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Legalization of such substances as marijuana, heroin, and cocaine surely will reduce the prices of these harmful addictive drugs. By the law of the downward sloping demand function, their consumption will rise. But by how much? According to conventional wisdom, the consumption of these illegal addictive substances is not responsive to price. Limited empirical evidence from the 1970s does not support this view. Nisbet and Vakil (1972) report a price elasticity of demand for marijuana ranging from -1.0 to -1.5 in an anonymous mail questionnaire of U.C.L.A. students. Silverman and Spruill (1977) estimate the price elasticity of demand for heroin in an indirect manner from the relationship between crime and the price of heroin in a monthly time series of 41 neighborhoods in Detroit. They obtain an elasticity of -.3.

These empirical estimates are too unreliable to be given much weight. However, conventional wisdom is contradicted also by Becker and Murphy's (1988) theoretical model of rational addiction. Their analysis implies that addictive substances are likely to be quite responsive to price. Empirical applications of the model to the demand for such legal addictive substances as cigarettes (Becker, Grossman, and Murphy (1990); Chaloupka (forthcoming)) and gambling (Mobilier (1990)) support this prediction. In addition, related work on the demand for heavy consumption of alcohol by Cook and Tauchen (1982) is consistent with the notion that price elasticities of addictive goods are relatively large.

In this paper we summarize Becker and Murphy's model of rational addiction and the empirical evidence in support of it. We use the theory and evidence to draw highly tentative inferences concerning the effects of legalization of currently banned substances on consumption in the aggregate and for selected groups in the population.

Addictive behavior is usually assumed to involve both "reinforcement" and "tolerance." Reinforcement means that greater past consumption of addictive goods, such as drugs or cigarettes, increases the desire for present consumption. But tolerance cautions that the utility from a given amount of consumption is lower when past consumption is greater.

These aspects of addictive behavior imply several restrictions on the instantaneous utility function

$$U(t) = u[c(t), S(t), y(t)], \quad (1)$$

where $u(t)$ is utility at t , $c(t)$ is consumption of the addictive good, $y(t)$ is a non-addictive good, and $S(t)$ is the stock of "addictive capital" that depends on past consumption of c and on life cycle events. Tolerance is defined by $\partial u / \partial S = u_s < 0$, which means that addictions are harmful in the sense that greater past consumption of addictive goods lowers current utility. Stated differently, higher $c(t)$ lowers future utility by raising future values of S .

Reinforcement ($dc/dS > 0$) requires that an increase in past use raises the marginal utility of current consumption: ($\partial^2 u / \partial c \partial S = u_{cs} > 0$). This is a sufficient condition for myopic utility maximizers who do not consider the future consequences of their current behavior. But rational utility maximizers also consider the future harmful consequences of their current behavior. Reinforcement for them requires that the positive effect of an increase in $S(t)$ on the marginal utility of $c(t)$ exceeds the negative effect of higher $S(t)$ on the future harm from greater $c(t)$.

Becker and Murphy (1988, p. 680) show that a necessary and sufficient condition for reinforcement near a steady state (where $c = \delta S$) is

$$(\sigma + 2\delta)u_{cs} > -u_{ss} \quad , \quad (2)$$

where u_{cs} and u_{ss} are local approximations near the steady state, σ is the rate of time preference, and δ is the rate of depreciation on addictive capital. Reinforcement is stronger, the bigger the left hand side is relative to the right hand side. Clearly, $u_{cs} > 0$ is necessary if u is concave in $S(u_{ss} < 0)$; that is, if "tolerance" increases as S increases.

It is not surprising that addiction is more likely for people who discount the future heavily (a higher σ) since they pay less attention to the adverse consequences. Addiction to a good is also stronger when the effects of past consumption depreciate more rapidly (δ is larger), for then current consumption has smaller negative effects on future utility. The harmful effects of smoking, drinking, and much drug use do generally disappear within a few years after a person stops the addiction unless vital organs, such as the liver, get irreversibly damaged.

Reinforcement as summarized in equation (2) has the important implication that the consumption of an addictive good at different times are complements. Therefore, an increase in either past or expected future prices decreases current consumption. The relation between these effects of past and future prices depends on both time preference and the depreciation rate.

The figure illustrates several implications of our approach to addiction, where $S(t)$ is measured along the horizontal axis and $c(t)$ along the vertical one. The line $c = \delta S$ gives all possible steady states where c

and S are constant over time. The positively sloped curves A^1 give the relation between c and S for an addicted consumer who has a particular utility function, faces given prices of c and y , and has a given wealth. The initial stock (S^0) depends on past consumption and past life cycle experience. Both c and S grow over time when S^0 is in the interval where A^1 is above the steady-state line, and both fall over time when S^0 is in the intervals where A^1 is below the steady-state line.

The figure shows clearly why the degree of addiction is very sensitive to the initial level of addictive capital. If S^0 is below \underline{S} in the figure, a rational consumer eventually lays off the addictive good. But if S_0 is above \underline{S}^1 , even a rational consumer becomes addicted, and ends up consuming large quantities of the addictive good.

The curve A^1 intersects the steady-state line at two points: $\underline{c}^1 = \delta \underline{S}^1$, and $c^*^1 = \delta S^*^1$. Other relevant points are where $c = 0$ and $S \leq S^1$. The second point and third set of points are locally stable. If initially $c = 0$, $S \leq S^1$, and a divorce or other events raise the stock of addictive capital to a level below \underline{S}^1 , c may become positive, but eventually the consumer again refrains from consuming c . Similarly, if initially $c = c^*^1 = \delta S^*^1$, c falls at first if say finding a good job lowers S from S^*^1 to a level $> \underline{S}^1$. But c then begins to rise over time and returns toward c^*^1 . The other steady state $\underline{c}^1 = \delta \underline{S}^1$, is locally and globally unstable: even small changes in S cause cumulative movements toward $c = 0$ or $c = c^*^1$.

Unstable steady states are an important part of the analysis of rational addictions, for they explain why the same person is sometimes heavily addicted to cigarettes, drugs, or other goods, and yet at other times lays off completely. Suppose the consumer starts out at $c^*^1 = \delta S^*^1$, and experiences favorable events that lower his stock of addictive capital

below S^* , the unstable steady state with A^1 . The consumer goes from being strongly addicted to eventually giving up c entirely. If A^1 is very steep when S is below the unstable steady state -- if reinforcement is powerful in this interval -- consumers would quit their addiction "cold turkey" (see the more extended analysis in Becker and Murphy 1988).

To analyze rational addict's responses to changes in the cost of addictive goods, suppose they are at $c^*^2 = \delta S^*^2$ along A^2 , and that a fall in the price of c raises the demand curve for c from A^2 to A^1 . Consumption increases at first from c^*^2 to \hat{c} , and then c grows further over time since \hat{c} is above the steady state line. Consumption grows toward the new stable steady state at $c^*^1 = \delta S^*^1$. This shows that long run responses to price changes exceed short run responses because initial increases in consumption of addictive goods cause a subsequent growth in the stocks of addictive capital, which then stimulates further growth in consumption.

Since the degree of addiction is stronger when A is steeper, and since long run responses to price changes are also greater when A is steeper, strong addictions do not imply weak price elasticities. Indeed, if anything, rational addicts respond more to price changes in the long run than do non-addicts.¹ The short-run change is smaller than the long-run change because the stock of addictive capital is fixed. Even in the short run, however, rational addicts respond to the anticipated growth in future consumption since future and current consumption of addictive goods are complements for them. But the ratio of short- to long-run responses does decline as the degree of addiction increases.²

The presence of unstable steady states for highly addictive goods means that the full effect of a price change on consumption could be much greater for these goods than the change between stable steady states given

in footnote 1. Households with initial consumption capital between \underline{s}^2 and \underline{s}^1 in the figure would be to the left of the unstable steady state at \underline{s}^2 when price equals p^2 , but they would be to the right of the unstable steady state at \underline{s}^1 when price equals p^1 . A reduction in price from p^2 to p^1 greatly raises the long run demand by these households because they move from low initial consumption to a stable steady state with a high level of consumption.

Temporary changes in prices of addictive good have smaller effects on consumption than permanent changes -- even when all changes are utility compensated. The reason is that the complementarity between present and future consumption is less relevant with temporary price changes since future prices do not change.

The total cost of addictive goods to consumers equals the sum of the good's price and the money value of any future adverse effects, such as the negative effects on earnings and health of smoking, heavy drinking, or dependence on crack. Either a higher price of the good -- due perhaps to a larger tax -- or a higher future cost -- due perhaps to greater information about health hazards -- reduces consumption in both the short and long runs.

It is intuitively plausible that as price becomes a bigger share of total cost, long-run changes in demand induced by a given percentage change in the money price get larger relative to the long-run changes induced by an equal percentage change in future costs.³ Money price tends to be relatively more important to poorer and younger consumers, partly because they generally place a smaller monetary value on health and other harmful future effects.

Poorer and younger persons also appear to discount the future more heavily (this is suggested by the theoretical analysis in Becker (1990)). It

can be shown that addicts with higher discount rates respond more to changes in money prices of addictive goods, whereas addicts with lower rates of discount respond more to changes in the harmful future consequences.⁴

These implications of rational addiction can be tested with evidence on the demand for cigarettes, heavy consumption of alcohol, and gambling. Becker, Grossman, and Murphy (1990) fit models of rational addiction to cigarettes to a time series of state cross sections for the period from 1955 to 1985. We find a sizable long-run price elasticity of demand ranging between $-.7$ and $-.8$, while the elasticity of consumption with respect to price in the first year after a permanent price change (the short-run price elasticity) is about $-.4$. Smoking in different years appear to be complements: cigarette consumption in any year is lower when both future prices and past prices are higher.

Chaloupka (forthcoming) analyzes cigarette smoking over time by a panel of individuals. He finds similar short-run and long-run price elasticities to those we estimate, and that future as well as past increases in cigarette prices reduce current smoking. He also finds that smoking by the less educated responds much more to changes in cigarette prices than does smoking by the more educated; a similar result has been obtained by Townsend (1987) with British data. Lewit, Coate and Grossman (1981) and Lewit and Coate (1982) report that youths respond more than adults to changes in cigarette prices. By contrast, the information that began to emerge in the early 1960s about the harmful long-run effects of smoking has had a much greater effect on smoking by the rich and more educated than by the poor and less educated (Farrell and Fuchs (1982) for the U.S.; Townsend (1987) for Britain).

Cook and Tauchen (1982) examine variations in death rates from cirrhosis of the liver (a standard measure of heavy alcohol use), as well as variations in per capita consumption of distilled spirits in a time series of state cross sections for the years 1962 through 1977. They find that state excise taxes on distilled spirits have a negative and statistically significant effect on the cirrhosis death rate. Moreover, a \$1 increase in 1982 prices in a state's excise tax lowers death rates by a larger percentage than it lowers per capita consumption (10.8 percent versus 7.2 percent).

Mobilia (1990) applies the rational addiction framework to the demand for gambling at horse racing tracks. Her data consist of a U.S. time series of racing track cross sections for the period from 1950 through 1986 (tracks over time are the units of observation). She measures consumption by the real amount bet per person attending (handle per attendant), and price by the takeout rate (the fraction of the total amount bet that is retained by the track). Her findings are similar to those in the rational addictive studies of cigarettes. The long-run price elasticity of demand for gambling equals $-.7$ and is more than twice as large as the short-run elasticity of $-.3$. Moreover, an increase in the current takeout rate lowers handle per attendant in both past and future years.

The evidence from smoking, heavy drinking, and gambling rather strongly supports our model of rational addiction. In particular, long-run price elasticities are sizable and much bigger than short-run elasticities, higher future as well as past prices reduce current consumption, lower income persons respond more to changes in prices of addictive goods than do higher income persons, whereas the latter respond more to changes in future harmful effects, and younger persons respond more to price changes than

older persons. It seems reasonable to us that what holds for smoking, heavy drinking, and gambling tends to hold also for drug use, although direct evidence is not yet available, and many experts on drugs would be skeptical. Lacking the evidence, we simply indicate what to expect from various kinds of price changes if responses of drug addicts are similar to those of persons addicted to other goods.

To fix ideas, consider a large permanent reduction in the price of drugs -- perhaps due to partial or complete legalization -- combined with much greater efforts to educate the population about the harm from drug use. Our analysis predicts that much lower prices could significantly expand use even in the short run, and it would surely stimulate much greater addiction in the long run. Note, however, that the elasticity of response to very large price changes would be less than that to modest changes if the elasticity is smaller at lower prices.

The effects of a fall in drug prices on demand would be countered by the education program. But since drug use by the poor would be more sensitive to the price fall than to greater information about harmful longer-run effects, drug addiction among the poor is likely to become more important relative to addiction among the middle classes and rich. For similar reasons, addiction among the young may rise more than that among other segments of the population.

A misleading impression about the reaction to permanent price changes may have been created by the effects of temporary police crackdowns on drugs, or temporary Federal "wars" on drugs. Since temporary policies raise current but not future prices -- they would even lower future prices if drug inventories are built up during a crackdown period -- there is no complementary fall in current use from a fall in future use. Consequently,

even if drug addicts are rational, a temporary "war" that greatly raised street prices of drugs may well have only a small effect on drug use, whereas a permanent "war" could have much bigger effects, even in the short run.

Clearly, we have not provided enough evidence to evaluate whether or not the use of heroin, cocaine, and other drugs should be legalized. A cost-benefit analysis of many effects is needed to decide between a regime in which drugs are legal and one in which they are not. What this paper shows is that the permanent reduction in price caused by legalization is likely to have a substantial positive effect on use, particularly among the poor and young.

REFERENCES

- Becker, Gary S. "Optimal Discounting of the Future." Department of Economics, University of Chicago, April 1990.
- Becker, Gary S.; Grossman, Michael, and Murphy, Kevin M. "An Empirical Analysis of Cigarette Addiction." National Bureau of Economic Research Working Paper No. 3322, April 1990.
- Becker, Gary S., and Murphy, Kevin M. "A Theory of Rational Addiction." Journal of Political Economy, 96, No. 4 (August 1988), 675-700.
- Chaloupka, Frank J. "Rational Addictive Behavior and Cigarette Smoking." Journal of Political Economy, forthcoming.
- Cook, Philip J., and Tauchen, George. "The Effect of Liquor Taxes on Heavy Drinking." Bell Journal of Economics, 13, No. 2 (Autumn 1982), 379-390.
- Farrell, Phillip, and Fuchs, Victor R. "Schooling and Health: The Cigarette Connection." Journal of Health Economics, 1, No. 3 (December 1982), 217-230.
- Lewit, Eugene M.; Coate, Douglas; and Grossman, Michael. "The Effects of Government Regulation on Teenage Smoking." Journal of Law and Economics, 24, No. 3 (December 1981), 545-569.
- Lewit, Eugene M., and Coate, Douglas. "The Potential for Using Excise Taxes to Reduce Smoking." Journal of Health Economics, 1, No. 2 (August 1982), 121-145.
- Mobililia, Pamela. "An Economic Analysis of Addictive Behavior: The Case of Gambling." Ph.D. dissertation, City University of New York Graduate School, 1990.
- Nisbet, Charles T., and Vakil, Firouz. "Some Estimates of Price and Expenditure Elasticities of Demand for Marijuana among U.C.L.A.

Students." Review of Economics and Statistics, 54, No. 4 (November 1972), 473-475.

Silverman, Lester P., and Spruill, Nancy L. "Urban Crime and the Price of Heroin." Journal of Urban Economics, 4, No. 1 (January 1977), 80-103.

Townsend, Joy L. "Cigarette Tax, Economic Welfare and Social Class Patterns of Smoking." Applied Economics, 19 (1987), 355-365.

FOOTNOTES

1. Becker and Murphy (1988 consider price effects in the context of a quadratic instantaneous utility function of the form

$$u(t) = \alpha_c c(t) + \alpha_s S(t) + (1/2)\alpha_{cc}[c(t)]^2 \\ + (1/2)\alpha_{ss}[S(t)]^2 + \alpha_{cs}c(t)S(t),$$

where α_c and α_{cs} are positive, and all other parameters are negative. They show [1988, equation (18), p. 685] that the long-run change between stable steady states in response to a permanent change in p_c is

$$\frac{dc^*}{dp_c} = \frac{\mu}{\alpha_{cc} B'},$$

where μ is the marginal utility of wealth, and

$$B' = 1 + \frac{\alpha_{ss} + (\sigma + 2\delta)\alpha_{cs}}{\alpha_{cc}\delta(\sigma + \delta)}$$

The term B' , which ranges between 0 and 1 for an addictive good, measures the degree of addiction. Since a decrease in B' means greater addiction -- $B' = 1$ indicates no addiction -- the long run change in c is positively related to the strength of the addiction.

2. One can show that a rational addict's short-run response to a permanent change in p_c equals

$$\frac{dc_s}{dp_c} = -\frac{\lambda}{\delta} \frac{dc^*}{dp_c},$$

where $-\delta \leq \lambda \leq 0$, and λ is larger when the degree of addiction is stronger (see Becker and Murphy [1988, pp. 679-80]). Therefore, the ratio of the short to long term response gets larger as the degree of addiction (measured by λ) is larger. One can also show that dc_s/dp_c itself gets larger as the degree of addiction increases.

3. With a quadratic utility function, the discounted value of future cost in steady states equals

$$\frac{-u_s}{\sigma+\delta} = \frac{-\alpha_s - \alpha_{ss} S - \alpha_{cs} c}{\sigma+\delta} .$$

If these costs change because of a change in α_s , the induced change in steady-state consumption would be

$$\Pi_c \frac{dc}{d\Pi_c} = \frac{dc}{d \log \Pi_c} = \frac{-\alpha_s}{\alpha_{cc} B' (\sigma+\delta) \mu} = \frac{\Pi_c}{\alpha_{cc} B'} .$$

where $\Pi_c = -\alpha_s / (\sigma+\delta) \mu$. Hence, from footnote 1, the ratio of the changes in c due to changes in $\log p_c$ and $\log \Pi_c$, respectively are

$$\frac{dc/d \log p_c}{dc/d \log \Pi_c} = \frac{p_c}{\Pi_c} .$$

This ratio depends only on the ratio of these prices.

In the text we claim that Π_c is larger for adults, and for the rich and more educated. One reason why this is so is that an increase

in the addictive stock is likely to lower earnings as well as utility by reducing the time available for work. To include this effect, redefine α_s to include a component $\mu\beta w$ that gives the effect of S on earnings, where w is the hourly wage rate and β is the negative effect of S on working time. An increase in the absolute value of β would have a larger effect on cost when w is greater.

4. An increase in the rate of time preference (σ) both raises the response to a change in money price (p_c) and lowers the response to a change in future costs (Π_c) if

$$\frac{-\alpha_{ss}}{\delta^2} > \frac{\alpha_{cs}}{\delta} ,$$

and

$$-\alpha_{cc} > \frac{\alpha_{cs}}{\delta} .$$

An increase in c between steady states where $c = \delta S$ reduces the marginal utility of c , while the increase in S raises it. The second inequality states that the direct effect exceeds the cross effect. The first inequality assumes that the increase in S has a larger effect on its marginal utility than does the increase in c . If u is concave, at least one of these inequalities must hold, for then

$$-\delta^2 \alpha_{cc} - \alpha_{ss} > 2\delta \alpha_{cs} .$$

We assume that both hold.

By differentiating with respect to σ the absolute value (n) of the long run change in c induced by a change in p_c (given in footnote 1), we get

$$\frac{\partial n}{\partial \sigma} = \frac{-[\mu(\alpha_{ss} + \delta\alpha_{cs})]}{\alpha_{cc}^2 \delta(\sigma + \delta)^2 B'^2} .$$

This equation is positive by the assumption $-\alpha_{ss} > \delta\alpha_{cs}$.

Differentiating the absolute value (m) of the long run change in c with respect to $\log \Pi_c$ (given in footnote 3), we get

$$\frac{\partial m}{\partial \sigma} = \frac{(\sigma + \delta)\delta(\alpha_{cc} \delta + \alpha_{cs})(-\alpha_s)}{[\alpha_{cc} \delta(\sigma + \delta) + \alpha_{ss} + (\sigma + 2\delta)\alpha_{cs}]^2} .$$

This equation is negative by the assumption $-\alpha_{cc} \delta > \alpha_{cs}$.

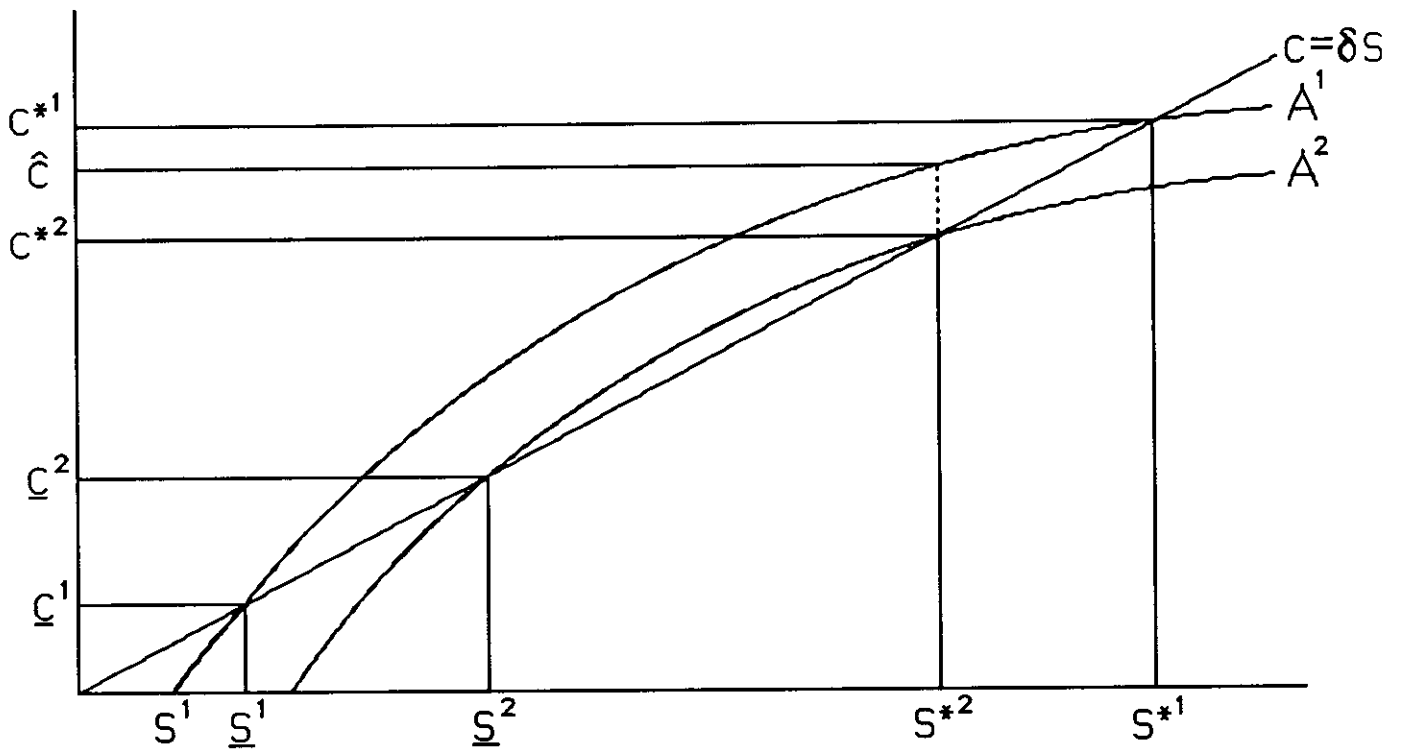


FIGURE 1