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Modelling value of time for trip chains in daily schedules

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Abstract

The decision about spending time on an activity, switching to the next activity and transport mode used to travel to the next activity location depends on money value of time; opportunity cost of time at activity. Optimal condition of transition between two activities occurs when their marginal utility of time is equal. The presented framework in this paper models the marginal utility of activity to express the money benefit earned by spending each unit of time at the given activity. The proposed model is generalized for the schedule with any number of activities as contrast to previous studies, where such models were used for schedules with fixed number of activities. This framework can be used to calculate the loss in value of time due decreased activity participation resulting from travel delays.

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Keywords: Value of time; Opportunity cost of time;

1. Introduction

Money value of time of an individual varies according to the types of the activities at which it is spent. The decision about spending time on an activity, switching to the next activity and transport mode used to travel to the next activity location depends on money value of time; opportunity cost of time at activity[1]. For example, during early morning, an individual who has to be at work at 9 am will like to stay at home rather than starting work at 7 am. So, opportunity cost of work activity before/after the preferred start/end time will be minimum[2]. Net benefit earned by spending time on any activity is bound by the preferred start time of the activity and its duration. On the other hand,

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start time of the activity and activity duration also depends on travel mode; eventually travel duration. Where travel duration also depends on selected mode and respective travel delay associated with selected mode. Mode of travel can be selected out of available modes to the individual in order to keep travel duration minimum with available travel budget. Hence, activities in daily schedule are optimized to escalate the net benefit earned by time distribution in all activities and required travel by a trade-off between money and time spent on the travel. This is important, for example, for decision to pay an extra euro cent to avoid getting delayed for one-unit time depends upon the individual's urgency for being at destination.

In order to evaluate the benefit earned by spending time in activities and traveling, a model is presented in this paper. A marginal money value of time function is used to estimate the value of time of an individual coupled with type of activities. For the given activity, this model is used to calculate the net profit earned by spending time on this activity by the individual. The time spent on the activity is subject to the activity start time; in other words, in case of undesirable activity start time due to late/earlier arrival, net profit earned cannot be maximum as compared with optimal case. In such scenarios, this model is used to calculate the lost benefit which could be earned by starting the activity at preferred start time.

Any unwanted incident in transportation system can cause significant disruptions in transportation system which creates losses in capacity and efficiency of the system. Such situations may lead to travel time increase that propagate to the nearby transportation network through queues and congestions. Delay in travel duration can impair the expected activity participation; hence earned satisfaction cannot reach at expected level which can result in loss of value of time. Daily schedules consist of the chain of daily activities which are partially flexible which means that time lost during one trip can be compensated from all of the succeeding activities if there is no hard deadline. To compensate the lost time, activity start time and duration are recalculated for all of the succeeding activities after the time loss incident[3]. To capture the loss due to decreased participation in all activities, accumulated benefit is calculated by applying this model to all activities in the schedule for comparison between optimal and recalculated timings.

This paper is organized as follow: Section 2 provides the conceptual theory of presented framework. It describes the utility function is sum of marginal utilities of all activities in the schedule, then it describes the marginal utility function of an activity. Section 3 provides a procedure to calibrate the parameters used in marginal utility. Section 4 provides the conclusion drawn from this work.

2. Opportunity cost of time

The decision about allocation of available resources to different activities is made to maximize the satisfaction to fulfil the individual's needs. Time and money are vital resources which are used to accomplish the long and short-term goals. Time is a finite resource which neither can be acquired nor stored but can be distributed in daily activities such that it yields maximum satisfaction[4]. Time spent on different activities can be valued in term of foregone opportunity; opportunity cost of time of any activity in a daily schedule is the net benefit of the time spent in next best alternative activity[1].

2.1. Theoretical framework

The framework modelled in this work postulates that individuals take part in daily activities and make trips to travel between activities. There are fixed number of activities with a given sequence for each individual which construct the daily schedule of that individual. Each activity has a preferred start time, duration and the location. The initial daily schedules of whole population of study area are generated using activity-based model FEATHERS[5] and are considered optimal. Optimal schedule connotes that activity start time and duration are considered optimized and preferred by the individual which yields maximum satisfaction required by the individual by activity participation. It is the maximum benefit earned by the individual by spending time at different activities and trips during the day and it is represented by utility function U. Total utility of the schedule is sum of utility of all activities and disutility of all trips in the schedule. The utility gained by spending a unit time on any activity is expressed as marginal utility which is the function of start time and time of the day. Such models have formulated previously by Ettema and Timmermans[6], Zhang et al.[7] and Jenelius[8], however all previous models only formulate the fixed number of activities. In this work, the described framework is used to calculate the value of time for schedules created by an