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The variation in the value of travel-time savings and the dilemma of high-speed rail in China

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ABSTRACT

This paper examines the variation in the value of travel-time savings (VTTS), a fundamental element determining the market demand for high-speed rail. Following a review of time allocation theories, a time allocation model for general travel behavior is proposed as a further elaboration of Evans' (1972) activities analysis. There are relationships among activities that can be expressed using a linear inequality to show the constraints on the arrangement of activities. This model indicates that two or more activities can be simultaneously rearranged to improve time management, which may be a source of variation in VTTS. This time allocation model can explain why large-scale high-speed rail construction in China faces significant market risks and a high likelihood of economic loss. Data from a new ticket sales and booking system for railway passengers indicate that passengers prefer conventional overnight sleeper trains, rather than high-speed trains, for long-distance travel, which supports the analysis of the time allocation model.

1. Introduction

Travel is widely thought to be derived demand, and a reduction in travel time is assumed to benefit passengers. Therefore, reducing travel time has remained an important consideration in transportation infrastructure investment. How passengers evaluate the value of travel-time savings (VTTS) is a fundamental determinant of the market demand and is also a critical parameter in decisions about the speed target value, which is especially important for high-speed rail construction because of the large capital investment required for rail infrastructure.

China began large-scale high-speed rail (HSR) construction in 2004, and more than 10,000 km of high-speed lines were in operation by the end of 2013. In China, none of the high-speed lines in operational reach breaks even, and the revenues from high-speed rail lines cannot even cover the interest on construction loans.

The most obvious benefit of HSR is that it saves travelers time. HSR's revenue depends on the value it offers to passengers, i.e., on the market demand for HSRs. While travel market demand is very complex, travelers consider not only travel time, ticket price and travel time reliability (Li et al., 2010; Bates et al., 2001; Abate et al., 2013) but also suitable departure and arrival times. For a long-distance journey at night, the passenger may not want to arrive earlier at the destination, e.g., at midnight. Thus, faster is not necessarily always better, and the VTTS varies depending on the situation. However, in project appraisals, a common assumption is that the VTTS is a constant.

An interesting paper (Wu et al., 2014) on the problems surrounding HSR in China estimates that the VTTS of a 500-km HSR between Beijing and Shanghai is 4.49 Euro and that the VTTS between Zhengzhou and Xian is 3.34 Euro, which is the

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average value of time multiplied by the travel time saved by HSR. They conclude that because the value of time is low in China, except in the richest and most densely populated areas, the full initiation of HSR throughout the country will be difficult to justify. In many areas, building advanced conventional railways is a better solution to address China's rail capacity problems.

We agree with this conclusion, which is based on the assumption that the VTTS is constant. Our paper emphasizes that the VTTS is not constant, especially in long-distance travel, which can further justify this conclusion. Another problem of the paper mentioned above is that its analysis is based on a 500-km HSR model, which is suitable for European countries, where the distance of travel by HSR is rarely more than 500 km. However, in China, the distances between major cities are more than 1000 km; at this distance, conventional sleeper trains rather than HSR is the first choice of most travelers. This paper will provide a theoretical explanation for this phenomenon.

This paper focuses on the special nature of VTTS, which is the key to understanding the market demand in long-distance travel. First, some time allocation models are reviewed to clarify the concept of VTTS, and their assumptions are rechecked. Second, a time allocation model is proposed to present the components of VTTS and its mechanisms of variation. Third, this time allocation model will provide insight into the problems of HSR construction in China. Empirical evidence shows that HSR has no comparative advantage over air travel and conventional sleeper trains for long-distance travel, and the large-scale construction of HSR may become a serious drag on China's economic development[1] (Zhao, 2006).

Currently, encouraged by HSR construction in China, a number of countries, such as the U.S., India, and Brazil, are considering building HSR as a component of a 21st-century sustainable transportation infrastructure. The analysis of this paper encourages policymakers in those countries to be cautious in their HSR market demand analysis based on China's experience with HSR.

2. A review of time allocation theory

2.1. The evolution of the time allocation model

Including a time dimension in an economic model is challenging because the characteristics of the time resource are different from those of other economic resources, and the time factor is too "slippery" to analyze. Becker (1965) made the first attempt to develop a general treatment of the allocation of time in all non-work activities. First, he assumed that the time spent consuming a good is fixed; for example, drinking a cup of coffee requires 10 min. Due to this strict assumption, Becker failed to explain the value of time savings. Second, Becker assumed that one period of time can only be used to consume one good, which does not agree with common sense. For example, people commonly watch a film and drink a cup of coffee simultaneously. Some shortcomings of Becker's model were addressed by Johnson (1966) and DeSerpa (1971).

In contrast with Becker, Johnson argued that work time must be included in the utility function because work and leisure are distinct variables that are involved in time allocation decisions. Johnson also separated the money budget constraint and the time budget constraint, clearly making the time dimension an independent constraint in his model. Different specifications of the utility function and constraints lead to different conclusions. According to Johnson's model, the marginal rate of the substitution of income for leisure or the value of travel time must be less than the money wage rate. Although this conclusion may contradict some characteristics of time, the value of time can change with specific situations. Various qualitative factors, such as travel convenience, comfort, and safety level, can affect the value of travel time. Albert Einstein once illustrated the relativity of time by saying, "When a man sits with a pretty girl for an hour, it seems like a minute. However, let him sit on a hot stove for a minute and it's longer than any hour." In this example, the value of spending time with a pretty girl must be higher than the money wage rate. The value of time varies based on its usage and the specific situation. Johnson's conclusion must result from an incorrect specification in the model, particularly its inelastic time constraint.

Evans (1972) thought that Johnson confused the value of a relaxation in the time constraint with the value of time used in a particular activity. He created a model using an activities analysis to show the relationship between activities. Evans' activities analysis is an important contribution, which changes the implicit assumption in time allocation models that the consumer is free to allocate his time among activities. In fact, the activities analysis increases an additional linear inequality constraint in Johnson's model to represent the relationship between activities. For example, the additional constraint relates the time that a consumer spends traveling to the cinema to the time that he actually spends at the cinema. This relationship was represented by a linear inequality $a_t \geqslant ba_c$, where a_t and a_c denote the travel time and the time spent at the cinema, respectively, and b is a constant. However, the most important issue is how the activities analysis can illustrate different activity arrangements.

DeSerpa (1971) provided a new explanation of the value of time savings (VTS). By introducing a series of inequality time constraints, DeSerpa defined the concept of VTS. DeSerpa's utility function includes n types of consumption goods, n units of time allocated to each good, and n inequality constraints. The inequality constraints indicate the extents of time for the activities, but they do not define the relationship between activities, as in Evans' model. The question is whether the time allocated to one activity is independent of the time spent on another activity or whether these activities can be rearranged. What is the value of time if several activities occur simultaneously? For example, a man is sitting on a train with a pretty girl and

[1] Zhao Jian's opinion was cited not only by Chinese media but also by the *New York Times*, the *Washington Post*, *Time* magazine and the *Financial Times*.