Transportation Research Part B 93 (2016) 162–180

Contents lists available at ScienceDirect

Transportation Research Part B

journal homepage: www.elsevier.com/locate/trb

Introducing relations between activities and goods consumption in microeconomic time use models

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ARTICLE INFO

Article history:
Received 25 October 2015
Revised 21 July 2016
Accepted 22 July 2016
Available online 1 August 2016

Keywords:
Time use model
Value of time
Leisure
Work
Microeconomics
Time management
Utility theory
Utility maximization

ABSTRACT

We present a microeconomic model for time use and consumption for workers with an improved treatment of the (technical) relations between goods and time. In addition to the traditional time and income constraints, an improved set of restrictions involving explicit relations between consumption of goods and time assigned to activities is included in two versions. In each version, a system of equations involving a subset of the consumer's decision variables is obtained, including (1) work time, (2) activities that are assigned more time than the minimum, and (3) goods that are consumed above the minimum. The system cannot be solved explicitly in the endogenous decision variables but is used to set a stochastic system for econometric estimation through maximum likelihood. The models are applied to analyze weekly time use and consumption data from Netherlands for year 2012. The results obtained by this new "goods and time" framework are compared with previous research in terms of the value of leisure and the value of work, showing substantial differences in the valuation of time.

1. Introduction

Workers' behavior in terms of their use of time has been studied from many perspectives and in many disciplines, including labor economics and transportation. Among such studies, the common thread has been the attempt to explain workers' time use as a function of exogenous variables with the aim to understand the frequency, duration, and sequence of activity participations (see Bhat and Koppelman, 1993). A key component of such a time-use analysis is an understanding of workers' willingness to pay to decrease travel time, which incorporates several effects, including the value of doing something else (leisure or work). In particular, changes in transportation affect travel time and, therefore, have an impact on the allocation of time to non-travel activities.

Many approaches have been used to understand the allocation and valuation of time. One of the most popular approaches is the expansion of the basic microeconomic consumer theory by including time in a utility function that represents

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http://dx.doi.org/10.1016/j.trb.2016.07.014
0191-2615/

unconstrained ordinal preferences and adding temporal restrictions besides the budget constraint. As known, consumer theory looks at the individual as if he or she chooses what he or she prefers; from this viewpoint, utility (an unobservable artifact) is only a construction from which (observable) demand functions can be obtained. The essence of these models is that the individual assigns money to buy goods and invests time to undertake activities through a strategic underlying equilibrium mechanism between money and time; as known, time cannot be "saved" but it can certainly be reallocated after changes in exogenous conditions (e.g. income, prices). Since these microeconomic models simultaneously consider time and income constraints and choices involving money and time, different types of time values can be developed, including value of time as a resource, value of working time, and value of assigning time to an activity. These values are important in the evaluation of transportation policies, because the benefits of the reduction of travel time can be economically measured using the different estimated values of time.

Becker's study (1965) appears to be the first to include time and its value in microeconomic consumer theory. Becker proposed final goods—combinations of market goods and preparation time—as the argument of the utility function and the inclusion of a total time constraint, time equivalent of the typical total income restriction (see Pollack, 2003 and Cherchye et al., 2015 for discussions). According to Beckerś framework, the value of time as a resource is equal to the individual's wage rate. Some years later, DeSerpa (1971) modified Becker's model by including directly goods consumption and time allocation in the utility function. DeSerpa also added technological restrictions, linking the consumption of goods with a certain minimum time of consumption. DeSerpa was the first to clearly define leisure activities (those the individual assigns more time than the minimum) and its value, obtaining relations between the different values of time. As a derivation of the first order conditions, DeSerpa indicated that the value of leisure is equal to the total value of work (wage rate plus the intrinsic value of working time); he further indicated that the willingness to pay to save time in an activity is equal to the value of leisure (the value of doing something else) plus the value of time assigned to that activity. Evans (1972) proposed a utility function depending only on time assigned to activities and a new type of restriction linking time assigned to different activities, i.e., the time assigned to a particular activity could be directly related to the time assigned to another one. As noted by Jara-Díaz (2003), the money budget constraint in Evans' model contains a transformation of activities into the consumption of goods that can be interpreted as another type of technical relation between goods and time.

Since the theoretical frameworks of Becker, DeSerpa, and Evans, the literature of microeconomic time use models has expanded in several directions (for a detailed review, see Jara-Díaz, 2007), including the study of travel time and mode choice within the goods-leisure tradeoff framework (Train and McFadden, 1978), investigations related to home-production (Gronau, 1986), time-specific analysis (Pawlak et al., 2015, López-Ospina et al., 2015) and of course more theoretical developments regarding the type of restrictions and variables that should be considered in the consumer theory framework. Thus, building from DeSerpa (1971) and Evans (1972), Jara-Díaz (2003) showed that there are two types of *technical* relations between goods consumed and time assigned to activities. Simply put, they can be stated as minimum activity times that depend on the amount of goods needed to perform them (a generalization of DeSerpa) and minimum consumption of goods induced by the activities undertaken (a generalization of Evans). These two families of relations can be treated as yet additional constraints in a consumer behavior microeconomic framework including time use, such that exogenous changes (e.g. re-design of the transit system or improvements in communication systems) will affect these relations and induce a change in time use patterns.

If a good is consumed, there may be a minimum consumption level or expenditure associated with that good. Similarly, if an activity type is participated in, there may be a minimum level of time investment required in the participation (for example, taking a child to the doctor's office entails some minimum level of time spent at the doctor's office). Individuals may generally prefer to strictly stick to the minimum consumption (or expenditure) level for some goods (let this set of goods be denoted by G^R), while may consume (or expend) more than the minimum for some other goods (let this set of goods be denoted by G^F). In a similar vein, individuals may invest the minimum possible time for certain activity types (let this set of activity types be A^R), while they may invest more than the minimum for certain activity types (let this set of activity types be A^F, the leisure activities according to DeSerpa).

In their simplest form, both types of technical relations were introduced by Jara-Díaz and Guevara (2003) and expanded in Jara-Díaz et al. (2008) as exogenously given minimum levels of good consumption and time allocation, a very simplified manner to account for these types of constraints. Jara-Díaz et al.'s (2008) formulation considered, as usual, that consumption of different goods and time assignment to different types of activities are the consumer's decision variables. Although quite limited as a representation of the technical constraints, the simple formulation allowed for a closed analytical solution in three types of variables: (1) time assigned to activities beyond the minimum (those in A^F), (2) work time, and (3) amount of goods consumed above the corresponding minimum (those in G^F). By considering additive interdependent errors in the resulting equation system, the utility parameters can be estimated and, for the first time, the (marginal) values of leisure and work were actually estimated and computed. Here, the value of leisure is equal to the value of time as a resource.

However, there is a component of the total value of leisure that is different from the value of time as a resource. This difference cannot be revealed with Jara-Díaz's (2008) model because, as suggested by Konduri et al. (2011) and shown by Jara-Díaz and Astroza (2013), explicit relations between goods consumed and time assigned are needed. To begin accounting for this, here we consider two models: one where time allocated to activities impose minimum consumption of certain goods, a generalization of Evans (1972); and another where goods consumed impose a minimum necessary time to activities, a generalization of DeSerpa (1971). Unlike previous empirical models, all these minima become endogenous. That is, we explicitly tie goods consumption (or expenditures) levels to time-use. Although closed solutions cannot be obtained in either