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By Any Means Necessary? Modelling the Link Between Private Budgets and Public Projects Using Mental Accounting

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Overview

One of the most substantial challenges facing practitioners of social cost-benefit analysis is in accurately measuring preferences over public goods. The use by many such studies of (implicit) trade-offs between private and public goods conflicts with research demonstrating gaps between the choices made by 'consumers' and 'citizens'. We propose a new framework for conceptualizing these choices within a unified set of preferences, referred to as the cognitive budgeting model (CBM). The CBM uses well-established cognitive constraints to operationalize mental accounting in a modified utility tree; individuals adapt to the complexity of large choice sets by nesting items within a multi-tiered budget. However, this also leads to 'imperfect fungibility' (Hess et al., 2012) by restricting choices between items in different nests, with important implications for the use of CBA in transport projects.

Introduction

Cost-benefit analysis (CBA) has long served as an important planning tool, particularly for evaluating and ranking transport infrastructure investments (see, e.g., Eliasson & Lundberg, 2012; Grant-Muller et al., 2001; Hayashi & Morisugi, 2000; Odgaard, Kelly, & Laird, 2006). Standard CBA assumes that willingness-to-pay in (hypothetical) markets can be used to value the effects of government projects (Fuguitt & Wilcox, 1999). This notion, often referred to as 'consumer sovereignty' (Sugden, 2007), has been criticized for failing to recognize potential disconnects between private choices and preferences over public goods. Such a 'consumer-citizen duality'

(Ackerman and Heinzerling, 2004; Hauer, 1994) has been supported by recent empirical evidence (Alphonce et al., 2014; Mouter and Chorus, 2016). For instance, Mouter et al. (2017) find that individuals in their role as citizens assign a higher relative value to safety (versus travel time) than they do in their choices as drivers (consumers of mobility).

Despite competing interpretations of the consumer-citizen duality (Blamey et al., 1995; Curtis and McConnell, 2002; Nyborg, 2000; Ovaskainen and Kniivila, 2005; Nyborg, 2000), we believe public spending to be, directly or indirectly, an extension of personal spending. Households effectively permit public authorities to spend a portion of their own income for them; paying for certain goods ourselves can be inefficient - by failing to realize economies of scale – while unenforced collective investment can lead to suboptimal equilibria on a societal level (Fischbacher et al., 2001). If the government budget is an extension of individual budgets, then we need a means of comparing the two from the household's perspective. In this paper, we present a simple model for doing so.

Model

Individuals (consciously or subconsciously) manage decisional complexity by grouping goods into sets; a single, highly-dimensional consumption problem becomes a number of smaller ones. Bridging this gap between cognitive capacity and task difficulty facilitates utility optimization, lessening reliance on heuristics (Heiner, 1983). Drawing inspiration from Terence Gorman's classic two-stage budgeting model (1995) and the 'utility tree' described by Robert Strotz (1957), we propose a mental accounting procedure for dividing the full space of goods $\mathbb{X}$ over an individual-specific budgetary hierarchy $\mathcal{B}$.

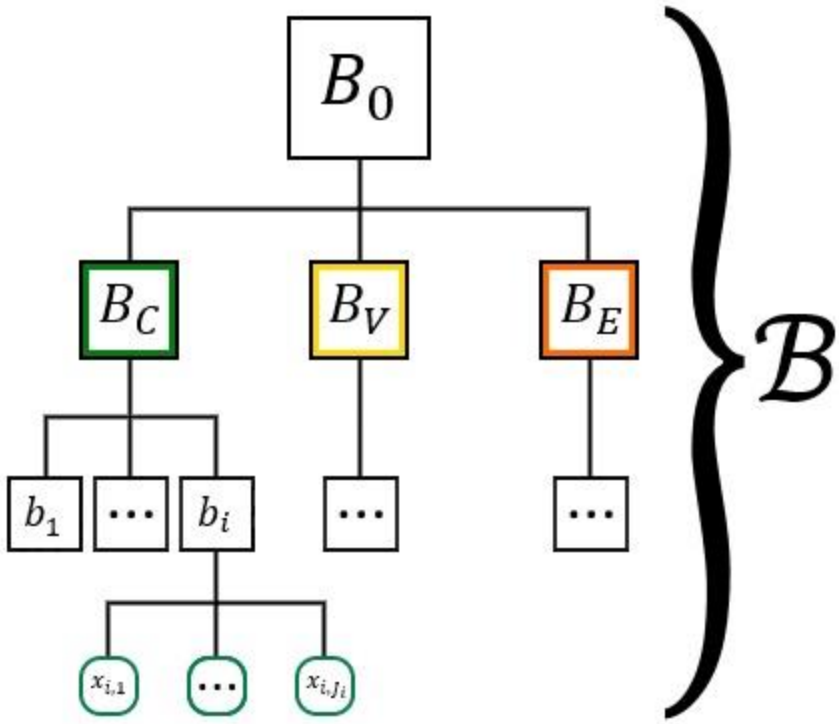

Figure 1: Illustration of $\mathcal{B}$

Gross income – the budget constraint before taxes, fixed contributions, or mental accounts – is denoted B_0. This contains three broad categories. Consumption, labelled as B_C, is uncommitted disposable income. This category is where the most active optimization takes place, and most closely resembles the assumptions of traditional choice models. Voluntary delegation B_V is disposable income whose day-to-day use is determined by another party, but which the individual can retake control over at relatively low cost. Such 'club goods' (Buchanan, 1965; Scotchmer, 2002) include gym memberships and online streaming subscriptions, both of which allow individuals to take advantage of economies of scale and avoid making complex purchasing decisions for themselves. Finally, enforced delegation B_E is tax-financed spending. This is relatively difficult for the individual to reallocate, and includes classic public goods such as national security, street lighting, and highways, which the private sector generally cannot provide efficiently.

Each category is broken down into budgets representing spending on a class of related goods – 'food' or 'clothing' under B_C or 'investments in highways' under B_E, for instance. Every

budget $b_i,\ i \in \{1, \dots, I\}$ is composed of either two or more sub-budgets[1], or of a set of goods $X_i = \{x_{i1}, x_{i2}, \dots, x_{iJ_i}\}$, where J_i is the size of the choice set within budget b_i. To distinguish between these two cases, a budget containing only goods is labelled a 'primary budget', while one containing other budgets is a 'secondary budget'.

This is deliberately flexible: from a transport perspective, for instance, an individual may choose to divide their budget for mobility into sub-budgets for work-related mobility and leisure-related mobility. Earlier research suggests the importance of separability in determining what belongs to which budget (Gorman, 1995). Generally, the less similar two goods are, the further away they are from each other along the tree. With the structure of $\mathcal{B}$ established, the individual allocates B_0 across budgets, with the monetary value of each secondary budget being the sum of its sub-budgets. As with determining the structure, the exact allocation procedure is not very important at this stage.

Optimizing within a primary budget b_i is straightforward given prices and the budget constraint. This is not yet enough, however, to provide insight into the ex-post choices between private and public goods.

Out-of-Budget Valuations

We distinguish between 'observed' and 'experienced' utility. The latter results from preferences satisfying the assumptions of utility theory, such that every individual has an underlying utility function $u^{\exp}$ over all goods in $\mathbb{X}$. As mental accounting is inconsistent with unified utility functions (Hess et al., 2018), however, an individual employing cognitive budgeting cannot directly observe $u^{\exp}$; instead, they can obtain utility 'signals' by approximating its local derivative. As such, we present utility in marginal rather than aggregate terms:

$$v_{ij}^{\text{obs}} = \frac{\partial u^{\text{obs}}}{\partial x_{ij}} = \tilde{v}_{ij} + \sum_{m \in S_{ir}} \eta_m = \tilde{v}_{ij} + \sum_{m \in S_{ir}} V_m + \sum_{m \in S_{ir}} \epsilon_m, \quad \epsilon_m \overset{iid}{\sim} \mathcal{N}(0, \sigma^2)$$

$$v_{ij}^{\text{exp}} = \frac{\partial u^{\text{exp}}}{\partial x_{ij}} = \tilde{v}_{ij} + \sum_{m \in S_{ir}} V_m = v_{ij}$$

We define good or set $r \neq b_i$ as the 'reference point' for valuation. From r, we find the shortest path S_{ir} to good x_{ij} along the tree. Our observed value of x_{ij} is the sum of its idiosyncratic value $\tilde{v}_{ij}$ and noise and signal values for every budget in between.

[1] 'Sub-budget' is a relational term: a budget can be another's sub-budget just as one person can be another's child.

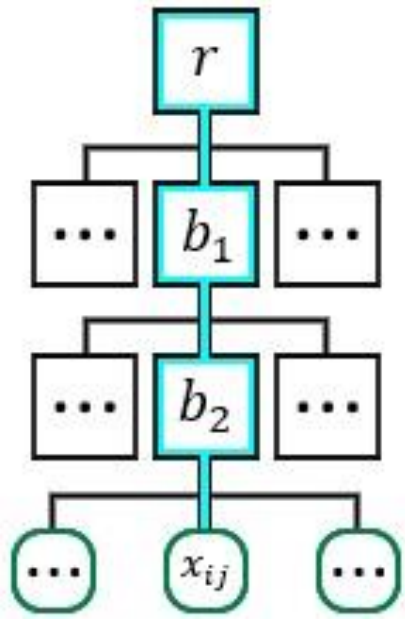

Figure 2: Out-of-budget valuation from reference point r, with shortest path highlighted. In this example, $v_{ij}^{\text{obs}} = \tilde{v}_{ij} + (V_1 + \epsilon_1) + (V_2 + \epsilon_2)$.

While each good has a 'true' utility value v_{ij}, each containing budget captures some of this as a separate additive term, leaving the residual $\tilde{v}_{ij}$ for any observed utility that is not common to all other goods in the set. The V_m terms represent the utility that items in each nest have in common – such as (almost) all shoes being able to protect your feet from a hot sidewalk – while ϵ_m represents the difficulty in choosing between unrelated goods. The individual cannot distinguish between the components of v_{ij}^{obs} prior to consumption, but knows the total variance of the noise terms. This budgeting comes at the cost of complicating direct comparisons between goods in different mental accounts, with noise levels increasing as our choice crosses more categories. A similar logic applies to budget- or category-level valuations, which are more relevant when discussing willingness-to-pay – the primary difference is that these require aggregation of multiple utility signals to generate a shadow price.

External reference points arise when comparing goods from different categories. Uncertainty over inter-budgetary choice problems could lead to not only suboptimal decision-making, but perhaps even the unobserved adoption of new simplifying heuristics (Heiner, 1983). This combination of decisional framing and mental accounting violates fungibility across budgets (Hess, Orr, and Sheldon, 2012), justifying the selective relaxation of the assumptions of optimal decision-making: the less an individual conceives of two goods as belonging to related choice sets, the less confident we are in the evaluation made between them.

Discussion

Coping with the complexity of choice may influence decision-making over public goods. We perceive functions outsourced to governments differently from those within our control, weakening the fungibility between the two. Imposing an (implicit) trade-off between personal income and new highway lanes or railroad underpasses forces households to make the kind of decision they had intended to leave to someone else. Comparing the qualities of very different goods introduces noise, and failure to determine how individuals address this – whether by expected utility maximization, heuristics, or some other means – introduces uncertainty into the measurement of preferences. Efficiency within a delegated budget is therefore difficult to reach through comparisons to individuals' disposable incomes. Further refinements regarding how individuals address noisy utility signals could help explain empirical findings of imperfect fungibility (Hess et al., 2012). This has particular implications for the reliability of the contingent valuation method (CVM), which assumes complete fungibility across budgets. The CBM also lends support to the notion of replacing willingness-to-pay for public goods with 'willingness-to-allocate' within a single budget.

While we have broadly outlined the cognitive budgeting model, much work remains in making it a useful tool for practitioners of CBA. Beyond the logical follow-up of making concrete predictions for cases in the transport literature, our theoretical contributions need empirical verification. Nevertheless, we are confident that the CBM represents a potentially significant first step towards improving the way we perform cost-benefit analyses for public projects.

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