y_i\,|x_i]}{\partial x_i} = \lambda_i \beta = \lambda_i e^{(\beta' x_i)} \quad (4)$$

The PRM is nonlinear and maximum likelihood can be used for parameter estimation as a mathematical simplicity as revealed in equation 5:

$$\ln(L) = \sum_{i=1}^{n}[-\lambda_i + y_i\,(\beta' x_i) - \ln(y_i)!] \quad (5)$$

Equidispersion implicitly assumes that "the formula for the probability of an occurrence is a deterministic function of the explanatory variables –it is not allowed to differ between otherwise- identical individuals" (Kennedy, 1998, p. 247). However, this assumption is relaxed by introducing an unobserved heterogeneity effect into the conditional mean called scale variable. This leads to a different model called NBRM, in which the conditional variance is larger than conditional mean (equation 6):

$$f(y_i|x_i) = \frac{\Gamma(\theta+y_i)}{\Gamma(\theta)\Gamma(y_i+1)} r_i^{y}(1-r_i)^{\theta}, \text{ where } r_i = \frac{\lambda_i}{\lambda_i + \theta_i} \quad (6)$$

Conditional mean of this distribution is λi and conditional variance is λi (1 + (1/θ) λi). The elasticities of the NBRM are still estimated as in equation 4 (Green, 2007).

This fact implies that it will be vital to test for overdispersion if you use the PRM. Even with the correct specification of the mean structure, estimates from the PRM -in the case that there is overdispersion- will be inefficient with standard errors that are biased downwards (Long, 1997, p.236). Several tests are suggested for overdispersion (Green, 2003; 2007) without estimating a NBRM. Since the PRM and the NBRM are nested, the log-likelihood of the NBRM needs to be improved over the PRM in case overdispersion is present, and this can be checked by a Log-likelihood Ratio (LR) test as indicated in equation 7:

$$LR = 2\,(ln\,(L_{NBRM}) - ln\,(L_{PRM})) \quad (7)$$

LR shows a chi-square distribution and any value larger than critical threshold with two degrees of freedom favors the NBRM. The case of overdispersion in count data will exist due to potential unobserved heterogeneity in that the events are thought to be seriously independent, and so the rate parameter, which refers to the conditional mean, will become to behave as a random variable itself. Such a case will necessitate further modeling approaches such as mixed modeling approach (A.Colin Cameron & Pravin K. Trivedi, 2005). At this juncture, Negative Binomial Regression Model (NBRM), which is taken into consideration as the specific kind of mixture modeling approach, will come into considerations (A.Colin Cameron & Pravin K. Trivedi, 2005). On the other hand, new modeling approaches (other than PRM & NBRM) will also come into considerations due to the potential case of excess zero observations in daily number of motorized trips of an individual. Thus, the structures of zero censored models & zero truncated models will come into considerations. The selection among these models is purely based on the theoretical requirements depending on the research question & the related variables in that whether it is vital to involve the zero counts of the main dependent variable into the models or not. In the zero censored models, the zero counts for the main dependent variable and the remaining positive counts are modeled separately, while in the zero truncated models, the zero counts are directly eliminated from the model structure (A.Colin Cameron & Pravin K. Trivedi, 2005). In such a case, the research question is diverted to the induced motorized passenger mobility demand considerations, in which it is intuitively required to include the positive counts for the related variable. In other words, the zero truncated model structure will fit better when compared to the zero censored model structure in modeling the daily number of motorized trips. The basic mathemathical representation of that model structure is asserted as in equation 8 (A.Colin Cameron & Pravin K. Trivedi, 2005):

$$F(y|\theta, y>=1) = \frac{f(y|\theta)}{1-F(0|\theta)}, \quad y= 1, 2, \ldots \tag{8}$$

, where f (y|θ): probability distribution function (pdf), F (y|θ) = Prob. [Y<=y]: cumulative distribution function (cdf) with relates to the random variable y, and θ is a parameter vector.

The indication of the zero truncated model structure, together with the negative binomially distributed variable called number of daily motorized trips (motor_y), will explicitly signal that the single index model for daily number of motorized trips will fit better especially within the structure called Zero Truncated Negative Binomial Regression Model.

It is needless to say that there are many variations of such models to improve the estimation efficiency (please refer to Green, 2007; Long, 1997; Cameron & Trivedi, 2005; and Winkelmann, 2008 for details). Application of these models takes place in many diversified areas: crime analysis, disease occurrence, doctor visits, occupational injuries, software faults, accident analysis and prevention, manufacturing defects to name the few. On the other hand, these models will only be capable of dealing with non-linear nature of the main dependent variable called number of daily motorized trips with refers to the potential excess zero observations. In other words, such these single index models will not be able to cope with the third (iii) and fourth (iv) requirements, which refer to the cases called endogeneity and simultaneity. Since, our model may have another important specification problem probably causing endogeneity bias: the dependent variable and the key independent variable (i.e. total of reported travel times in minutes spent in these motorized travels) may have causal relationship. The dependent variable is determined by an explanatory variable in a way as the explanatory variable is also determined by the dependent variable in turn. In such situations, since the error term is correlated with the dependent variable(s), the conventional methods will producebiased parameter estimates.

In principle, endogeneity bias is a form of omitted variables bias, and Mokhtarian and Cao (2008) summarizes seven different techniques to deal with endogenity problems: (a) direct questioning, (b) statistical control,(c) instrumental variables model, (d) sample selection model, (e) joint discrete choice model (f) cross-sectional structural equations, and (g) longitudinal models. Concerning our model, only three of them: instrumental variables; sample selection model; and structural equation models seem meaningful. On the other hand, non-linear nature of daily number of trips, potential excess zero observations in the number of daily trips, and potential simultaneity between the number of daily trips and daily travel times still wait to be coped with. Therefore, further modeling approaches, which have not been highlighted yet by the study of Mokhtarian and Cao (2008), will be required. In this context, the Simultaneous Equations Model (SEM) structure comes into agenda, which will overcome both endogeneity and simultaneity. On the other hand, classical SEM structure will still fall short for the research asserted in this article. If both main dependent variables of our model were the types of gaussian distributed continious variables, it would be possible to assert the classical types of SEM with refers to Two Stages Least Squares (2SLS) or Three Stages Least Squares (3SLS) regression model structures. Herein, it will be possible to designate such a model structure via including the theoretically justifiable instrumental variables between the main dependent variables so as to eliminate the potential cases called endogeneity & simultaneity between daily number of motorized trips and daily motorized travel time. On the other hand, one variable (daily number of motorized trips) will be non-linear count variable, while the other (daily motorized travel time) will be gaussian distributed continious variable, which will make the classical SEM structure fail (please refer to Green, 2007; Cameron & Trivedi, 2005 for details). Therefore, the concept of newest methodological approach called path analysis, namely Generalized Simultaneous Equations Model (GSEM) structure, will come into considerations. Because, it will be possible to involve both linear and non-linear equations together within the same equations system by such this GSEM structure.

In fact, the intuitive effort that is exhibited here stand for the justification of the final model selection, namely path analysis called GSEM. In these models, the dependent variable will be the total number of motorized trips realized by an individual within 24 hours. The main explanatory variable will be the negative of total motorized travel time spent in minutes for these daily trips, since travel time defines a disutility. The remaining explanatory variables will be the personal and family characteristics, as it is explained in the data section. Furthermore, there is also one more dependent dummy variable, asserting that whether the individual selects to travel at least once in a day or not (mot_y_s). Herein, since the dummy dependent variable called mot_y_s will refer to the binary variable, it will refer to a probability structure as a dependent variable. In the light of these views, the related GSEM structure will seem to be in the form as asserted in the following table and figure (see Table 1 and Figure 1).

Table 1. *Designation of GSEM structure (*).*

Dependent Variable	Function	Function Family	Function Link
motor_y	f (motor_s, X_i)	Negative binomial mean distribution	Logarithm
motor_s	g (estimated_motor_y , motorfft , mot_y_s X_i)	Normal distribution (Gaussian Family)	Identitiy Link
mot_y_s	Φ (X_i)	Probit function family	

(*) where
f: [Negative Binomial Distribution Function | Conditional mean function: exp(Xeβe)] Here, in Xeβe, the abbreviation "e" refers to the "exponential" form.

g: [Gaussian Linear Function | Conditional mean function: g(XLβL)]. Here, in XLβL, the abbreviation "L" refers to the "linear" function form.

Φ: [Probit Function | Conditional mean function : Φ(Xpβp)]. Here, in Xpβp, the abbreviation "p" refers to the "probit" function form.

Xi: vector of covariates defining individual based socio-economic variables in the GSEM system, in that; Xi :c (male_d , h_head_d , hh_inc , oto_s , hhsize , age , tahsil_y , hbw_d , hbs_d).

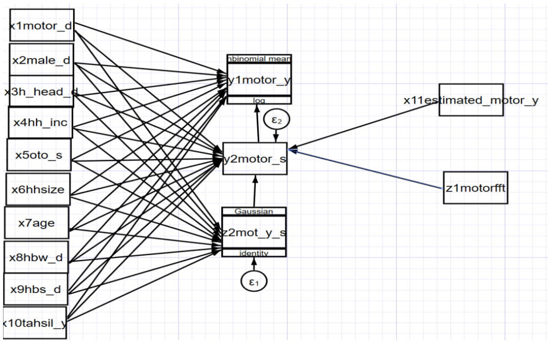

Figure 1. *GSEM Path Structure.*

Furthermore, subsequent to the designation of model structure, the calculation of the related marginal elasticities will come into minds. In this regard, three main methodological frameworks will be asserted in calculating the marginal elasticities after the related non-linear models:

a) Estimating averages of Marginal Elasticity (ME) per each individuals,

b) Calculating ME at means, that computer programs generally carry out this,

c) Marginal Elasticity estimation at X = X* , where X* is a specific value that is theoretically meaningful (Cameron & Trivedi, 2005).

The intuitive explanation with refers to the marginal elasticity calculation in nonlinear models is explained by equation 9:

$$ME = \frac{\partial E[Y|X]}{\partial (Xj)} \tag{9}$$

By equation 9, the function g(.) will have a non-linear mean functional form. Then, the single index model will take the form as in the equation 10:

$$E[Y \mid X] = g(X'\beta)$$

$$\frac{\partial E[Y|X]}{\partial (Xj)} = g'(X'\beta)\beta j \tag{10}$$

Afterwards, the relative effects of changes in regressors will take the form (equation 11) :

$$\frac{\partial (E[Y|X]/\partial Xj)}{\partial (E[Y|X]/\partial Xk)} = \frac{\beta j}{\beta k} * \frac{g\prime(X'\beta)}{g\prime(X'\beta)} = \frac{\beta j}{\beta k} \tag{11}$$

On the other hand, for the side of finite difference method concept, the logic will transform to equation 12:

$$\frac{\Delta(E[Y|X])}{\Delta(Xj)} = g(X+e_j, \beta) - g(X, \beta) \tag{12}$$

, where ej is the vector of jth entry, when other entries are zero.

Lastly, for the cases of exponential conditional mean distributions, the function will take the form as revealed in equation 13 (Cameron & Trivedi, 2005):

$$E[Y|X] = \exp(X'\beta)$$

$$\frac{\partial E[Y|X]}{\partial (Xj)} = E[Y|X]^*\beta j \tag{13}$$

In the light of these indications, the marginal elasticty calculations will intuitively get the form as equation 14:

$$\frac{1}{N} * \sum_{i=1}^{i=N} \frac{\partial(\hat{E}(motor_{yi}|Xi, motor_s i))}{\partial(motor\_s\ i)} \tag{14}$$

Average Marginal Effect of motor_s on motor_y for an individual 'i' :

Average Marginal Effect of any Xi on motor_y for an individual 'i' (equation 15):

$$\frac{1}{N} * \sum_{i=1}^{i=N} \frac{\partial(\hat{E}(motor_{yi}|Xi, motor_s i))}{\partial(Xi)} \tag{15}$$

To summarize, the expected conditional mean calculation (with regards to the marginal elasticity estimation) within such a stochastic nature will mathematically be explained as revealed in the equation 16:

$$\frac{\frac{1}{N} * \left(\sum_{i=1}^{i=N} \frac{\partial\hat{E}(motor\_yi|Xi, motor\_si)}{\partial(motor\_si)} * \sum_{i=1}^{i=N} \frac{\partial\hat{E}(motor\_si|Xi,\ motor\_yi,\ motorfft)}{\partial(Xi)} \right)}{\frac{1}{N} * \left(\sum_{i=1}^{i=N} \frac{\partial\hat{E}(motor\_si|Xi, motor\_si, motorfft)}{\partial(motor\_yi)} * \sum_{i=1}^{i=N} \frac{\partial\hat{E}(motor\_yi|Xi,\ motor\_si)}{\partial(Xi)} \right)} \frac{\partial(\text{motor\_y})}{\partial(\text{motor\_s})} \tag{16}$$

To conclude, the GSEM model structure seems to be able to cope with all the technical obstacles, namely non-linearity of daily number of motorized trips, potential excess zero problem in daily number of motorized trips, potential endogeneity of daily motorized travel time, and potential simultaneity between daily number of motorized trips and daily motorized travel time. Firstly, this model structure will deal with the non-linear nature of number of daily motorized trips (motor_y) with the indication of the NBRM structure into the GSEM design. Secondly, the GSEM concept will cope with the potential problem of excess zero observations for the variable called number of daily motorized trips. Herein, it will be guaranteed that the potential zero counts in daily number of trips are automatically eliminated via the indication of the condition asserting that the individual exhibits at least one motorized trips in the day (mot_y_s=1). Thirdly, the related GSEM structure will be able to tackle with the potential endogeneity of daily motorized travel time of an individual (motor_s) in modeling the number of daily motorized trips (motor_y) with helps of the indication of free motorized flow time (motorfft) as the theoretically justified instrumental variable (Figure 1). In this context, the number of daily motorized trips (motor_y) will be modelled with helps of the related socio-economic characteristics & the related dummy variables, and this derived estimated value of the number of daily motorized trips (estimated_motor_y) will then be used in modeling the dependent variable called daily motorized travel time (motor_s). This will make the model structure satisfactory in dealing with the cases called endogeneity and simultaneity between number of daily motorized trips (motor_y) and daily motorized travel time (motor_s).

Table 2. *Comparison of the Models (*).*

MODEL	Copes with the non-linear nature of "motor_y"	Copes with the "excess zero problem" for "motor_y"	Copes with the "endogeneity" of "motor_s" in modeling "motor_y"	Able to deal with the case of "simultaneity" between "motor_y" & "motor_s"
Poisson Regression Model (PRM)	✔	X	X	X
Negative Binomial Regression Model (NBRM)	✔	X	X	X
Zero Truncated Models	✔	✔	X	X
Classical SEM structures, such as 2SLS & 3SLS	X	X	✔	✔
Generalized Simultaneous Equations Model (GSEM)	✔	✔	✔	✔

(*) ✔ : the asserted property is satisfied; (X): the asserted property is not satisfied.

4. Discussions

For decades, it has been realized that the efforts of satisfying all the requirements -with refers to the unendingly increasing travel demand of the individuals- constitute such a kind of vicious circle. In this sense, the new policy concept called travel demand management policies have been adopted. This policy framework will be defined as a paradigm shift in transportation planning. On the other hand, the operational sides of such considerations fall short in the developing countries. In an other words, it is required further empirical studies, highlighting the practical sides of the monitoring such travel demand management policies. In this context, the notion called induced motorized passenger mobility demand comes into considerations. Herein, the efforts of exploring the leading factors of daily motorized trip makings constitute the operational baselines for travel demand management policies. In other words, an explicit measurement for induced motorized passenger mobility demand is required to carry out such a concrete empricial baseline, which highlights the prominent performance indicators of the travel demand management policies. In this sense, unlike any previous research, this study has fisrtly asserted the hypothesis called " the less travel time that the individual spends in a day, the more number of trips he/she will exhibit in that day". In addition, a new methodological proposal has been developed in this paper so as to test such a new hypothesis for the future studies. In the light of these views, a new methodological proposal -subsequent to the methodological discussions- has been exhibited.

In accordance with the new research question, firstly, the variable called daily number of motorized trips refers to a type of non-linear count variable, while the variable called daily motorized travel time exhibits a kind of gaussian distributed continious variable. Secondly, the number of daily motorized trips of an individual (motor_y) will probably involve excess amounts of zero observations. Thirdly, the cases called endogeneity & simultaneity between the variables called daily motorized travel time of an individual and number of daily motorized trips of this individual will probably be the case in such researches. That is to say, daily number of motorized trips will be determined by the variable called daily motorized travel time in a way as this variable (daily motorized travel time) will also be determined by the dependent variable (daily number of motorized trips) in turn. So as to cope with all these technical obstacles, the path analysis called Generalized Simultaneous Equations Model (GSEM) structure has been asserted in this paper.

5. Concluding remarks

In the lights of the views of this article, four main guidelines for future researches will be as in the followings;

1. Instead of the classical investigations on the marginal effect of change in travel time on Vehicle Miles Traveled (VMT), the new researches -taking the marginal effect of travel time on specifically the number of trips into account- will be adopted.
2. The disaggregated type of approaches should be adopted with refers to the behavioral units, namely household and individuals. Such kind of data collection approach will be expected to make the aggregated estimation errors dramatically decrease.
3. A type of convenient simultaneous equations model structure is to be developed with refers to the potential research question of such future studies, taking the number daily motorized trips and daily motorized travel time in the core as the main dependent

variables. In this respect, as it is discussed in the part of Methodological Discussions in detail, one of the main dependent variables (number of daily motorized trips) will be a non-linear count variable, while the other (daily motorized travel time) will be a kind of gaussian distributed continious variable. Furthermore, such related variables will exhibit a kind of simultaneous relationship, all of which will make the classical Simultaneous Equations Model (SEM) structure fall short.

4. The spatial resolutions of the related studies should refer to area-wide approach instead of the ones called facility or corridor based approaches so as to grasp system-wide marginal elasticity coefficients between number of daily motorized trips and daily motorized travel time. Otherwise, the related estimated marginal elasticity coefficients will refer to the concept of partial urban equilibrium, which will explicitly fall short in highlighting the practical sides of urban scale travel demand management policies.

This article proposes a research focusing on the interrelationship between the daily motorized travel time of the individuals and the number of daily motorized trips of the related individuals for the first time in literature. In the light of this effort, a methodological proposal for such a research question has been asserted with refers to the generalized simulatenous equations model structure. Subsequent to this contribution, it is aimed to construct a methodological baseline for monitoring and assessing the performance of any transportation project with refers to ongoing discussions for travel demand management policies for the related future studies.

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