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Revealed Preferences for Randomization: An Overview†

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A widely documented aspect of decision-making is that the same person often makes a different choice from the same set of options—a phenomenon called stochastic, or random, choice. How should this be interpreted, and how should we apply revealed preferences, the fundamental tool to connect observable choices with utilities?

Two approaches are common. First, behavior may be stochastic because preferences themselves are stochastic: each choice reveals a preference, and the stochasticity of choice is a stochasticity of preferences.

Second, preferences may be stable, but subjects make stochastic mistakes; this is the approach implicit in typical empirical analysis. This view weakens the revealed preference approach positing that every choice reveals not a preference but rather a preference with a mistake.

In the past decade, several studies investigated a third possibility: that stochastic choice is due to an explicit *desire to randomize*. Suggested by Machina (1985), individuals may *prefer* to give a stochastic answer, as they may be unsure or have strict preferences for mixtures. Revealed preferences are thus applied directly, considering the *stochasticity itself* as a choice—the most direct application of the idea.

This paper aims to discuss recent evidence of stochastic choice as deliberate randomization. Understanding stochastic choice is of primary relevance for economics, and revealed preferences are the main tool to connect observations with utilities; it is paramount to understand how to apply it. In general, welfare considerations and out-of-sample predictions vary greatly depending on the interpretation.

I. Evidence of Deliberate Randomization

Classical experiments documented stochastic choice for the same individual by asking similar questions repeatedly, with repetitions distant from each other in time and usually separated by other questions. A tendency to give different answers is extensively documented in studies of human perception, where subjects are asked to indicate the alternative with higher values in some dimension like the number of dots or the length of a bar. Similar patterns are also found in incentivized experiments on choice. Mosteller and Nogee (1951) and Tversky (1969) are classical studies that document different answers to the same choice between gambles. In these experiments, repetitions are distant from each other, and subjects are not told that choices are repeated. Countless studies have since shown how widespread this phenomenon is.[1] While exact results vary, almost all subjects select different lotteries from the same choice sets at least once, and the majority do so often.

In the past decade, many studies aimed to test whether such inconsistency could be seen as a deliberate choice. They adopted essentially three approaches.

A. *Approach 1: Consecutive Repeated Choices*

A first method explicitly places the repetitions in a sequence. If subjects display the same stochasticity, this mitigates the concern that it is due to preferences changing, preferences discovery, or imperfect recall.

This method was introduced in Agranov and Ortoleva (2017) and Dwenger, Kübler, and Weizsäcker (2018). In Agranov and Ortoleva

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[1] Agranov and Ortoleva (2021) include more recent references. In some cases, repetitions were presented in the same experimental session, while in others, they were presented in sessions days apart.

(2017), subjects experienced distant repetitions as in classical experiments as well as consecutive repetitions; with the latter, subjects were explicitly told that each question was repeated. Most participants (71 percent) chose different answers also with consecutive repetitions, and stochastic choice behavior is strongly correlated in the two cases (distant and in-a-row repetitions). Notably, stochasticity is documented almost exclusively in questions where no option is "clearly better" than the other, i.e., "hard" questions. Essentially, no subjects randomize in other types of questions. It should be noted that "hard" questions are not necessarily those in which the expected values, or utilities, are the closest. The experiment shows that differences in expected utility (EU) between the options have limited predictive power and cannot account for the variation in stochasticity. Additional experiments show similar tendencies to randomize in questions on time preferences and allocations across different participants.[2] Dwenger, Kübler, and Weizsäcker (2018) ask subjects to make a choice twice from the same choice set and randomly determine which of these selections determines subjects' payments. They find that 28 percent of subjects choose different lotteries in the two repetitions.

B. *Approach 2: Coin Flip*

Other experiments allowed subjects to delegate their choice to an external randomization device, e.g., a coin flip, which could be costly or not. In Dwenger, Kübler, and Weizsäcker (2018), 53 percent of subjects delegate the decision to a free coin flip, while in Agranov and Ortoleva (2017), 29 percent do so when the coin flip is costly.[3]

Similar methods have been employed in other domains. For social preferences, subjects in Sandroni, Ludwig, and Kircher (2013) choose between two allocations (€7.5 only to themself or €5 to both) and a coin flip. About a third of participants choose to randomize, while this percentage drops to 6 percent when the 2 allocations involve only consumption goods for the self (money and a mug). In Cettolin and Riedl (2019), subjects choose between a risky outcome, an ambiguous one, and a 50-50 gamble between the two. About half of the participants choose the gamble.

C. *Approach 3: Convex Budget Sets*

Another set of studies allows subjects to make choices from approximately convex budgets, allowing them to choose a wider range of probabilities to randomize. Sopher and Narramore (2000) use it to study choice between gambles and find that most subjects choose mixtures of lotteries and that these mixtures are consistent over time.

Feldman and Rehbeck (forthcoming) use this method and add a verification stage after the choice to encourage subjects to think carefully and reduce noise. They find that almost all subjects (95 percent) randomize at least once during the experiment and roughly 45 percent of all choices display randomization.[4]

Agranov and Ortoleva (2021) use a modified MPL in which, in each row, subjects can specify the probability of the left and the right option. Defining the "range" as the set of rows for which subjects choose to randomize, they find that more than three-quarters of subjects report ranges and that ranges are "very large"; for example, when asked to choose between $\$x$ for sure and \$20 or \$0 with equal chances, on average subjects want to randomize for all xs between \$5.30 and \$12.[5]

Miao and Zhong (2018) use this method to study a dictator game in which participants can

[2] A final questionnaire asking subjects why they randomize found a predominance of answers in line with the idea of not being sure of what to choose. Reaction time data for consecutive repetitions also showed that subjects spent a long time thinking about the first instance but almost no time in subsequent ones, as if formulating and then implementing a plan.

[3] Permana (2020) introduces the option "I am not sure what to choose" in a standard multiple price list (MPL), in which case subjects receive a random draw between the two alternatives. This option is chosen less than 10 percent of the time, suggesting the importance of wording. See also Hey and Carbone (1995).

[4] They also compare this method with the consecutive repeated choices from the same choice sets as in Agranov and Ortoleva (2017) and Dwenger, Kübler, and Weizsäcker (2018), finding high consistency.

[5] Additionally, for the majority of participants, ranges involve values in the risk-seeking domain; i.e., the range spans beyond the risk-neutral value of the lottery, in contrast with typical definitions of risk aversion (also beyond EU).

choose any mixture between two allocations. About half of the participants prefer a mixture.

D. *Stochasticity across Domains*

Agranov, Healy, and Nielsen (2020) ask whether choice stochasticity is correlated across domains. They consider four domains: objective lotteries with first-order stochastic dominance (FOSD) (probability matching tasks), lotteries with no FOSD relation, games with strategic certainty, and games with strategic uncertainty. For each decision problem in each domain, subjects are asked to make their choice 20 times, with 1 randomly selected for payment. A substantial fraction of subjects randomize in each domain, and there is a significant correlation in stochasticity across domains. This indicates that there are "mixing types," who have a preference for randomizing in all domains, and "nonmixers," who always pick the same option in all 20 repetitions. In additional treatments, subjects make the 20 choices sequentially, learning after each replica whether it is paid before moving to the next and stopping after the paid replica is discovered. They find that mixing is significantly diminished in questions with stochastic dominance, but not in other questions, showing the robustness of the desire to randomize.[6]

E. *Field Evidence*

Dwenger, Kübler, and Weizsäcker (2018) analyze data from a German university admissions clearinghouse, noting that it requires students to submit multiple rankings of universities; these rankings are submitted at the same time, and only a randomly chosen one matters. They document that 14 percent of students report inconsistent rankings, even when there are no strategic reasons to do so. This shows the relevance of deliberate randomization in important life decisions. Zhang and Zhong (2020) show in a field experiment that potential donors increase donations by 20 percent if given the option to flip a coin between which charity to donate to. Levitt (2021) reports a field experiment offering subjects to flip a coin to make difficult decisions and shows how subjects tend to follow its directions.

F. *Related Evidence*

Chew et al. (2019) show that some violations of monotonicity in MPLs are correlated with preferences to randomize. Friedman and Ward (2022) show that a large majority of subjects have stochastic belief reports in games that cannot be driven by learning or measurement error.

Several papers use nonincentivized designs that capture related concepts. Cohen, Jaffray, and Said (1985) allow subjects to express that they "do not know," finding that it is often used (but this is not incentivized). Other papers measure preference imprecision (e.g., Butler and Loomes 2007; Cubitt, Navarro-Martinez, and Starmer 2015 and references therein): in addition to choices, subjects are asked to report the strength of their preferences (which is inconsequential); these papers find sizable ranges with low strength and relate it to several biases. Enke and Graeber (2021) measure "cognitive uncertainty" by asking subjects to first choose from an MPL but also, in a second screen, indicate two bounds they are "certain" about (also inconsequential for payment). They find sizable ranges and relate them to behavior in different areas.

Arts, Ong, and Qiu (2021) elicit both the incentivized desire to randomize and nonincentivized measures of decision confidence. They find that randomization probabilities relate systematically to self-reported decision confidence.

II. Theoretical Background

Agents whose choices maximize complete, monotone preferences following EU should never strictly prefer to randomize.[7] Thus, documenting preferences for randomization documents violations of complete preferences under EU.

A first possibility is that subjects have complete preferences that violate EU and have parts of strict convexity in probabilities. In rank-dependent EU, or cumulative prospect theory (Quiggin 1982; Tversky and Kahneman 1992), preferences cannot be strictly convex

[6] Rubinstein (2002) and Loomes (1998) also document randomization in probability matching tasks, where it leads to strictly dominated choices.

[7] In fact, a strict preference for randomization violates betweenness, a property more general than independence.

if probability weighting is pessimistic. Under Cautious EU, preferences are in general convex (Cerreia-Vioglio, Dillenberger, and Ortoleva 2015). Machina (1985); Fudenberg, Iijima, and Strzalecki (2015); and Cerreia-Vioglio et al. (2019) analyze the theoretical implications of non-EU for stochastic choice.

Alternatively, evidence of randomization can be seen as evidence of *incompleteness*. Intuitively, subjects may be unable to compare two alternatives and prefer to randomize between them. A large and growing literature has studied incomplete preferences and their possible completions; see Nishimura and Ok (2021) for a review.[8]

III. Discussion and Conclusions

Recent empirical evidence shows how decision-makers have a *desire to randomize*. This is documented using different methods, subject pools, and domains.

Naturally, this is not the sole reason for stochastic choice: preferences do vary, and mistakes are made, generating stochastic behavior. The evidence discussed in this article suggests that the desire to randomize is an *additional* cause.

Many aspects of the desire to randomize are yet to be explored. For example, are people averse or seeking randomization with losses? Early results in Agranov et al. (2022) show that the same subjects who like randomization for gains dislike it for losses. Future research will have to identify clear patterns across domains.

[8] Incompleteness and non-EU are related. For example, Cerreia-Vioglio, Dillenberger, and Ortoleva (2015) derived Cautious EU both from complete non-EU preferences and as completions of incomplete preferences. See also Nishimura and Ok (2021).

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