



Is there a stepping stone effect in drug use? Separating state dependence from unobserved heterogeneity within and between illicit drugs

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ABSTRACT

Empirically, teenagers who use soft drugs are more likely to use hard drugs in the future. This pattern can be explained by a causal effect (i.e., state dependence *between* drugs or stepping-stone effects) or by unobserved characteristics that make people more likely to use both soft and hard drugs (i.e., correlated unobserved heterogeneity). I estimate a dynamic discrete choice model of alcohol, marijuana and hard drug use over multiple years, and separately identify the contributions of state dependence (*within* and *between* drugs) and unobserved heterogeneity. I find statistically significant “stepping-stone” effects from softer to harder drugs, and conclude that alcohol, marijuana and hard drugs are complements in utility.

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1. Introduction

Heated debates have arisen as states such as Colorado and Washington have decriminalized marijuana at the same time as the federal government has continued enforcement of laws against the drug. Given the limited evidence on the health impacts of marijuana (e.g. Prinz, 1997), supporters of the federal position have often implicitly relied on the argument that use of marijuana leads to an increased use of harder and more socially disruptive drugs, such as cocaine and amphetamines. Casual observation suggests that most users of hard drugs start off using alcohol and/or marijuana. Whether the use of softer drugs actually *causes* the future use of hard drugs (or the continued use of soft drugs) is unclear. The dynamic patterns could arise from a change in preferences that occurs among those who use softer drugs, i.e., a true “state dependence” effect (e.g., Heckman, 1981a). Alternatively, they could simply reflect the fact that certain individuals are more likely to consume drugs at any point in time—a heterogeneity effect.

Disentangling the state dependence *between* drugs (i.e., stepping-stone effect) from unobserved heterogeneity is potentially

important for policy. For instance, assume that a policy maker's goal is to reduce long term use of hard drugs. If there is a stepping-stone effect from marijuana to hard drugs, any small shock that leads some young people to use marijuana at some point in time will have a long-term effect on further use of harder drugs. Consequently, policies to prevent marijuana use can be an effective channel for preventing long term use of hard drugs. Similarly, if there is state dependence *within* hard drug consumption (i.e., true state dependence), policies that prevent the use of hard drugs at younger ages may have a lasting benefit in reducing longer-term use of hard drugs.

Statistical models that separate state dependence from unobserved heterogeneity have been widely used to model welfare participation (e.g. Plant, 1984; Enberg et al., 1990; Card and Hyslop, 2005), dynamic labor supply of married women (e.g. Hyslop, 1999), self-reported health (e.g. Halliday, 2008), sexual behavior among teenagers (e.g. Arcidiacono et al., 2011), charitable giving (e.g. Meer, 2013) and many other outcomes. These models are also used in marketing to separate tastes based on habit formation in brand purchases (e.g. Keane, 1997). In the marketing literature, the estimated parameters are often used to simulate the effects of a shock on consumption of a particular brand (e.g., caused by a promotion or sale) on the long term purchases of the brand. My goal in this paper is similar. In particular, I use the estimated model of dynamic drug use to simulate whether an exogenous shock that

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reduces marijuana or alcohol consumption will have a long-term effect on use of hard drugs.

This study develops two models. First, I develop a multiple-equation trivariate logit model with correlated unobserved heterogeneity and state dependence that allows me to estimate “within-drug” state dependence (e.g., the causal effect of current alcohol use on future alcohol use) and “between-drug” state dependence or stepping stone effects¹ (e.g., the effect of current alcohol use on future use of hard drugs), with the ultimate goal to explain the effects of lagged drug use on current use. Second, I extend previous models that separately identify correlation in preferences from true complementarity or substitutability in utility (e.g. [Gentzkow, 2007](#)) to also include state dependence within and between drugs, with the ultimate goal to also explain contemporaneous consumption of drugs. As robustness checks, I also develop a multiple-equation probit model that allows the time-varying shocks to be correlated across drugs, as well as a model with higher order dependence and models with heterogeneous state dependence.

Throughout, I use mass-point mixing models to account for time-invariant multidimensional unobserved heterogeneity (e.g. [Heckman and Singer, 1984](#)).² My models also include flexible controls for the initial conditions problem caused by the fact that some individuals in my data source, the National Longitudinal Survey of Youth 1997 (NLSY97), are first interviewed after they have already initiated soft (or even hard) drug use (e.g. [Heckman, 1981b](#)).³ Finally, I control for drug and time-specific variables that affect the utility of one drug while leaving the utilities for other drugs unaffected, such as share of drug treatment admissions that were attributed to alcohol, marijuana or hard drugs, respectively, and an indicator for whether the individual is at least 21 years old.

Much of the existing drug-use literature has overlooked the role of individual preferences in drug consumption, and interpreted the fact that most young adults consume marijuana before consuming hard drugs as evidence of a “gateway” effect (e.g. [Mills and Noyes, 1984](#); [Newcomb and Bentler, 1986](#); [Yamaguchi and Kandel, 1984](#), among many others). A notable exception is [Van Ours \(2003\)](#), who uses a mixed proportional hazards model to study the extent to which first-time marijuana consumption affects first-time cocaine consumption. [Van Ours \(2003\)](#) concludes that, while marijuana initiation has a significant stepping stone effect on future initiation into cocaine, the main factor driving the initiation of both drugs is unobserved heterogeneity.

Relative to the existing literature, I make three main contributions. First, I extend the consideration of state dependence and unobserved heterogeneity to a multiproduct setting, where the products are not necessarily mutually exclusive.⁴ Second, I ex-

tend existing techniques for separating complementarity or substitutability from correlation in preferences ([Gentzkow, 2007](#)) to now incorporate state dependence within and between drugs. Third, to the best of my knowledge, I am the first to consider stepping-stone effects in a general dynamic setting where past use of each of several drugs can affect the current use of each drug. Looking at the effect of each of the three drugs on future consumption patterns allows me to compare the relative size of the stepping-stone effects of marijuana and alcohol on consumption of hard drugs. I can also test whether the use of hard drugs causes increased future consumption of softer drugs (a “reverse” stepping-stone effect).⁵

My empirical results suggest that alcohol, marijuana and hard drugs exhibit strong positive state dependence within drug that is highly robust across specifications. Also, softer drugs have a modest-sized stepping-stone effect on harder drugs. That is, alcohol use has a positive stepping-stone effect on future use of marijuana and hard drugs, and marijuana use has a positive stepping-stone effect on future use of hard drugs. The “reverse” stepping stone effect from harder to softer drugs is statistically insignificant in most of my specifications, and is uniformly smaller than the effect from softer to harder drugs, indicating that the primary stepping-stone effect operates from softer to harder drugs. I also find strong evidence that drugs are complements in utility. For instance, consuming alcohol and marijuana together leads to higher utility than the sum of the utility derived from consuming alcohol alone and marijuana alone.

This study also presents strong evidence that the state dependence within and between drugs is heterogeneous across individuals. In particular, the state dependence *within* drug for each of the three drugs increases with age, indicating that the habit of consuming a particular drug may be harder to break with age. On the other hand, the stepping-stone effects decreases with age, indicating that early consumption of softer drugs may have an impact on consumption of harder drugs. Also, state dependence within drug is higher among those with higher addiction capital accumulation (i.e., state dependence within drug j is higher the longer the time that has elapsed since the first time the respondent used drug j). A limitation of the models I develop in this paper is the assumption that unobserved heterogeneity in tastes for drug use can be decomposed into the sum of a purely permanent component and a purely transitory component. To examine the extent to which this assumption causes misspecification, I present a sample-analogue of generalized residuals that allows me to diagnose misspecifications arising from serial correlation or from contemporaneous correlations in the predicted transitory components of the three drugs, after accounting for unobserved heterogeneity.

This paper is organized as follows. The next section discusses the data, while Section 3 presents two models with homogeneous state dependence and stepping-stone effects. Section 4 discusses empirical results, presents specifications diagnostics, and discusses alternative specifications as a robustness check. Section 5 presents models with heterogeneous state dependence and stepping-stone effects, and presents counterfactual experiments. Finally, Section 6 summarizes and concludes.

2. Data

I use restricted data from the National Longitudinal Survey of Youth 1997. The NLSY97 survey collects longitudinal information

¹ Previous research uses the term “stepping-stone effect” from drug k to drug j to describe how initiation into drug k increases the likelihood of initiation into a harder drug j . For this paper, I refer to the stepping stone effect from drug k to drug j as the causal effect of drug k consumption in period t on drug j consumption in period $t + 1$. The stepping stone effect is equivalent to the first-order state dependence *between* two drugs. Drug j and k exert stepping-stone effects on each other. On the other hand, first-order state dependence *within* drug is the causal effect of drug j consumption in period t on drug j consumption in period $t + 1$.

² That is, I let the data tell me whether individuals who have a high time-invariant preference for marijuana also have a high time-invariant preference for hard drugs and alcohol. I treat the distribution of the unobserved component as discrete and drawn from the mixture distribution (e.g. [Heckman and Singer, 1984](#)). Each type p is assigned a vector $(\alpha_p^a, \alpha_p^m, \alpha_p^h, \alpha_{p,0}^a, \alpha_{p,0}^m, \alpha_{p,0}^h)$. This specification allows correlation between these six random effects within type.

³ NLSY97 started collecting data on hard drug use starting in 1998.

⁴ Existing models that separate state dependence from unobserved heterogeneity establish whether past consumption of a particular product increases the probability of future consumption of that particular product. In the setting of illicit drugs, it is critical to allow a more flexible structure that addresses how past consumption of a particular drug increases the probability of future consumption of not only that particular drug, but also other drugs (i.e. state dependence between drugs or stepping-stone effects).

⁵ Let drug k be a softer drug than drug j (alcohol is softer than marijuana and marijuana is softer than hard drugs). I refer to the stepping-stone from harder to softer drugs (from drug j to k) as the “reverse” stepping-stone effects.

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