The economics of trip scheduling, travel time variability and traffic information

Peer, S.

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English Summary

This dissertation sheds light on various aspects of travelers' scheduling behavior in the presence of recurrent and non-recurrent congestion. In particular, the role of travel time information is emphasized, as it determines whether travelers consider a specific delay as recurrent or non-recurrent, and, as a consequence, to which extent travelers are able to adjust their scheduling choices accordingly. A good understanding of these choices at the level of the individual traveler is crucial for predicting travelers' responses to transport policies, and thus for an accurate evaluation of these policies.

All analyses contained in this thesis take into account recurrent congestion, which is the source of two different types of costs: Costs due to travel time losses and schedule delay costs. The latter result if drivers, when facing recurrent congestion, decide for an arrival time that differs from their preferred arrival time. While the costs caused by travel time losses are taken into account in all analyses (Chapters 2–6), schedule delay costs are considered only in Chapters 3–6. Costs related to non-recurrent congestion are taken into account in all chapters, either as a function of the standard deviation of travel times (Chapter 2), or of schedule delays (Chapters 3–6).

Chapter 2 establishes a method to compute the costs of non-recurrent congestion (variability) as a function of the costs that result from travel time losses caused by recurrent congestion (mean delay). The relation between variability (expressed in terms of the standard deviation) and mean delay shows to be close to linear. Assuming that the unit valuations attached to travel time and variability gains are constant, the costs of non-recurrent congestion can be defined as a mark-up to the costs associated with the travel time losses due to recurrent congestion. This is an important result as it implies that the costs of non-recurrent congestion can be approximated using a fairly simple rule of thumb.

Chapter 2 distinguishes between two measures of variability, which differ in their assumption on how well drivers are informed about day-specific characteristics that potentially affect travel times (e.g. weather conditions, day of the week, season). 'Rough information' implies that travelers consider all deviations from the average (time-of-day-specific) travel time as non-recurrent delays, while 'fine information' implies that only deviations from the day- and time-of-day-specific travel time expectation are regarded as non-recurrent delays. The costs of non-recurrent congestion are fairly sensitive with respect to which type of information drivers have. For instance, assuming a reliability ratio[1] of 0.8 and a link length of 10 km, an increase in the costs of mean delay of 10 Euro is associated with an increase of 3.2 Euro in the costs of non-recurrent congestion if travelers have only rough information, as opposed to an increase of 2 Euro if travelers have fine information. The relation between variability and mean delay depends also on link-specific characteristics, most importantly link length. Ceteris paribus, the costs of variability increase in link length, however, less than proportionally. Finally, the relation between variability and mean delay is also affected by the relative predominance of free-flow, flow-congested and hyper-congested traffic states at a certain time of day. For a given mean delay and time of the day, the costs of variability are highest if free-flow conditions apply on most days, and lowest if hyper-congested conditions tend to prevail.

While Chapter 2 focuses on the aggregate (network link) level, Chapters 3–6 analyze disaggregate scheduling decisions of individual travelers. Chapters 3–5 contain empirical analyses, using revealed preference (RP) data from a real-life peak-avoidance experiment conducted in the Netherlands.[2] Participants of the experiment were eligible for a monetary reward if they avoided using a specific highway link during the morning peak. In Chapter 4, the RP data are combined with data from a stated preference (SP) experiment. Finally, Chapter 6 comprises a theoretical bottleneck model with endogenous scheduling decisions. It does not use any empirical data as input.

In order to estimate scheduling models employing the random utility framework, travel time measurements must be available for the chosen as well as the unchosen departure time alternatives. Chapter 3 argues that for obtaining unbiased valuations of travel time, it is crucial to use door-to-door travel times in RP-based scheduling models. The main reasoning is that travel times tend to be correlated positively across links. So, if due to a lack of data only travel times on subparts of the trip are considered, or fixed travel times are assumed on some links, differences between peak and off-peak travel times may be underestimated, leading to an overestimated value of time. Moreover, non-recurrent congestion can only be taken into account if the analyst knows to which extent travel times differ across days. This renders the use of travel time data from surveys or traffic assignment models challenging as these tend to be deterministic.

For the case of the peak avoidance experiment that is covered in Chapters 3–5, continuous measurements are only available for the highway link along which the peak-avoidance experiment took place. In addition to these, sparse GPS measurements for

[1] The reliability ratio is defined as the value of reliability (VOR) divided by the value of time (VOT).
[2] *Spitsmijden* experiment in Dutch: See Appendix A for an overview of the experimental setup.

the remaining relevant parts of the network are available. Using these two data sources, Chapter 3 implements a geographically weighted regression (GWR) model to approximate day-, time-of-day- and location-specific door-to-door travel times, which then allow for deriving measures of expected travel times and travel time variability. The analysis shows that biased valuations of time result if very rough travel time approximations are used.

Chapter 4 focuses on travel time perceptions. Participants of the peak avoidance experiment were asked to report their average travel times for their morning commute. These reported travel times were then contrasted with actual, observed travel times. It is found that on average participants overstate travel times by a factor of ca. 1.5 compared to actual travel times. Chapter 4 tests the hypothesis brought forward by Brownstone and Small (2005) stating that if drivers overestimate delays in reality, they should react to stated delays (e.g. in an SP experiment) as if they were overestimated too. For this purpose, a joint model including RP and SP observations from the same drivers is estimated. If the hypothesis was true, drivers with a higher ratio of reported to actual travel times are expected to have an SP-based value of time that is relatively low compared to their RP-based value of time. This effect shows to be relatively minor in the context of the peak avoidance experiment considered here. Moreover, no evidence is found that drivers act in reality as if they would overestimate travel times to a similar extent as they overstate them. It can therefore be concluded that there is strong evidence of 'overstating', however, much less evidence of 'overreacting', neither in SP nor in RP. The results obtained in Chapter 4 thus serve as a note of caution regarding the use of reported travel time data.

Chapters 5 and 6 introduce a distinction between long-run choices of travel routines and short-run choices of (daily) departure times, taking into account that travel times typically vary across days. In the long-run model, drivers choose their routine arrival time subject to the recurrent congestion pattern and their long-run preferred arrival time. The latter is considered exogenous, and is defined as the preferred moment of arrival if congestion was always absent. In the short run, drivers have better information about travel time realizations on a given day than in the long run, when they are only aware of the recurrent congestion pattern. Given this short-run information, they may decide to choose a departure time that results in an arrival time different from their routine arrival time. Chapter 5 models this distinction in an empirical setting, whereas Chapter 6 adopts the theoretical framework of bottleneck congestion to model the differences between long-run and short-run scheduling preferences (Vickrey, 1969; Arnott et al., 1990).

Chapter 5 finds that the long-run and short-run values of travel time and schedule delays (on a given day) diverge strongly, namely by factors between 2 and 5. So, changes in travel time that are considered recurrent (hence, long-run changes) are valued significantly higher than changes that are non-recurrent (hence, short-run changes), most likely because recurrent changes in travel time can be exploited better through the re-scheduling of routines. Conversely, schedule delays are valued higher if they are non-recurrent. An intuitive explanation is that incidental changes induce higher costs because travelers find it difficult to adapt their schedules in the short run.

Chapter 6 focuses on the equilibrium implications of the distinction between long-run and short-run scheduling decisions. Under the assumption that the long-run preferred arrival time is equal across drivers, the user equilibrium implies that short-run preferred arrival times are dispersed in time. The social optimum can then be achieved by applying long-run tolls and first-best short-run tolls, simultaneously. In the second-best situation with short-run tolls being the only available pricing instrument, the same welfare level as in the social optimum can be achieved by applying so-called complementary short-run tolls. Finally, if only long-run tolls can be levied, the social optimum is not reachable any longer.

References

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