Transportation systems are affected by uncertainties of various sorts. As a result, reliability has become a critical dimension in user experience of transportation services. On one hand, lack of reliability either encourages overly conservative risk-averse behavior or leads to uncomfortable, sometimes disastrous, disruptions to personal and business schedules. On the other hand, users’ risk-taking behavior in presence of uncertainties may collectively affect the “equilibrium” of traffic in the system, and hence the design and operational decisions.

In this study, a unified approach is proposed to model heterogenous risk-taking behavior in route choice based on the theory of stochastic dominance (SD), a tool widely used in finance and economics. We show that, the paths preferred by travelers with different risk-taking behavior can be obtained by enumerating the corresponding SD-admissible paths, and that general dynamic programming can be employed to generate these paths. The relationship between the SD theory and several route choice models found in the literature is also discussed. These route choice models employ a variety of indexes to measure reliability, which often makes the problem of finding optimal paths intractable. We show that the optimal paths with respect to these reliability indexes often belong to one of the three SD-admissible path sets. This finding offers not only an interpretation of risk-taking behavior consistent with the SD theory for these route choice models, but also a unified and computationally viable solution approach through SD-admissible path sets, which are usually small and can be generated without having to enumerate all paths.

We also introduce two applications of the stochastic dominance approach. In the first, the first-order SD is used to solve the percentile user-equilibrium traffic assignment problem, in which travelers are assumed to choose routes to minimize the percentile travel time, i.e. the travel time budget that ensures their preferred probability of on-time arrival. The second application considers the optimal path problems with second-order stochastic dominance constraints, which arise when travelers are concerned with the tradeoff between the risks associated with random travel time and other travel costs. Risk-averse behavior is embedded in such problems by requiring the random travel times on the optimal paths to stochastically dominate that on a benchmark path in the second order. For each application, we give a formulation and briefly discuss solution algorithms.

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