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Investigating the impact of high-speed rail equipment visualization on mode choice models: Case study in central Texas

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ABSTRACT

High-speed passenger rail (HSR) is seen as an ideal solution for fast, safe, and resource-efficient mobility for intercity travel. For proposed HSR service, stated preference (SP) surveys are necessary to obtain the data needed for ridership forecasting. In SP surveys, it may be helpful to include images of the options being examined to support respondent decision-making. However, it is unclear from the current literature how images of a passenger train included in an SP survey affect mode choice models developed from the resulting survey data. This paper presents a case study examining the impacts of including images of proposed high-speed passenger trains in SP surveys for HSR service planning activities based on a survey of residents in two communities in Central Texas. Three groups were examined − a control group with a "text-only" description of proposed rail service, an image of an average-quality train, and an image of a premium-quality train. Analysis of the survey responses found that the value of time (VOT) for respondents viewing the premium image was nearly twice the VOT for the text-only condition. However, the premium-quality train image had a lower error variance, resulting in a data set that was less "noisy" than the other image or the base condition. This analysis provides a starting point for a broader discussion on how HSR is portrayed in surveys and the potential for eliciting bias based on the images displayed.

1. Introduction

High-speed passenger rail (HSR) is seen by many in the U.S. transportation policy and planning communities as an ideal solution for fast, safe, and resource-efficient mobility in high-demand intercity corridors between 100 and 500 miles in total endpoint-to-endpoint length (FRA, 2009, 2010; Peterman et al., 2009). While this means of travel has been implemented widely and with much success in Europe and Asia for several decades (e.g., Givoni, 2006; Campos and de Rus, 2009), development of a world-class HSR system in the U.S. has not been realized. In the U.S., passenger rail in the Northeast Corridor (Washington D.C.–New York–Boston) can reach up to 150 miles per hour in some places along the route, but average speeds are generally much lower, resulting in an average speed of just over 80 miles per hour (Schwieterman and Sheidt, 2007). Outside of the Northeast, although efforts have been ongoing for several decades (e.g., Fisher and Nice, 2007; FRA, 1997; Schwieterman and Sheidt, 2007), HSR development has been unsuccessful. Proposals across the U.S. totaling more than 15,000 route-miles have been identified as potential HSR corridors, including major initiatives in California, the Midwest, and the Southeast as well as privately-led efforts in Florida and Texas.

A critical element of the planning and decision-making process for transportation systems investments is understanding how travel demand is impacted by a proposed investment. For example, the introduction of a new travel mode can affect a mode shift for some travelers, improve travel conditions for other travelers, and stimulate new trips. Understanding these impacts is essential for informed decision-making for new transportation investments. For new transportation modes such as high-speed intercity passenger rail, it is difficult to forecast potential ridership and mode shift, as well as the resulting impacts on other parts of the transportation system, using historical data where no such data exist. Additionally, it is difficult to isolate the effects of certain factors such as travel time or travel cost from existing data, where the many aspects of traveler decision-making are confounded and not easily measured. The use of stated preference (SP) surveys can overcome these issues by presenting survey respondents with hypothetical situations in an environment where the key variables can be varied in a controlled manner such that the trade-offs can be

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accurately measured (Steer Davies Gleave, 2011a). Consequently, many ridership studies for proposed HSR routes in the U.S. utilize SP data to support mode choice modeling and ridership forecasting activities (e.g., AECOM Consulting and Wilbur Smith Associates, 2002; Cambridge Systematics, 2008, 2012; Louis Berger Group Inc., 2015). SP mode choice models for HSR services have also been discussed in the academic literature (e.g., Bhat, 1995, 1997a,b; González-Savignat, 2004; Hensher, 1997; Outwater et al., 2010).

Recent developments in HSR and passenger rail expansion in the U.S. have raised the conversation about the issue of forecasting accuracy and the uncertainties associated with ridership forecasting. The accuracy of demand forecasting for "mega-projects" such as HSR initiatives has been questioned (e.g., Flyvbjerg et al., 2005); international experience in Korea (Lee and Chang, 2006) and Taiwan (Cheng, 2010) has highlighted the issues of over-estimating HSR ridership at the planning stages. Accuracy in mode choice modeling for HSR routes is also essential to an accurate economic appraisal of proposed HSR initiatives. For instance, one key benefit of HSR service is the time savings realized by travelers using HSR instead of other modes. The monetary value of this time savings is calculated using the expected value of time (VOT) of the rail travelers, which is also estimated primarily from stated preference models. Accurate estimates of rail traveler VOT are essential to accurately calculating the economic benefits derived from time savings (e.g., Brand et al., 1992, 2001; Hultkrantz, 2013; Steer Davies Gleave, 2011b). Consequently, for numerous reasons, an accurate mode choice model is critical to informed decision-making for HSR projects.

One particular concern in the application of SP surveys for HSR is the issue of familiarity of the individual taking the survey with all the travel choices presented in the survey. Specifically, a respondent may not be familiar with proposed HSR services that are the subject of the survey and therefore may not have enough information to make a decision when presented with a hypothetical travel choice (Steer Davies Gleave, 2011a). To mitigate this concern, the design of the survey would likely incorporate a description of proposed HSR services and the features of the service on the basis that the respondent might be unfamiliar with HSR. Images of the proposed services may also be included with the description. On one hand, including images provides respondents with additional information which may be helpful in aiding the respondent in making choices presented in the survey. On the other hand, the presentation of the equipment may introduce an unintended bias in the survey responses, particularly if the images do not portray a realistic scenario in terms of how the actual HSR services may appear. Understanding how images affect responses to an SP survey for passenger rail planning is needed to understand how the underlying mode choice models are impacted. At a minimum, it is unclear from the current literature how images of a passenger train included in an SP survey affect the development of mode choice models from the resulting survey data. This paper seeks to add clarity to this issue by presenting a case study examining the impacts of including images of proposed high-speed passenger trains in SP surveys for HSR service planning activities based on a survey of residents in two communities in Central Texas.

2. Literature review

Stated preference surveys are used to obtain information for planning new travel modes or significant changes to existing travel modes for which current behavioral data cannot adequately predict future preferences. Because there are very few HSR routes in the U.S., SP surveys are used to assist with demand forecasting and related service planning activities. The quality of the data obtained from an SP survey is related to a number of factors, one such factor being the level of "realism" in the SP exercise. Since SP surveys are commonly undertaken to study a hypothetical product or travel alternative, designers typically wish to include as much information as possible to aid the respondent in understanding the choice task. The main motivation for improving the realism of the exercise is to reduce respondent burden, which in turn improves both the quantity and the quality of the survey responses. To this end, some literature suggests the use of visual representations of attributes or alternatives in an SP survey to supplement verbal or written descriptions. Several benefits of including pictorial representations of attributes or alternatives in choice experiments have been identified in the literature (Bradley, 1988; Green and Srinivasan, 1978; Jansen et al., 2009):

- Certain attributes or alternatives may be difficult to describe with text descriptions;
- Visualization may improve comprehension and understanding of the choice task by reducing information overload, resulting in better choices;
- Visualization may lead to higher perception homogeneity because images may be open to less individual interpretation than written descriptions; and
- The choice task may be more interesting or less fatiguing to respondents.

Visual material in the name of improved realism is designed to aid the respondent in understanding the choice task. In these applications, the common phrase "a picture is worth a thousand words" is appropriate to describe the motivation for adding images to a survey. Most research on the subject of adding images to SP surveys has focused on topics where visual material may be useful to respondents. For example, the work of Louviere et al. (1987) in the context of destination choice for state parks found no difference between visual and verbal descriptions of the state parks. In their study of consumer preferences for car stereo equipment, Vriens et al. (1998) found that pictorial representations of the equipment improved respondents' understanding of the complex design attributes of the equipment while written representations resulted in greater predictive accuracy. As computing and graphics technology have improved, the level of detail that can be examined in a research study on the impacts of images in SP surveys has also increased. For example, Orzechowski et al. (2005) incorporated visualization into text descriptions of housing choices and found that the images had no effect on the validity of the survey responses and provided greater reliability. Jansen et al. (2009) examined the impacts of images in two small-scale studies of housing and neighborhood preferences in the Netherlands. They found that including the images resulted in differences in the choice models; these differences were attributed to the accidental (i.e., extraneous) details included in the images. Patterson et al. (2017) found that the use of virtual reality material in a landscape preference survey resulted in more significant variables and an improved model fit as compared to the text-only model.

The use of visual material to add realism to the SP exercise in transportation applications is not a new concept (e.g., Carson et al., 1994) and appears to be standard practice, particularly for complex situations. Visualization applications for SP surveys in the transportation realm include studies of crash risk on urban streets (Iragüen and Ortúzar, 2004), non-motorized travel preferences (Clifton and Perez, 2015; Tilahun et al., 2007), and customer preferences for premium transit options (Hensher and Mulley, 2015). The use of visualization in the context of SP surveys for passenger rail planning also appears in the literature, although far less common. Since the proposed rail service is the hypothetical alternative in an SP survey, providing respondents with some visual material describing the proposed rail service has been mentioned in the literature. In a survey supporting the design of a very fast train (VFT) system in Australia, Gunn et al. (1992) reported providing the respondent with a "realistic brochure describing the VFT service, including a route map, a timetable, a picture of the train, and a description of some service features." In their questionnaire, Gehrt and Rajan (2007) reported providing the respondent with "color photos of