

Commuters and traffic information: A revealed preference study on route choice behavior

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Abstract

The past decades have seen an increased interest in the role of information to alleviate congestion. The relationship between travelers' behavior and information, however, is not clear yet and the need of more experiments has been claimed in the literature. From May 9th, 2011 to July 12th, 2011 a revealed preference (RP) route choice experiment was conducted in the Netherlands. With the aid of GPS devices and travel diaries, we investigated the behavior of 32 commuters with similar origins and destinations in reaction to different sources and conditions of information.

Descriptive analysis of the data set with respect to the use of information suggests that travelers, commuters in particular, do not tend to use information to better plan departure times but instead use it to anticipate expectations regarding traffic conditions.

Keywords

Route choice behavior, traffic information, revealed preference experiment, GPS devices, travel diaries

1 Introduction

The potential of traffic information to influence travelers' behavior and consequently to steer them to less congested routes has led to an increased interest in the role of traffic information to support travelers in their route choice tasks and to help alleviate congestion (Bogers, 2009; Arnott et al., 1991; Denant-Boèmont and Petiot, 2003; Avineri, 2006; Chorus et al., 2008). However, when traffic information is provided travelers have to decide whether to comply and the complexity of the decision increases when travelers aim to adjust their expectations based on the provided traffic information (e.g. travel time and queue length). Consequently, for a proper understanding of travelers' behavior, it is fundamental to take into account the relationship between behavior, in particular route choice behavior, and traffic information (types and reliability).

The available sources of traffic information are quite extensive and vary from non-personalized public information, semi-personalized public information and personalized real-time traffic information. Non-personalized traffic information usually refers to general traffic conditions in the network and information regarding major congested areas is reported irrespective of the interest of the traveler. This type of information is usually provided via radio or television. Semi-personalized public information, on the other hand, relates to major highways between a specific origin and destination pair of interest of the traveler. This is the type of information usually displayed on Variable Message Signs (VMS) panels next/above roads or provided by websites specialized in traffic information provision. Finally, personalized real-time traffic information provides the current traffic situation (travel times, delays, length of the queues) not only about the highways but also on local roads of interest for a specific origin and destination.

Understanding how travelers react to these different sources of information and whether provision of (more) information is beneficial to the network conditions requires further investigation. Travelers confronted with too much information may become oversaturated and may show some difficulties to process information leading to the development of simple heuristics to solve the situation. Besides this, travelers may overreact to the information and thereby cause additional fluctuations to the traffic in the network and as a result, instead of solving congestion, provision of information would possibly lead to even more congestion at other locations. Thus, travelers' behavior also has to be incorporated in traffic forecasts (Selten et al., 2007).

A number of experiments regarding travelers' reaction to traffic information has been reported in the literature, but they are limited to either stated preference (SP) surveys in which travelers are asked which route to choose given a specific context and type of information (De Palma and Picard, 2005; Zhang et al., 2010) or interactive route choice experiments in simulation environments in which, similar to a game, travelers make consecutive route choices and their behavior towards risk and different types and quality of information is investigated (Chen and Mahmassani, 1993, Chen et al., 1999; Koutsopoulos et al., 1994, Selten et al., 2007; Ben-Elia and Shifan, 2010; Bogers, 2009). The interest in SP experiments, including travel simulators, has enormously increased because they are relatively cheap, allow more flexibility of scenarios and are efficient. This type of experiments, however, are subject to the usual drawbacks of using SP data such as their external validity.

Several revealed preference (RP) datasets have been used in the literature to analyze route choice behavior. These are either surveys in which (i) travelers report their past route choices which, however, are often hardly related to an actual network in terms of alternatives and traffic conditions (Mahmassani et al., 1993; Rose et al., 2008), (ii) GPS data is used but little or nothing is known about information access, trip purposes, etc. (Frejinger and Bierlaire, 2007; Bierlaire et al., 2010). Besides these limitations, most RP studies only use cross sectional data, i.e., one choice observations for each individual, because collecting RP data with repeated observations for the same group of people requires a strong commitment of the respondents and a longer data collection period (Axhausen et al., 2002). As a result, the type of RP data that has usually been collected are of limited use for the assessment of behavioral changes over time.

This paper proposes to investigate travelers reaction to traffic information over time in a real congested network. In particular we are interested to investigate whether travelers check travel information, which sources, and whether information is used to influence their behavior. This is done throughout a descriptive analysis of the use of traffic information of the revealed preference route choice experiment conducted in the Netherlands from May 9th, 2011 to July 12th, 2011 with 32 commuters with similar origin and destination. Participants were subjected to different sources and conditions of information provision. GPS traces, travel diaries and interviews were used to investigate their behavior. For the analysis presented in this paper we are considering valid trips for which travel diaries were also filled in and this resulted in 897 valid GPS traces and travel diaries from which around 374 refer to trips made before provision of personalized traffic information and 523 afterwards.

The next section introduces the setup of the experiment focusing on its characteristics and on the traffic information. Then, in Section 3, a descriptive analysis of the data set with respect to travelers' use of traffic information is presented. Finally, conclusions and next steps are discussed in Section 4.

2 Experimental design and setup

The RP survey consisted of investigating the route choice behavior in relation to information provision between home and work of 32 commuters during 9 weeks, from May 9th, 2011 to July 12th, 2011, between Delft and The Hague in the Netherlands. Participants were selected among staff and students of the Delft University of Technology, 44% consisting of women and 56% of men. The age of the participants ranged from 23 to 60 years old, among which 41% were between 35 and 45 years old. Their commute frequency varied between 2 and 5 days/week, with the majority of travelers, 61%, commuting 5 days/week. For a detailed description of the experiment, we refer to Ramos et al. (2012).

The data collection preparations consisted of equipping the participants with GPS devices to be used during their commute trips and with a personalized tool of information provision. In addition, participants were asked to fill in a travel diary after each trip, which consisted of questions regarding their reaction to traffic information, perceptions about the trip made and expectations about their next trip.

2.1 Target group and OD pair investigated

As we are interested in investigating travelers' route choice behavior in relation to information provision, it was decided that the investigated OD pair should be connected by at least three comparable and distinct alternative routes. This is because we believe that in general travelers have a preferred route which is likely to be the one chosen the most when no information is provided. Thus, the potential of information to influence travelers to change to their least preferred routes (that, however, are as feasible as the most preferred route) would be made clearer with at least three routes. By comparable we mean that the alternative routes should have approximately the same length (otherwise the routes may not be seen as alternatives) and by distinct that they should have different characteristics, thus belonging to different classes/categories of roads, i.e. motorways, local roads, etc.

According to the database of the Mobility Research Netherlands of 2008 (Mobiliteitsonderzoek Nederland, 2008) there were about 2 million car commuters in the Netherlands, of which 60% live within 19 km distance from work, 24% between 19 and 40 km and 16% over 40 km (Dutch MON database, 2008). In order to have a representative OD pair, thus making the chosen scenario correspond to the largest share of commuters driving during peak hours in the Netherlands (and thus the largest added value of providing traffic information), we have decided that the distance between the OD pair should be within 20 km. Besides this, because this research is part of a research program focusing on the Sustainability of the Randstad, the area investigated should be in the Randstad. The Randstad is the region in the western part of the Netherlands with the highest likelihood of occurrence of congestion (Randstad-Wikipedia, 2011).

Given the requirements of amount of comparable alternative routes, of having commuting distances representative of great part of the population, to facilitate the selection of participants, contact them whenever needed and logistical requirements (collect GPS and solve problems during the data collection), one of the locations was chosen to be Delft, where the great majority of this research is being conducted, and the other location was chosen to be The Hague. This approach allows us to generalize the results for similar travel distances, get familiar with the network and as the participants work in Delft, this approach also helps ensure similarity in trip purposes. The city centers of Delft and The Hague are situated approximately 16 km apart, however, depending on the exact home location of the participants, their commuting distance varies. The reader has to keep in mind that strictly speaking we investigate more than one OD pair as not all participants live at the same location (although all work at the Delft University of Technology). As a result, we have similar OD zones that result in the same set of (alternative) routes.

2.2 Information provision

As we are interested in investigating how travelers react to traffic information over time, we had to take into account the sources of information provision, the instant information was provide, i.e. pre-trip or en-route information, compliance with different sources of information, etc.

Depending on the moment information was provided, different sources were available. For pre-route information, travelers could check radio, television, websites,

TomTom, etc. For en-route information, radio, VMS and TomTom were available. This approach allows comparing the potential of different sources and types of information, as both prescriptive information (via TomTom) and descriptive information (via VMS) were provided, influence travelers. In addition, given the distinct moments information could have been accessed, we can also investigate the influence of both pre-trip and en-route information.

In order to achieve the proposed objective, travelers were split into two groups of information provision. Group 1 consisted of 20% of the travelers who did not receive any personalized information, i.e. TomTom were *not* available to them. As any traveler, however, they were allowed to check existent (public) sources of traffic information, such as websites, radio, VMS, etc. Depriving travelers to check public sources of information would not be in accordance to reality and would require change of habits of listening to the radio, watching television and consciously ignore existent VMS panels. Although information was available, as it was not personalized and required travelers to actively check these sources, we consider it as no information. Group 1 is therefore denominated as *non-informed travelers*.

Group 2 consisted of the remaining 80% of the travelers who were subjected to two treatments regarding information provision: (i) no information treatment that corresponded to the initial three weeks of data collection and worked as a reference period and (ii) information treatment that lasted for the subsequent six weeks in which travelers received personalized real time traffic information via TomTom navigation devices of the type Via LIVE 120 – Europe, from now called TomTom. Group 2 is denominated as *informed travelers*. Table 1 summarizes the number of participants under each condition of information provision.

The personalized real time traffic information provided via TomTom consists of a recommendation regarding the fastest route between origin and destination and the estimated arrival time and delay (in relation to free-flow travel time) considering the indicated departure time. In addition, travelers could plan the departure time based on the traffic situation and to compare the travel times on the actual recommended route with an alternative route (see Figure 1). As a result, we consider that the participants were equipped with a proper tool of information provision which would potentially help them choose the best route (and departure time) between origin and destination.



Figure 1: Example of the type of traffic information provided by TomTom

Table 1: Conditions of information provision

Period	Treatment	
	<i>No information</i> (or free information sources)	<i>Information</i> (free information sources + <i>TomTom</i>)
Initial 3 weeks	100% (32 participants)	0% (0 participants)
Last 6 weeks	20% (6 participants)	80% (26 participants)

Use of information was *not* imposed to the participants. Instead, at the beginning of the experiment, they were told to check traffic information whenever they wanted. In other words, they were told to make their trip related decisions, i.e. route choice, departure time and use of information, the way they wanted to as in a regular trip. No change in behavior, besides using the GPS device and filling in the travel diaries, was imposed to the participants. None of the participants owned TomTom devices before the experiment and as such they did not have previous experience with the TomTom system. They were introduced to the TomTom system during the experiment.

2.3 Travel diary and interviews

We consider the use of travel diaries as the most appropriate way to get deeper insight into how travelers react to information, the type of information that appears to be more useful to travelers, what people actually recall from the information received and, moreover, whether travelers comply with information and under which conditions. In addition, it helps investigating whether travelers have a good perception of what actually happened during the trip and whether and how expectations are updated based on past/recent experiences.

Therefore, besides carrying GPS devices during their commute trips, the participants were asked to fill in a travel diary after each trip. The travel diary consisted of five sections related to (i) general information such as date of the trip, origin and destination; (ii) behavior towards pre-trip information, such as whether they checked pre-trip information, sources of information provision, whether they complied with it (if not, why not), whether the information favored the intended route and what they remembered from it, (iii) behavior towards en-route information containing questions similar to the ones related to pre-trip information; (iv) feedback about the trip just made, consisting of questions regarding the actual travel time, whether (in hindsight) the participants would have chosen the same route and departure time and whether (and what) additional traffic information was needed; and, finally, (v) expectations about the next trip with respect to their intended route choice and departure time, expected travel time and also flexibility regarding arrival time at the destination.

In order to get to know travelers' perceptions regarding the use of information and characteristics of the routes, they were also interviewed in three occasions: at the beginning, in the middle (after five weeks of data collection) and at the end of the experiment. At the beginning of the experiment they were asked about (i) perceptions regarding fastest, most reliable and most unpredictable route, (ii) preferred routes to and from work (and why), (iii) usual departure times, (iv) frequency of use of pre-route and en-route information and (v) willingness to pay to use traffic information. In the middle of the experiment travelers were interviewed with respect on how they had reacted to the provided real time traffic information, i.e., (i) how often the route

suggested by TomTom matched their expectations, (ii) how often they followed the suggested route, (iii) how satisfied they were with the information provided and (iv) how reliable they considered the information. Finally, at the end of the experiment, a combination of questions presented at the beginning and in the middle of the experiment were asked again in order to try to identify changes in travelers' perceptions over time.

3 Results and discussion

The analyses presented in this section focus on three main aspects: travelers' willingness to check travel information and their perceptions about this, sources of travel information that travelers seem to be more interested and compliance with travel information. These analyses are carried out for both *informed and non-informed* travelers and for different timing of information provision, i.e. pre-trip and en-route information. They were done based both on the *travel diaries* and *interviews*.

3.1 Travelers' willingness to check information and their perceptions

Outcomes of the *interviews* show that (i) as time evolves, *informed travelers* tend to check travel information more often (ii) en-route information appears to be more interesting than pre-trip information for *informed travelers* and the contrary to *non-informed travelers* and (iii) equipping travelers with an appropriate tool of traffic information provision increases the likelihood information is used (Table 2). These results also suggest that although informed travelers are more willing to look for information while driving (or just before starting the trip), they do not tend to use it as a tool to plan departure times. In other words, although informed travelers have been equipped with an appropriate tool of information provision to help better plan departure times, they do not seem to be using it for this purpose. Travelers seem to be more interested to know the best route given they depart "*now*". As reported by the participants, information was usually checked when they were just inside the car and not beforehand while still at home or in the office.

In addition, we also observed that around 77% of the informed travelers reported that only less than 30% of the times the route suggested by *TomTom* was different from their intended route. For this group of travelers, 95% reported to have followed the information provided over 70% of the times. One informed traveler, however, reported that the route suggested by *TomTom* differed from the expectations over 70% of the times and as a result compliance rates reduced to less than 30% of the times. Based on the GPS traces it was possible to observe that only few travelers showed an explorative behavior while most of them, even during the *information* treatment stick to the preferred routes: around 75% of the times the chosen route was the same as the preferred route either to or from work. This suggests the importance of habit for route choice decisions and consequently raise questions concerning how travelers react in case the traffic information is not aligned to expectations. This is definitely a point to be further investigated. If travelers comply with information only when it is aligned with their expectations, the potential of information to influence travelers' route choice behavior may be considerably lower than expected. Regarding satisfaction with the information, over 75% of the informed travelers reported to be satisfied or very satisfied with the *TomTom* information and around 80% of them considered it to

be reliable over 70% of the times. So, the fact that information was not usually checked is apparently not related to lack of confidence in the information.

Table 2: Percentage of travelers checking information based on interviews*

Period	Overall		Informed Travelers		Non-Informed Travelers	
	Check Pre-Trip Info	Check En-Route Info	Check Pre-Trip Info	Check En-Route Info	Check Pre-Trip Info	Check En-Route Info
1. At the beginning of the experiment	19%	38%	12%	38%	43%	29%
2. Middle of the experiment (5 weeks)	41%	72%	38%	81%	50%	33%
3. At the end of the experiment	50%	66%	54%	73%	33%	33%

* Results refer to participants' perception of "usually" checking travel information. Definition of "usually" was not presented.

Table 3: Percentage of travelers checking information based on the travel diaries

Treatment	Number of Trips			Overall		Informed Travelers		Non-Informed Travelers	
	Overall	Informed Travelers	Non-Informed Travelers	Check Pre-Trip Info	Check En-Route Info	Check Pre-Trip Info	Check En-Route Info	Check Pre-Trip Info	Check En-Route Info
No Info treatment	374	316	58	16%	34%	16%	37%	3%	14%
Info treatment	523	464	59	41%	67%	38%	64%	14%	44%

These, however, are travelers' perceptions regarding the use of information. As after each trip travelers filled in a *travel diary* reporting how they had reacted to information, we could also investigate whether they had actually checked traffic information after each trip. Table 3 depicts how often travelers check travel information after each trip. By comparing Tables 2 and 3 it is possible to observe that travelers' perception regarding the use of en-route information is similar to the actual use. However, the actual use of pre-trip information is substantially lower than the perceived use. This reinforces our argument that travelers are more interested in trying to find an alternative solution in case their preferred regular route is too congested rather than finding out what the best alternative route is. The fact that the travelers are very familiar with the network and aware of the regularity of traffic jams might also play an important role.

3.2 Influence of different sources of information provision

In terms of sources of information provision, radio appears to be the preferred source of public information even when compared to VMS. This may be due to the fact that, as reported by some travelers, it is not so straightforward to understand the messages provided by the VMS. It is clear, however, that when personalized traffic information is available, it turns out to be the main used source of traffic information (Table 4).

Table 4: Usage of each source of information based on the travel diaries*

Treatment	Considered sources of Pre-Trip info					Considered sources of En-Route info			
	Internet	Radio	TV	Tom Tom	Other	Tom Tom	Radio	VMS	Other
No Info treatment	31%	63%	3%	0%	7%	0%	58%	54%	9%
Info treatment	1%	28%	0%	82%	0%	88%	11%	29%	88%

*The total percentage is higher than 100% because more than one source of information could be checked.

3.3 Compliance with information provision

Regarding compliance with information, an interesting fact observed is that although en-route information is checked more often, travelers are more willing to comply with pre-trip information (Table 5). This may be influenced by (i) the fact that changing

routes while en-route would imply taking local roads and thus the resultant time-saving would not be so large, (ii) habit, so being aware of a delay was already “good” and travelers prefer then to stick to their own routes or (iii) information matches intended route and as a result although travelers are actually also “following” the information, it may be perceived as unnecessary/not needed. From Table 5 it is also possible to observe that in general informed travelers are more willing to comply with information than non-informed travelers which reinforces the benefit of provision of personalized traffic information.

Table 5: Compliance with all sources of information based on the travel diaries*

Treatment	Number of Trips			Overall		Informed Travelers		Non-Informed Travelers	
	Overall	Informed Travelers	Non-Informed Travelers	Comply with Pre-Trip Info	Comply with En-Route Info	Comply with Pre-Trip Info	Comply with En-Route Info	Comply with Pre-Trip Info	Comply with En-Route Info
<i>No Info treatment</i>	374	316	58	64%	50%	67%	49%	50%	2%
<i>Info treatment</i>	523	464	59	82%	75%	84%	75%	50%	24%

* The percentages are calculated based on the number of trips in which information was actually checked

4 Conclusions and next steps

This paper presents some findings of an RP route choice experiment conducted in the Netherlands between May 9th, 2011 and July 12th, 2011 in which the route choices of 32 participants were tracked with the aid of GPS devices. In this paper we focus on travelers reaction to traffic information in a real congested network over a period of 9 weeks and in particular we investigate whether travelers check travel information, which sources, and whether information is used to influence their behavior. The RP survey resulted in 897 observed trips with correspondent *travel diaries* of which 374 refer to trips made before provision of personalized traffic information and 523 otherwise.

Descriptive analyses of our data set suggest that equipping travelers with proper devices to provide personalized real time traffic information substantially increases the likelihood they will use it to assist their travel related decisions. However, as discussed before, the information provided was most of the times aligned with travelers expectations. Thus, no substantial change in their route choice patterns was observed and the consequent impact on network dynamics remains to be investigated. This is particularly the case for situations in which the traffic information diverges from travelers expectations.

In addition, although en-route information appears to be checked more often, travelers are more willing to comply with pre-trip information. This may be influenced by (i) the fact that changing routes while en-route would imply taking local roads and thus the resultant time-saving would not be so high, (ii) habit, so being aware of a delay was already “good” and travelers prefer then to stick to their own routes or (iii) information matches intended route and as a result although travelers are actually also “following” the information, it may be perceived as unnecessary/not needed. In addition, as the information provided was most of the times aligned with travelers intentions, no substantial change in their route choice patterns was identified. Thus, it clearly remains to be investigated how travelers would react in case the information was not aligned to their expectations.

The fact that travelers do not appear to have an explorative behavior, suggest that the role of habit in route choice decisions might be very strong. As we are dealing with commuters, it is very likely that the explorative phase has already passed and they have “*learned*” about routes’ characteristics and consequently what their best choice is. In case habit plays such a stronger role, provision of information that is not aligned to travelers’ expectations might consequently lead to even lower compliance rates and impact on network dynamics. Conversely, if habit does not play such a stronger role, more emphasis should be put on research that focus on the role of routes’ characteristics, thus allowing to further investigate aspects such as the ones mentioned in item (i) above.

We are aware of the limitations of our data set which consisted of investigating the behavior of only 32 commuters. Nevertheless, based on the data sample of our RP experiment we could observe important aspects of travel behavior that diverge from what has been reported in the literature. While on the one hand our sample has limitations, findings reported by the literature are often based on SP experiments. More RP experiments are definitely mandatory before definitive conclusions can be made. Our RP experiment is one of the first attempts to investigate travelers’ behavior in a real setting and we hope this encourages more research in this direction.

Research already in progress concerns estimation of a route choice model based on the RP data and transportation network of this experiment. Based on a model estimation we intend to discuss findings of this paper such as that travelers appear to be risk prone when making route choice decisions.

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