XXXVI CONFERENZA ITALIANA DI SCIENZE REGIONALI

MODELS FOR ROUTE CHOICE EVOLUTION: INFLUENCE OF EXPERIENCE AND INFORMATION WITH EXPERIMENTATION IN A REAL CASE

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SOMMARIO

Route choice is the observable result of a complex and not observable process occurring in human minds. Choices simultaneously made by users highly influence the network congestion levels. Considering the impacts of choices on the life quality both of users and not users of the transport system and the growing sensibility for the sustainability of life on Earth, investigating the mind process behind users' behaviour with a quantitative approach is an interesting area of research.

In this work, high relevance was reserved to users' perception of alternatives: a great effort, aimed to obtain some more insights in the way users build their "idea" of a generic alternative and in the weight associated to the "idea" (how the considered alternative is perceived) at the choice time, was made. Users' perception of alternatives is modified over time because of information received and experience acquired. On purpose, a mathematical model was specified in order to represent choice set formation, users' perception of alternatives and its updating, due to information acquired and experiences got on the network.

One of the most important application that this kind of work may have in the future consists in the possibility to forecast and maybe control users' behaviour: diversifying information provided to users and/or defining specific driving policies, the road traffic could be redistributed real-time in space (different routes) and time (different time slots), reducing congestion and improving the quality of life.

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1. Introduzione

Network flows and travel times on the network depend on the interaction between travel supply, which consists of infrastructures and organisational elements, and transport demand, which is the result of choices made by users at different levels (i. e. destination/mode/route). The travel supply performances are represented by the level of service: its value depends on network flows (Cascetta (2001), Cascetta (2006)). On the other hand, the transport demand, composed by users that want to move on the network, makes choices amongst alternatives composing the perceived choice sets: the way users perceive the alternatives characteristics (attributes) influence users' choices (Cascetta (2001), Cascetta (2006)).

The route choice may be considered as the link between demand and supply because the perceived attributes influencing this choice level are strictly related to the travel supply (i. e. travel time, route length): for this reason, it plays a key role in the modelling of the transportation system. Assuming the route choices only influenced by the objective and measurable characteristics of alternatives is a quite restrictive hypothesis, which ignores the entire world related to users' perception. In order to capture the influence of perception on users' behaviour, the formation of the choice set was investigated both studying works available in the literature and observing users' behaviour in a real network. It is worth noting that perception cannot be considered static: it is evolving day by day due to the new experiences of the network and to information acquired. The massive presence of IT applications in common people routine, provide easily accessible and low cost information. The new technologies which information is diffused with contribute to make the evolution of users' perception quicker and quicker. The real experiment carried out during the survey campaign confirmed the key role played by information on users' behaviour and the obtained results allowed drawing some interesting conclusions.

In the work presented in this paper (which is a brief synthesis of the thesis work (De Maio 2014)), a deep analysis of the phenomenon, supported by theoretical studies and experimental evidences was carried out. The main outputs of the research consist in:

- specification of a day-to-day model for the simulation of choice set and route choice updating;
- specification of a transition model, representing users' changes of mind;
- development of a real experiment for data collection;
- trials of calibration and validation of the proposed models.

The main innovative elements are summarized in the following:

- (GENERATION) the choice set is evolving day-by-day according to users' perception of alternatives and is composed by a limited number of alternatives (the fixed choice set, eventually composed by all the feasible alternatives available on the network is considered an unrealistic hypothesis);
- (PERCEPTION) differently to some previous works, users' perception is modelled involving several aspects and not only the expected travel time;
- (CHOICE) the learning process occurring in users' minds is represented in the specified model (users not immediately aware of changes on the network/new alternatives available).

2. State of the art

In the transportation science, it is usually hypothesized that the system reaches a steady state: models based on the intra-period stationary hypothesis will be referred as static; on the contrary, models not based on it will be referred as dynamic. Amongst the dynamic models, particular interest was put on the ones simulating the inter-period variations (day-to-day models).

A brief description of the state of the art of the static models is reported in paragraph 2.1; whereas the state of the art of the dynamic models is summarized in paragraph 2.2.

2.1 *Static context*

One of the most interesting works on route choice in static context was developed by Manski (1977): he introduced the necessity to distinguish two phases, the generation of the choice set and the choice. After Manski some researchers proposed to split the generation phase in two phases: the generation of the choice set and the perception phase (Ben Akiva et al. (1984), Russo et al. (1995)). According to this view, the route choice model is specified through three levels: generation, perception and choice. In order to simplify the complex structure of the specification of a route choice model, some researchers proposed models with two or one level (Ben Akiva et al. (1995)).

In the literature, the generation phase was developed adopting mono-set/multi-sets and exhaustive/selective approaches. Whatever is the adopted approach, either the exact or the heuristic algorithms can be used.

The perception phase may be simulated using an explicit approach or an implicit approach. In the case of the second approach, an attribute representing user's perception is included in the specification of the choice model (Cascetta et al. (2001), Cascetta et al. (2002)). However, because of the complexity of the two approaches, generally the perception phase was not developed and a single choice set with perception probability equal to one was considered.

In relation to the choice level, two different families of models were used in the literature: the Random Utility Models (RUM), based on the random utility theory (Cascetta (2001)) and the Fuzzy Utility Models (FUM), based on the Fuzzy Logic (Zadeh (1965)). To the family of RUM models belong the Logit, the C-Logit (Cascetta et al. (1997) and Russo et al.(2003)), the Path Size Logit (Ben Akiva et al. (1999)), the link nested logit (Vovsha et al. (1998)), the probit model (Daganzo (1979)).

2.2 *Dynamic context*

If a day-to-day approach is adopted, the system is endlessly evolving and not necessarily converging to an equilibrium state. For this reason the day-to-day models are also called "non-equilibrium" models. Several researchers delved into this topic (Cascetta (1987), Watling et al. (2013)) and some experiments (Iida et al. (1992)) demonstrated that, in a dynamic context, the reaching of the equilibrium is influenced by the availability of information to users.

Because of the relevant influence of information provided to users, several researchers underlined the importance to correctly model the influence of information on users' behaviour (Polydoropoulou et al. (1996)) and the variety in users' responses to different kinds of information received: Bifulco et al. (2011) distinguished between instantaneous and predictive information; Watling et al. (1993) treated with prescriptive information instead of the most diffused descriptive ones; Parvaneh et al. (2012) demonstrated that the type of information (quantitative/qualitative, public/private, pre-trip/en-route) influences the switching behaviour. The influence of information reliability on users' behaviour and users' compliance to information were also investigated (Parvaneh et al. (2012). Mahamassani et al. (2000)).

2.2.1 Perception

The updating of users' perception, due to information and experience, was represented through mathematical models: a group of researchers defined some "measures of perception" whereas some others focused their attention on the evolution of the perceived travel time.

In relation to the first group, three works were considered. Chorus et al. (2009) specified a logsum measure able to take into account both aware and unaware benefits due to changes on the network, overcoming one of the most diffused and restrictive hypothesis which assumes the generic user immediately aware of an eventual change occurring on the network. Han et al. (2011) introduced two different measures to represent users' perception of alternatives: the activation level and the aspiration level. On the first

depends the composition of the choice set in the generic day j, whereas the second represents the user's inclination to explore. The combination of the two measures, specified as dynamic quantities, decides the evolution of the perceived choice set. Mahmassani et al. (1987) proposed the theory named bounded rationality with indifference bands; they assumed that the user decides to switch, not choosing the habitual alternative only if the gain obtained overcomes the so called "indifference bands".

In relation to the second group, researchers tried to model how the perceived travel time of a generic alternative in the current day, depends on the previous experiences (Horowitz (1984), Iida et al. (1992), Hazelton et al. (2004)). Mahmassani et al. (1986), in his myopic adjustment approach, included only the travel time experienced in the previous day. Some researchers proposed models able to take into account both experience and information (Ben Akiva et al. (1991), Jha et al. (1998), Tian et al. (2010), Parvaneh et al. (2012)).

2.2.2 Generation

The evolution of users' perception of alternatives due to information and experience may lead to an updating of the perceived choice set: a new alternative may enter the choice set. A learning process occurs in users' minds, stimulated by inputs coming from the surrounding environment. The evolution of the choice set is a complex topic: in this work three contributes, coming from different fields of research were considered.

Decrop (2010) delved into the formation of the choice set of the touristic destination (tourism research), hypothesizing a three steps process (consideration, evaluation, constraints). In the work developed by Han et al. (2011) the user has to choose the location for his activity (transportation research) and the evolution of the choice set is modelled through the activation level and the aspiration level, described above. In the end the user may confirm the previous choice (habit), change his mind choosing a different alternative already present in the choice set (exploration) or choosing a new alternative not previously present in the choice set (exploration). Manski (2004) delved into the social learning, related to the choices made by previous cohorts (social science research). Although the kind of choices treated by Manski is quite different than the route choice, his work resulted interesting because investigated how the ambiguity which characterizes a new alternative tends to decrease over time.

2.2.3 Choice

The choices are distinguished by Gao et al. (2010) in three groups: choices in certainty conditions, choices in uncertainty conditions and choices in risk conditions. Route choice belongs to the second group.

The choice models available in the literature may be based or not based on the Expected Utility Theory (EUT). The Random Utility Models (RUM), well known and diffused, are based on the EUT. The non EUT models were specified in order to overcome some paradoxes that characterize the EUT models. The non EUT models include in the modelling phase, not only utility of alternatives, but also the users' risk aversion. On the other hand the difficulties in their application made researchers prefer RUM in the most of the cases, sometimes introducing specific terms to make the model more true-to-life. In order to overcome the limits of the EUT models, were proposed models based on alternative theories: for example Henn et al. (2006) represented uncertainty through the possibility theory.

3. Methodology: proposed models

In this section, the methodology adopted to address the studied phenomenon is presented. As reported in the state of the art, the correct and most true-to-life way to model route choice requires considering three different levels: the generation of the choice set, the perception and the choice. According to the three levels approach, section 3.1 reports the methodology proposed for the generation and perception levels and section 3.2 describes the methodology proposed for the choice level.

3.1 Generation and perception

In the literature, several algorithms were proposed for the generation phase (Russo et al. (2006)) and researchers explored their different properties, advantages and disadvantages comparing the results obtained from applications on test and real networks. Generally, the algorithms for alternatives generation are not able to take into account the behavioural rules that truly define the process of the choice set formation. For this reason, the choice set generated through the well consolidated algorithms may result quite different than the currently perceived choice set.

Moreover, quite often the choice set is hypothesized to be static and composed by the entire feasible loop less alternatives available on the network. Both of these two hypotheses are quite restrictive. Indeed considering that users' perception of alternatives evolves over time because of the changed knowledge and awareness of the network, the choice set composition may change over time. In addition to this, researchers demonstrated that the human mind has a limited capacity of retention: therefore people are able to consider only a restricted number of alternatives, demonstrated to be from three to six (Quattrone et al. (2011)).

Hypothesizing a fixed choice set, only the choice could change over time: the role of perception is completely ignored and many of the possible situations are not simulated. In the reality, the choice set, not observable and existing only in people minds, changes his composition acquiring and loosing alternatives.

Considering the illustrated premises, the approach proposed in the thesis for the generation phase tries to overcome the limits present in some of the previous works. For example, contrary to a usual assumption, if a new alternative enters the choice set it is not necessarily the next choice.

As stated above, although users may be aware of a large number of alternatives, the choice set is composed only by alternatives considered for the choice: this kind of alternatives is referred as the perceived ones. In order to identify the alternatives composing the choice set, the measure of perception, specified in section 3.2, is used. Assumed that users are able to retain a limited number of alternatives k (Quattrone et al. (2011)), the k paths which minimize the measure of perception compose the choice set. Considering that the measure of perception is evolving day by day, also the composition of the choice set results daily updated.

3.2 Choice

Observing users' behaviour, researchers realized the relevant influence of habit on users' choices: people behaviour reveals a sort of inertia at changing mind about the habitual choice, increased by eventual activity constraints and phenomenon like captivity.

However, if users are stimulated by external events (i.e. changes on the network, new alternatives available) may evaluate a different alternative. A key role in this process is played by experiences acquired on the network and information received, that could modify users' awareness of alternatives. Some of the works of the state of the art assume the user is immediately aware of eventual new alternatives available on the network. On the contrary in this work, it is assumed that the user may not become aware of new alternatives available on the network and, anyway, awareness is not immediate.

Summarizing, users' choices seem to be influenced by three main elements: habit, information received pre-trip and/or en-route and experience acquired on the network, which directly modify users' perception of travel times.

The model presented in the following (day-to-day model) simulates users' perception of alternatives and allows describing the choice made in the current day (De Maio et al. (2013)). The travel times experienced on the network in the previous day/s deeply influence users' perception. The strong link between the present choices and the past experiences, suggests the necessity to specify a day-to-day model, able to take into account all the previous experiences. However, users' choices are not only influenced by the perceived travel times: many aspects contribute at creating user's perception of a generic alternative. In the specification of the day-to-day model proposed in this work, each user p associates to each perceived alternative r (belonging

to the choice set), in each day j, a measure of perception ($m_{r,p}^{j}$), expressed as a convex combination through the parameter β of two terms: the perceived utility of alternative r in day j ($u_{r,p}^{j}$) and the previous day (j-1) measure of perception ($m_{r,p}^{j-1}$) (equation 1). The value of β defines the reciprocal importance of the current day component and of the previous day measure of perception. It is worth noting that, because of the way the measure of perception is calculated, the previous day measure of perception somehow contains the measures of perception of all the days before.

$$m_{r,p}^{j} = \beta\, u_{r,p}^{j} + (1 - \beta)\, m_{r,p}^{j-1} \qquad (1)$$

The specification of the expected value of the perceived utility ($v_{r.p}^{j}$) (equation 2 and equation 3) depends on the distance ($dist_r$), the perception component ($\mathbf{x_r^j}$), the information component ($\mathbf{y_r^j}$) and the experience component (e_r^{j-1}).

$$E(u_r^{j}) = v_r^{j} \qquad (2)$$

$$v_r^{(j)} = \varphi\, (dist_r, \mathbf{x_r^j}, \mathbf{y_r^j}, e_r^{j-1}) \qquad (3)$$

A possible specification of the vectors of attributes (equation 4 and equation 5) present in the model specification (equation 3) is reported below and commented in the following:

$$\mathbf{x_r^j} = (t_{rmin}^{j}, t_{rmean}^{j}, t_{rmax}^{j}, [t_{rVAR}^{j}]^{1/2}, \ldots)^{T} \qquad (4)$$

$$\mathbf{y_r^j} = (t_{\ rinfo}^{j}, AV_{rinfo}^{j} \ldots)^{T} \qquad (5)$$

The attribute $dist_r$ represents the length of route r.

The vector of the perception component $\mathbf{x_r^j}$ may be specified through the average (t_{rmean}^{j}), the maximum (t_{rmax}^{j}), the minimum (t_{rmin}^{j}) and the variance (t_{rVAR}^{j}) of the perceived travel time: it represents the user's perception of alternative r in day j. User's perception is updated day by day according to the experiences got on the network in the previous day, through a procedure specified on purpose.

The vector of the information component $\mathbf{y_r^j}$ could be specified through the travel time obtained as information, for example by ATIS (t_{rinfo}^{j}), or as the availability of information in day j on route r (dummy variable AV_{rinfo}^{j}). Similarly the experience component e_r^{j-1} represents the travel time experienced on route r in day j-1, different than zero only if alternative r was the one chosen in day j-1. It could also be represented as a dummy variable. The information and experience component represents the reality and may be different than the perception component: indeed, the user could have a wrong perception of alternative r and the learning process may correct it.

The perception component is updated according to the experiences got on the network in the current day. The updated perception component, together with the current day information component, the previous day experience component and the previous day measures of perception, are the inputs of the model for the estimation of the current day measure of perception.

The main novelties of the day-to-day model proposed in this work are summarized in the following:

a. the measure of perception is specified through different components instead of the only perceived travel time;

b. all the previous experiences are taken into account in the specification of the measure of perception and not only the one of the previous day.

The conclusions drawn from the laboratory experiment for data collection and the first results obtained from the trials of calibration of the day-to-day model stimulated the investigation of a peculiar aspect: the transition from the previous state j-1, in which alternative r was chosen, to the current state j, in which alternative k is considered. The investigation of the elements that influence the transition provided more insights in the inertia phenomenon and in the switching behaviour. A transition model, able to simulate the transition from the previous state to the next one was specified. Each user associates a perceived utility of transition to alternative k. According to the random utility theory, the user p in day j will choose the alternative k characterized by the maximum transition utility. The expected value of the transition utility is expressed as a function of:

- the characteristics of alternative r (choice of day j-1);
- the characteristics of the generic alternative k (considered in day j);
- the comparison between the previous state and the current day.

4. Experimentation and results

When a dynamic phenomenon has to be investigated, the panel/longitudinal survey should be preferred to the cross-sectional survey (one-shot or retrospective) because of the quality of collected data and of the consequent results obtained from the calibrations. On the other hand, this type of survey presents many practical difficulties and researchers generally preferred to develop laboratory-like or simulation experiments (Mahmassani et al. (1987), Iida et al. (1992), Meneguzzer et al. (2013), Avineri et al. (2006), Ben Elia et al. (2010)). In many cases the Stated Preferences method (SP) and the Revealed Preferences method (RP) were used together in order to get more insights in the studied phenomenon (Polydoropoulou et al. (1996)).

A few words should be spent on the method to be adopted for calibration when the data are collected through a panel survey. Indeed, the collected observations are characterized by two levels of correlation: both observations related to the same user in different times (correlation at user's level) and observations related to different users (correlation at sample level) are correlated. The classic methods used for calibration are not able to take into account these correlations: therefore, alternative methods should be used for calibration (Johnson et al. (1982), Chang et al. (1988), Keane (1994), Srinivasan et al. (2003), Abel Aty et al. (2006), Mahmassani et al. (1999)).

4.1 Survey campaign and experiment

In this section the survey campaign is described and the structure of the experiment is presented. Moreover, the way information and experience components were simulated is summarized and the rules for the formation and updating of the choice set are explained.

4.1.1 The experiment design

The campaign for data collection was developed in Reggio Calabria in May-July 2013. A day-to-day disaggregated experiment was designed in order to observe both perception of alternatives - formation of the perceived choice set – and users' choices. People involved in the experiment were interviewed at least for six consecutive days about the route chosen on a pre-fixed o-d pair in the slot time 8 a.m. – 10 a.m. of a generic weekday. The sample was composed by 35 users, chosen amongst students, PhD students, researchers and professors. The trip chosen for the experiment originated in the city centre, nearby the Museum of Magna Grecia (Reggio Calabria), and terminated in the suburb, at the Engineering Faculty of the Mediterranea University (Reggio Calabria).

4.1.2. The experiment structure

At day 1 of the experiment, each user composing the sample was asked to figure himself in the designed situation and to indicate on the map the preferred route (choice), considering to make the trip with a private

car. Moreover, the generic user was interviewed about eventual additional evaluated routes (perception). The choice set of the considered user in day 1 consists of the chosen route and of all the other routes indicated as perceived.

4.1.3 Experience and information in the experiment

As discussed in the previous sections, information and experience play a key role in the studied phenomenon: for this reason, both the components were simulated in the experiment, focusing attention on the influence of information reliability on route choice. For this aim, three different policies of information were defined: according to policy 1 no additional information were provided; according to policy 2, users received right information; according to policy 3, users received incorrect information. Each user of the sample was associated to one of the policies and three groups were obtained. Obviously users involved in the sample were completely unaware of the three policies of information. Moreover, each user of each group was informed about the experienced travel time on the route preferred in the previous day.

4.1.4 The updating of perception and choice

The choice level was investigated every day (users were asked about the chosen route every day of the experiment) whereas the perception level was re-investigated only in the third day in order to not stress people (users were asked about other eventually perceived routes). Because of the repetition of the experiment, the evolution in users' choice and the updating of users' perception resulted observable.

4.1.5 The observation of the perceived choice set

The latent perceived choice set, existing only in users' minds, was "observed" during the experiment. Indeed, stating the rules for the choice set formation, the composition of the choice set perceived by each user in every day of the experiment was known. According to the established rules, the alternatives belonging to the choice set are: the route chosen in the current day, the routes eventually indicated as perceived, the routes which the user becomes aware of because of information received. In the experiment the choice set may only enlarge (no alternative may exit the choice set). Moreover, an eventual new alternative entering the choice set is neither immediately nor necessarily chosen.

4.1.6 Users' characteristics

In the literature the influence of users' socio-economic characteristics on the way information received by ATIS are perceived was widely investigated and contrasting conclusions were drawn (Abel Aty et al. (2006), Khattak et al. (1993), Mahmassani et al. (2000)). For this reason, users involved in the experiment were also interviewed about the availability of a private mean of transport, their age and knowledge of the network.

4.1.7 Simulation of the experience and information components

In order to provide users with information and experienced travel times a simulation tool was used. The travel supply of the study area is modelled through a network consisting of 241 nodes and 444 links. The congested travel times are simulated applying the BPR model, which parameters were calibrated using the data of congested travel times collected on the network. The transport demand is aggregated in 12 centroids. The o-d matrix was estimated through a reverse assignment procedure, repeated several times in order to obtain also the corrected BPR parameters consistent with transport demand.

4.2 Analyses

People belonging to the sample know the network very well (level of knowledge good/excellent) and, except four of them, everybody else have a private mean of transport available. The results of the analyses carried out on the sample in relation to the generation and perception phase are summarized in paragraph

4.2.1, whereas the results related to the choice phase and the transition phenomenon are summarized in paragraph 4.2.2.

4.2.1 Generation and perception

Users belonging to the sample perceived 9 alternatives during the experiment, ordered according the congested travel time calculated with the simulation tool. Combining the 9 alternatives, 511 choice sets may be composed. However, users revealed to perceive only 19 choice sets (3.7%), composed maximum by 5 alternatives because of the limited human retention capacity and the shortness of the experiment. In the first days the choice sets composed by a few alternatives (1 and 2) are the most perceived ones. In the last days, the most perceived choice sets are composed by 3 alternatives and some people perceive also choice sets composed by 4 and 5 alternatives. The most perceived alternatives were k1, k3 and k4.

For each of the three groups, the evolution of the choice set was analysed. It was found that information provided to users influence the evolution of the choice set: in particular, the evolution for users belonging to group 2, who received correct information, resulted to be much quicker if compared to the evolution for users belonging to group 1. On the contrary, the evolution of the perceived choice set for people belonging to group 3 resulted to be delayed in the last days, probably because users became aware of the unreliability of information received.

4.2.2 Choice and transition

Similarly to the generation and perception level, also at the choice level a great influence of information received was observed. Indeed, choices made by users of group 1 evolve very slowly: the most chosen alternative at the end of the process was k3 (convergence). They received no stimulus to explore other alternatives. On the contrary, users of group 2 quickly realized that the best alternative was k1 because of correct information received. Since the second day of the experiment, they switched to alternative k1 (convergence), leaving k3 and k4 preferred in the first day. The new choice was supported by the travel times experienced on the network which confirmed the travel times obtained as information. Differently, people of group 3 did not find in the experienced travel time any confirm of the travel times obtained as information: therefore a great variability in choices was observed. Realizing the unreliability of information received, some people decided to come back to the first choice and did not consider information received anymore, whereas some other carried on exploring the network using information received.

In order to obtain some more insights in the users' behaviour at choice level, the switching behaviour was analysed. According to the conclusions drawn above, users of group 2 present the absolute highest percentage of switching: it occurs in the second day. The switching percentage decreases day by day for people belonging to group 1 and group 2, whereas for people of group 3 a great variability is observed.

Users' choices revealed that both the network knowledge level and the unreliability of information received influence users' compliance to information. Indeed, a high knowledge of the network makes the user very confident with his first choice whereas a low knowledge of the network makes the user more willing to explore. Considering two users with the same knowledge of the network, it was observed that an increase in the reliability of information makes the user more compliant to information received and the convergence to the best choice is quicker.

In this work the transition from the previous state to the next one was investigated. The analyses carried out on the sample allowed identifying 36 possible transitions. The results revealed that the most likely transitions are the ones that confirm the choice made in the previous day, because of the inertia effect.

4.3 Calibration results

In this section, the results obtained from the first trials of calibration are presented both for the day-to-day model (paragraph 4.3.1) and for the transition model (paragraph 4.3.2).

4.3.1 Day-to-day model calibration results

The panel data collected during the survey campaign was used for the calibration. As already discussed, the observations of a panel data are correlated and the classic methods for calibration are not able to take into account the correlation. Anyway, assuming that the specified day-to-day model is somehow able to represent the correlation between successive choices, the calibration was carried out using the Maximum Likelihood Method. The probability of choosing alternative r in day j is calculated according to the Logit model (RUM) as reported in equation 6:

$$P_r^j = \frac{\exp E(m_r^j)}{\sum_{i=1}^{n(j)} \exp E(m_i^j)} \tag{6}$$

For the validation phase both informal tests (check of signs) and formal tests (ρ^2 and %right) were used. The trials of calibration carried out differs for the groups of users involved, the type of choice set (static or dynamic), the number of days of experimentation.

The calibrated parameters resulted quite steady across the trials of calibration carried out. The value obtained for the calibrated β (see equation 1) reveals that the relevance of the previous days component and of the current day component is quite similar in the studied phenomenon. The experience component is characterized by a much greater weight compared to the information component. Moreover, an attribute representing the unreliability of information was introduced in the specification: the calibrated parameter suggests that the quality of information provided thoroughly influences users' choices.

4.3.2 Transition model calibration results

Similarly to the day-to-day model, also for the transition model a simplified approach was adopted for calibration, knowing the limits of the obtained results. The probability of transition was calculated using a Logit model. The Maximum Likelihood Method is used for the calibration and similar tests are used for the validation.

Similarly to the day-to-day model, also for the transition model the calibrated parameters resulted quite steady across the trials of calibration carried out. Moreover, in some trials of calibration an attribute representing the evolution of the choice set was introduced in the specification: in these cases, the statistics resulted improved. This is likely due to the relevant influence of the updating of the choice set at the choice level.

One of the calibrated models was applied for the estimation of the probabilities of transition. The results obtained from the application of the calibrated model reproduced quite well the results obtained from the analyses carried out on the sample.

5. Conclusions

The route choice in a dynamic context was analysed in the thesis. The evolution of users' perception and choices and the updating of the choice set were thoroughly investigated, trying to overcome some of the restrictive hypothesis diffused in the literature (fixed choice set composed by all the feasible loop less alternatives, users immediately aware of changes on the network, new alternatives entering the choice set immediately chosen, users' perception only based on travel times, and so on.).

A day-to-day model and a transition model were specified and a real experiment was developed to collect data. Specific attention was focused on the influence of information and its reliability on users' behaviour. A great effort was made in the representation of the learning process occurring in users' minds through mathematical relationships. The switching behaviour and the transition from the previous state to the next one were investigated.

In the end, some trials of calibration were carried out. Although several restrictive hypotheses were introduced in the calibration phase in order to simplify the procedure and many points are still opened, some interesting conclusions can be drawn from the results obtained. In relation to the day-to-day model, it was found that the distance plays a key role; information and experience represented by dummy variable, instead of travel times, works better during the calibration phase; the reliability of information provided to users produces a great influence on users' behaviour. The calibration of the transition model, which specification was suggested by the first analyses on the collected date, revealed the relevant influence of the choice set evolution on the transition from a state to another (link between the choice set level and the choice level); the results confirmed the unwillingness to modify the previous choice because of the well known inertia/habit phenomenon.

Further developments would consist in the development of other trials of calibration adopting more sophisticated methods and/or other specifications of the models. Some more insights in the studied phenomenon may be provided widening the data set.

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