An Advanced Traveler General Information System

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SUMMARY

This study explores the use of an advanced traveler general information system (ATGIS), which informs transportation users about their fuel consumption and health-related emissions costs and transforms the way users make travel choices. We provide a novel modeling approach that calculates theses costs for alternative travel choices and estimates the effects of an ATGIS without a need for major computationally-expensive changes in the existing models. We also provide the insights required for the design of an ATGIS. Using a metropolitan area, Fresno, CA as the case study, we found several interesting results: i) the ATGIS impact is closely related to pre-system perceived fuel and emissions costs by users; ii) providing the information about emissions costs, although the costs are small relative to fuel and time costs, could effectively improve system performance; and iii) the ATGIS is more effective under high gas prices and with poor pre-system costs perceptions.

Keywords- *Advanced traveler information system, Fuel consumption, Emissions costs.*

BACKGROUND

The advanced traveler information system, a major cyber-physical system (CPS), has been developed based on the notion that providing exact and online travel time information would efficiently change users' travel behavior. Generally, the emphasis is on travel time information rather than providing fuel and other travel costs information. However, implementing a scheme informing users of fuel and emissions costs could make them more sensitive to these costs and could potentially save million dollars of energy and mitigate environmental footprints of (urban) transportation.

Building on an earlier effort, the present study models and estimates the effects of an ATGIS on people's travel choice behavior. We simulate the problem using four different behavioral assumptions and formulations: the user equilibrium (UE), multi-user general cost equilibrium (MUGCE), general cost equilibrium (GCE), and random general cost equilibrium (RGCE) problems. The last three models are new formulations proposed by this study.

The MUGCE Model is based on the multi-user equilibrium concept, in which one group of users has complete information on fuel and emissions costs of possible routes and chooses the least-general-cost paths (m=1), and the other group has no clear information and chooses routes based only on travel time (m=2), as in the basic UE. The GCE Model simulates a condition where users consider all travel costs in their travel choices, assuming only one user group. The RGCE Model is the same as the GCE model, except that instead of actual fuel and emissions costs, the random perceived fuel and emissions costs are considered.

PROPOSED RESEARCH

In this study, we examine several research questions: a) what is the impact of providing the information in various already (pre)perceived information conditions?, b) how effective is the ATGIS compared to a congestion pricing (CP) scheme?, c) what effects do travel demand (peak vs. off-peak), fuel price levels, and emissions cost rates have on the policy's success?, and d) what are the results of providing emissions costs information to users in addition to fuel cost and travel time information? Our empirical application is the Fresno city's road network.

Using the EMFAC-2011 model, we calculate the emission and fuel consumption factors for different vehicle classes at different speed levels. Figure 1 shows the calculation process and the estimated morning peak emissions costs for an average vehicle. The emissions and fuel consumption costs can be also calculated for each vehicle class, for various travel demand levels (off-peak hours), for various assumptions about cost parameters, and for each travel mode choice.

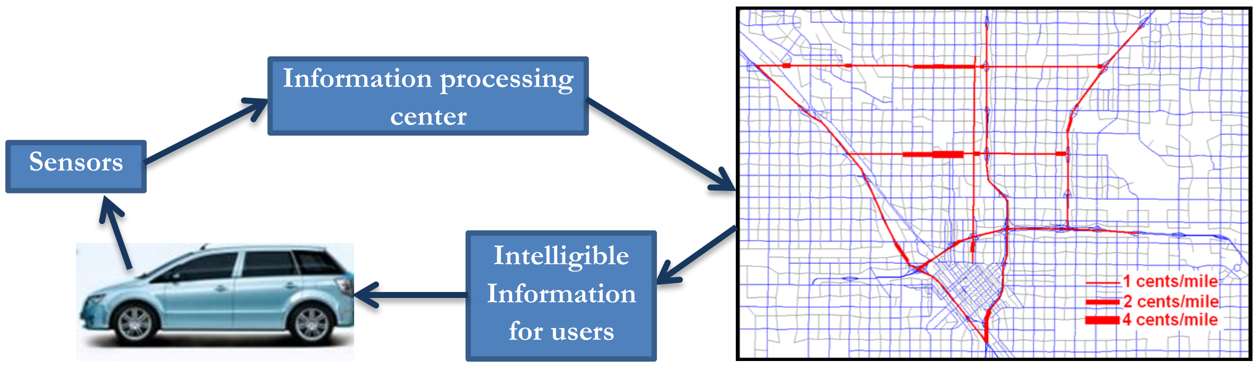

FIG. 1 A CPS informing Emissions costs on few Alternative roads (cents/mile)

In addition, we solve the various problems described in the previous section under different conditions. As shown in Figure 2, the provision of information about emissions costs, with the market penetration of %100, significantly reduce the total travel time of the transportation system (1% and 0.6% for peak and off-peak periods) and the total system-wide fuel consumption (0.6% and 0.4% for peak and off-peak periods), relative to when no emissions are perceived by all users. The addition of emissions costs, although negligible relative to fuel and time costs, could effectively reduce total system-wide travel time saving millions of dollars in a major metropolitan area.

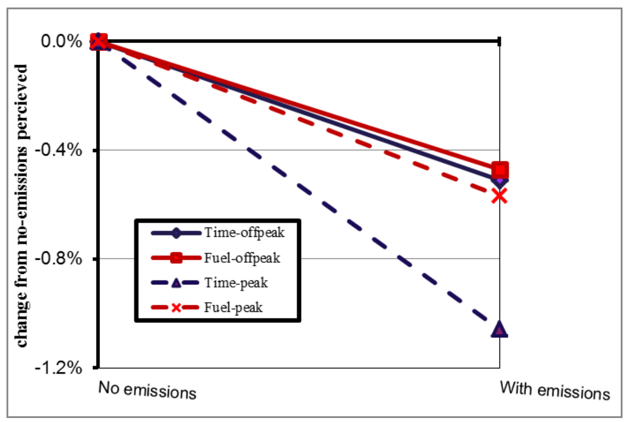

FIG. 2 ATGIS effects on the system-wide travel costs (poor perceptions about emissions)

POTENTIAL IMPACTS

- ❖ This study provides the insights required for the real-world design of an ATGIS, especially about the appropriate mechanism to compute fuel consumption and emissions accurately, and the potential impact of such information system on a transportation system.
- ❖ Our results show that an ATGIS can efficiently change travel behavior, especially under high fuel prices and poor users' perceptions, however, its impact is closely related to pre-system perceived fuel and emissions costs. In fact, when users pre-perceive higher general travel costs than the actual costs, an ATGIS could diminish system performance by inducing a higher travel demand.
- ❖ The ATGIS effects depend on the level of demand. For peak hours, the effects would be higher on the CBD than on the whole system (the opposite for off-peak). For congested conditions (peak), providing the information would decrease travel on the CBD. But for off-peak hours, would increase travel on shorter but more congested CBD-based routes.
- ❖ The addition of emissions costs, although negligible relative to fuel and time costs, could effectively reduce total system-wide travel time and fuel consumption by about 1% and 0.6% for peak hours (in the case of no perceived costs prior to ATGIS). These seemingly small changes could save millions of dollars in a major metropolitan area.
- ❖ From a social welfare view, an ATGIS for a medium size city could reduce total social costs by as much as $1053 m (high gas price, no pre-perceived costs) to $48 million (low gas price, precise pre- perceived costs).