

1) Here we consider the “recreational” demand for opioids. The applicability of rational choice to the demand for addictive drugs is a matter of vigorous debate. The argument against notes that drugs cause “persistent changes in the brain structures and functions known to be involved in the motivation of behavior” and that frequently “the addict expresses a desire not to consume drugs prior to, after, or even during the drug intake.” We therefore do not model individual choice as a utility-maximization problem.

We begin by treating all opioids as a homogeneous commodity with a single price  $p$ . Therefore, consumers with income  $y$  face a budget constraint  $y = r c + p q$ , where  $q$  is the quantity of opioids,  $c$  is the quantity consumed of all other goods, and  $r$  is their price.

- a) Suppose that each consumer chooses a point on his budget set randomly. Each point is equally likely to be chosen. What is market-level opioid demand as a function of  $p$  and the distribution of income? Could an increase in  $p$ , holding incomes constant, increase aggregate opioid consumption?
- b) Does market-level demand satisfy symmetry, homogeneity, or adding up?
- c) Suppose instead that most consumers set  $q = 0$ , but that a random subset of them spend all of their disposable income on opioids. [Here disposable income refers to income after spending on necessities such as food] Does market-level demand satisfy symmetry, homogeneity, or adding up?

Now we acknowledge that opioids come in a variety of chemical forms, which differ in terms of their potency. Potency adjusted, the various forms are such good substitutes that they are frequently referenced in terms of “morphine equivalents,” which is the units we now use to measure  $q$ .

The most potent opioids, (heroin and various fentanyl analogs, hereafter “heroin”) are illegal even for human medical uses. They are manufactured outside of the U.S. and smuggled here illegally. The less potent opioids can be obtained by prescription. Both obtaining a prescription and accessing illegal markets have a fixed cost that is independent of the quantity purchased.

- d) Draw an individual’s budget set in the  $[q, c]$  plane. What points in the set are dominated by at least one other point in the set?
- e) If an individual spends all disposable income on opioids, but never chooses a dominated point from the budget set, how does his total demand vary with the price of prescription opioids? Does market-level demand satisfy symmetry, homogeneity, or adding up?

- f) If instead an individual spends a fixed budget share on opioids (including variable and fixed costs), but never chooses a dominated point from the budget set, how does his total demand vary with the price of prescription opioids? Does market-level demand satisfy symmetry, homogeneity, or adding up?
- g) How would the demand curve from (f) be differed if individuals maximized a Cobb-Douglas utility function defined over  $c$  and  $q$ ?

2) Here we consider a three-good model, with quantities consumed  $c$ ,  $x$ , and  $y$ . Preferences are described by the utility function  $u(c, F(x, y))$ , where  $F$  is a homogenous function. An excise tax is levied on good  $x$  at rate  $t$ .

- a) How does the cost function vary with  $t$ ?
- b) We define deadweight loss as the difference between (i) the effect of  $t$  on cost and (ii) the tax revenue obtained by taxing good  $x$ . Describe some properties of the deadweight loss function.
- c) Use the demand-for- $x$  curve to illustrate the deadweight loss. Are you using Hicksian or Marshallian demand?
- d) How does  $t$  affect the price of  $F$ ? Illustrate the deadweight loss using the demand-for- $F$  curve.
- e) Use your results for (c) and (d) to show how the same tax revenue could be raised more efficiently using also levying an excise tax on good  $y$ . Should  $x$  and  $y$  be taxed at the same rate?
- f) How many degrees of freedom are available in this demand model? What elasticity restrictions does it place on the general model  $u(c, x, y)$ ?