Available online at www.sciencedirect.com

SCIENCE DIRECT®

Economics Letters 91 (2006) 34–38

economics letters

www.elsevier.com/locate/econbase

# Violations of betweenness or random errors?

Pavlo R. Blavatskyy *

*Institute for Empirical Research in Economics, University of Zurich, Winterthurerstrasse 30, CH-8006 Zurich, Switzerland*

Received 12 January 2005; received in revised form 15 August 2005; accepted 6 October 2005
Available online 10 February 2006

**Abstract**

A betweenness axiom states that if $A$ and $B$ are equally good then a mixture of $A$ and $B$ is equally good as well. This note demonstrates that the violations of the betweenness axiom documented in several experimental studies can be alternatively attributed to the effect of random errors.


*Keywords:* Decision theory; Stochastic utility; Betweenness; Quasi-convex; Quasi-concave

*JEL classification:* C91; D81

## 1. Introduction

In choice under risk (e.g., Knight, 1921), a betweenness axiom states that if an individual is indifferent between two lotteries then a probability mixture of these two lotteries is equally good (e.g., Dekel, 1986). Apart from its normative appeal, the betweenness axiom is attractive because it is compatible with the Allais paradox (e.g., Chew, 1983) and it is sufficient for proving the existence of Nash equilibrium (e.g., Crawford, 1990). This note reexamines the experimental methodology of several studies conducted in the late 1980s and early 1990s to test the descriptive validity of the betweenness axiom. A casual survey of this literature suggests that betweenness axiom is not a descriptive axiom. However, when this empirical evidence is thoroughly examined, a more favorable picture emerges.

* Tel.: +41 1 6343586; fax: +41 1 6344978.
*E-mail address:* pavlo.blavatskyy@iew.unizh.ch.

0165-1765/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.econlet.2005.10.011

The literature on stochastic utility (e.g., Loomes and Sugden, 1998) reached a generic conclusion that some behavioral patterns, which appear as a systematic violation of a certain principle when taken at a face value, may actually support the principle once a stochastic specification is allowed. The present note demonstrates that this generic conclusion applies also to the case of the betweenness axiom. The violations of the betweenness discovered in several experimental studies can be in fact the result of random errors in choice under risk.

## 2. Experimental evidence on betweenness

This section briefly summarizes ten well-known experimental studies conducted in the late 1980s and early 1990s that document a systematic violation of the betweenness axiom. Coombs and Huang (1976) (experiment 1), Chew and Waller (1986), Camerer (1989), Battalio et al. (1990), Gigliotti and Sopher (1993) (experiments 1 and 3) and Camerer and Ho (1994) all find that, on average, 68% of subjects respect the betweenness. The remaining subjects are split between quasi-convex (i.e. they dislike randomization) and quasi-concave (i.e. they like randomization) preferences approximately in a non-corresponding proportion of 24% to 8%. This alleged systematic violation of the betweenness emerges when some lotteries used in the experiment are located on the edges of the probability triangle (e.g., Machina, 1982).

Coombs and Huang (1976) (experiment 2), Camerer (1992), Starmer (1992), and Gigliotti and Sopher (1993) (experiment 2) find that, on average, 76% of subjects respect the betweenness and a split between quasi-convex and quasi-concave preferences is non-systematic (approximately in a non-corresponding proportion of 14% to 10%) when all of the lotteries used in the experiment are located inside the probability triangle. Additionally, Camerer and Ho (1994) find that the asymmetry of the betweenness violations disappears and Bernasconi (1994) finds that the number of the betweenness violations decreases (although not their asymmetry) when the mixture of two lotteries is presented in a compound rather than a reduced form.

Finally, Prelec (1990) finds that 76% of subjects reveal quasi-concave preferences and only 24% of subjects respect the betweenness when probability mass of the hypothetical lotteries is largely shifted to the worst outcome. Camerer and Ho (1994) replicate this result for one lottery triple "TUV" in the experiment with real payoffs. Bernasconi (1994) documents a similar strong asymmetric violation of the betweenness in two lottery pairs (1 and 3), where a modal choice pattern is inconsistent with the betweenness axiom.

To sum up, the experimental studies frequently document an asymmetric split between quasi-convex and quasi-concave preferences. However, a modal choice is inconsistent with the betweenness axiom only in a few lottery pairs. Such empirical evidence has been accepted initially as a strong support for frequent violations of the betweenness (e.g., Camerer, 1992). The next section shows that this experimental evidence is actually consistent with stochastic betweenness theories formalized in the mid-1990s after the wave of experimental tests of the betweenness.

## 3. A reexamination of experimental methodology

All experimental studies mentioned in Section 2 employ the same method to test for the betweenness violations. An experimenter determines two lotteries $L_1$ and $L_2$ and an individual is asked to choose his