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Research Article

Residential Location, Mobility, and Travel Time: A Pilot Study in a Small-Size Italian Metropolitan Area

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This research concerns the topic of Land Use and Transport Interaction (LUTI) models. In particular, the patterns between residential households' location and mobility choices are analyzed and simulated. The attributes that influence household residential location choices belong to four categories: socioeconomic and mobility attributes of households and/or of their components; land use; real-estate market; transport system. The paper presents the results of a pilot study on households' location and mobility patterns in the metropolitan area of Reggio Calabria (Southern Italy). The pilot study is divided into two stages. In the first stage, a survey allowed to collect information and identify existing patterns about residential and mobility choices of a sample of households. In the second stage, a residential location model is proposed and some preliminary calibrations are presented in a prototypal way. The pilot study could be extended and improved in terms of spatial extension and sample dimension in order to allow a complete specification-calibration-validation process of the model. The model development can support the land use-transport planning process in the Metropolitan City of Reggio Calabria.

1. Introduction

Land Use and Transport Interaction (LUTI) models simulate the two-way relationship between land use and transport systems in urban areas. The LU-to-T relationship influences transport, in the component of travel demand. On the other side, the T-to-LU relationship plays a prominent role in the spatial organization of the area, influencing activity location and land prices [1–4].

This paper investigates some elements concerning the T-to-LU relationship. In particular, it focuses on causal mechanism that links the transport network (supply) performances and costs, such as travel times [5, 6], to the residential location and mobility choices (e.g., destination, mode). This mechanism, which implies both long term decisions (i.e., change of residential location) and short-term decisions (e.g., modal shift), was studied in the literature with both empirical and modelling approaches (see, among others, [7–11]).

As far as the modelling approach is concerned, the residential location models present in the literature can be grouped in two broad classes. The former is named gravitational-entropic, and it is based on gravitational theory and/or on entropy maximization principle [12, 13]. The latter is named discrete choice, and it has random utility as theoretical background. In the sphere of discrete choice models [14–16], the above described casual mechanism could be explained and simulated in terms of what extent travel cost (e.g., time), and other characteristics (attributes), maximizes the individual (dis)utility of a citizen (or other decision-maker unit) associated with residential location choices.

The paper presents the results of a pilot study on households' location and mobility patterns in the metropolitan area of Reggio Calabria (Southern Italy). The pilot study is finalized to address a number of issues [17] such as the target population, the structuring of the questionnaire and the survey execution, the mobility and residential location patterns, and the attributes that affect the residential location choice process.

The pilot study is divided into two stages.

(i) The first stage concerns a survey, which has been designed and executed in order to collect information about residential and mobility choices of a sample of households living in the Italian Metropolitan City of Reggio Calabria (Italy). In 2014, a national law formally defined and introduced the metropolitan cities in Italy, which imposed the building of new institutional and functional assets to these new administrative entities [18, 19].

(ii) The second stage concerns the specification and calibration of household residential choice models in a prototypal way, with the objective of investigating in which measure the residential location choices of households are affected by network travel times.

The results of the pilot study concern the following:

(i) empirical evidences of households' residential location and mobility patterns;

(ii) specifications and calibrations of a prototypal discrete choice model of residential location choices.

In the above context, the research concerns the identification of the factors/drivers that could influence household residential (re)locations inside a small-size metropolitan area, as the Metropolitan City of Reggio Calabria, in the medium-long term. These elements could support the land use-transport planning process, in behalf of the institutional and functional building process of the Metropolitan City of Reggio Calabria. The development of the complete model is out of the scope of this research.

The paper, after this introduction, is structured into four sections. Section 2 presents a state of the art of discrete choice models on residential location. Section 3 reports the theoretical background of the specified residential model and the main elements of the pilot study. Section 4 describes some preliminary results of a specification-calibration-validation process of a prototypal residential model. The research perspectives are reported in the last section.

2. Residential Location: A Literature Review on Discrete Choice Models

The scientific literature on residential location models can be grouped in two broad classes. The first class is composed of gravitational-entropic models, based on gravitational theory and/or on entropy maximization principle (e.g., [12, 13]). To the second class belong the discrete choice models, which refer to random utility theory [14–16].

Without being exhaustive, the attention is focused on research papers relating on discrete choice models of residential location choice of households inside urban areas. They may be classified according to the following criteria:

(1) Theoretical background;

(2) Level of aggregation of decision-maker: aggregate/disaggregate;

(3) Typology of model attributes: 3(a) socioeconomic, 3(b) land use, 3(c) real estate market, and 3(d) transport.

As far as the theoretical background is concerned, it is worth noting that the location model is always based on the simulation of the agents' choices (behaviour). Therefore, models can belong, or not, to the class of random utility theory with discrete choice model. The random utility theory with discrete choice model was initially proposed by McFadden [14] who proposed a discrete choice model to estimate the relative influence of location-specific attributes on residential location choices. Further studies were proposed by Anas and Duann [20] which were part of more complex system of models to simulate the whole LUTI process. Later, Frenkel et al. [21] developed a logit model that has been used to simulate the residential location choice of a category of inhabitants of a metropolitan area: the knowledge-workers. Some modelling approaches estimate effects of spatial distribution of urban freight facilities [22], also analyzing retail-store movements in relation to shopping trip behaviours [23]. The logit model is the most widespread one in literature. A logit model is specified in [24] to investigate the relationship between residential location choices, gender, and commuting trips in the Tel Aviv metropolitan area. Lee and Waddell [25] presented a nested logit model to investigate the patterns between residential mobility and location choice in Seattle (USA). Out of models belonging to the random utility theory, Manaugh et al. [26] presented a logistic regression analysis for estimating regional home-work location according to trip length in Montréal (Canada). In their study, sociodemographic variables at the individual and household level do not have enough explanation capacity of trip length variability. de Palma et al. [27] carried out a semi-hedonic regression of the selling prices of new and existing detached houses and apartments, based on a wide number of attributes regarding the real estate market of the Ile-de-France region.

According to the level of aggregation of decision-maker, the difference is between considering the main agent who makes the decision (which is representative of the whole household) and whether the location choice is modelled as the result of an interaction among the members of the household (see [28]). Aggregate models use the whole household as in [29], where the residential location choices of households are estimated, by analyzing a sample of households living in Texas. Disaggregated models consider each single member, as in [30] that investigated the residential location choice process in a transitional housing market, as the one of Beijing (China). Marcucci et al. [31] worked on residential location preferences and relative decision power in three-member households of the city of Rome and of the Friuli-Venezia-Giulia region (Italy).

According to the typology of model attributes, the following four classes may be considered. Concerning socioeconomic attributes (3(a)), Prashker et al. [24] considered the age and sex as relevant attributes in their study, which reveals significant differences of behaviour between men and women. The work of Wu et al. [30] includes the level of education, income, and number of children as relevant variables in residential location choices. A common attribute to describe the land use characteristics (3(b)) is related to population density. Bhat and Guo [29] introduced it to capture the clustering effect of households. The presence of green areas [30] and the density of underground stations [32] are also considered as factors that affect the household location choices. The attributes of the real estate market (3(c)) are generally related to the floor-space stock and the selling price. Balbontin et al. [32] focused on the importance of dwelling and neighborhood attributes in residential location modelling in the center of Santiago de Chile. Ibeas et al. [33] studied interactions between transport and real-estate values in urban systems; they presented different kinds of hedonic models to estimate house price variations in metropolitan areas in relation to accessibility conditions. Some authors studied spatial effects related to interactions between trip generation, accessibility, and real estate values [34, 35]. As far as transport attributes are concerned (3(d)), the distance from the CBD is frequently considered. Prashker et al. [24] considered travel distance and travel time by car and bus, while Wu et al. [30] considered average commuting time. Manaugh et al. [26] considered commuting distance from home to work as attribute that qualifies the transport system.

In relation to the literature review, the research contribution of the paper concerns the analysis of residential location process of households in the attempt to identify the attributes/factors that drive their choices, with a specific focus on the travel time attribute (3(d)), attribute related to transport system). The case study is a small-size metropolitan area, the Metropolitan City of Reggio Calabria (Southern Italy). The prototypal model presented considers the demand side of the residential location process, based on a behavioural approach by maximizing the utilities of households in choosing their residential location zone (random utility theory with discrete choice model). The input variables of the model are connected to travel time on the network from the residential origin to the job/school destinations, and the output variable is the probability of the household to choose a zone as residential location.

3. Residential Location: A Pilot Study on a Small-Size Italian Metropolitan Area

The pilot study aimed to address a number of issues, including the target population, the structuring of the questionnaire and the survey execution, the mobility and residential location patterns, and the attributes that affect the residential location choice process.

The target population (households) was selected from a study area inside the Metropolitan City of Reggio Calabria (Figure 1). The study area includes the Municipality of Reggio Calabria and a set of municipalities lying along the Thyrrenian and part of Ionian coast (depicted in light grey in Figure 1). The dimensions of the study area are about 560 km^2 with a population of about 275,000 inhabitants and 11 municipalities. The largest municipality is Reggio Calabria, which occupies an area of about 236 km^2 with about 182,551 of inhabitants. The study area represents the most populated portion of the Metropolitan City of Reggio Calabria, as it has 49% of the whole population, with an average population density of 491 inh./km^2 (against 108 inh./km^2 in the remaining part).

The study area was discretized into 14 zones. The Municipality of Reggio Calabria was subdivided into four zones called Center, North, South, and Hill.

The study area was also aggregated into three territorial areas:

(i) Tyrrhenian, including the zones of Gioia Tauro (1), Palmi (2), Seminara (3), Bagnara Calabra (4), Scilla (5), and Villa San Giovanni (6);

(ii) Reggio Calabria, including the Municipality of Reggio Calabria, subdivided in four zones: Center (8), North (7), South (9), and Hill (10);

(iii) Ionian, including the zones of Motta San Giovanni-Lazzaro (11), Montebello Ionico (12), Melito Porto Salvo (13), and Roghudi (14).

As far as the transport infrastructures and services are concerned, the Tyrrhenian area has more infrastructural facilities (highway, double-line railway, and SS18 national road) and transport services than Ionian area (national road and single-line railway) in terms of quantity and quality. Transport infrastructures and services in the Tyrrhenian area have a European relevance and they represent principal connections to North Italy.

The questionnaire is structured into two sections. The first section concerns information about the household unit, as a whole. The second section is dedicated to individual household component.

The survey (first stage of the pilot study) was developed in two steps:

(1) A preliminary version of a questionnaire is submitted to a small group of households, in order to validate it;

(2) An advanced version of the questionnaire is submitted to a larger group.

The survey was proposed to respondents during two weeks, by interviewing them at home or via e-mail. The number of interviewed households was 51, for 182 components. Some papers in literature (see [17]) identify the sufficient sample size to execute a correct pilot study. Isaac and Michael [36] say that sample sizes "between 10 and 30 have some advantages, such as simplicity, easy calculation,

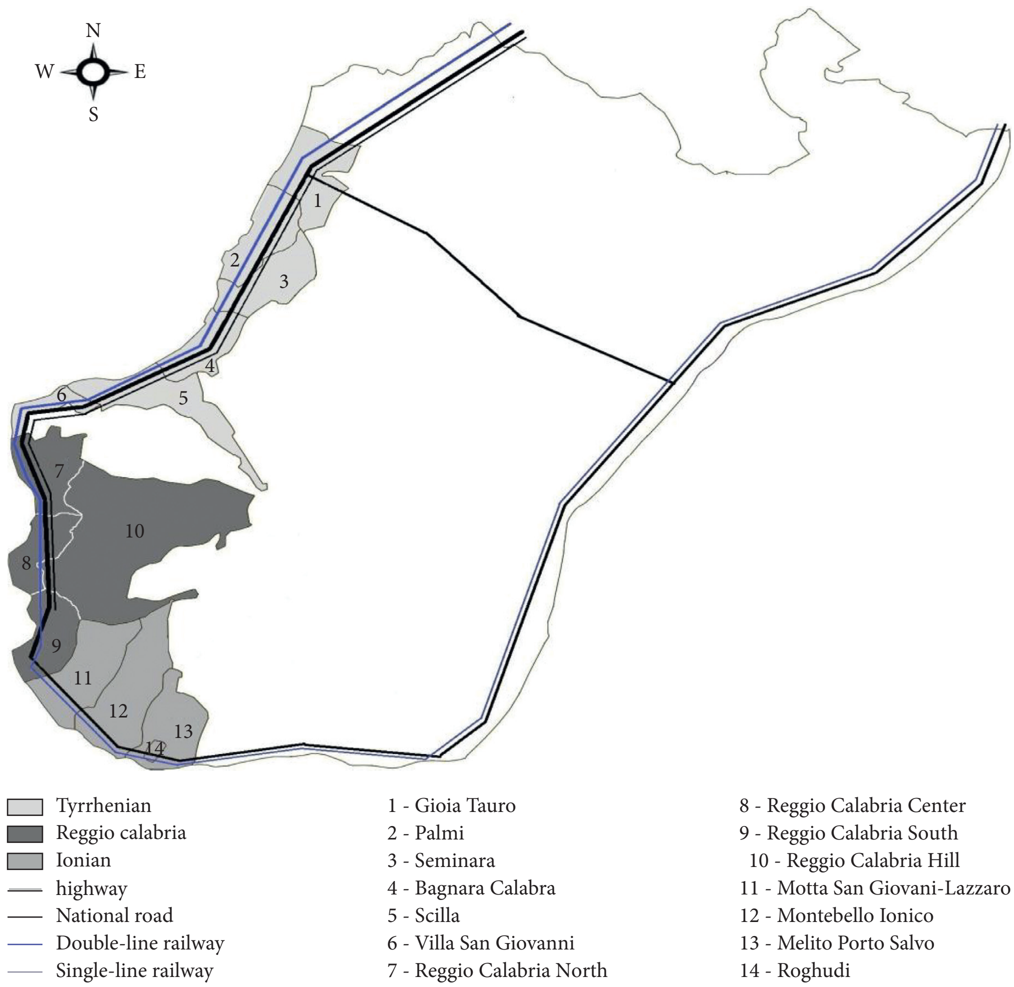


Figure 1: Study area, zoning, and itineraries of main transport facilities.

and the ability to test hypotheses." Hertzog [37] makes different recommendations for sample size ranging from 10–15 in feasibility studies to 30 to 40 for pilot studies. In the opinion of the authors, the size of the sample is sufficient to execute a correct pilot study whose results are presented in the following.

The next part of the section concerns the mobility and location patterns and the attributes that affect the residential location choice process.

It is structured as follows. Section 3.1 concerns the specification of a behavioural discrete choice model of residential location. Section 3.2 focuses on the characteristics of the households of the survey sample. Section 3.3 presents the analysis and discussion of the attributes obtained from the survey.

3.1. Theoretical Background. The proposed model is a behavioural discrete choice model of residential location, assuming the household as decision-maker.

The residential location choice relates to the demand side of residential location process, which can be as the result of an "equilibrium" of the interaction between the demand of residence locations and the supply of land [3].

According to the random utility theory [14–16], a household i chooses a zone, among the set of available zones Q, $o \in Q$, to locate the residence by maximizing the associated perceived utility, U^i_o.

As the utility, U^i_o, is a random variable, it is not possible to establish with certainty which zone will be chosen by the household for living/residing, while it is possible to express the probability that the zone o, belonging to Q, will be chosen from household as the probability that the perceived utility of zone o, U^i_o, is greater than the perceived utility of every other zone q, U^i_q:

$$p^i_{o\in Q} = \mathrm{Prob}\left(U^i_o > U^i_q\right), \quad \forall q \neq o, q \in Q, \tag{1}$$

where Q is the choice set or the set of available alternatives (zones) for the household.

Assuming that the perceived utility, U^i_o, is independently and identically distributed (i.i.d.) according to a Gumbel across the alternatives, equation (1) is specified with a multinomial logit. Further model specifications proposed recently, based on different distributions for the utility (i.e., Fuzzy or Quantum Utility models), for a different choice level could be tested [35].

The probability of choosing a zone o as residential zone for household i is

$$p^i_{o\in Q} = \frac{\exp\left(E\left[U^i_o\right]\right)}{\sum_{q\in Q}\exp\left(E\left[U^i_q\right]\right)}, \quad (2)$$

where o, zone; i, household; Q, total number of zones (available alternatives); and $E[U^i_o]$, expected value of perceived utility U^i_o.

The expected value of perceived utility is a linear combination of attributes and weights:

$$E\left[U^i_o\right] = \sum_k \beta_k x^i_{o,k}, \quad (3)$$

where $x^i_{o,k}$, value of the attribute k of the alternative (zone) o for the household i and β_k, weight associated with attribute k to be calibrated.

The attributes may belong to four categories: (a) socioeconomic attributes of household; (b) land use attributes; (c) real estate attributes of residential buildings; (d) transport system attributes.

3.2. Level of Aggregation of Decision-Maker. The survey was carried out in order to obtain some elements about the structure of the sample of households. The analysis of the interviews shows that the sample is mainly composed of households with four components. The age groups of 25–34 and 55–65 years are the most represented (Figures 2(a) and 2(b)).

3.3. Typology of Model Attributes

3.3.1. Relevant Attributes: Specification and Estimation. For what concerns the case study, the specification of attributes for each category is reported as follows:

(1) Socioeconomic and mobility attributes of household: professional/school status; origin-destination (OD) matrix of daily trips; and transport modes for home-work and home-school trips;
(2) Land-use: population, employees in industry sector, employees in retail sector, and employees in service sector;
(3) Real-estate market: average sale price per zone for residential buildings;
(4) Transport supply: density of bus stops per zone, density of rail stations per zone, and active accessibility of each zone.

The socioeconomic and mobility attributes were obtained by means of the survey, proposed to the sample of households living in the three defined territorial areas defined above (Figure 1).

The land-use data concern the population and employment census data, available on the website of the Italian National Institute of Statistics [39]. The number of employees per zone of the study area was subdivided considering the following sectors: industry, retail, and services.

The data of the real-estate market concern the average selling price per zone of residential buildings, which was obtained from the website of the Italian Real Estate Market Observatory (http://www.agenziaentrate.gov.it).

The data of the transport system concern the supply of public transport, in particular the number of bus stops per zone and the number of railway stations per zone. The number of stops and stations is obtained from the information available on websites of public transport companies of the municipalities of the study area. The travel time has been estimated considering the private car as transport mode, on an average working day from 11 : 00 am to 12 : 00 am. Some information about the quality of the transport infrastructure [40] could be considered in the future.

3.3.2. Relevant Attributes: Analysis and Discussion

(1) Socioeconomic and Mobility Attributes of Household. Respondents are categorized as employees in the public and private sectors, freelancers, housewives/husbands, or retired people. The number of the unemployed of the sample is small (Figure 3(a)). The respondents who are students are mainly undergraduates and high school students (Figure 3(b)).

The home-work and home-school OD matrix of the sample of households for an average working day is presented in Table 1. The trips inside each territorial area (elements of the diagonal) present the highest percentages, in particular the trips inside the Municipality of Reggio Calabria (35.2%). A percentage of respondents (16%) travels to destinations located outside the study area. The number of trips between the different territorial areas is lower and they mainly have the Municipality of Reggio Calabria as destination.

The majority of the sample does not travel every day for home-work purpose, while the other part of the sample performs at least one daily trip (Figure 4(a)). Respondents who do not travel daily for home-school purpose are the majority (Figure 4(b)). The private car is the preferred mode to travel for the sample of households, followed by pedestrian trips and trips by bus (Figure 5).

(2) Land-Use. Figures 6(a) and 6(b) show that the study area is characterized by the presence of a great pole, the central macro-zone of the Municipality of Reggio Calabria with more than 100,000 inhabitants (Figure 6(a)). The municipalities of Villa San Giovanni, Palmi, and Gioia Tauro (Tyrrhenian area) and the macro-zones of Reggio Calabria (North, South, and Hill) have more than 10,000 inhabitants. The central area of Reggio Calabria has more than 25,000 employees in the service sector, and the main part of

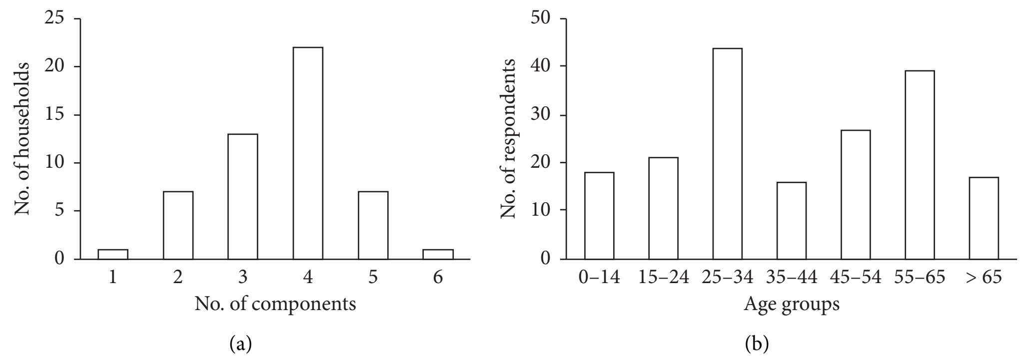


Figure 2: (a) Household number of components; (b) age groups.

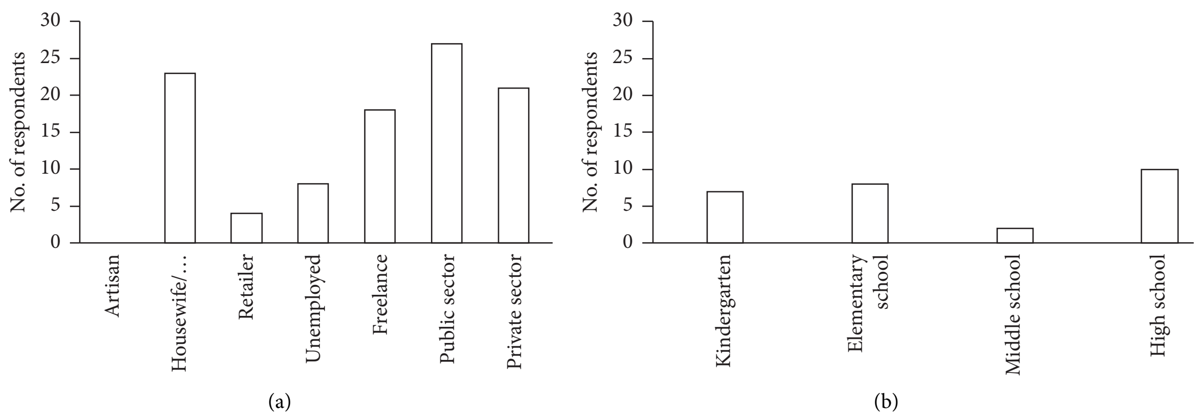


Figure 3: (a) Job status; (b) school status.

Table 1: Home-work and home-school OD matrix (%) of the sample.

	Reggio Cal. (%)	Thyrrenian (%)	Ionian (%)	Outside (%)	Total (%)
Reggio cal.	35.2	1.6	0.0	6.4	43.2
Thyrrenian	6.4	16.8	0.8	4.8	28.8
Ionian	4.8	0.8	17.6	4.8	28.0
Total	46.4	19.2	18.4	16.0	100.0

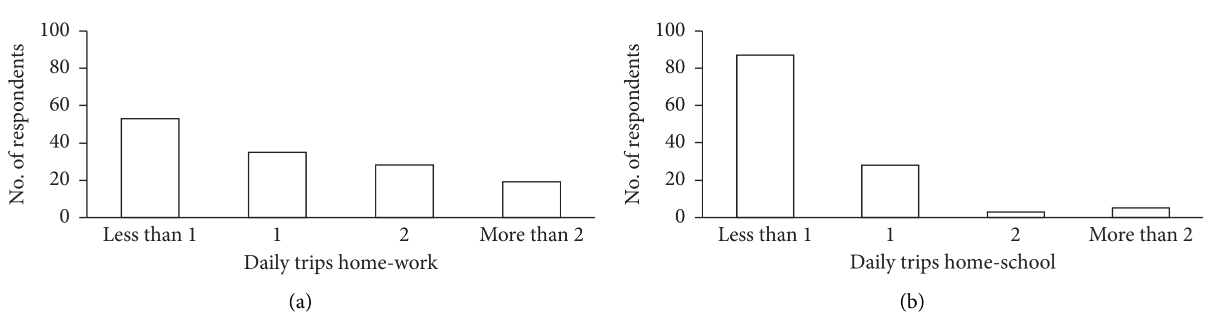


Figure 4: (a) Frequency of home-work trips; (b) frequency of home-school trips.

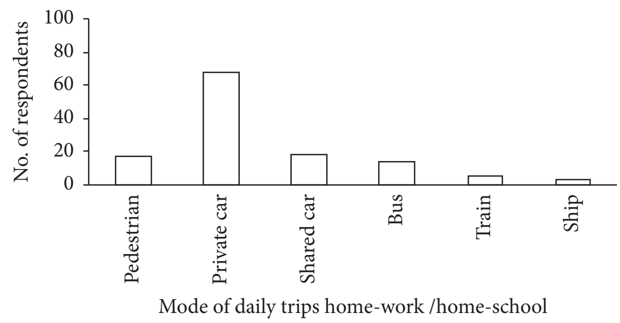


Figure 5: Modal split among existing transport modes.

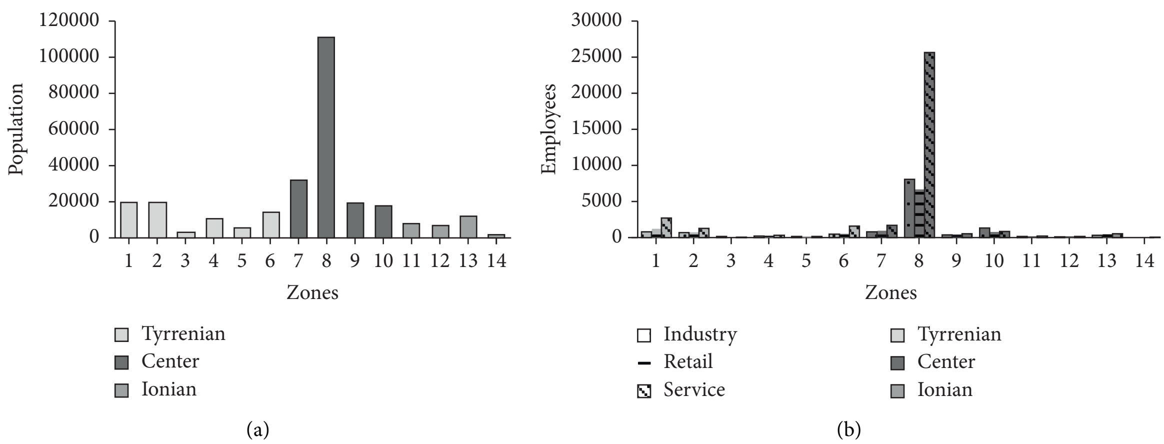


Figure 6: Distribution of (a) population and (b) industry, retail, and service employees.

employees in industry and retail sectors, if compared with the other territorial areas (Figure 6(b)).

(3) Real-Estate Market. The average selling price per zone of residential buildings is 700 €/m^2 with a minimum value of 500 €/m^2 in a zone of Hill macro-zone and a maximum value of 1,100 €/m^2 in the central area of the Municipality of Reggio Calabria. There are three zones where the selling price of residential buildings is more than the average value (Figure 7).

(4) Transport Supply. The presence of the pole inside the Metropolitan City of Reggio Calabria is in line with the high densities of bus stops and rail stations in that macro-zone. In the central area of Reggio Calabria, there are 5 bus stops/km^2 (Figure 8(a)) and 0.20 stations/km^2 (Figure 8(b)). One urban bus company operates inside the Municipality of Reggio Calabria providing transit services, while several bus companies offer suburban bus services in the Tyrrhenian and Ionian areas.

The active accessibility is estimated as the sum of travel times along the minimum path of the road transport network to reach all zones of the study area from a given zone. The value increases from central area to peripheral zones of the study area. The lowest values of accessibility (maximum values of travel times) are estimated for zones belonging to Ionian area (Figure 9).

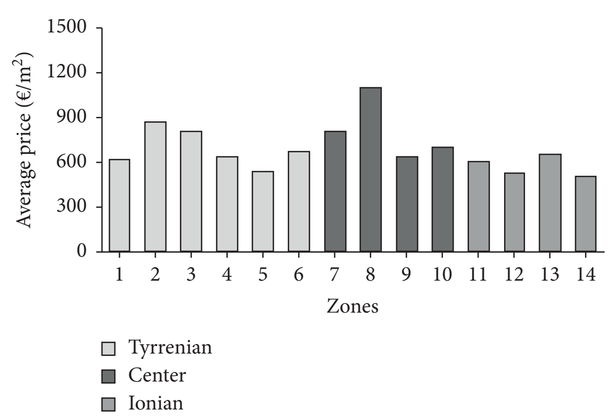
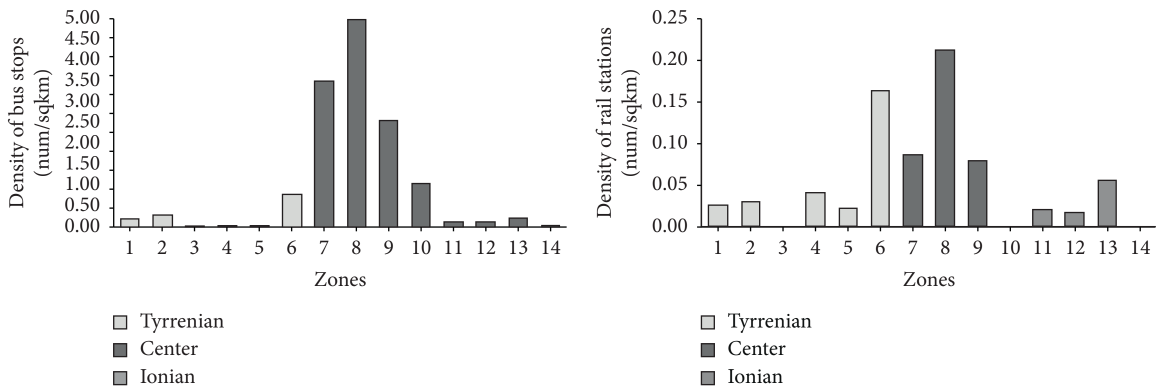


Figure 7: Average selling price per zone of residential buildings.

4. Residential Location: Model Calibration

The last part of the pilot study regards the calibration of a prototypal discrete choice model of residential location, in



(a) (b)

Figure 8: Density of (a) bus stops and (b) railway stations.

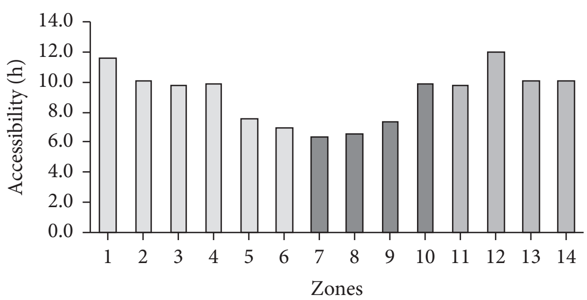


Figure 9: Active accessibility.

order to investigate in which measure the residential location choices of households are affected by travel times on the transport network.

Several calibration tests of equation (2) are performed by means of Maximum Likelihood (ML) method, considering different combinations of attributes belonging to the four defined categories.

According to the calibration results, the whole set of calibrated models has been classified into three classes:

(i) Models with incorrect sign and low statistical significance of parameters;

(ii) Models with correct sign and low statistical significance of parameters;

(iii) Models with correct sign and acceptable statistical significance.

The models belonging to classes (i) and (ii) are discarded and they are not further considered in the analysis. The models belonging to class (iii) present attributes related to the transport supply, in particular travel times on the road network (see Table 2).

The specification of the utilities of models (iii) is reported in the following.

The utility of model 1 is specified as the linear combination of parameters and attributes of travel time, t_HH_Comp, of the first four components of the household:

$$E\left[U_o^i\right] = \beta_{t\_HH\_\mathrm{Comp1}} \cdot t\_HH\_\mathrm{Comp1} + \beta_{t\_HH\_\mathrm{Comp2}} \cdot t\_HH\_\mathrm{Comp2} + \beta_{t\_HH\_\mathrm{Comp3}} \cdot t\_HH\_\mathrm{Comp3} + \beta_{t\_HH\_\mathrm{Comp4}} \cdot t\_HH\_\mathrm{Comp4}. \quad (4)$$

The utility of model 2 is calculated by means of equation (5) by considering a specific parameter for each of the main three territorial areas of the study area: Reggio Calabria, Tyrrhenian Area, and Ionian Area (see Figure 1):

$$E\left[U_o^i\right] = \begin{cases} \beta_{t\_\mathrm{center}} \cdot t\_\mathrm{center} & \text{if zone o} \in \text{Reggio Calabria,} \\ \beta_{\mathrm{t\_tyrrhenian}} \cdot t\_\mathrm{tyrrhenian} & \text{if zone o} \in \text{Tyrrhenian area,} \\ \beta_{t\_\mathrm{ionian}} \cdot t\_\mathrm{ionian} & \text{if zone o} \in \text{Ionian area.} \end{cases} \quad (5)$$

The utility of model 3 is specified by means of equation (6) introducing a dummy variable related to travel time threshold of 10 minutes from the city center:

$$E\left[U_o^i\right] = \beta_{t\_\mathrm{HH}} \cdot t\_\mathrm{HH} + \beta_{t<10\,\mathrm{min}} \cdot t < 10\,\mathrm{min}. \quad (6)$$

The calibrated parameters of models specified by means of equations (4)–(6) are reported in Table 3. Model of equation (4) takes into account each individual travel time for up-to-four-components household. The negative signs of the calibrated parameters are in line with the nature of the attribute: their values indicate that disutility increases if the household is formed by more than two components. Model of equation (5) considers travel times to reach the three macro-zones: Reggio Calabria, Tyrrhenian, and Ionian. The parameters indicate that the utility decreases more for the households living in macro-zone Tyrrhenian than the others. For what concerns model of equation (6), the parameter of travel time is negative (with a high t-student value), while the parameter of the dummy attribute is positive, indicating that the negative impact of travel time is mitigated for reduced values of travel time (less than 10 minutes). The low t-student value indicates low significance of the calibrated parameter.

The calibrated models are validated by means of test on the likelihood ratio and on the goodness of fit of the model,

Table 2: Definitions of attributes of the proposed location models.

Symbol	Definition
t_HH	Sum of travel times of home-work and home-school morning trips of all household members
t_HH_Comp1. . .4	Travel times of home-work and home-school morning trips for single household member (up to 4 members)
t_center	Travel times from center zone of Reggio Calabria to each zone (see Figure 1)
t_thyrrhenian	Travel times from Tyrrhenian zones to each zone (see Figure 1)
t_ionian	Travel times from Ionian zones to each zone (see Figure 1)
$t < 10$ min	Dummy attribute indicating if the zones are less than 10 minutes far from the city center

Table 3: Calibration results.

	Model		
	1	2	3
Attribute	β (t-stud)	β (t-stud)	β (t-stud)
t_HH_Comp1	−4.504 (−3.2)		
t_HH_Comp2	−4.080 (−2.4)		
t_HH_Comp3	−5.498 (−3.8)		
t_HH_Comp4	−6.596 (−3.2)		
t_center		−5.509 (−6.4)	
t_tyrrhenian		−5.256 (−6.6)	
t_ionian		−4.947 (−6.2)	
t_HH			−5.358 (−6.1)
$t < 10$ min			0.953 (1.2)

Table 4: Validation tests of the calibrated models.

Test	Model		
	1	2	3
L[0]	−134.59	−134.59	−134.59
L[β(ML)]	−73.04	−71.43	−72.27
Nβ	4	3	2
ρ^2	0.46	0.47	0.46
ρ^2_adj.	0.39	0.40	0.39

as statistic, ρ^2, and adjusted statistic, ρ^2_adj. The results of the tests are shown in Table 4. The null parameter of maximum likelihood function, L[0], has a constant value, while it assumes a decreasing value for the associated values of calibrated parameters, L[β(ML)]. Model 2 presents values of ρ^2 statistics equal to 0.47 and ρ^2_adj equal to 0.40, which are slightly higher than the corresponding values associated with models 1 and 3.

5. Conclusions and Research Perspectives

The objective of the research was to estimate households' location and mobility choices inside a small-size Italian metropolitan area. The research was divided into two stages. The first stage concerned a survey in order to collect information and identify residential and mobility patterns of a sample of households. The second stage regarded the specification and calibration of some prototypal discrete choice models.

At this stage of the research, the models with values of calibrated parameters having correct sign and acceptable statistical significance are the ones with attributes connected with travel time on the road network. The presence of a relative great attraction pole of mobility in the metropolitan area, represented by the Municipality of Reggio Calabria, has relevant influence in the residential location choice of households, as the t-student values of the attributes t_center, t_tyrrhenian, t_ionian of model 2 show. Moreover, these first results show the role of travel times in residential location choices. For instance, the higher parameter's value estimated for the variable t_ionian with respect to the other two variables (model 2) confirms the low level of infrastructural facilities of the Ionian area.

The result of this pilot study can be useful in order to support the land use-transport planning process in the Metropolitan City of Reggio Calabria. In particular, a further development of this study in terms of spatial extension and sample dimension could allow for estimating the effects on households' residential choices caused by investments on new road transport infrastructures (e.g., a new highway that connects Tyrrenian and Ionian areas bypassing the zone "center" of Reggio Calabria).

The following research perspectives are foreseen for the next future. The survey will be extended to households belonging to all municipalities of the metropolitan area of Reggio Calabria. The modelling framework will be extended and improved by means of a complete specification-calibration-validation process: new functional forms and utility specifications including socioeconomic, land use, and real estate market attributes in order to better capture the household location choice behaviour. The proposed model will be applied in order to support a strategic transport planning process [41]. The final aim is to support evaluation of effects of land use-transport scenarios on sustainability and equity [42, 43].

Data Availability

The underlying data used to support the results of the study are not freely available due to respondents' privacy.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] J. D. Herbert and B. H. Stevens, "A model for the distribution of residential activity in urban areas," *Journal of Regional Sciences*, vol. 2, no. 2, pp. 21–36, 1960.

[2] T. de la Barra, *Integrated Land Use and Transport Modelling. Decision Chains and Hierarchies*, Cambridge University Press, Cambridge, UK, 1989.

[3] F. Russo and G. Musolino, "A unifying modelling framework to simulate the Spatial Economic Transport Interaction process at urban and national scales," *Journal of Transport Geography*, vol. 24, pp. 189–197, 2012.

[4] R. Cordera, Á Ibeas, L. dell'Olio, and B. Alonso, *Land Use–Transport Interaction Models*, CRC Press, Taylor & Francis, Boca Raton, Florida, USA, 1st edition, 2018.

[5] F. A. Marcianò, G. Musolino, and A. Vitetta, "A system of models for signal setting design of a signalized road network in evacuation conditions," *WIT Transactions on the Built Environment*, vol. 111, pp. 313–323, 2010.

[6] G. Musolino and A. Vitetta, "Short-term forecasting in road evacuation: calibration of a travel time function," *WIT Transactions on the Built Environment*, vol. 116, pp. 615–626, 2011.

[7] Á. Ibeas, R. Cordera, L. dell'Olio, and P. Coppola, "Modelling the spatial interactions between workplace and residential location," *Transportation Research Part A: Policy and Practice*, vol. 49, pp. 110–122, 2013.

[8] P. Coppola, Á. Ibeas, L. dell'Olio, and R. Cordera, "LUTI model for the metropolitan area of Santander," *Journal of Urban Planning and Development*, vol. 139, no. 3, pp. 153–165, 2013.

[9] I. Thomas, J. Jones, G. Caruso, and P. Gerber, "City delineation in European applications of LUTI models: review and tests," *Transport Reviews*, vol. 38, no. 1, pp. 6–32, 2018.

[10] F. Niu, F. Wang, and M. Chen, "Modelling urban spatial impacts of land-use/transport policies," *Journal of Geographical Sciences*, vol. 29, no. 2, pp. 197–212, 2019.

[11] F. Russo and A. Comi, "Investigating the effects of city logistics measures on the economy of the city," *Sustainability*, vol. 12, no. 4, p. 1439, 2020.

[12] A. G. Wilson, "A statistical theory of spatial distribution models," *Transportation Research*, vol. 1, no. 3, pp. 253–269, 1967.

[13] A. G. Wilson, *Entropy in Urban and Regional Modelling*, Pion Press, London, UK, 1970.

[14] D. McFadden, "Modeling the choice of residential location in spatial interaction theory and planning models," in *Spatial Interaction Theory and Planning Models*, A. Karlqvist, L. Lundqvist, and F. Snickars, Eds., Springer, Berlin, Germany, 1978.

[15] M. Ben-Akiva and S. Lerman, *Discrete Choice Analysis: Theory and Application to Travel Demand*, The MIT Press, Cambridge, MA, USA, 1985.

[16] E. Cascetta, *Transportation Systems Analysis. Models and Applications*, Springer-Verlag, New York, NY, USA, 2008.

[17] G. A. Johanson and G. P. Brooks, "Initial scale development: sample size for pilot studies," *Educational and Psychological Measurement*, vol. 70, no. 3, pp. 394–400, 2010.

[18] G. Boggero, "The establishment of metropolitan cities in Italy: an advance or a setback for Italian regionalism?" *Perspectives on Federalism*, vol. 8, no. 3, 2016.

[19] D. Musolino, "Characteristics and effects of twin cities integration: the case of Reggio Calabria and Messina, "walled cities" in Southern Italy," *Regional Science Policy & Practice*, vol. 10, no. 4, pp. 315–334, 2018.

[20] A. Anas and L. S. Duann, "Dynamic forecasting of travel demand, residential location and land development," *Papers in Regional Science*, vol. 56, no. 1, pp. 37–58, 1985.

[21] A. Frenkel, E. Bendit, and S. Kaplan, "Residential location choice of knowledge-workers: the role of amenities, workplace and lifestyle," *Cities*, vol. 35, pp. 33–41, 2013.

[22] A. Nuzzolo, A. Comi, and E. Papa, "Simulating the effects of shopping attitudes on urban goods distribution," in *Procedia–Social and Behavioral Sciences*, pp. 370–379, Elsevier, Amsterdam, Netherlands, 2014.

[23] S. Hounwanou, A. Comi, J. Gonzalez-Feliu, and N. Gondran, "From city center to urban periphery: retail-store movement and shopping trip behaviours. Indications from Saint-Etienne," in *Transportation Research Procedia*, pp. 363–372, Elsevier, Amsterdam, Netherlands, 2018.

[24] J. Prashker, Y. Shiftan, and P. Hershkovitch-Sarusi, "Residential choice location, gender and the commute trip to work in Tel Aviv," *Journal of Transport Geography*, vol. 16, no. 5, pp. 332–341, 2008.

[25] B. H. Y. Lee and P. Waddell, "Residential mobility and location choice: a nested logit model with sampling of alternatives," *Transportation*, vol. 37, no. 4, pp. 587–601, 2010.

[26] K. Manaugh, L. F. Miranda-Moreno, and A. M. El-Geneidy, "The effect of neighbourhood characteristics, accessibility, home-work location, and demographics on commuting distances," *Transportation*, vol. 37, no. 4, pp. 627–646, 2010.

[27] A. de Palma, K. Motamedi, N. Picard, and P. Waddell, "A model of residential location choice with endogenous housing prices and traffic for the Paris region," *European Transport-Trasporti Europei*, vol. 31, no. 31, pp. 67–82, 2005.

[28] D. A. Hensher, J. M. Rose, and W. H. Greene, *Applied Choice Analysis*, Cambridge University Press, Cambridge, UK, 2nd edition, 2015.

[29] C. Bhat and J. Guo, *Residential Location Choice Modeling: Accommodating Sociodemographic, School Quality and Accessibility Effects*, Department of Civil Engineering, University of Texas at Austin, Austin, TX, USA, 2001.

[30] W. Wu, W. Zhang, and G. Dong, "Determinant of residential location choice in a transitional housing market: evidence based on micro survey from Beijing," *Habitat International*, vol. 39, pp. 16–24, 2013.

[31] E. Marcucci, A. Stathopoulos, R. Danielis, and L. Rotaris, *Residential Location Preferences and Relative Power in Three Member Households: A Choice Experiment*, Research Gate, Berlin, Germany, 2009.

[32] C. Balbontin, J. de Dios Ortúzar, and J. D. Swait, "Importance of dwelling, neighbourhood attributes in residential location modelling: best worst scaling vs. Discrete choice," *Procedia-Social and Behavioral Sciences*, vol. 160, pp. 92–101, 2014.

[33] Á. Ibeas, R. Cordera, L. dell'Olio, P. Coppola, and A. Dominguez, "Modelling transport and real-estate values interactions in urban systems," *Journal of Transport Geography*, vol. 24, pp. 370–382, 2012.

[34] R. Cordera, P. Coppola, L. dell'Olio, and Á. Ibeas, "Is accessibility relevant in trip generation? Modelling the interaction between trip generation and accessibility taking into account spatial effects," *Transportation*, vol. 44, no. 6, pp. 1577–1603, 2017.

[35] R. Cordera, P. Coppola, L. dell'Olio, and Á. Ibeas, "The impact of accessibility by public transport on real estate values: a comparison between the cities of Rome and Santander," *Transportation Research Part A: Policy and Practice*, vol. 125, pp. 308–319, 2019.

[36] S. Isaac and W. B. Michael, "Handbook in Research and Evaluation," Educational and Industrial Testing Services, San Diego, CA, USA, 1995.

[37] M. A. Hertzog, "Considerations in determining sample size for pilot studies," *Research in Nursing & Health*, vol. 31, pp. 180–191, 2008.

[38] A. Vitetta, "A quantum utility model for route choice in transport systems," *Travel Behaviour and Society*, Travel Behaviour and Society, vol. 3, pp. 29–37, 2016.

[39] ISTAT, "Population and Employment Census Data," Italian National Institute of Statistics, Rome, Italy, 2011.

[40] F. G. Praticò and R. Vaiana, "A study on the relationship between mean texture depth and mean profile depth of asphalt pavements," *Construction and Building Materials*, vol. 101, pp. 72–79, 2015.

[41] G. Chilà, G. Musolino, A. Polimeni, C. Rindone, F. Russo, and A. Vitetta, "Transport models and intelligent transportation system to support urban evacuation planning process," *IET Intelligent Transport Systems*, vol. 10, pp. 279–286, 2016.

[42] L. Caggiani, R. Camporeale, and M. Ottomanelli, "Facing equity in transportation network design problem: a flexible constraints based model," *Transport Policy*, vol. 55, pp. 9–17, 2017.

[43] F. Russo, C. Rindone, and P. Panuccio, "European plans for the smart city: from theories and rules to logistics test case," *European Planning Studies*, vol. 24, no. 9, pp. 1709–1726, 2016.