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Abstract

Laboratory experiments give researchers a great deal of control, making them useful for testing analytical models. In this monograph I discuss methodological issues in designing and conducting laboratory experiments. I also summarize some of the recent advances in using laboratory experiments in Operations Management.

Contents

1

Introduction

Much of the work in Behavioral Operations Management (BOM) lives at the boundary of analytical and behavioral disciplines — work that has a substantial tradition. In the next section I will briefly summarize the history of the uses of laboratory experiments in economics, and how the field of BOM can learn from this tradition.

Laboratory experiments are a major method we use in BOM. Similar methods have been employed in a number of other social science fields, including economics (auctions), psychology and sociology (social networks), law (jury behavior), political science (coalition formation), and anthropology and biology (reciprocity).

There are three major purposes that laboratory experiments serve [105]. (1) To test and refine existing theory. Much of the BOM work so far has been on this topic. For example, experiments testing behavior in the newsvendor model [10, 114] test how well people are able to optimize under uncertainty. (2) To characterize new phenomena leading to new theory. An excellent example is the literature on social preferences. For example, Loch and Wu [85] found in a lab experiment that concerns with status and relationship have an effect on the performance of the wholesale price contract. Cui et al. [28] develop a fairness model

and apply it to the setting of a wholesale price contract, to formally characterize conditions that may lead to channel coordination with the wholesale pricing. Özer et al. [97] develop a model of trust and trustworthiness that explains some of the regularities in their lab experiment. (3) To test new institutional designs. This type of work has not yet made its way in the operations literature, but there are several notable examples in economics, such as designing the Federal Communications Commission (FCC) auctions for radio spectrum [49] or designing the market for medical interns [103].

Laboratory studies complement other methods by bridging the gap between analytical models and real business problems. Analytical models are built to be parsimonious and general, and are primarily normative in nature. They use assumptions to make the mathematics tractable. These models can be tested using a variety of empirical methods, including surveys, field studies, field experiments, or laboratory experiments. Empirical methods, are by their nature, descriptive. All empirical methods involve a trade-off between the internal and the external validity. Surveys and field studies that use secondary data have high external validity (they are close to the real settings being studied), but may be low on internal validity (the ability to establish the cause and effect relationship based on the data) because they often suffer from being confounded, or not having all the data that would ideally be required. This is because researchers cannot directly manipulate the factors or levels in the study — they have to accept data that is available to them.

The relative advantage of experiments is control. Experiments can take place in the field or in the laboratory, and field and lab experiments also differ in their level of control and in their level of external validity (field experiments have higher external validity, but usually allow for less control). Laboratory experiments can be designed to fully manipulate all factors at all desired levels, and to match the assumptions of the analytical model being tested. So laboratory experiments are high on the internal validity, but because the environment is often more artificial, they are lower on the external validity.

A good experiment is one that controls the most plausible alternative hypotheses that might explain the data. It also allows the

researcher to cleanly distinguish among possible explanations. For example, the Schweitzer and Cachon [114] study looks at the behavior in the newsvendor problem. In the setting in which the critical fractile is above 0.5 (called the high profit condition) the authors find that average orders are below the optimal order and above the mean demand. At this point a potential plausible explanation is risk aversion — risk averse newsvendor should order less than the risk neutral newsvendor. But the Schweitzer and Cachon [114] design cleverly includes a low profit condition, with the critical fractile below 0.5. In that treatment risk aversion still implies that orders should be below optimal, but the authors find that orders are above optimal. Thus, the design can clearly rule out risk aversion as the (only) explanation.

Three factors make experimental work rigorous. The first one is theoretical guidance. To interpret the results of an experiment, researchers need to be able to compare the data to theoretical benchmarks. Systematic deviations from theory can provide insights into factors missing from the analytical model, and guidance into how the model can be improved.

The second factor is induced valuation. In his seminal paper, Smith [116] explains how a reward medium (for example money) can be used to control the objectives of the laboratory participants. When participants are rewarded based on their performance in the experiment, researchers have a cleaner test of how people pursue their goals. This test is not confounded by not knowing what those goals are.

The third factor is careful control of institutional structure. Strategic options and information available to participants should match with those assumed by the theoretical model. For example, real bargaining is typically done face-to-face and is often unstructured, making modeling bargaining extremely challenging. But some assumptions can be imposed on the bargaining process to make a model tractable, while still capturing some essential features of real bargaining. For example, bargainers may assume to exchange alternating offers, and to capture the fact that no bargaining process can go on forever we may assume that the pie they are bargaining over is discounted at each iteration. These two assumptions allow for a tractable model [108] that provides useful insights and clear empirical predictions. A model can be

further streamlined by assuming that the bargaining process is finite. It turns out that what the model predicts about how the pie will be split depends on length of the bargaining process, and the relative discount rates of the two players. These predictions cannot be tested in the field because real bargaining processes are substantially different from the model, but the model can be tested in the laboratory. For example, Ochs and Roth [93] found that in a finite version of this bargaining game, players in the second period often make offers that are less in absolute terms than the original first period offers they received. These "disadvantageous counteroffers" however, are better in relative terms. Bolton [13] showed, among other things, that these fairness concerns are significantly reduced when players are paid based on a tournament structure.The results of these, and many other tests, provided seminal insights that formed the basis for the theory of social preferences [11, 39].

One of the questions that are often asked about laboratory experiments is about whether their results can be carried over into the real world. Smith [117] addresses this question with the concept of *parallelism*. He writes: "Propositions about the behavior of individuals and the performance of institutions that have been tested in laboratory micro economies apply also to non-laboratory micro economies where similar *ceteris paribus* conditions hold."(p. 936). In other words, behavioral regularities persist as long as relevant underlying conditions are substantially unchanged.

The art of designing good experiments (as well as the art building good analytical models) is in creating simple environments that capture the essence of the real problem while abstracting away all unnecessary details. Thus, the first step in doing experimental work is to start with an interesting theory. What makes a theory interesting is that (1) it has empirical implications, and (2) these implications are worth testing, meaning that they capture a phenomenon that is sufficiently real and interesting so that learning about it adds to our knowledge of the real world.

This monograph focuses on controlled laboratory experiments used to test existing, and develop new, theory in Operations Management. Much of the methodology I discuss is in line with economics rather

than psychology, which also provide a valid and useful, but different, paradigm. The rest of this monograph is organized as follows: in Section 2 I will present a (very) short history of experimental economics, focusing specifically on some fundamental games that proved to be important in economics as well as in BOM. These games will come up again in subsequent sections. In Section 3 I will discuss some basics of experimental design as well as "best practices" for conducting laboratory experiments. In that section I will touch on issues related to providing a context, the effect of subject pool, the effect of incentives, and the uses of deception. The goal of Sections 4, 5, and 6 is to outline how experiments have been used to shed light on behavioral factors within three different operational contexts that have been the focus of my research: the behavior in the Newsvendor problem (Section 4), supply chain contracts (Section 5), and procurement auctions (Section 6). I conclude this monograph in Section 7 with a discussion of my view of future trends and promising directions for future research.

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