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What floats your boat? Preference revelation from lotteries over complex goods

Jonathan K. Yoder^{a,*}, Adrienne M. Ohler^b, Hayley H. Chouinard^a^a Washington State University, School of Economic Sciences, United States^b Illinois State University, Department of Economics, United States

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ABSTRACT

We examine a type of lottery used to distribute some publicly held resource access rights. The lottery provides participants with the opportunity to choose among a set of simple gambles over multi-attribute goods. Participant choices result in an endogenous distribution of success rates over gambles that reflects tradeoffs between the relative desirability of the available goods and the probability of winning. When lottery winnings are multi-attribute goods, lottery outcomes provide sufficient information to estimate hedonic prices, marginal utility, and marginal rates of substitution among attributes. We develop a model for characterizing preferences from this information set. We apply our model to Idaho's Four Rivers Whitewater Recreation Lottery, which allows applicants to apply for one permit among a large set of alternative river/day combinations that provide varying river and weather characteristics. This lottery structure shows promise as a foundation for economic experiments for preference revelation.

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Introduction

Lotteries of various forms have been used to distribute flu vaccines, public school choice, hunting and rafting permits, public market space for vendors, land, and public housing. Idaho's Four Rivers Lottery for Whitewater Rafting allows people to apply for a permit to raft one of Idaho's four most popular wilderness rivers. An applicant applies for one particular river and day among many possible river-day combinations. The choice among rivers and days is consequential because these river sections differ in their characteristics, and because water and weather characteristics vary substantially through the permit season. Some river/days are far more preferred than others, resulting in a distribution over the probability of winning a permit that ranges from less than 4% to nearly 100%. The basic structure of the Four Rivers Lottery is often used to distribute recreational permits and some other publicly held goods.

This lottery structure provides applicants a choice among a set of simple gambles, each of which provides the possibility of winning one associated complex (multi-attribute) good. The results yield a set of equilibrium probabilities of winning, one for each good, determined by applicants' willingness to accept a lower chance of winning for a more preferable good. These equilibrium probabilities can be interpreted as relative prices that reflect the hedonic values of the goods' attributes. Because these prices are probabilities, an expected utility perspective on applicant choice allows the characterization of

* Corresponding author: Fax: +1 509 335 1173.

E-mail address: yoder@wsu.edu (J.K. Yoder).

marginal rates of substitution among characteristics, marginal utilities, and complete von Neumann–Morgenstern (vNM) utility maps.

We develop a model of applicant choice that provides a foundation for mapping applicant preferences. We apply the model to several years worth of data from the Four Rivers Lottery. Our estimation strategy proceeds by (1) estimating applicant expectations over river characteristics for the upcoming river rafting season, (2) estimating application rates over the available river/date alternatives, and (3) using the structure of the model of application rates to characterize preference relations.

The structure of this lottery is at the intersection of several extensive literatures: decision-making under risk or uncertainty and expected utility theory, endogenous risk in decision-making, general equilibrium models, demand for multi-attribute goods, and nonmarket valuation methods such as hedonic pricing and conjoint analysis. Though a great deal of literature has covered one or more of the characteristics of this lottery structure, direct examination of it is limited to a useful but methodologically narrow empirical literature focused on valuation methods.

The literature spawned by the expected utility framework of [von Neumann and Morgenstern \(1947\)](#) focuses largely on decisions over gambles with exogenous probabilities associated with prospective outcomes. For example, the now standard treatment of Arrow–Debreu general equilibrium with uncertainty is based on exogenous probabilities over state-contingent goods ([Arrow and Debreu, 1954](#); [Debreu, 1959](#); [Radner, 1968, 1970](#); [MasColell et al., 1995](#)). The endogenous distribution of win rates distinguishes the lottery we examine from much of this literature. The theoretical literature on random allocation mechanisms examines a broad set of random allocation structures. Of these, a pseudo-market mechanism ([Hylland and Zeckhauser, 1979](#)) and a generalization of it ([Budish et al., 2013](#)) develop a pricing mechanism that induces endogenous allocation probabilities over multiple assignments most similar in outcome to the lotteries examined in this paper, though the market and preference revelation structure differs.

Another extensive literature focuses on preferences over multi-attribute goods. [Lancaster \(1966\)](#) formalizes the relationship between the utility received from the activity of consuming complex goods and the attributes embodied in them, and [Keeney and Raiffa \(1976\)](#) develop an extensive examination of expected utility theory as applied to multi-attribute goods. Again, however, [Keeney and Raiffa \(1976\)](#) rely on fixed exogenous outcome probabilities throughout, and focus largely on individual, multi-outcome gambles.¹ In contrast, [Rapoport et al. \(2002\)](#) develop a model of multiple simple lotteries like the case we examine that provides the foundation for Nash-equilibria probabilities of winning. However, they focus on simple goods, so their model does not facilitate examination of tradeoffs among attributes of complex goods as we do.²

Other literature focuses on endogenous risk due to self-protection against environmental risk ([Shogren, 1991](#); [Shogren and Crocker, 1991](#)). This literature primarily examines single gambles with multiple (sometimes continuous) and unidimensional outcomes. A related literature focuses on choice among complex goods as a function of environmental risks, and relates these risks to option value, other welfare measures, and hedonic prices ([Freeman, 1993](#); [Bin et al., 2008](#)). In this literature, risk as probability of harm is exogenously associated with each potential outcome, and represents one attribute of the set of goods from which people choose. In the lottery we examine, the probability of any given outcome depends on participant preferences over the full set of available gambles.

While a general treatment of this specific lottery structure is sparse in the literature, a series of papers develops a useful but methodologically narrow approach to estimate demand and willingness to pay for lottery goods and their characteristics.³ [Nickerson \(1990\)](#) uses data most similar to ours, and develops the foundations for modeling aggregate lottery application rates. We extend this analysis to make inferences about preferences over the attributes of the goods.⁴

Three related papers ([Scrogin et al., 2000](#); [Scrogin and Berrens, 2003](#); [Scrogin, 2005](#)) (we refer to this group of papers as “SB”) examine hunting demand under New Mexico’s big game lottery system. These papers have goals similar to ours, but differ in one crucial way. As described above, applicants choose among gambles based on *ex ante* perceptions of the full set of success probabilities. All three SB papers base estimates of *ex ante* success probabilities on application rates from past lotteries and current lottery quotas. [Scrogin and Berrens \(2003\)](#) and [Scrogin \(2005\)](#) use these estimated success probabilities as explanatory variables in a second stage random utility model for applicant choice over lottery alternatives. The second stage model provides the structure to estimate compensating surplus relating to changes in quality attributes.

¹ [Keeney and Raiffa \(1976\)](#) cover a great many lottery and gamble structures, including several extensive examples. We found no examination of endogenous outcome probabilities.

² In addition, most of the attention in [Rapoport et al. \(2002\)](#) is on fixed group sizes. They examine the case of distributions over group sizes, but do not examine the economic process of selection into an applicant pool.

³ [Evans et al. \(2009\)](#) and some recent related literature develop theoretical models of hybrid allocation systems of the form of sequential or joint auction/lottery systems. [Evans et al. \(2009\)](#) focus on unidimensional homogeneous goods, and the interaction between auctions and a lottery, and so their framework is not very useful for our objectives.

⁴ See also precursors [Akabua et al. \(1999\)](#), [Boxall \(1995\)](#), and [Loomis \(1982a,b\)](#) relating to valuation of hunting using lottery data, and [Loomis \(1980\)](#) using rafting data for valuation. These papers are all travel cost models, with the latter ones using various forms of random utility models. Several papers focus on allocating public school classroom seats via lotteries. While the parents’ application choice affects the probability of winning and may reflect their values for academic standards, convenience in transportation, classroom type, and ethnic composition of a school, no research on public school lotteries model preferences for school characteristics as we do here, but instead look at differences in schooling outcomes as a function of competition in schools (e.g. [Cullen et al., 2006](#)). Additional papers that examine school choice via school lotteries but are methodologically unrelated to ours include (e.g. [Hastings and Weinstein, 2008](#); [Hastings et al., 2005](#)).

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