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Experimental Economics and choice in transportation: Incentives and context ☆

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ABSTRACT

This paper reviews the preconditions for successful applications of Experimental Economics methods to research on transportation problems, as new transportation and research technologies emerge. We argue that the application of properly designed incentives, the hallmark of Experimental Economics, provides a high degree of experimental control, leading to internal validity and incentive compatibility. Both of these are essential for ensuring that findings generalize to contexts outside the immediate application. New technologies, such as virtual reality simulators, can generate external validity for the experiments by providing realistic contexts. GPS and other tracking technologies, as well as smart phones, smart cards and connected vehicle technologies can allow detailed observations on actions and real-time interactions with drivers in field experiments. Proper application of these new technologies in research requires an understanding of how to maintain a high level of internal validity and incentive compatibility as external validity is increased. In this review of past applications of Experimental Economics to transportation we focus on their success in achieving external and internal validity.

1. Introduction

One fundamental goal of transportation science is to understand behaviour of stakeholders relevant to transportation problems. Planners and researchers in transportation science have relied heavily on concepts of traffic equilibrium and relatively untested assumptions about user behaviour. Much of the behavioural data used to test these assumptions has relied on surveys, interviews and focus groups, where the questions pertain either to historic actions or intended actions under various hypothetical traffic circumstances with no consequences (see Hensher, 2010 for a comprehensive review). While direct observations of behaviour in the field would be preferred, the often prohibiting cost of undertaking large-scale field studies makes them rare. Experimental Economics (hereafter EE) offers an alternative method that allows direct observations with actual consequences but at lower cost and with the advantage of being able to control and manipulate traffic circumstances and contexts along the lines of stated choice.

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Emerging technologies in the area of transportation may transform how research is conducted, and what questions that can be answered. Two important foundations of good research design is internal and external validity, both of which matter to the successful incorporation of new technologies in research. Internal validity refers to the extent to which the causal relationships can be inferred, while external validity is the extent to which these causal relationships can be generalized to other settings (other people, situations, etc.). EE uses incentives that are compatible with Induced Value Theory (Smith 1976, 1982) to implement internal and external validity (through the existence of actual consequences of actions taken). This theory states that to gain experimental control over motivations that influence choices, it is often critical to design reward structures to induce values (or motivations). The reward structures should be designed such that the rewards are the dominant source of motivation during the experiments. The reliance on Induced Value Theory distinguishes EE from survey data collection methods including stated choice methods. While it may be possible to design surveys that induce intrinsic motivations that satisfy these criteria, we restrict this review to experiments that rely on extrinsic, and thus directly observable, motivations.[1] External validity can be further strengthened through the use of natural contexts and participants from populations with relevant experiences. Additional field relevant attributes can be introduced via text, images or visual simulations.

The predominant mode of behavioural data generation in transportation relies on stated choice surveys. The stated choice approach presents participants with a set of choice situations that vary in travel related attributes such as mode of transportation, travel routes, departure and arrival times, as well as travel times, possibly in addition to policy variables such as road pricing. The stated choice approach provides researchers with responses to a large set of circumstances at a low cost. The weakness of the approach is the lack of actual consequences, which is likely to lead to both noise and biases in responses. [2] Hensher (2010) and Fifer et al. (2014) discuss these difficulties and propose some solutions. Revealed preference elicitation is an alternative method that relies on actual consequences. Applications of this method frequently rely on natural experiments, i.e. changes in transportation that are not controlled by the researcher (see for example Small et al., 2005). Data collection under revealed preference can use either interviews about past choices or direct collections using GPS technology. However, they cannot be relied on to study multiple policy changes in a comparative fashion, and the cost of collecting such revealed preference data can be high. While stated choice studies may suffer from bias due to the lack of real incentives, revealed preference studies may suffer from poorly defined non-chosen alternatives, lack of significant variance of key variables, and other measurement errors (Hensher, 2010). EE is similar to stated choice studies in that circumstances and contexts can be manipulated directly and similar to revealed preference studies in that actual consequences are incorporated. It is worth noting that EE has reached a level of maturity equal to other fields in economics and that it is widely accepted as a tool in economists' methodological tool box.[3]

Our review is timely given the advent of innovative communication technologies such as smart phones (Ben-Elia and Ettema (2011a,b)), smart cards (Pluntke and Prabhakar, 2013) and connected vehicles (albeit currently through OBD ports for instance Hultkrantz and Lindberg, 2011). These technologies create opportunities to conduct controlled, large scale incentivized field studies at a lower cost. They allow researchers to make more reliable observations on actions and conditions, and they make it possible to have real-time communications with study participants. Further, the improvement in Virtual Reality technology has made it possible to conduct immersive and realistic laboratory experiments that have a higher degree of external validity. Furthermore, many concerns about the applicability of EE to transportation has been raised out of misconceptions about the method, and there is therefore a need for clarifications. Our article is meant to fill this gap and to provide an improved understanding both the difficulties in and the value of generating internal and external validity by reviewing lessons from past applications of EE to transportation.

In this review we restrict our attention to studies that rely on Induced Value Theory and that have a direct link to transportation questions. We focus on experimental design factors rather than the appropriateness of the theory or the econometric estimation techniques.[4]

2. Background and evidence

Individual choice experiments in transportation concern route choice, mode choice and departure time choice. The policy questions that these experiments want to inform include congestion pricing, public transit funding, and constructing additional lane miles and routes. There are two primary perspectives in the literature: a focus on the choice of an individual when the attributes of the choice options, including the congestion conditions, are exogenous, and a focus on the choices of groups of individuals when they affect attributes such as the congestion level such that these are endogenous. Applications with

[1] For readers that are interested in understanding the difficulties in generating intrinsic motivations that fulfil the criteria we refer to Hensher (2010), Fifer et al. (2014), Cummings et al. (1995), Blumenschein et al. (2008), Champ et al. (2009, 1997), Johannesson (1999), Li and Mattsson (1995), Moore et al. (2010), and Morrison and Brown (2009).

[2] Such hypothetical response biases have been demonstrated in Cummings et al. (1995), Holt and Laury (2002), andHarrison and Rutström (2008).

[3] EE has grown exponentially and now includes several dedicated journals, the Economic Science Association with over 500 members, and four winners of the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel (Reinhard Selten, Vernon L. Smith, Elinor Ostrom, Alvin E. Roth). Ortmann (2016) recounts key episodes from the history of Experimental Economics.

[4] We have selected articles for this review based on scopus and google scholar searches with key words "Transportation" and "Experimental Economics". We also emailed the members of the Economic Science Association (ESA) to identify additional papers. We do not claim that we have been able to exhaustively review all existing work in transportation that rely on Induced Value Theory.