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Analysis

A parsimonious, stacked latent-class methodology for predicting behavioral heterogeneity in terms of life-constraint heterogeneity

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ABSTRACT

Our conjecture is that for many recreational activities a significant amount of the variation in the sites visited can be explained, and predicted, by variation in life constraints such as kids, BMI (body-mass index) fitness, skill, and health. The objective is to develop a parsimonious method for identifying behavioral heterogeneity caused by life-constraint heterogeneity and separating it from that caused by preference heterogeneity. We estimate, for two different recreational activities, with two independent data sets, how much behavioral heterogeneity can be attributed to life-constraint heterogeneity. We develop and estimate a stacked latent-class approach to life constraints, assuming individuals have many correlated life constraints. First, at the bottom of the stack, a latent-class life-constraint model is specified and estimated; then life-constraint class becomes a covariate in a behavioral latent-class model of participation and site selection. We find, with both simple statistics and behavioral models, that life-constraint classes explain a significant amount of the observed behavioral heterogeneity. Prediction is a critical reason to distinguish the influence of current constraints from the influence of current preferences: it is easy to directly observe life-constraint levels. Stacked latent-class models have many potential applications, besides ours.

1. Introduction

Modeling and estimating the observed variation in recreational behavior (behavioral heterogeneity), not caused by price and income variation, are the *raisons d'être* for much research in recreation demand.

One objective is to develop a parsimonious method of identifying behavioral heterogeneity caused by constraint heterogeneity and separating it from that caused by preference heterogeneity. We do this by developing and estimating stacked latent-class models of constraints and behaviors: the output from a latent-class model of constraints becomes a covariate in a latent-class model of behavior.

Our conjecture is that for many recreational activities, a significant amount of the variation in the sites visited can be explained, and predicted, by the simultaneous variation in a large number of correlated explanatory variables, variables such as number of kids, marital status, BMI (body-mass index) fitness, skill, disease, resting heart rate, alcohol consumption, cigarette consumption, and blood pressure.

While a variable that helps explain behavioral variation is often referred to as a "preference shifter," we argue that it is proper and more productive to call explanatory variables of the above sort *life constraints*. Behavioral heterogeneity, not due to price and income variation, is typically assumed due, in total, to preference heterogeneity. We find this misguiding.

We are in good company when we argue that preference heterogeneity should be separated from constraint heterogeneity and that preference heterogeneity should not be relied on to explain most behavioral heterogeneity. Stigler and Becker (1977) conclude that "no significant behavior has been illuminated by assumptions of differences in tastes." Their view is now foreign to many in recreation

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demand. Their argument is that because preference heterogeneity can explain all behavioral heterogeneity, it explains "nothing." They argue that little is gained by attributing behavioral differences to preference variation; more strongly they argue that much unexplained behavioral variation is explained by constraint variation, if one looks hard enough.

We begin by defining behavioral heterogeneity, preferences, preference heterogeneity, constraints, and constraint heterogeneity, doing so in terms of a simple choice model with only one life constraint, a model that we abandon for being intractable when there are a large number of correlated life constraints.

Behavioral heterogeneity is simply the variation in behavior across individuals. [2]

Since we argue that it is important to distinguish between preferences and constraints, it is important that both be carefully defined.

In economics there is not an explicit and generally accepted definition of the word *constraint*. For the purpose of this paper, we define a "constraint" as an exogenous variable or exogenous mapping between variables that influences the behavior of the individual, exogenous in the sense that the individual cannot change it in the choice period. A constraint is a *relevant exogenous variable* or *mapping*.

The price of a Coke is an example of a constraint that can be represented by a level of a variable, so is an individual's weight. The "budget constraint" is an example of a constraining exogenous *mapping*, another example of a constraining mapping is how fast one can hike as a function of one's weight, fitness, and level of effort.

Exogeneity is necessary but not sufficient: by our definition, a constraint must also influence behavior. The temperature on Saturn is exogenous to us all, but has no influence on the behavior of most of us, so is not a constraint; the weather on Earth is a constraint.[3]

Note that many current constraints are determined by past choices and behaviors, sometimes our choices, sometimes those of others. For instance, being married is, in the short run, a constraint. That it is a constraint does not mean that all those married ones would prefer to be un-married; married being a constraint only means that marital status can't be changed in the current choice period and that being married influences one's behavior. Or to take another example, having three children is hopefully—but need not be—a function of one's past preferences, but it is not a "function" of one's current preferences; it is a given. It is noteworthy that economists are comfortable calling "income" a constraint, but some of us are uncomfortable when these other variables are referred to as constraints.

What is, and is not, a constraint is obviously a function of the length of the choice period: the shorter the decision period the fewer the choices. In our two recreation applications we take the view that the decision period is a few days to a week, so the levels of many variables are fixed in the decision period (people typically do not plan short recreation trips months or years in advance). We will, for example, take the average level of overall exercise per week and skill level in the recreation activity as exogenous when each trip choice is made.[4] Alternatively, if one viewed the individual as simultaneous choosing, in early adulthood, how many children to have, whether to become an expert mountain biker, who to marry, and how many hours they would exercise per week in 2012, these would all be, at the beginning of adulthood, choice variables, not constraints.

An individual's preferences are, simply put, the order in which he would choose "states." While preferences can change, the ordering is exogenous in the choice period.[5]

Preferences are typically represented with either a direct or an indirect utility function: a direct utility function associates a number with every conceivable consumption bundle such that higher ranked bundles, states of consumption, are given larger numbers, whereas the indirect utility function associates a number with every conceivable state of the world such that higher ranked states are given larger numbers. A state is defined in terms of the levels of a vector of relevant exogenous variables. In addition to prices and income, these include the exogenous amount of attribute c in good/activity j. The indirect utility function represents the individual's preference ranking of constraints such that preferences are embodied in the functional form and parameter values: preferences being what converts the constraint vector into a number.

In this research, we extend the list of relevant exogenous variables. For example, BMI is a constraint, and BMI affects one's ability to recreate and enjoy recreation. Number of kids is another constraint, so is having a disease. For expositional simplicity we will refer to age, gender, race and other *born-withs* as "constraints" adding the adjective "life" to reflect constraints determined by the life one has experienced.

Life-constraints are levels of consumer durables with high disposal costs—there is no free disposable of spouse, kids, or weight. In the short run, one no longer has choice over these dimensions, and one's demands for other commodities become derived demands. Kids, for example, increase the demand for commodities that complement kids (minivans, trips to Disneyland, easy hiking trails) and decrease the demand for substitutes for children (e.g. high-end restaurant meals, and skill, time, and endurance-intensive recreation). Unfitness and excess weight influence the ability to recreate (negatively complement recreation and complement sedentary activities). Lack of skill, strength, or endurance can remove some activities from the choice set. Current income is a life constraint, so are religious and ethical beliefs, and one's "moral duty."

The distinction between preference heterogeneity and constraint heterogeneity is made concrete by identifying parameters, variables, and functional forms that are the determinants of what one does. One can completely specify an individual's behavior by specifying their indirect utility function: its functional form, its variables, and its parameters. It is a complete determinant of what the individual will do given the levels of the variables in the indirect utility function. The functional form for the indirect utility function is typically assumed the same for all individuals. Parameters take constant numerical values from the individual's perspective; they might differ across individuals but, in the choice period, are exogenous constants for the individual. Such parameters are what we typically want to estimate. Preference heterogeneity is typically *characterized* by allowing some of the parameters in the indirect utility function, the "preference parameters," to vary across individuals.

Making this concrete with a simple discrete-choice example, assume that individual i must choose one of J alternatives, $j=1, 2,\ldots, J$, where income not spent on the alternative is spent on the numeraire. Assume income in the choice period is y_i, and that p_{ji} is the price of alternative j for individual i, such that if the individual chooses alternative j they spend $(y_i - p_{ji})$ on the numeraire. For

[2] We chose the word "behavior" rather than "choice," because it is our conjecture that all behaviors are not chosen/selected.

[3] Some would call the weather on Saturn a "non-binding constraint". In our terminology, a non-binding constraint is simply an exogenous variable with no influence.

[4] Justifying—skill level is acquired gradually, and while one can exercise less, or a bit more, than they did in the previous week, one cannot, without risking injury, rapidly increase exercise time, and since exercise exhibits properties of addiction (Rhodes et al., 2003) large cutbacks are often unpleasant. Being skilled implies one practiced the activity in the past, but does not imply that one, now, participates—we abandon activities when we are bored or because the levels of other life constraints change (e.g., kids arrive).

[5] The reader might correctly note that by our definition of constraint one's "preferences" are a constraint: standard consumer theory assumes preferences are exogenous and influence behavior. So, to keep the two terms separate we will use the word *preferences* to denote the exogenous order in which an individual would choose states, and the word *constraint* to denote all other exogenous influential variables and mappings.