A Parsimonious Approach to Multidimensional Choice Models of Urban Transport[1].

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Abstract

For its computational simplicity, the regular Multinomial Logit model (MNL) has been extensively used to model one-dimensional or multidimensional choice situations. At a microeconomic level however and when applied to large choice sets, the introduction of variables that transcribe individual heterogeneity of choices, leads to identification issues and computational difficulties. As a result, its original formulation characterizes only choices. However, as many authors show, the resulting model suffers from the application of the famous Independence of Irrelevant Alternatives at the aggregate level, which induces serious errors in the estimation of market shares and demand elasticities. Moreover, one can wonder if this linear functional form of the utility function is relevant in economics.

The contribution of this paper to transportation analysis is threefold: First, we address the crucial question of the dimensionality of the choice set. We develop a transportation demand model using a utility functional form that is parsimonious in the number of parameters to be estimated. Note that this form is economically relevant since it has been derived from a microeconomic problem by the principle of utility maximization. Second, the cross-product mathematical form depicts the heterogeneity in the individual travel behavior by allowing the introduction of socioeconomic variables. At the same time, the introduction of individual heterogeneity brings the application of the Independence of Irrelevant Alternatives property at the individual level while it does not apply anymore at the aggregate level. Using data drawn from a 1997 Montpellier household survey, our approach is applied to the joint choice of mode of transport and destination of the trip for a given purpose (work, school, shopping and leisure). We consider four modes of transport and fifty potential destinations. Finally, the model has good empirical properties since it estimates 200 alternatives without any identification issue and any need of simulation methods. It is estimated for each purpose using simple maximum likelihood and compared to the regular MNL one. Estimation results, market shares and their price elasticities are computed for both models and detailed by purpose. They emphasize the flexibility of our functional form that does not impose structure on the possible market level of demand elasticities in the way the regular MNL does.

Keywords: discrete multidimensional choice modeling, transportation demand, urban transport, heterogeneity of choices.

1-Introduction.

With the development of cities and trade, transportation demand analysis becomes of capital importance to generate efficient transport policies. Transport projects like investments in infrastructure, changes in operating and pricing policies cannot be adopted without a prior analysis of what the consumer behavior will be, without any idea of modes of transport market shares or city areas market shares. In particular, it is useful to forecast the response of users to changes brought about by political measures. This is a hard task since the analyst cannot observe the determinants of travelers choice. He is only able to attribute choice probabilities to individuals. In this paper, we try to improve the probability the analyst attributes to the traveler. In this aim, we use a microeconomic approach to derive a travel demand model, which is disaggregate at the individual level. Individual travel demand is described with discrete variables, in particular by the individual's choice of mode of transport (car, bus, two-wheel vehicles, and walk) and destination of the trip (The district of Montpellier has been divided into 50 areas of potential destinations). Moreover, the individual choice is defined for a given purpose (work, school, shopping, and leisure). We use the principle of utility maximization to analyze individual preferences, which are represented by a random utility function since it is not known with certainty by the analyst. This principle assumes that each individual chooses the single simultaneous choice - mode of transport and destination of the trip - that yields him the greatest utility. By now, we consider this simultaneous choice and call it an alternative. 200 alternatives are available to the individual. The treatment of this simultaneity requires a multidimensional analysis that implies to solve the following issues. The first one is the treatment of interdependencies of choices to remedy the consequences of the Independence of Irrelevant Alternatives (I.I.A) property and allow reasonable aggregate forecasts. Let us recall by an example what imbalance this property incurs. So forth, let us consider the simplest case of a group of individuals living in the same area and who can choose between walk and bus to reach a given destination. Assume that this destination is far enough from their home area to justify that bus market share is fifty times greater than walk market share. Now, let us assume that authorities decide to set in motion a tramway that stops at the same destinations as the bus, but suppose that it runs faster and is more comfortable. Intuitively, one can expect most individuals to take the tramway and take the bus only when the tramway is not available. Bus market share tends to become close to walk one. This intuition contradicts the application of the I.I.A property which maintains the ratio fifty for one unchanged. Note that this property is very restrictive since one of the main objectives of the paper is to develop a model that can simulate the impacts of market share variations. By the introduction of an heterogeneity component, our model leads to the non-application of the I.I.A property. In the literature, the prevalent model derived from discrete choice analysis is the regular MultiNomial Logit model (see Ben-Akiva and Lerman (1985)). Its linear utility function and its closed form mathematical structure results in a computational simplicity that confers it a good reputation. However, when applied to large choice sets, the introduction of individual heterogeneity leads to identification issues whereas the absence of heterogeneity results in the application of the Independence of Irrelevant Alternative (I.I.A) property at the aggregate level. And it is transcribed by bad aggregate forecasts and very unrealistic substitution patterns. Furthermore, one may ask oneself about the relevance in economics of such a linear functional form. In the literature, most authors have focused on the problems induced by this I.I.A property and tried to relax the assumptions from which it comes, that is the independence of random error terms of the utilities of two distinct alternatives. The first model stemmed from these research is the Nested Logit Model exposed by McFadden in 1978, in which the simultaneous choice is decomposed in a succession of conditional ones. This decomposition produces non-zero covariances between utilities of subsets of alternatives. In our case for example, we could decompose the joint choice of mode of transport and destination of the trip into the cross product of the mode choice conditional to the destination choice and the marginal destination choice. One create in the same way a non-zero covariance between utilities of alternatives with a common destination. But this method remedies only partly to the problem since it allows for correlations between errors of one or the other dimension (not both). Another reply to the I.I.A issue is the Multinomial Probit model. It is a kind of ideal model since it allows for non-zero covariances between utilities of all alternatives. And this entails very flexible substitution patterns. However, this increase in flexibility comes at the expense of very high multivariate integrals to evaluate when calculating joint choice probabilities, the number of which is increasing with the number of alternatives in the choice set. Hence, the development of simulators of these probabilities (see Ben-Akiva and Bolduc (1996)). Furthermore, this model implies a very large number of parameters to be estimated if one allows a completely free covariance matrix (see Horowitz, (1991) for a discussion). Finally, an alternative approach to generate realistic substitution patterns is the one developed by Berry, Levinshon and Pakes in 1997.

Modeling the choice of autos makes, they tried to neutralize the I.I.A property effect by constructing individual preferences that include individual observed and unobserved characteristics. Using aggregate data that constrained them to make some assumptions on information, they conclude however that the introduction of individual heterogeneity seems to be required to generate reasonable own-and cross-price elasticities. However, as far as we know, no extension of such models have yet been made in the case of very large choice sets. The second issue is to solve the computational difficulties and especially identification issues due to the large number of alternatives of choice. In this paper, we try to keep computational properties of the MNL model and we formulate a variant, which is both parsimonious in the number of parameters to be estimated and allows to treat a large number of alternatives of choice. In addition, the specification of the utility function accounts for population heterogeneity so that this model does not suffer of consequences of the I.I.A property at the aggregate level. It remains however tractable and is estimated using simple maximum likelihood. Estimation results, market shares of the different alternatives and their price elasticities underline the flexibility of our functional form that does not impose structure on the possible market level of demand elasticities in the way the regular MNL does. The paper is organized as followed: In Section 2, we set the analysis framework and the econometric foundations of our model. Section 3 develops our theoretical economic NL.MNL mode and shows that the identification conditions are simplified because of the small number of parameters introduced. Moreover, the possibility to introduce individual heterogeneity leads to a flexible structure of substitution patterns. Section 4 makes a short analysis of the data and describes the estimation procedure.

In section 5, we have reported determinants of the joint choice as well as the alternatives market shares and their elasticities both in our model and the regular MNL one. Section 6 concludes and gives some extensions of our research.

2- The analysis framework.

Consider a traveler who simultaneously chooses the mode of transport and the destination of his/her trip for different purposes like school, work, leisure or shopping[2].

Assumption 1: *All these potential modes and destinations are actually feasible to each individual. Physical availability, monetary resources, time availability, and informational constraints define the feasibility.*

Define the choice set as the set of all potential modes and destinations combinations.

Let $M = \{ m_1, m_2, m_3, ..., m_{J_M} \}$ be the set of all possible modes for a given purpose, $D = \{ d_1, d_2, d_3, ..., d_{J_D} \}$ the set of all possible destinations for a given purpose. Then, $\Omega = M \times D = \{ (m_1, d_1), ..., (m_1, d_{J_D}), (m_2, d_1), ..., (m_2, d_{J_D}), (m_{J_M}, d_1), ..., (m_{J_M}, d_{J_D}) \}$ represent all potential modes and destinations of a given traveler. Ω is the individual choice set (card $\Omega = J_M J_D$).

[2] The assumption that consumers decide which location to go to, is disputable for work and school purposes. However, the decision must be seen jointly with the mode of transport one. Moreover, our objective is to develop a model from which we can transcribe the whole travel demand.

Suppose utility for consumer i from good (d, m) is:

$$U_{i,(d,m)} = \overline{V}_{i,(d,m)} + e_{i,(d,m)} \;,\; (d,m) \in \Omega \quad (1)$$

where

- $\overline{V}_{i,(d,m)}$ is the systematic component of the utility function of individual i choosing alternative (d,m).
- $e_{i,(d,m)}$ is a random error component, which captures the effect of unmeasured variables, maximization errors or observational deficiencies on the part of the analyst. Errors $\left(e_{i,(d_1,m_1)}, e_{i,(d_1,m_2)}, \dots, e_{i,(d_{J_D},m_{J_M})}\right)$ are assumed to be independently and identically Generalized Extreme Value (G.E.V) distributed so that :

$$F\left(e_{i,(d_1,m_1)}, e_{i,(d_1,m_2)}, \dots, e_{i,(d_{J_D},m_{J_M})}\right) = \exp\left(-G\left(\exp\left(-e_{i,(d_1,m_1)}\right), \exp\left(-e_{i,(d_1,m_2)}\right), \dots, \exp\left(-e_{i,(d_{J_D},m_{J_M})}\right)\right)\right)$$

Then,

$$P_{i,(d_{J_D},m_{J_M})} = \frac{\exp(\overline{V}_{i,(d_{J_D},m_{J_M})}) G_l\left(\exp\left(\overline{V}_{i,(d_1,m_1)}\right), \exp\left(\overline{V}_{i,(d_1,m_2)}\right), \dots, \exp\left(\overline{V}_{i,(d_{J_D},m_{J_M})}\right)\right)}{mG\left(\exp\left(\overline{V}_{i,(d_1,m_1)}\right), \exp\left(\overline{V}_{i,(d_1,m_2)}\right), \dots, \exp\left(\overline{V}_{i,(d_{J_D},m_{J_M})}\right)\right)}$$

where G_l is the nth partial derivative of function G which satisfies the following properties:

Let $G(y_1, \dots, y_k, \dots y_n)$ with $y_1, \dots, y_k, \dots y_n \geq 0$, here we have $y_k = \exp\left(\overline{V}_{i,k}\right)$ et $k = (d_{j_d}, m_{j_m})$

- G is non-negative
- G is homogeneous of degree $m > 0$, that is:

  $G(ay_1, \dots, ay_k, \dots ay_n) = a^m G(y_1, \dots, y_k, \dots y_n)$

- $\lim_{y_i \to \infty} G(y_1,...,y_k,...y_n) = \infty$, for $k = 1,2,...,J_n$
- The lth partial derivative of G with respect to any combination of l distinct y_k, $k = 1,2,...,J_n$ is non-negative if l is odd, non-positive if l is even.

3: The Model.

3-1: Introduction

Consider the preference structure above where $\left(e_{i,(d_1,m_1)}, e_{i,(d_1,m_2)},..., e_{i,(d_{J_D},m_{J_M})}\right)$ is assumed to be independently and identically Generalized Extreme Value distributed with some parameters that depend on individuals and alternatives so that:

$$\tilde{F}\left(e_{i,(d_1,m_1)}, e_{i,(d_1,m_2)},..., e_{i,(d_{J_D},m_{J_M})}\right) = \exp\left(-G\left(\exp\left(-\Phi_{i,(d_1,m_1)} e_{i,(d_1,m_1)}\right),..., \exp\left(-\Phi_{i,(d_{J_D},m_{J_M})} e_{i,(d_{J_D},m_{J_M})}\right)\right)\right)$$

In this case, $P_i(d,m)$ is difficult to express but the advantage of such an assumption is that the marginal distributions for $e_{i,(d,m)}$ which generates this G.E.V class have an extreme value distribution with variance $\frac{p^2}{6} \frac{1}{f^2_{i,(d,m)}}$ so this is a method of allowing the variances of the stochastic term in utility to vary across individuals and products.

Moreover, when $f_{i,(d,m)} = f_i \quad \forall (d,m)$, choice probabilities have a nice analytical formula:

$$P_{i,(d,m)} = \frac{\exp(f_i \overline{V}_{i,(d,m)}) G_n \left(\exp\left(f_i \overline{V}_{i,(d_1,m_1)}\right),\ldots,\exp\left(f_i \overline{V}_{i,(d_{J_D},m_{J_M})}\right)\right)}{G\left(\exp\left(f_i \overline{V}_{i,(d_1,m_1)}\right),\ldots,\exp\left(f_i \overline{V}_{i,(d_{J_D},m_{J_M})}\right)\right)}$$

3-2: The Non Linear Multinomial Logit model (NL.MNL).

The NL.MNL model is derived from a microeconomic maximization problem.

Proposition 1:

Consider that the budget spends on transports of individual i only represents a percentage of his total income w. He maximizes his utility in order to determine his optimal number of trips. His maximization program is the following:

$$\max_{n_{(d,m)}} \left\{ n_{(d,m)} (1 + x'_{(d,m)} b + \ln(1 + z'_i g) - \ln n_{(d,m)}) + hn \right\} \quad \mathbf{(2)}$$

subject to:

$$p_{(d,m)} n_{(d,m)} + A_{(d,m)} + n = w \qquad (3)$$

where

- $n_{(d,m)}$ *is the number of trips made toward destination d with mode of transport m*
- $x_{(d,m)}$ *is a vector of characteristics of choice (d,m) except for the trip price,* b *is the vector of coefficients associated.*
- z_i *is a vector of characteristics of individual i,* g *is the vector of coefficients associated.*
- n *summarizes other goods than transport,* h *is the individual propensity to consume good* n *.*
- $p_{(d,m)}$ *and* p_n *(=1) are respectively the trip price normalized by* p_n *and the unit price of good* n *.*

- *w is the individual's income (normalized by* p_n *).*
- $A_{(d,m)}$ *is the subscription charge of alternative (d,m) (normalized by* p_n *).*

First order conditions give the optimal number of individual i trips :

$$n^*_{(d,m)} = (1 + z_i g)\exp(x'_{(d,m)}\, b - hp_{(d,m)}) \quad (4)$$

Then, the indirect utility function can be expressed as:

$$V_{i,(d,m)}(p,y) = (1 + z'_i\, g)\exp(x'_{(d,m)}\, b - hp_{(d,m)}) + h(w - A_{(d,m)})$$ [3]

The resulting individual i joint choice probability of the destination-mode couple is:

$$P_i(d,m) = \frac{\exp\left((1 + z'_i\, g)\exp\left(x'_{(d,m)}\, b - hp_{(d,m)}\right)\right)}{\sum_{(d',m')\in\Omega}\exp\left((1 + z'_i\, g)\exp\left(x'_{(d',m')}\, b - hp_{(d',m')}\right)\right)} \quad (6)$$ [4]

Proof: see Appendix 1.

The contribution of this specification is first to depict as best as possible the heterogeneity in the individual travel behavior and let the estimation feasible. It tries to capture heteroskedasticity of random error terms across the different alternatives through the introduction of individual heterogeneity, which consists of observable heterogeneity by the introduction of individual characteristics and unobservable heterogeneity by their interactions with the alternatives attributes. The individual characteristics may be intrinsic characteristics such as age or gender, characteristics of activity (income or professional status) and(or) concern accessibility to the different alternatives like the vehicles at disposal in the

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[3] For empirical reasons, we have assumed $h(w - A_{(d,m)})$ constant and that heteroskedasticity is entirely captured by individual characteristics and their interactions with choices.

[4] In the following paragraphs, we consider the price as an alternative characteristics so that $x'_{(d,m)}\, b - hp_{(d,m)} = x'_{(d,m)}\, b$

household or the driving license possession[5]. The interactions between these variables and the alternative attributes associate the trip choice of an individual to his observed characteristics. They convey how data match observed individual attributes to the chosen alternative by creating a link between a category of traveler (characterized by a set of attributes) and a given alternative (with its own characteristics). For example, they transcribe the intuition that active persons are used to go to work by car and that retired or unemployed people would better travel by bus. In other words, they express the way one individual will substitute one alternative for another with similar characteristics. Moreover, as noticed by Berry, Levinshon and Pakes, these interactions generate reasonable own and cross elasticities. From an empirical point of view, this specification allows to add only one parameter for each individual characteristic introduced and as a result, solves the identification problem met in the regular MNL model. Indeed, the introduction of any socio-economic variable (reflecting the individual heterogeneity) in the linear model is made as an alternative specific one, which implies as many as $card\Omega - 1$ parameters to estimate, for each alternative specific dummy variable introduced (one of them being taken as a reference). In our case, this would represent 150 parameters to estimate for each socio-economic variable introduced when it is linked to the mode of transport, 196 when it is linked to the destination, and 199 when it is linked to both. And this process is additive when one new variable is introduced. This leads to an obvious identification issue. Our specification of the utility function is inspired from Hanemann (1984). It was previously intended to deal with

[5] Weaknesses of our approximation of individual travel behaviour to the reality will then be partly due to the lack of variables that determine preference intensities. It is very hard to measure for example the individual's availability to the different alternatives since household survey often neglect to gather such information as individual localisation (distance from home to work, to the closest school…).

econometric models of discrete-continuous consumer choices based on the utility maximization decision. In his paper, Hanemann (1984) considered the example of a consumer who has to decide both which product to choose and how many units of this good to buy (the consumer buys only one brand of substitute goods at a time). As far as our problem is concerned, it could have been possible to see the destination choice as the choice of a kilometric distance to run, i.e as a continuous choice, the mode of transport choice remaining discrete. Nevertheless we will assume in subsequent paragraphs that the travelers joint choice is entirely discrete so as to use discrete choice theory. The adequacy of our problem to this form of specification just intends to justify the structure of the travelers preferences we adopt in the paper. Finally, this specification is derived from the principle of maximization applied to this Hanemann utility function. Note that this comes down to assume that $f_i = (1 + z'_i g)$ and $\overline{V}_{(d,m)} = \exp(x'_{(d,m)} b)$. The f_i term may be interpreted as the number of individual potential trips corrected by a proportion $\overline{V}_{(d,m)}$ characterizing the chosen alternative. Note that the linear model allows simple interactions of the form $f_i = z_i$ and $\overline{V}_{(d,m)} = x'_{(d,m)} b$, but this specification has no economic foundation, which makes it difficult to interpret. Assume that $x_{(d,m)}$ only contains the trip price and the Origin-Destination travel time and consider his maximum utility or his minimum disutility. Whatever the individual characteristics, it is reached when the individual gets a free highly speed mode (ideally, a zero O-D travel time). This confers him a zero utility, which contradicts the intuition that the individual satisfaction is all the more important than the mode of transport price is low and that it varies with individual characteristics. Moreover, this specification does not allow to identify between individual and alternative effects, which is especially important to get effects of political measures on individual demand.

3-3: Properties of the model.

3-3-1: I.A.N.P

Proposition 3:

The Independence of Irrelevant Alternatives property does apply at the individual level but it does not apply to the population as a whole:

$$\frac{\overline{P}(d,m)}{\overline{P}(k,l)}=\frac{\sum_{i=1}^{n}\left(\frac{\exp\left((1+z'_i\,g)\exp\left(x'_{(d,m)}\,b\right)\right)}{\sum_{(d',m')\in\Omega}\exp\left((1+z'_i\,g)\exp\left(x'_{(d',m')}\,b\right)\right)}\right)}{\sum_{i=1}^{n}\left(\frac{\exp\left((1+z'_i\,g)\exp\left(x'_{(k,l)}\,b\right)\right)}{\sum_{(d',m')\in\Omega}\exp\left((1+z'_i\,g)\exp\left(x'_{(k',l')}\,b\right)\right)}\right)} \tag{7}$$

One can expect reasonable aggregate market shares forecasts.

3-3-2: Own and cross price elasticities.

Proposition 4:

The marginal variation of the individual joint choice (d,m) probability resulting from a change in the value of some given alternative characteristic k of alternative (d',m') can be expressed as:

$$E^{P_i(d,m)}_{x_{k,(d',m')}}=b_k\,x_{k,(d',m')}\left(d_{(d',m')}-P_i(d',m')\right)\left((1+gz_i)\exp(x'_{(d',m')}\,b)\right) \tag{8}$$

At an aggregate level, the modification of alternative (d,m) market share $\overline{P}(d,m)$ *resulting from a change in the kth characteristic of alternative (d',m') can be written as:*

$$E^{\overline{P}(d,m)}_{x_{k,(d',m')}} = \frac{\sum_{i=1}^{n} b_k x_{k,(d',m')}(1+gz_i)\exp(x'_{(d',m')}\, b)P_i(d,m)\left(d_{(d',m')} - P_i(d',m')\right)}{\sum_{i=1}^{n} P_i(d,m)} \tag{9}$$

with

$$d_{(d,m)} = 1 \;\; when \;\; (d,m) = (d',m') \;\; for\ own\ elasticity\ of\ substitution.$$

$$d_{(d,m)} = 0 \;\; when \;\; (d,m) \neq (d',m') \;\; for\ cross\ elasticity\ of\ substitution.$$

Contrary to the regular MNL model, the individual demand fluctuation in reaction to a price increase will depend not only on the attribute of the strategic[6] alternative (for example, the price of alternative $d = (d',m')$) and on its actual market share but also on the individual characteristics. For example, a decrease in the bus line frequency will not have the same impact on the households possessing two cars than on the households possessing none. This confirms the intuition that travelers with different levels of income will not be affected in the same way, the higher level of income individuals should be less affected to a price increase than the lower level of income one. Moreover, the interactions between individual and alternative characteristics can be interpreted as the way the strategic alternative “fits” the individual. For example, the reaction to a price increase will be all the more important than alternative (d’,m’) “fits” less him in terms of comfort and quality of service. An increase in the fuel charge will induce lower elasticities for individuals who are used to drive by car. At the aggregate level, the increase in efficiency of this functional form is also undeniable. Let us consider cross elasticities. The modification of the individual demand behavior resulting from a change in the

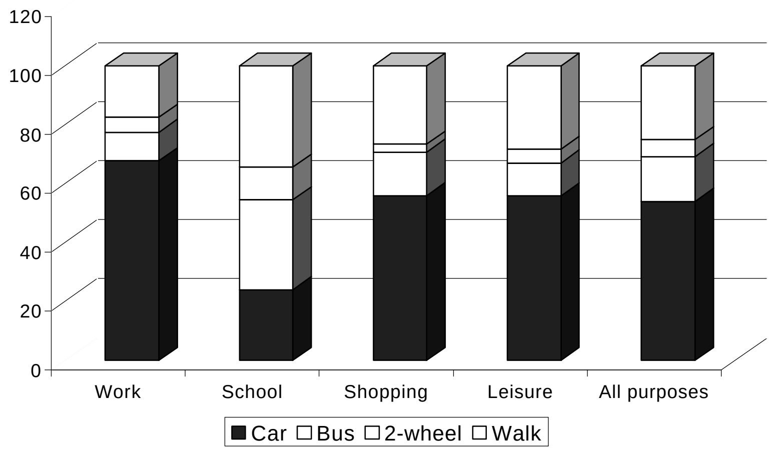
[6] We qualify as strategic the alternative at which the change is aimed.

alternative (d',m') characteristics depends on alternative (d,m), on individual characteristics but also on the whole set of alternatives by the mean of $P_i(d,m)$ and especially on the strategic[5] alternative. Trips whose characteristics are "more" similar will have higher cross-elasticities. For example, travelers having a high preference for quality will tend to attach higher utility to comfortable modes, which will induce larger substitution effects between comfortable modes than between non-comfortable ones.

4-Empirical analysis.

4-1: The data.

The data used in the present study are disaggregate data. They have been drawn from a Montpellier household survey provided by Khi-2 marketing research firm. Because of social movements, the investigation was conducted during two distinct periods, from November to the middle of December 1996 and from January to the middle of February 1997. 2832 households (6341 individuals aged 11 and more) were interviewed in Montpellier and its 14 districts on their own composition, on their characteristics as well as on a characterization of trips household members made the day before and the day before this day. The sample is a non-random stratified one. Then, to make it representative of the Montpellier population, quotas were defined on the professional status of the household chief, on the household structure and on the days chosen by the individual to travel. We define a trip as a more-than-300-meters drive or run between two places on a public road. One trip can imply several modes of transport but following its definition, this case will be registered only when the individual does more than 300 meters for each mode. Moreover, we consider it is linked to only one purpose. For example, an individual who stops shopping on the way to work will be described by two trips, one from home to the shopping center for the "shopping" purpose and one from the shopping center to his workplace for the "work" purpose. Of course, this definition will entail an under-evaluation of the number of walk trips and as a consequence of the total number of trips. Furthermore, the investigation neglects professional trips, and those made by students living outside the investigation area but studying in Montpellier or living in student dormitories. Each trip is characterized by its mode of transport (the most used to travel) and its destination.



***Graph 1:* Modes of transport observed market shares(%).**

Modes of transport include car, bus, two-wheel vehicles and walk. Graph 1 gives a brief overview of each mode of transport representativeness by its observed market share. All trips purposes together, market shares are of 54% for the car, 15.2% for the bus, 5.8% for two-wheels and of 25% for the walk, (We neglect in this study other modes like ambulances or taxis, which are marginally used with 1.2% of total trips. We also neglect trips made for other purposes than those previously quoted). A purpose by purpose analysis emphasizes the dominance of car mode except for the school purpose where the bus is prevailing and 2-wheels are not negligible. As for destinations, Montpellier has been divided into fifty destination areas, 36 for Montpellier and 14 for its districts. Appendix 2 gives a representation of these areas and their attractiveness, dark areas being the most popular areas in terms of destinations- A more detailed analysis shows that areas generating the most trips can be divided in three categories, which represent about half the destinations reached. Center areas (Comédie-gare, le Centre historique, Rondelet-Gambetta and Antigone) represent 21.6% of the destinations, working districts as La Paillade, Lemasson and Les Cévennes represent 8.8% of trips, northwest satellite areas like Hôpitaux-Facultés, Aiguelongue, and Le parc Agropolis represent also about 9% and finally outskirts areas like Castelnau le Lez, Lattes and Saint Jean de Vedas represent 9% of total trips.

4-2: The specification.

The model specification requires the introduction of five sets of variables, some of which being instrumented to enrich the model and avoid issues linked to endogeneity. These variables include alternative-specific constants, socio-demographic characteristics, characteristics of modes of transport (price, travel time by O-D), level of service variables (frequency, distance of the individual to the first bus stop). To characterize trip destination, we have constructed two indexes of areas potential: one absolute index of the destination area permanent attractiveness and the same index relative to the departure area. Construction of these indexes is briefly described below as well as price and travel time constructions.

4-2-1: The final specification

Variables introduced are defined in appendix 4. VP (respectively TC, VEL, MAR) corresponds to a variable that is one when the individual chooses the car mode (respectively TC, VEL, MAR) and zero when he or she uses one of the other three modes. For identification reasons, we assume the walk mode (MAR) as a reference. Other variables being apart, a positive coefficient of the car mode intercept indicates that travelers prefer using car than walk to reach their destination. These constants give an intuition of the relative market shares in the sample. ATTRAC1(X_1) is a measure of the destination area permanent attractiveness. We define it as the aggregate forecast of the number of trips made toward the destination area. Definitions of variables introduced in this estimation as well as estimation results are given in appendix 3. A positive sign of ATTRAC1 coefficient means that the more popular the area in terms of destination, the more the individual will tend to travel toward it. ATTRAC2(X_2) measures the relative attractiveness of the chosen destination area to his home location (X^0) and the destination area that the individual should see as the most attractive in terms of number of trips. This index is defined as:

$$X_2 = \frac{X_1^{\ 2}}{X^o \times \max(\frac{X_1^{\ 2}}{X^o})} = \frac{X_1^{\ 2}}{\max(X_1^{\ 2})}$$

A negative coefficient of ATTRAC2 means that the bigger the difference of attractiveness between the two destinations, the more the individual will be tempted to choose the most attractive destination (different from the one he has chosen). PRICE denote the price of usage of the mode. To establish it, we have attributed in an arbitrary way a category of car to the household members according to their hierarchy. The biggest car to the household head, the second biggest to the partner, the third biggest to the older child...,i.e. the higher the hierarchy, the bigger the car. The basic price used is the kilometer price[7] of the "Auto-Journal" 1997, which is different for petrol cars and diesel cars (between 4 and 15 horsepower). The trip price is then this basic price multiplied by a scanned distance Origin-Destination or when we are not aware of this distance, we used an estimation of the distance. Now, let us consider an individual using a different mean of transport. In this situation, we still evaluate the price the individual trip paid if he had traveled by car. To this aim, we attribute it the kilometer price associated either to the car he has used last during the two-days survey or the average prk (7 horsepower) if he hasn't used any. In the case the individual used a car park, the charge is added to the trip price. Considering a bus trip, the trip price does not depend on the distance made. It is the ticket price or the subscription's charge plotted on a two days period (survey period of time). Let us consider an individual using another mode of transport, we evaluate the price of his trip by bus by taking into account either the charge he has paid on his last bus journey during the two-day survey or the ticket price if he

[7] This basic price accounts for expenses generated by the acquisition, the use and the depreciation of the car.

hasn't traveled by bus. A negative sign of PRICE corresponds to the rational preference of the consumer to be low charged. TOD is the Origin-Destination estimated travel time. Bus observed travel time has been regressed on a theoretical time (calculated from the kilometric distance and the bus commercial speed) and on factors of congestion (see appendix 3) that can alter it. As far as car is concerned, a theoretical measure of travel time is difficult to obtain. The adjustment of travel time is then made according to a distance as the crow flies, factors of congestion and number of car parks. Variables are listed appendix 3 and results presented in table 4 of this appendix. A negative sign of TOD coefficients corresponds to the preference for spending as less as time possible in transport[8]. INVFRQ corresponds to a variable specifying the inverse of the frequency of the mode of transport, that is the number of hourly times the bus passes through the bus stop according to the period of the trip departure. Introducing the inverse of the frequency allows computing an infinite frequency for the car, two-wheels and walking modes. A negative sign of this coefficient entails a positive sign associated to the frequency, which means that the user always prefers a high frequency mode. Finally, DISTOP gives a measure of the mode of transport accessibility. It gives the distance in meters between the approximate individual home location and the closest bus stop[9]. Socio-economic variables introduced vary according to the purpose of the trip. A description of these variables is given in appendix 4. In some cases, we multiply a discrete quantitative variable by a dichotomic one. For the work purpose for example, we multiply the number of vehicles at disposal in the household by the position of the

[8] Indeed, travel time comes as a subtraction of all other consuming activities, hence the common assimilation of the traveler’s utility function as a disutility or a cost (see de Palma 1998).

[9] As household addresses were not all coded, we have assumed in this case that the individual lives at the barycentre of the area and we affect as DISTOP, the mean of this variable on coded home locations.

individual within the household (household head or not). In this case, the estimated coefficient can be interpreted either as the effect of the household head vehicles possession on travel choice as compared to the travel choice of the other members or to the same effect but compared to household heads possessing no cars. In the same way, the shopping model allows for interactions between gender and status (here, being retired or not). The coefficient can be both interpreted as the fact that a retired man drives or travels more or less than a retired woman and as the fact that retired men travel more or less for shopping than men of other status.

4-2-2: Estimation.

Both the regular MNL and the Non Linear MNL models have been estimated using maximum likelihood, each model being estimated for the four possible purposes (work, school, shopping and leisure).

The log-likelihood L associated to the NL.MNL model is the following:

$$L = \sum_{i=1}^{n} (1 + gz_i)\exp(x'_{(d,m)}\, b) - \sum_{i=1}^{n} \ln \sum_{(d',m')\in\Omega} \exp\{(1 + gz_i)\exp(x'_{(d,m)}\, b)\}$$

whereas the log likelihood associated to the regular model is:

$$L = \sum_{i=1}^{n} (x'_{(d,m)}\, b) - \sum_{i=1}^{n} \ln \sum_{(d',m')\in\Omega} \exp(x'_{(d',m')}\, b)$$

The final specification is based on a systematic process of eliminating variables in order to lead to the best goodness of fit measure**.** As such, we use the likelihood ratio index (rho-squared) suggested by Ben-Akiva and Lerman (1985)[10], which is defined by:

$$\bar{r}^2 = 1 - \frac{L(\hat{b}) - K}{L(0)}$$

where $L(\hat{b})$ is the log likelihood of the estimated coefficients $\hat{b}$ of the model, $L(0)$ is the log likelihood of our model without any explanatory variables and K is the number of explanatory variables including the constant[11].

5-Empirical results.

5-1: Empirical results.

Estimation results as well as adjustment measures of NL.MNL model are presented in table 1. Since the indirect utility function can be decomposed into the sum of a term depending only on alternatives characteristics and a term involving the cross product of these variables with individual characteristics and since the exponential function is an increasing one, effects of level of service variables can be independently interpreted from socio-demographics. On the contrary, effects of the latter cannot be interpreted as direct effects of the category of

***Table 1:* Estimation Results of the Non Linear model**

[10] This ratio is based on the idea of estimating the expectation of the sample log likelihood for the estimated parameter values over all samples, with the log likelihood of the sample we do have available. Furthermore, we subtract the number of explanatory variables (including the constant) from the log likelihood of our sample to compensate both the fact that the estimated parameters will not be the maximum likelihood estimator in other samples and that we evaluate the log likelihood at the estimated values rather than at the true parameters.

Variables	*Work Estimated Values*	*School Estimated Values*	*Shopping Estimated Values*	*Leisure Estimated Values*
ATTRAC1	0.6423	0.0222	0.0022	0.0493
	(36.289)	(10.224)	(2.100)	(7.114)
ATTRAC2	-0.2522	-0.0669	-0.0045	-0.3146
	(-28.786)	(-7.395)	(-1.960)	(-6.812)
TOD	-0.1727	-0.3551	-0.0343	-0.1183
	(-21.823)	(-14.496)	(-2.182)	(-4.185)
PRICE/100	-0.2484		-0.0702	-1.4269
	(-9.104)		(-2.027)	(-3.847)
PRICE		-0.1396		
		(-7.656)		
INVFRQ	-0.6346	-0.2667	-0.0539	-4.8739
	(-6.178)	(-6.490)	(-1.574)	(-5.816)
DISTOP	0.0002	0.0003		
	(3.631)	(2.621)		
CHIEFNBV	0.1124			0.0021
	(4.739)			(2.383)
GENDER	-0.1981			
	(-5.139)			
GENDER*10		-0.1036		
		(-2.125)		
GENDER*100				0.0012
				(0.828)
AGE (11-24)*100		0.1154		
		(17.322)		
AGE (25-59)	0.0741			
	(1.263)			
DRVLICE	0.1018			
	(2.054)			
DRVLICE*100			0.4997	
			(2.267)	
NB2R		0.1866		
		(1.018)		
NBCAR*10		-0.0362		
		(-1.289)		
RTRD*100				0.0043

[11] It is quite similar to the measure proposed by Horowitz (1982,1983) except that the last one's correction is of K/2 instead of K. We adopt a measure more adapted to our parsimonious specification since it put a higher weight on explanatory variables introduced than in the Horowitz one.

				(2.541)
HOUSEW*100			0.3764	0.0045
			(2.191)	(1.785)
RTRD*GENDER*100			0.0651	
			(1.389)	
CAR	0.0415	0.1940	0.004	0.318
	(5.904)	(6.786)	(1.354)	(-2.758)
BUS	0.0777	0.6854	0.0098	0.7245
	(3.377)	(9.028)	(1.331)	(4.005)
2WHEELS	-0.2405	-0.4957	-0.0537	-15.4797
	(-14.718)	(-10.026)	(-2.030)	(-4.836)
Adjustment: $\overline{r}^2$	18.87%	25.85%	19.44%	12.09%

individual on his transport choice, but rather as a sensitivity of the individual to the preceding effects. Signs of alternatives characteristics parameters are consistent with a-priori expectations, except for the DISTAR variable for which the unexpected weakly positive effect may be explained by its bad construction because of the lack of many home locations. Furthermore, we retire this variable in the case of non-obligatory purposes (shopping, leisure) because of its insignificance and its null effect, which may be explained by the fact that a traveler organizes a-priori his leisure and shopping activities whatever his localization. Thus, individuals travel all the more with a given mode of transport than this mode is lower charged, than travel time is shorter and than frequency of the mode and attractiveness of the destination area is higher. Let us analyze the effects of the interactions between a category of traveler and his transport choice. Let us consider trips made for the work purpose. It seems that household chiefs, households possessing many vehicles and 25-59 aged individuals are those who have the biggest work trips potential. This may be explained by a better financial position of these households and by the fact that bus cannot deserve such a variety of workplaces with accuracy. An interesting effect is that women are more sensitive than men to the preceding effects. Note that

AGE(25-59) coefficient is only significant at a 20% level, which is certainly due to the fact that the proportion of 15-24 people working is not negligible in the sample. Now, let us examine the school model results. As expected, the biggest representativeness of trips for this purpose corresponds to the 11-24 population, that is the vast majority of students, individuals possessing a two-wheels and those who possess no car with a lower significance. This last effect would certainly have been enhanced if students living in school cities had been included in the sample. Note also that students living outside the investigation area but studying in this area (who are more likely to run long distances by car) have not been computed in the sample. This model seems equally to well transcribe the prevalence of women trips (51.4% against 48.6% for men) and the higher sensitiveness of women to variations of alternatives characteristics. Trips made for the shopping purpose concern essentially people who possess their driving license, housewives rather than men or women with other status (with a 10% significance) and retired men rather than men with other status. Finally, let us consider leisure activities. They represent a larger number of trips made by retired people and housewives. This may be explained by the fact that these two categories of travelers have more free time. Now, let us compare these results with the MNL ones (see appendix 5, table 5). For identification reason as we mentioned above, we introduced only alternative constants and level of service variables in the computation of the regular MNL model. Estimated parameters are generally bigger than those found in the non-linear case and of the same sign except in the work model where the estimated parameters associated to variables ATTRAC1 and ATTRAC2 are respectively negative and positive coefficients contrary to the non-linear case. This new result contradicts the reasonable intuition that each individual is likely to work in the most attractive area in terms of number of jobs and that knowing the most attractive area in terms of number of trips will influence his primary choice. Moreover, stronger coefficients of the DISTAR variable than in the NL.MNL model stresses the unexpected sign of this variable.

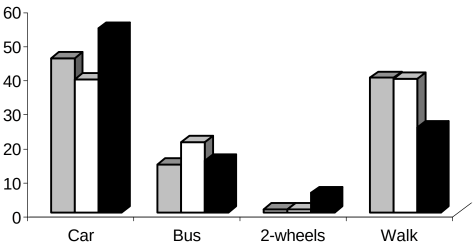
5-3: Empirical results of market shares

Empirical results of market shares of both models as well as observed market shares are presented in appendix 6, detailed by purpose[12]. They are reported in the form of a 50×4 matrix for which each column details each mode market share for a given purpose in a succession of “sub-market shares” giving the part of each mode market share in a given destination as compared to the total mode market share. If we add up a column of this matrix, we get the aggregate mode market share. Graph 2 points out that our model seems a little more fitted to the data than the regular linear one despite an over-evaluation of walk trips to the detriment of car and two-wheels modes (see data analysis). However, in the political perspective of setting new infrastructures or more scarily new modes of transport, it seems of capital importance to get a precise measure of the part of each mode in the different districts of the city. To get a better idea of the results and because of the large number of areas, we restricted our analysis to significant examples of this representativeness both for each purpose and all purposes together. Graph 3 gives

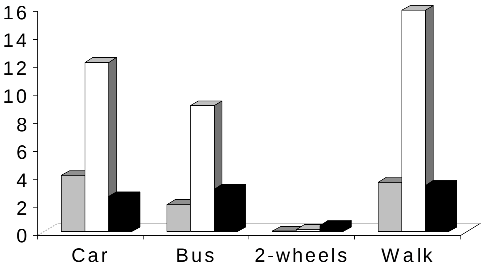
[12] It is quite evident that our model is globally less adapted to trips made for ”obligatory purposes”(work and school) than to ”non-obligatory” purposes (shopping and leisure) since tries to transcribe the choice of destination as well as the mode one. In the short term, indeed, for the school and work purpose, the individual will not choose the destination. Nevertheless, the tendency of the detailed market shares is preserved which is not always the case in the linear model.

the representativeness of Comédie-Gare area in the market share of each mode (see appendix 2 for a representation of the areas). Observed market shares gives a 2.5% and 3.3% representativeness to respectively car and walk trips for this area. Our model predicts a representativeness of respectively 4% and 3.5% whereas the linear model estimates 12% and 15.8% of total trips made toward this area with the two modes. This distortion is especially obvious for the school purpose (Graph 4) where the linear model forecasts 46.9% of total trips made toward Antigone against 11.9% in the NL.MNL

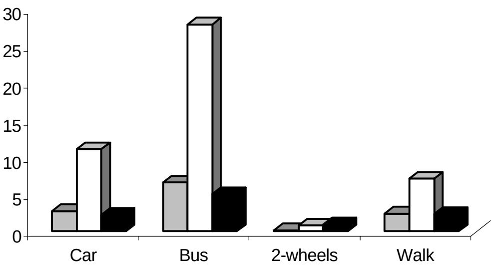
Graph 2 :
Modes of transport market shares, all purposes.



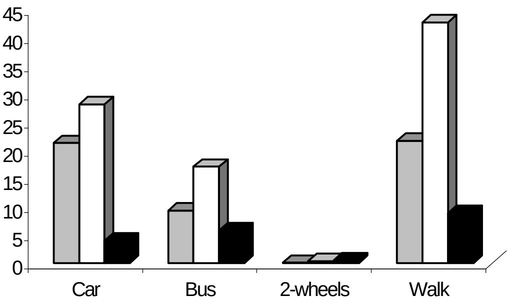
Graph3 :
Trips toward Comédie-Gare, all purposes.



Graph 4
Trips toward Antigone, school purpose.



Graph 5 :
Trips toward Comédie-Gare, shopping purpose



NL.MNL MNL Data

model and 10.5% according to the data. As for “non-obligatory” purposes and especially for the shopping purpose (see graph 5), the linear model seems equally unsuitable with an estimation of 40% of total trips toward Comédie-Gare against 11% in the NL.MNL model and 11.8% in reality.These striking examples tend to show that the linear model is not adapted to analyze the part of each mode of transport in a given district as compared to the total market share of the mode. By the way, it shows that the reasonable market shares forecasts resulting from this model hide compensations of serious errors at a disaggregate level. On the contrary, our model fits best the data both at a disaggregate and at the aggregate level.

5-4: Empirical results of price elasticities.

Elasticities of demand are of strategic importance in transportation analysis. They measure the response of users to changes brought about by new services, investments in infrastructures or changes in operating and pricing policies. In particular, price elasticities summarize the response of a decision-maker to a price increase, say the percent change in the expected individual or aggregate demand resulting from a one percent change in price. The estimated own-and cross-price elasticities of aggregate market shares of the alternatives have been computed both for each purpose and all purposes together[13]. Of course, they exclude alternatives including free modes (walk and bike). Graph 6 and graph 8 report own- and cross-price elasticities associated to the car mode for all potential destinations and both

[13] Matrices of these elasticities have not been reported in appendix since they represent 64 slides of A4 format. Nevertheless, they remain at disposal to any person interested.

models. They represent at the same time cross elasticities for different destinations reached by car. Table 2 summarizes descriptive statistics of own price aggregate elasticities. All are of expected sign. Let us analyze results purpose by purpose. For the work purpose, the estimated own-price elasticities are all of expected negative sign and range from -65.35 to -4.98. The maximum in absolute value is reached for car trips to Baillargues outskirts area whereas the minimum is reached for bus trips to Grabels. The low elasticity for bus trips to Grabels may be explained by the presence of reinforced bus lines to facilitate Montpellier access, the center of which generates more than 60% of Grabels inhabitants trips (see appendix 2). On the contrary, the very high price elasticity of Baillargues car trips gives the intuition of a district with a very diversified infrastructure and with a great proportion of trips made inside this area. Note very logically that price elasticities of bus demand are lower than car ones.

Table 2

Descriptive statistics of own- price elasticities of demand in thousandth.

	Non linear model	*Mode of transport*	*Destination*	*Linear model*	*Mode of transport*	*Destination*
Work						
minimum	-65.35	Car	Baillargues	-164.3	Car	Baillargues
maximum	-4.98	Bus	Grabels	-20.6	Bus	All areas
School						
minimum	-248.3	Bus	Antigone	-1008.2	Car	Baillargues
maximum	-8	Car	Palavas les	-52.6	Bus	Antigone

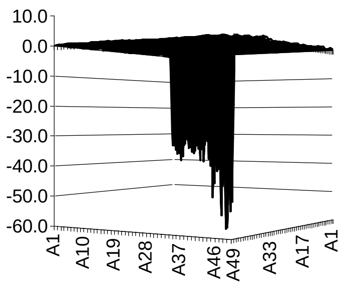
			flots			
Shopping						
minimum	-67.4	Car	Perols	-350.4	Car	Baillargue s
maximum	-1	Bus	Grabels	-37.7	Bus	All areas
Leisure						
minimum	-55.6	Car	Palavas les flots	-190.5	Car	Baillargue s
maximum	0	Bus	Baillargues Grabels	-13.6	Bus	All areas

This may be partly explained by the usual dependency of bus customers either physical (no possession of the driving license, retired people…) or financial (high school pupils, students). As far as school is concerned, elasticities range from -248.3 for bus trips to Antigone (-235.9 to Hôpitaux-Facultés) to -8 for car trips to Palavas Les Flots. The first two are the ones who generate the most trips for school purpose with a large number of trips made toward graduate schools of Antigone and the University Paul Valery in Hopitaux Facultés area. In the first case, the presence of three car parks may lead to a hard competition between car and bus modes whereas the University Paul Valéry is busy of students aged 18 and more who often drive. Moreover their central situation provide them a very rich infrastructure. Now, let us consider the results of the regular MNL model for this purpose. The maximum elasticity in absolute value is reached for car trips to Baillargues whereas for bus trips, elasticities all have the same amount of -106.5. The first result is quite amazing since Baillargues does not concentrate many students with 1700 to 5800 trips compared to Antigone and Hopitaux-Facultés areas, which represent till 53000 weekly trips. Now, let us compare to the work purpose. The relationship is reversed allowing for higher bus own-price elasticities than cars ones; Moreover, elasticities are bigger in absolute value. The first result may be explained by

NL.MNL model

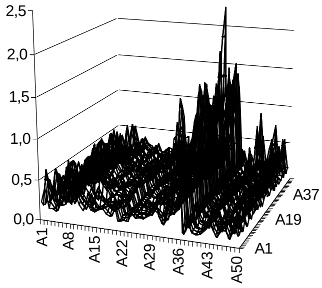
Graph 6 :

Effect of a 1% change in the car price on car market shares in 1000th.



Graph 7 :

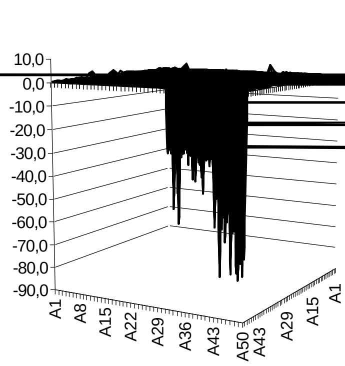
Effect of a 1% change in the car price on bus market shares in 1000th



MNL model

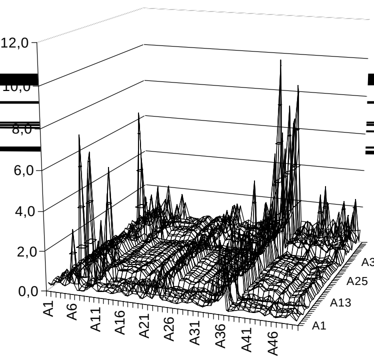
Graph 8 :

Effect of a 1% change in the car price on car market shares in 1000th.



Graph 9 :

Effect of a 1% change in the car price on bus market shares in 1000th.



the fact that bus market share is higher than the car one for this purpose whereas the second result refers to the precarious position of most students who prefer walk or ride to school. Let us now consider non obligatory purposes. Shopping elasticities reach their maximum in absolute value for car trips to Pérols and their minimum for bus trips to Grabels as in the work model. This may be explained by the presence of a rich transport infrastructure, an important shopping center and the Airport which generate many trips. As far as leisure is concerned, the biggest elasticity is reached to Palavas Les Flots close-to-the-sea destination whereas it is almost zero for trips to Baillargues and Grabels. In the linear model and for these two purposes, the maximum is reached for car trips to Baillargues whereas bus own price elasticities are identical whatever the destination of the trip as in the case of obligatory purposes. As far as cross elasticities are concerned, Graph 7 and 9 sum up the effect of a marginal increase in the car price (average price of usage) on the bus market shares for the different destinations. Whereas our model show that the core center elasticities are the highest in absolute value, the linear model let non negligible picks for trips to Croix-d'Argent for example. This is quite unintuitive since this area is not particularly rich of roads or bus lines to justify such a fierce competition between the two modes. To conclude, more than producing realistic elasticities, the big strength of our model against the regular linear model is its ability to differentiate alternatives at a disaggregate level. The forecast of identical own price elasticities whatever the destination is doubtful since we can expect each area to generate different reactions in terms of behavior by its own characteristics (closeness to the core center…).

6-Conclusions and directions for future research.

The contribution of this paper to transportation analysis is twofold: first, we address the crucial question of the choice set dimensionality in transport demand models. Second, we develop a theoretical model of transportation demand that depicts as best as possible the heterogeneity of individual travel behavior whatever the large choice set and allows to determine the expected probability of travel choice given the trip purpose. In order to deal with many alternatives, the literature tend to decompose the choice process in a sequence of conditional choices. In the case of the joint choice of mode of transport and destination of the trip, most authors consider the mode choice probability and then the destination choice probability conditional to the mode choice. This method, which gave rise to the Nested Logit Model has been extensively used. Nevertheless in many cases, it seems difficult to assess that the individual favors one choice to another in terms of his observed preferences. Moreover, many simulation methods have been developed in order to overcome difficulties links to the I.I.A consequences but these methods cause loss of precision and information. This becomes non negligible when the number of integrals to evaluate becomes large. Our model could be extended in several directions. First, it could be interesting to model interactions of decisions within the household to get a better idea of the information acquisition process and of household unobservables like habits. We could imagine the introduction of such variables as reputation of modes, districts…which can influence markedly the individual choice. Second, it could be interesting to put in random coefficients in addition to freeing up the interactions. This would transcribe the unobservable part of the individual choice in a better way, completing the heterogeneity representation and would result to even better estimated substitution patterns. From an empirical point of view, one could introduce this joint choice probability in the whole decision process of the individual to construct a simulation tool of transportation demand and examine for example the impacts of a pricing policy on congestion. Finally, we could think to introduce other parameters in the utility function with the perspective of optimally pricing. For example, one could think to internalize congestion since transport pricing seems incomplete without taking into account an individual marginal utility to pay for a reduction of congestion. We will try to investigate some of these questions in further research.

Appendix 1

Consider the following direct utility function of individual i from choice (d,m):

$$U_{i,(d,m)} = n_{(d,m)}(1 + x'_{(d,m)}\, b + \ln(1 + z_i g) - \ln n_{(d,m)}) + hv$$

where all the variables and coefficients have been defined in proposition 2.

The maximizing program of the individual is then the following:

$\max\limits_{x_{(d,m)}} \{ n_{(d,m)}(1 + x'_{(d,m)}\, b + \ln(1 + z_i g) - \ln n_{(d,m)}) + hv \}$ subject to .

$p_{n_{(d,m)}} n_{(d,m)} + A_{(d,m)} + p_n n = w$. Normalizing by $p_n = 1$ gives

$p_{(d,m)} n_{(d,m)} + v = w$

First–order conditions:

$$\frac{\partial U_{i(d,m)}}{\partial n_{(d,m)}} = 0 .$$

$$x'_{(d,m)}\, b + \ln(1 + z_i g) = \ln n_{(d,m)} .$$

$$n^*_{(d,m)} = (1 + z_i g) \exp(x'_{(d,m)}\, b - hp_{(d,m)}) .$$

Second order conditions:

$$\frac{\partial^2 U_{i(d,m)}}{\partial n_{(d,m)}{}^2} = -\frac{1}{n_{(d,m)}} < 0 \qquad \text{pour } n_{(d,m)} > 0$$

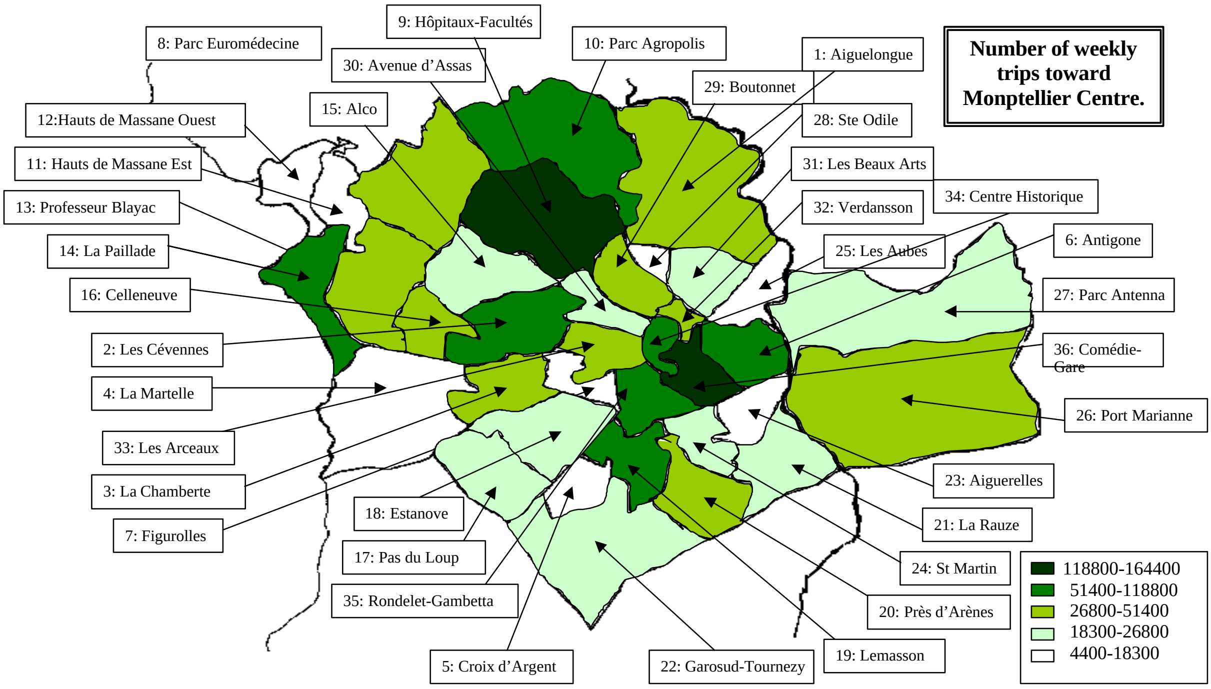
The maximum utility the individual can expect from choice (d,m) is then represented by the following indirect utility function:

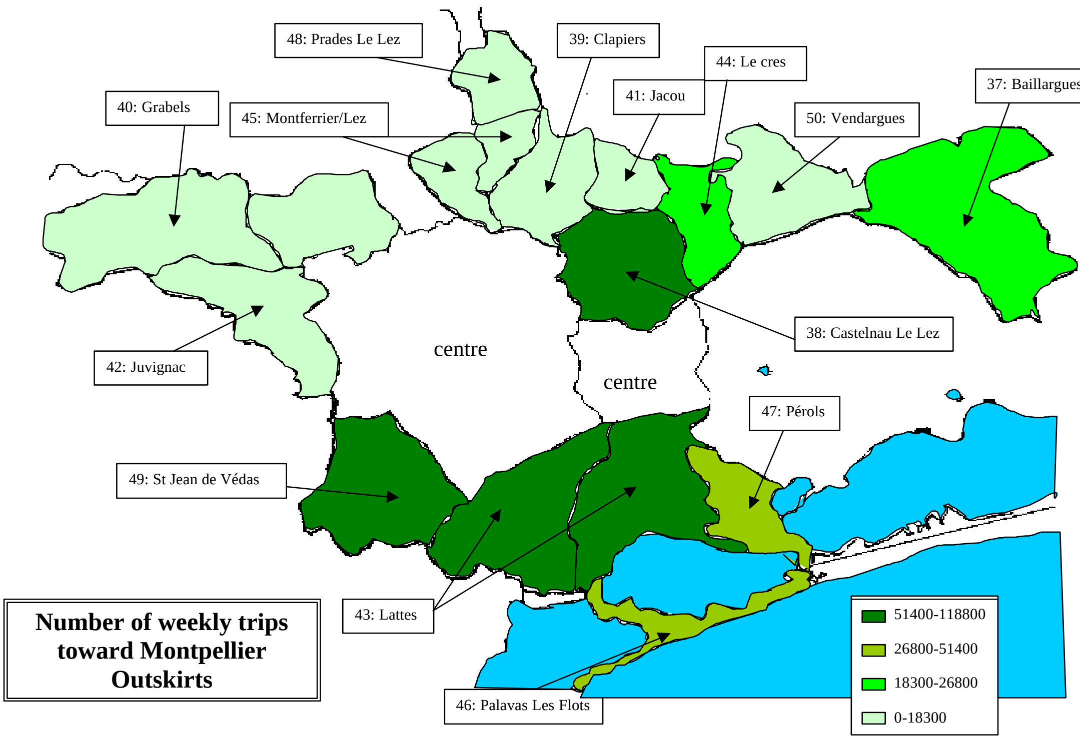
$$V_{i,(d,m)}(p, y) = (1 + z_i g) \exp(x'_{(d,m)}\, b - hp_{(d,m)})[1 + x'_{(d,m)}\, b + \ln(1 + z_i g)$$
$$- \ln(1 + z_i g) \exp(x'_{(d,m)}\, b - hp_{(d,m)})] + h[w - p(1 + z_i g) \exp(x'_{(d,m)}\, b - hp_{(d,m)}) - A_{(d,m)}].$$

$$V_{i,(d,m)}(p,y) = (1+z_i g)\exp\left(x'_{(d,m)} b - hp_{(d,m)}\right)\left(1+hp_{(d,m)}\right) - hp_{(d,m)}\left[(1+z_i g)\exp(x'_{(d,m)} b)\right] + h\left(w - A_{(d,m)}\right).$$

$$V_{i,(d,m)}(p,y) = (1+z_i g)\exp\left(x'_{(d,m)} b - hp_{(d,m)}\right) + h\left(w - A_{(d,m)}\right)$$

Appendix 2


Number of weekly trips toward Monptellier Centre.
1: Aiguelongue
2: Les Cévennes
3: La Chamberte
4: La Martelle
5: Croix d'Argent
6: Antigone
7: Figurolles
8: Parc Euromédecine
9: Hôpitaux-Facultés
10: Parc Agropolis
11: Hauts de Massane Est
12:Hauts de Massane Ouest
13: Professeur Blayac
14: La Paillade
15: Alco
16: Celleneuve
17: Pas du Loup
18: Estanove
19: Lemasson
20: Près d'Arènes
21: La Rauze
22: Garosud-Tournezy
23: Aiguerelles
24: St Martin
25: Les Aubes
26: Port Marianne
27: Parc Antenna
28: Ste Odile
29: Boutonnet
30: Avenue d'Assas
31: Les Beaux Arts
32: Verdansson
33: Les Arceaux
34: Centre Historique
35: Rondelet-Gambetta
36: Comédie-Gare
118800-164400
51400-118800
26800-51400
18300-26800
4400-18300


Number of weekly trips toward Montpellier Outskirts
37: Baillargues
38: Castelnau Le Lez
39: Clapiers
40: Grabels
41: Jacou
42: Juvignac
43: Lattes
44: Le cres
45: Montferrier/Lez
46: Palavas Les Flots
47: Pérols
48: Prades Le Lez
49: St Jean de Védas
50: Vendargues
centre
centre
51400-118800
26800-51400
18300-26800
0-18300

Appendix 3

Number of trips estimation models

Variables	Definitions of variables observed in the destination area
(W)CONST*	Constant
Work	
WPOPAC	Number of jobs
WADMBQ	Number of banks and administrations
School	
WEFLYC	Secondary school effective
WEFFAC	University effective
Shopping	
PCOM	Number of small shops
Leisure	
WPLCIN	Number of cinema seats
WBAREST	Number of bars and restaurants

Travel time estimation models

Variables	Definitions of variables observed in the destination area
(W)CONST*	Constant
Bus and car	
(W)POINTE	Dummy variable =1 if trip has been made during peak period, =0 otherwise
(W)DESTCEN	Dummy variable =1 if trip’s destination is a centre area, =0 otherwise

Bus only	
TRAJDIR	Origin-Destination distance as the crows flies
LTPBUS	Logarithm of theoretic travel time = 60*bus distance/commercial speed
Car only	
WNBPARK	Number of car parks
WLNVOLBI	Logarithm of the Origin-Destination distance as the crows flies

*:Variables preceded by w means that they were introduced in a model estimated by the white method

Table 3: **Determinants of number of trips estimated [14].**

Variables Y^d	*Work Estimated Values(White)*	*School Estimated Values(White)*	*Shopping Estimated Values(O.L.S)*	*Leisure Estimated Values(White)*
WCONST	2.903008	4.077097	2.987116	4.842259
	(3.938504)	(5.489610)	(3.124927)	(6.882003)
WPOPAC	0.573855			
	(5.790164)			
WADMBQ	0.060675			
	(1.187978)			
WEFLYC		0.496754		
		(8.186563)		
WEFFAC		0.237129		
		(3.314364)		
PCOM			0.820430	
			(10.076060)	
WPLCIN				0.162175
				(7.875054)
WBAREST				0.177613
				(4.279159)
Adjustment: $\overline{R}^2$	0.794	1	0.77	0.99

Table 4: **Estimation Results of travel time.**

Variables	*Bus Estimated Values(OLS)*	*Car Estimated Values(White)*
CONST	1.576021	1.627855
	(20.767321)	(18.147934)
POINTE	0.015465	0.132697
	(0.702497)	(0.493806)
DESTCEN	-0.126917	0.326826
	(-4.668031)	(27.799057)

[14] In all tables of estimation results, we specify parameters and t-values in parentheses.

TRAJDIR	-0.156211	
	(-4.356702)	
LTPBUS	0.586909	
	(27.900022)	
NBPARK		0.000000
		(0.000020)
LNVOLBI		0.402932
		(50.922304)
Adjustment: $\overline{R}^2$	0.956	0.975

Appendix 4

Variables	*Meaning*
Level-of service variables	
ATTRAC1	Estimate number of trips made in the chosen destination area
ATTRAC2	Index estimate of the scale of attractiveness of the chosen destination area
TOD	Trip's travel time
PRICE	Trip's travel charge
INVFRQ	Frequency inverse of the chosen mode
DISTOP	Distance of the individual's home location to the first bus stop
Socio--demographic variables	
CHIEFNBV	Mixed(quantitative/qualitative) variable : = to the number of available cars of the household head if the individual is the household head, =0 otherwise.
GENDER	Dummy variable = 1 if the individual is a man, =0 if the individual is a woman.
AGE (11-24)	Dummy variable = 1 if the individual is 11-24 years old, =0 otherwise
AGE (25-59)	Dummy variable = 1 if the individual is 25-59 years old, =0 otherwise
DRVLICE	Dummy variable = 1 if the individual is allowed to drive, =0 otherwise
NB2R	Number of two-wheeled vehicles in the household (including bikes, mopeds and motorbikes)
NBCAR	Number of cars available to the household
RTRD	Dummy variable =1 if the individual is retired, =0 otherwise.
RTRD*GENDER	Dummy variable =1 if the individual is a retired man, =0 otherwise
Alternative constants	
CAR	Car mode constant
BUS	Bus mode constant
2WHEELS	Two-wheels vehicle mode constant

Appendix 5

Table 5

Estimation Results of the simple MNL model

Variables	*Work* *Estimated Values*	*School* *Estimated Values*	*Shopping* *Estimated Values*	*Leisure* *Estimated Values*
ATTRAC1	-1.0396	0.1550	0.1228	0.0665
	(-1.317)	(15.120)	(12.644)	(9.966)
ATTRAC2	0.92	-0.4806	-0.2263	-0.3015
	(2.54)	(-10.456)	(-5.873)	(-5.501)
TOD	-1.8941	-2.0965	-2.0560	-1.7792
	(-47.404)	(-51.83)	(-37.764)	(-31.033)
PRICE		-0.1913		
		(-9.258)		
PRICE/100	-3.1087		-6.0293	-3.6287
	(-10.783)		(-11.423)	(-7.887)
INVFRQ	-4.0694	-1.5407	-2.4325	-1.9196
	(-6.6086)	(-8.905)	(-4.995)	(-3.165)
DISTOP	0.0016	0.0005		
	(3.004)	(1.525)		
CAR	0.4662	-0.2304	0.1923	-0.1627
	(5.837)	(-2.125)	(1.832)	(-1.733)
BUS	0.4808	1.3385	0.5841	-0.2076
	(2.602)	(8.666)	(3.366)	(-1.111)
2-WHEELS	-2.3709	-2.4039	-3.5230	-3.0191
	(-20.754)	(-21.236)	(-17.455)	(-18.364)

Appendix 6 :Market shares

Work purpose

	NL.MNL Model				MNL Model				Data			
Area	*Car*	*Bus*	*2-wheels*	*Walk*	*Car*	*Bus*	*2-wheels*	*Walk*	*Car*	*Bus*	*2-wheels*	*Walk*
Area1	0,896	0,007	0,004	0,229	1,164	0,008	0,005	0,422	1,081	0,104	0,083	0,193
Area2	5,906	0,172	0,012	0,380	2,912	0,094	0,006	0,204	3,275	0,384	0,117	0,628
Area3	0,261	0,003	0,000	0,080	1,537	0,020	0,000	0,466	0,859	0,118	0,000	0,195
Area4	0,294	0,000	0,003	0,013	0,697	0,000	0,004	0,029	0,649	0,000	0,113	0,037
Area5	0,113	0,000	0,000	0,001	1,354	0,000	0,000	0,010	0,705	0,000	0,000	0,008
Area6	4,016	0,202	0,129	0,737	1,660	0,086	0,079	0,352	3,189	0,660	0,330	1,304
Area7	1,543	0,002	0,000	1,116	0,495	0,001	0,000	0,385	0,753	0,053	0,000	0,288
Area8	3,224	0,042	0,011	0,021	1,264	0,018	0,004	0,007	2,385	0,242	0,202	0,005
Area9	10,638	0,088	0,091	0,605	3,751	0,039	0,042	0,279	6,294	0,350	0,558	0,838
Area10	2,411	0,073	0,013	0,796	1,787	0,046	0,012	0,617	2,423	0,493	0,139	0,571
Area11	0,766	0,365	0,000	0,151	0,780	0,390	0,000	0,172	0,400	0,435	0,000	0,100
Area12	0,144	0,000	0,000	0,200	0,247	0,000	0,000	0,368	0,265	0,000	0,000	0,136
Area13	1,290	0,101	0,002	0,086	1,310	0,111	0,002	0,090	1,288	0,163	0,052	0,134
Area14	1,335	0,042	0,033	2,079	1,433	0,037	0,041	2,384	0,893	0,133	0,147	1,966
Area15	0,320	0,007	0,000	0,036	0,796	0,018	0,000	0,098	0,808	0,034	0,000	0,036
Area16	0,608	0,011	0,004	1,423	1,214	0,018	0,005	3,026	0,907	0,055	0,146	1,705
Area17	0,905	0,039	0,003	0,068	0,703	0,035	0,003	0,049	1,124	0,430	0,037	0,073
Area18	0,774	0,000	0,008	0,056	2,600	0,000	0,034	0,183	1,343	0,000	0,113	0,156
Area19	0,874	0,012	0,000	0,237	5,065	0,065	0,001	1,351	2,022	0,166	0,013	0,597
Area20	2,414	0,013	0,000	0,016	0,809	0,005	0,000	0,006	1,556	0,064	0,000	0,025
Area21	0,243	0,000	0,003	0,000	1,842	0,000	0,020	0,000	0,896	0,000	0,041	0,000
Area22	0,917	0,016	0,014	0,244	2,016	0,026	0,021	0,434	1,780	0,158	0,299	0,057
Area23	0,021	0,000	0,000	0,004	1,237	0,000	0,000	0,264	0,272	0,000	0,000	0,074
Area24	0,421	0,017	0,000	0,483	0,561	0,018	0,000	0,578	0,497	0,128	0,000	0,446
Area25	0,053	0,000	0,006	0,230	0,097	0,000	0,012	0,455	0,096	0,000	0,104	0,257
Area26	2,988	0,065	0,006	0,037	2,516	0,066	0,005	0,031	2,908	0,400	0,189	0,052
Area27	0,610	0,011	0,000	0,029	0,470	0,008	0,000	0,024	0,722	0,069	0,000	0,095
Area28	0,093	0,000	0,000	0,287	0,230	0,000	0,000	0,670	0,108	0,008	0,000	0,144
Area29	1,273	0,060	0,003	0,173	1,010	0,048	0,003	0,166	1,287	0,225	0,067	0,218
Area30	0,520	0,006	0,001	0,382	1,273	0,018	0,001	0,972	0,673	0,055	0,043	0,547
Area31	0,770	0,000	0,001	0,833	0,954	0,000	0,000	1,061	0,818	0,000	0,025	0,473
Area32	0,192	0,014	0,006	0,077	0,364	0,020	0,011	0,190	0,584	0,139	0,158	0,219
Area33	1,463	0,078	0,008	0,123	0,456	0,033	0,003	0,057	0,826	0,338	0,076	0,259
Area34	1,492	0,773	0,062	0,786	0,394	0,203	0,014	0,275	1,504	1,803	0,920	1,054
Area35	5,761	0,063	0,029	0,948	1,207	0,016	0,006	0,243	2,683	0,292	0,348	0,626
Area36	2,141	0,648	0,077	1,179	0,505	0,147	0,022	0,346	2,557	1,765	0,420	1,783
Area37	0,691	0,000	0,000	1,160	2,788	0,000	0,000	5,033	0,750	0,000	0,000	0,429
Area38	3,395	0,073	0,011	0,295	1,564	0,036	0,007	0,132	2,533	0,351	0,087	0,142
Area39	0,204	0,000	0,000	0,021	0,894	0,000	0,000	0,081	0,366	0,000	0,000	0,111
Area40	0,051	0,000	0,000	0,000	0,362	0,000	0,000	0,000	0,180	0,000	0,000	0,000
Area41	0,463	0,000	0,000	0,018	1,825	0,000	0,000	0,071	0,685	0,000	0,006	0,021
Area42	0,689	0,000	0,010	0,154	1,140	0,000	0,018	0,251	0,817	0,000	0,024	0,085
Area43	2,839	0,002	0,007	0,633	1,166	0,001	0,003	0,279	2,716	0,014	0,024	0,187
Area44	0,509	0,002	0,007	0,444	0,436	0,003	0,007	0,467	0,581	0,047	0,063	0,127
Area45	0,303	0,000	0,000	0,003	1,994	0,000	0,000	0,023	0,788	0,000	0,000	0,006
Area46	1,629	0,000	0,001	1,356	2,117	0,000	0,000	3,005	1,422	0,000	0,019	0,233
Area47	1,666	0,000	0,030	0,285	1,604	0,000	0,043	0,420	1,539	0,000	0,056	0,125
Area48	0,727	0,000	0,000	0,523	2,657	0,000	0,000	1,914	0,520	0,000	0,000	0,288
Area49	2,627	0,000	0,030	0,401	1,124	0,000	0,016	0,196	3,106	0,000	0,113	0,154

Area50	2,564	0,000	0,001	0,883	1,881	0,000	0,000	1,518	1,319	0,000	0,062	0,172
Sum :	76,044	3,008	0,626	20,321	68,262	1,636	0,449	29,653	67,747	9,676	5,198	17,380

School purpose												
	NL.MNL Model				*MNL Model*				*Data*			
Area	*Car*	*Bus*	*2-wheels*	*Walk*	*Car*	*Bus*	*2-wheels*	*Walk*	*Car*	*Bus*	*2-wheels*	*Walk*
Area1	0,001	0,000	0,000	1,126	0,000	0,000	0,000	0,055	0,011	0,000	0,000	1,138
Area2	1,689	1,260	0,134	1,859	0,296	0,276	0,044	0,605	1,116	1,351	0,924	1,890
Area3	0,437	0,278	0,115	2,042	0,043	0,028	0,015	0,217	0,976	0,685	0,591	1,546
Area4	0,002	0,014	0,013	0,229	0,000	0,001	0,001	0,022	0,025	0,135	0,191	0,657
Area5	0,001	0,002	0,000	0,040	0,000	0,000	0,000	0,003	0,084	0,016	0,000	0,146
Area6	2,738	6,630	0,123	2,398	11,092	27,945	0,804	7,111	2,200	5,024	0,932	2,345
Area7	0,003	0,002	0,000	0,037	0,000	0,000	0,000	0,001	0,016	0,016	0,000	0,201
Area8	0,002	0,001	0,000	0,027	0,001	0,000	0,000	0,003	0,077	0,009	0,000	0,036
Area9	1,872	4,736	0,321	6,016	2,144	2,110	0,258	3,000	4,703	6,478	2,573	3,170
Area10	0,581	1,305	0,161	9,539	2,069	2,633	0,577	12,230	1,031	1,547	0,847	1,377
Area11	0,211	0,019	0,000	1,748	0,018	0,005	0,000	0,301	0,226	0,088	0,000	1,438
Area12	0,006	0,000	0,000	1,667	0,003	0,000	0,000	0,264	0,029	0,000	0,000	0,879
Area13	0,197	4,238	0,023	0,170	0,034	0,412	0,007	0,051	0,464	1,936	0,201	0,127
Area14	0,073	0,063	0,000	0,697	0,007	0,007	0,000	0,171	0,336	0,421	0,000	1,594
Area15	0,020	0,005	0,000	0,010	0,002	0,000	0,000	0,008	0,120	0,157	0,000	0,122
Area16	0,007	0,049	0,004	0,626	0,001	0,004	0,000	0,093	0,039	0,231	0,055	0,727
Area17	0,000	0,000	0,000	0,090	0,000	0,000	0,000	0,011	0,000	0,000	0,000	0,083
Area18	0,003	0,025	0,000	0,164	0,000	0,002	0,000	0,013	0,037	0,079	0,000	0,438
Area19	0,247	0,291	0,001	1,372	0,021	0,029	0,000	0,081	1,109	1,222	0,014	1,737
Area20	0,000	0,083	0,000	0,000	0,000	0,005	0,000	0,000	0,000	0,151	0,000	0,000
Area21	0,000	0,008	0,000	0,000	0,000	0,001	0,000	0,000	0,000	0,090	0,000	0,000
Area22	0,016	0,000	0,005	0,728	0,002	0,000	0,000	0,070	0,079	0,000	0,047	0,178
Area23	0,018	0,009	0,031	0,239	0,002	0,001	0,001	0,015	0,092	0,144	0,447	0,475
Area24	0,011	0,065	0,001	0,517	0,001	0,006	0,000	0,021	0,046	0,376	0,012	0,431
Area25	0,017	0,029	0,007	0,266	0,002	0,002	0,000	0,009	0,267	0,251	0,125	0,357
Area26	0,005	0,050	0,003	0,000	0,001	0,003	0,000	0,000	0,136	0,472	0,092	0,000
Area27	0,014	0,037	0,004	0,106	0,003	0,001	0,000	0,015	1,152	0,582	0,085	0,854
Area28	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Area29	0,254	0,275	0,018	0,060	0,031	0,027	0,001	0,008	1,161	0,689	0,239	0,184
Area30	0,302	0,101	0,002	0,541	0,037	0,010	0,000	0,051	0,853	0,470	0,020	0,736
Area31	0,005	0,021	0,000	0,484	0,000	0,002	0,000	0,022	0,096	0,135	0,000	0,647
Area32	0,030	0,191	0,010	0,336	0,003	0,015	0,000	0,014	0,362	1,004	0,203	0,825
Area33	0,338	0,039	0,000	0,000	0,027	0,005	0,000	0,000	1,105	0,239	0,000	0,000
Area34	0,199	1,914	0,191	2,240	0,888	3,960	0,759	5,402	1,087	1,433	0,581	1,835
Area35	1,903	4,527	0,029	12,110	1,423	2,551	0,039	5,834	1,073	2,206	0,360	3,157
Area36	0,016	0,117	0,000	0,085	0,001	0,008	0,000	0,004	0,361	0,694	0,000	0,800
Area37	0,085	0,000	0,314	4,283	0,009	0,000	0,152	1,926	0,131	0,000	0,682	0,931
Area38	0,230	0,149	0,057	0,389	0,021	0,013	0,010	0,070	1,018	0,908	0,327	0,422
Area39	0,112	0,280	0,009	0,153	0,009	0,023	0,001	0,011	0,260	0,433	0,056	0,373
Area40	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Area41	0,006	0,000	0,000	0,081	0,000	0,000	0,000	0,019	0,047	0,000	0,000	0,060
Area42	0,000	0,000	0,000	0,047	0,000	0,000	0,000	0,007	0,000	0,000	0,000	0,023
Area43	0,290	0,218	0,131	2,318	0,034	0,022	0,025	0,402	0,581	0,354	0,504	0,701
Area44	0,113	0,502	0,050	1,804	0,009	0,038	0,006	0,344	0,299	0,474	0,408	0,402
Area45	0,005	0,000	0,000	0,000	0,001	0,000	0,000	0,000	0,050	0,000	0,000	0,000
Area46	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Area47	0,015	0,000	0,111	0,448	0,001	0,000	0,022	0,099	0,054	0,000	0,559	0,359
Area48	0,022	0,000	0,000	0,740	0,013	0,000	0,000	0,188	0,153	0,015	0,000	0,425
Area49	0,047	0,000	0,016	0,619	0,010	0,000	0,002	0,098	0,866	0,012	0,079	0,559
Area50	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Sum :	12,141	27,532	1,881	58,446	18,261	40,144	2,726	38,870	23,932	30,529	11,155	34,385

Shopping purpose

	NL.MNL Model				MNL Model				Data			
Area	*Car*	*Bus*	*2-wheels*	*Walk*	*Car*	*Bus*	*2-wheels*	*Walk*	*Car*	*Bus*	*2-wheels*	*Walk*
Area1	0,340	0,013	0,007	0,844	0,110	0,004	0,001	0,489	0,759	0,162	0,040	1,310
Area2	1,763	0,079	0,000	0,094	0,689	0,038	0,000	0,034	2,093	0,263	0,000	0,280
Area3	0,047	0,000	0,000	0,062	0,016	0,000	0,000	0,029	0,045	0,000	0,000	0,089
Area4	0,051	0,005	0,000	0,215	0,034	0,001	0,000	0,194	0,226	0,072	0,000	0,551
Area5	0,230	0,027	0,003	0,036	0,069	0,003	0,000	0,013	0,514	0,181	0,041	0,196
Area6	1,050	0,106	0,002	0,467	0,421	0,052	0,001	0,208	1,056	0,346	0,131	1,093
Area7	0,031	0,000	0,000	0,220	0,013	0,000	0,000	0,162	0,121	0,000	0,000	0,393
Area8	0,573	0,025	0,002	0,035	0,257	0,023	0,001	0,015	1,438	0,252	0,009	0,018
Area9	0,548	0,034	0,002	0,116	0,211	0,006	0,000	0,044	1,375	0,199	0,165	0,293
Area10	0,797	0,037	0,000	0,085	0,311	0,006	0,000	0,069	1,867	0,261	0,000	0,129
Area11	0,115	0,049	0,000	0,185	0,119	0,037	0,000	0,173	0,195	0,138	0,000	0,176
Area12	0,022	0,000	0,000	0,001	0,005	0,000	0,000	0,004	0,112	0,000	0,000	0,005
Area13	0,639	0,026	0,000	0,060	0,262	0,009	0,000	0,057	1,486	0,135	0,000	0,146
Area14	0,679	0,239	0,000	0,841	0,332	0,131	0,000	0,648	0,657	0,833	0,000	1,501
Area15	0,971	0,000	0,001	0,632	0,398	0,001	0,004	0,283	1,222	0,089	0,166	0,791
Area16	0,572	0,064	0,002	1,662	0,328	0,053	0,000	0,872	0,516	0,282	0,012	0,825
Area17	0,333	0,009	0,001	0,048	0,114	0,000	0,000	0,025	0,862	0,047	0,019	0,113
Area18	0,526	0,026	0,000	0,459	0,192	0,018	0,000	0,196	0,829	0,127	0,000	0,575
Area19	0,868	0,075	0,000	1,386	0,312	0,028	0,000	0,513	1,118	0,406	0,000	1,638
Area20	2,587	0,120	0,007	0,115	1,132	0,048	0,001	0,068	2,804	0,522	0,125	0,317
Area21	0,388	0,048	0,000	0,116	0,136	0,005	0,000	0,049	1,129	0,300	0,000	0,452
Area22	0,057	0,000	0,000	0,141	0,014	0,000	0,000	0,052	0,224	0,000	0,000	0,292
Area23	0,357	0,000	0,000	0,097	0,119	0,000	0,000	0,028	0,840	0,000	0,000	0,145
Area24	0,270	0,031	0,000	0,939	0,080	0,013	0,000	0,307	0,248	0,156	0,000	1,051
Area25	0,006	0,003	0,000	0,051	0,002	0,001	0,000	0,019	0,012	0,041	0,000	0,079
Area26	0,333	0,017	0,001	0,043	0,102	0,002	0,000	0,014	0,784	0,086	0,055	0,070
Area27	0,173	0,000	0,000	0,000	0,045	0,000	0,000	0,000	0,366	0,000	0,000	0,000
Area28	0,133	0,000	0,000	0,485	0,036	0,000	0,000	0,280	0,108	0,000	0,000	0,280
Area29	0,527	0,089	0,000	0,211	0,188	0,030	0,000	0,113	1,013	0,924	0,000	0,702
Area30	0,212	0,000	0,000	0,327	0,094	0,000	0,000	0,255	0,452	0,000	0,000	0,599
Area31	0,344	0,000	0,000	0,752	0,126	0,000	0,000	0,348	0,440	0,000	0,000	0,844
Area32	0,044	0,050	0,001	0,260	0,011	0,016	0,001	0,080	0,150	0,323	0,115	0,522
Area33	0,696	0,075	0,012	0,121	0,299	0,042	0,002	0,087	0,633	0,284	0,134	0,279
Area34	1,456	0,498	0,006	1,176	0,765	0,282	0,002	0,611	1,634	1,206	0,168	1,782
Area35	3,456	0,856	0,016	8,100	2,241	2,313	0,015	7,362	0,970	1,862	0,175	2,845
Area36	4,564	3,227	0,107	3,106	13,709	15,941	0,277	9,967	3,088	4,917	0,914	2,910
Area37	0,368	0,000	0,022	1,206	0,221	0,000	0,008	1,217	0,235	0,000	0,018	0,160
Area38	2,932	0,014	0,025	1,651	1,491	0,005	0,012	1,361	2,488	0,118	0,202	0,643
Area39	0,123	0,000	0,000	0,008	0,065	0,000	0,000	0,008	0,166	0,000	0,000	0,029
Area40	0,108	0,008	0,000	0,330	0,051	0,000	0,000	0,187	0,204	0,047	0,000	0,157
Area41	0,514	0,000	0,000	0,087	0,244	0,000	0,000	0,050	0,385	0,000	0,000	0,050
Area42	0,234	0,000	0,000	0,278	0,116	0,000	0,000	0,147	0,472	0,000	0,000	0,134
Area43	7,930	0,015	0,009	0,332	6,503	0,008	0,004	0,608	7,531	0,034	0,063	0,093
Area44	3,407	0,000	0,000	0,000	1,433	0,000	0,000	0,000	1,531	0,000	0,000	0,000
Area45	0,124	0,000	0,000	0,000	0,056	0,000	0,000	0,000	0,098	0,000	0,000	0,000
Area46	0,480	0,003	0,000	2,599	0,195	0,000	0,000	2,237	0,716	0,068	0,000	0,445
Area47	6,201	0,016	0,011	2,750	4,394	0,026	0,005	2,714	5,588	0,075	0,055	0,986
Area48	1,147	0,000	0,007	0,275	0,791	0,000	0,002	0,502	0,612	0,000	0,033	0,200
Area49	8,399	0,000	0,007	1,078	6,708	0,000	0,006	1,057	3,971	0,000	0,022	0,179
Area50	0,599	0,000	0,000	1,460	0,343	0,000	0,000	0,858	0,559	0,000	0,077	0,202
Sum :	58,323	5,884	0,252	35,542	45,901	19,142	0,341	34,615	55,939	14,757	2,736	26,568

Leisure purpose												
	NL.MNL Model				*MNL Model*				*Data*			
Area	*Car*	*Bus*	*2-wheels*	*Walk*	*Car*	*Bus*	*2-wheels*	*Walk*	*Car*	*Bus*	*2-wheels*	*Walk*
Area1	1,100	0,033	0,009	0,332	0,162	0,002	0,002	0,172	2,395	0,143	0,078	0,882
Area2	0,325	0,023	0,015	0,177	0,069	0,000	0,003	0,027	0,656	0,082	0,126	0,521
Area3	0,060	0,015	0,032	0,036	0,007	0,000	0,003	0,016	0,141	0,065	0,264	0,093
Area4	0,186	0,000	0,004	0,062	0,029	0,000	0,000	0,028	0,421	0,000	0,033	0,165
Area5	0,396	0,024	0,000	0,075	0,073	0,001	0,000	0,015	0,795	0,080	0,000	0,218
Area6	2,444	0,148	0,012	0,496	0,357	0,010	0,000	0,055	3,103	0,351	0,086	1,035
Area7	0,198	0,008	0,021	0,086	0,040	0,000	0,001	0,003	0,422	0,042	0,194	0,244
Area8	0,318	0,008	0,001	0,014	0,061	0,000	0,000	0,003	0,748	0,032	0,009	0,032
Area9	1,415	0,082	0,000	0,277	0,240	0,002	0,000	0,058	1,866	0,262	0,000	0,557
Area10	0,678	0,060	0,016	0,021	0,103	0,002	0,000	0,023	1,543	0,259	0,152	0,056
Area11	0,175	0,000	0,001	0,032	0,052	0,000	0,000	0,034	0,349	0,000	0,019	0,079
Area12	0,226	0,000	0,007	0,228	0,056	0,000	0,000	0,202	0,508	0,000	0,094	0,602
Area13	0,566	0,153	0,005	0,081	0,083	0,010	0,000	0,097	0,770	0,415	0,030	0,119
Area14	0,473	0,040	0,015	0,143	0,202	0,006	0,000	0,089	0,907	0,118	0,105	0,359
Area15	0,371	0,000	0,008	0,055	0,061	0,000	0,000	0,039	0,871	0,000	0,071	0,114
Area16	0,851	0,011	0,000	0,512	0,217	0,001	0,000	0,360	1,639	0,034	0,000	1,231
Area17	0,382	0,001	0,000	0,016	0,058	0,000	0,000	0,001	0,913	0,006	0,000	0,057
Area18	0,255	0,027	0,004	0,110	0,048	0,001	0,001	0,014	0,490	0,097	0,037	0,304
Area19	0,624	0,060	0,014	0,229	0,129	0,002	0,001	0,095	1,250	0,200	0,125	0,616
Area20	0,301	0,029	0,005	0,000	0,043	0,001	0,000	0,000	0,724	0,125	0,045	0,000
Area21	0,403	0,025	0,000	0,122	0,062	0,001	0,000	0,031	0,818	0,084	0,000	0,284
Area22	0,188	0,000	0,004	0,021	0,029	0,000	0,000	0,042	0,423	0,000	0,032	0,051
Area23	0,059	0,000	0,001	0,059	0,009	0,000	0,000	0,008	0,109	0,000	0,011	0,175
Area24	0,138	0,116	0,000	0,512	0,025	0,009	0,000	0,159	0,297	0,472	0,000	1,394
Area25	0,238	0,012	0,005	0,096	0,039	0,001	0,000	0,029	0,489	0,081	0,039	0,296
Area26	1,011	0,037	0,008	0,087	0,149	0,001	0,000	0,007	2,251	0,147	0,079	0,291
Area27	0,486	0,008	0,008	0,000	0,062	0,000	0,000	0,000	1,053	0,049	0,063	0,000
Area28	0,032	0,000	0,000	0,019	0,003	0,000	0,000	0,017	0,068	0,000	0,000	0,043
Area29	0,668	0,076	0,011	0,231	0,111	0,006	0,000	0,046	1,388	0,212	0,140	0,616
Area30	0,201	0,040	0,028	0,187	0,042	0,001	0,002	0,082	0,381	0,140	0,198	0,467
Area31	0,290	0,011	0,001	0,614	0,055	0,001	0,000	0,331	0,484	0,043	0,011	1,321
Area32	0,510	0,075	0,004	0,271	0,045	0,004	0,000	0,033	0,967	0,204	0,028	0,720
Area33	1,169	0,041	0,010	0,246	0,178	0,002	0,000	0,037	1,053	0,125	0,080	0,420
Area34	4,477	0,480	0,018	1,518	0,316	0,032	0,003	0,176	2,675	0,744	0,123	1,711
Area35	1,893	0,214	0,000	0,349	0,194	0,016	0,000	0,069	0,829	0,293	0,000	0,326
Area36	21,315	9,280	0,052	21,720	28,224	17,106	0,275	42,772	3,930	5,748	0,431	8,815
Area37	0,224	0,000	0,023	0,029	0,071	0,000	0,022	0,087	0,581	0,000	0,124	0,045
Area38	1,214	0,073	0,006	0,154	0,177	0,002	0,001	0,095	2,247	0,356	0,049	0,260
Area39	0,139	0,000	0,004	0,089	0,026	0,000	0,001	0,023	0,313	0,000	0,019	0,188
Area40	0,480	0,000	0,004	0,090	0,060	0,000	0,000	0,114	1,184	0,000	0,030	0,161
Area41	0,662	0,000	0,000	0,054	0,112	0,000	0,000	0,046	1,594	0,000	0,000	0,114
Area42	0,493	0,012	0,004	0,111	0,148	0,000	0,002	0,105	1,100	0,107	0,021	0,246
Area43	1,697	0,000	0,059	0,140	0,178	0,000	0,004	0,096	2,423	0,000	0,595	0,184
Area44	0,370	0,000	0,019	0,062	0,098	0,000	0,000	0,117	0,692	0,000	0,134	0,113
Area45	0,190	0,000	0,000	0,000	0,054	0,000	0,000	0,000	0,398	0,000	0,000	0,000
Area46	4,301	0,000	0,048	0,942	0,481	0,000	0,028	1,795	3,513	0,000	0,393	0,562
Area47	0,362	0,005	0,028	0,493	0,070	0,002	0,005	0,480	0,769	0,031	0,178	0,763
Area48	0,476	0,000	0,015	0,065	0,261	0,000	0,003	0,119	0,782	0,000	0,112	0,116
Area49	0,783	0,007	0,010	0,504	0,112	0,000	0,001	0,220	1,481	0,065	0,063	0,970
Area50	0,369	0,000	0,045	0,231	0,092	0,000	0,010	0,363	0,953	0,000	0,261	0,416
Sum :	56,184	11,235	0,584	31,997	33,575	17,223	0,372	48,830	55,754	11,212	4,683	28,351

All purposes												
	NL.MNL Model				MNL Model				Data			
Area	Car	Bus	2-wheels	Walk	Car	Bus	2-wheels	Walk	Car	Bus	2-wheels	Walk
Area1	0,464	0,009	0,003	0,710	0,304	0,003	0,002	0,261	1,086	0,103	0,057	0,753
Area2	2,809	0,565	0,058	0,883	0,825	0,100	0,014	0,216	2,039	0,490	0,259	0,791
Area3	0,266	0,112	0,049	0,842	0,318	0,011	0,005	0,160	0,567	0,198	0,176	0,425
Area4	0,121	0,006	0,007	0,141	0,154	0,000	0,001	0,064	0,390	0,041	0,089	0,291
Area5	0,124	0,009	0,001	0,032	0,304	0,001	0,000	0,011	0,561	0,056	0,008	0,119
Area6	2,769	2,704	0,089	1,310	3,463	7,414	0,228	2,012	2,550	1,412	0,360	1,414
Area7	0,494	0,003	0,003	0,402	0,113	0,000	0,000	0,113	0,408	0,033	0,042	0,282
Area8	1,115	0,018	0,004	0,025	0,325	0,009	0,001	0,006	1,378	0,152	0,081	0,020
Area9	4,203	1,904	0,154	2,601	1,425	0,567	0,076	0,875	4,044	1,539	0,767	1,140
Area10	1,183	0,549	0,069	4,006	0,999	0,707	0,155	3,374	1,842	0,609	0,257	0,535
Area11	0,355	0,126	0,000	0,771	0,201	0,086	0,000	0,163	0,313	0,212	0,004	0,381
Area12	0,076	0,000	0,001	0,742	0,068	0,000	0,000	0,207	0,240	0,000	0,020	0,361
Area13	0,652	1,719	0,010	0,113	0,351	0,136	0,003	0,074	1,048	0,570	0,067	0,132
Area14	0,614	0,087	0,012	1,074	0,421	0,040	0,008	0,686	0,737	0,326	0,079	1,451
Area15	0,331	0,004	0,001	0,140	0,265	0,004	0,001	0,097	0,764	0,062	0,048	0,219
Area16	0,394	0,036	0,003	1,047	0,380	0,017	0,001	0,926	0,813	0,131	0,070	1,231
Area17	0,380	0,014	0,001	0,067	0,182	0,007	0,001	0,018	0,800	0,176	0,018	0,080
Area18	0,363	0,018	0,003	0,180	0,568	0,005	0,007	0,088	0,793	0,062	0,052	0,328
Area19	0,597	0,139	0,002	0,898	1,109	0,028	0,000	0,431	1,492	0,434	0,035	1,037
Area20	1,249	0,063	0,002	0,027	0,425	0,013	0,000	0,016	1,308	0,185	0,034	0,072
Area21	0,194	0,015	0,001	0,036	0,411	0,002	0,004	0,021	0,744	0,096	0,016	0,151
Area22	0,315	0,005	0,007	0,389	0,408	0,005	0,004	0,128	0,836	0,061	0,131	0,127
Area23	0,088	0,003	0,012	0,121	0,272	0,000	0,000	0,065	0,312	0,029	0,093	0,191
Area24	0,198	0,050	0,000	0,585	0,136	0,011	0,000	0,238	0,314	0,258	0,002	0,767
Area25	0,052	0,013	0,005	0,195	0,032	0,001	0,002	0,105	0,199	0,076	0,074	0,251
Area26	1,082	0,047	0,004	0,029	0,563	0,015	0,001	0,011	1,787	0,298	0,119	0,097
Area27	0,279	0,019	0,002	0,050	0,123	0,002	0,000	0,009	0,810	0,155	0,031	0,209
Area28	0,057	0,000	0,000	0,180	0,054	0,000	0,000	0,199	0,077	0,003	0,000	0,120
Area29	0,660	0,152	0,009	0,142	0,283	0,025	0,001	0,074	1,229	0,454	0,104	0,393
Area30	0,339	0,046	0,004	0,411	0,294	0,007	0,001	0,287	0,602	0,146	0,063	0,578
Area31	0,333	0,010	0,000	0,655	0,233	0,001	0,000	0,397	0,525	0,036	0,012	0,765
Area32	0,138	0,097	0,007	0,236	0,089	0,013	0,002	0,069	0,536	0,364	0,130	0,510
Area33	0,842	0,058	0,006	0,089	0,220	0,018	0,001	0,042	0,893	0,261	0,073	0,246
Area34	1,329	1,135	0,097	1,517	0,583	1,159	0,205	1,673	1,699	1,381	0,531	1,498
Area35	3,354	1,984	0,023	6,612	1,175	1,199	0,015	3,256	1,618	0,988	0,241	1,510
Area36	4,025	1,944	0,049	3,536	12,090	9,005	0,153	15,825	2,515	3,033	0,435	3,328
Area37	0,337	0,000	0,130	2,263	0,621	0,000	0,049	1,795	0,487	0,000	0,168	0,394
Area38	1,806	0,092	0,031	0,571	0,702	0,012	0,007	0,379	2,156	0,419	0,150	0,323
Area39	0,145	0,110	0,004	0,078	0,200	0,006	0,000	0,028	0,294	0,087	0,015	0,164
Area40	0,092	0,002	0,000	0,073	0,101	0,000	0,000	0,078	0,365	0,009	0,006	0,066
Area41	0,316	0,000	0,000	0,060	0,448	0,000	0,000	0,045	0,694	0,000	0,002	0,055
Area42	0,309	0,001	0,003	0,130	0,296	0,000	0,004	0,117	0,645	0,023	0,014	0,117
Area43	2,662	0,089	0,062	1,180	1,748	0,008	0,009	0,327	3,172	0,084	0,252	0,271
Area44	0,883	0,198	0,024	0,850	0,439	0,011	0,003	0,219	0,735	0,114	0,136	0,154
Area45	0,139	0,000	0,000	0,001	0,421	0,000	0,000	0,005	0,418	0,000	0,000	0,002
Area46	1,087	0,001	0,006	1,009	0,611	0,000	0,009	1,657	1,448	0,013	0,092	0,299
Area47	1,718	0,004	0,058	0,838	1,319	0,006	0,017	0,867	1,872	0,021	0,184	0,480
Area48	0,500	0,000	0,003	0,507	0,784	0,000	0,002	0,574	0,521	0,003	0,031	0,261
Area49	2,483	0,001	0,018	0,626	1,758	0,000	0,005	0,370	2,473	0,016	0,077	0,417
Area50	0,927	0,000	0,005	0,568	0,474	0,000	0,003	0,604	0,824	0,000	0,096	0,196
Sum :	45,246	14,159	1,044	39,551	39,083	20,652	1,002	39,262	53,974	15,222	5,804	25,001

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