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ENFORCEMENT OR TREATMENT? MODELING THE RELATIVE EFFICACY OF ALTERNATIVES FOR CONTROLLING COCAINE

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This paper presents a model that estimates the relative cost-effectiveness of four cocaine-control programs: three "supply control" programs (source-country control, interdiction, and domestic enforcement) and a "demand control" program (treating heavy users). Treatment emerges as by far the most cost-effective, and sensitivity analyses show that this result is very robust.

The current cocaine epidemic in the United States started in the late sixties, picked up momentum during the seventies, and is still going strong in the nineties. Although enforcement has increased dramatically since 1980, and both initiation into cocaine use and overall prevalence have declined since the mid-1980s, the number of heavy users has increased; where "heavy use" is defined here as at least weekly, and "light use" is use within the past year but less than weekly. (See Figure 1.) Indeed, since heavy users consume so much more cocaine per capita than do light users, total consumption of cocaine in the United States has remained near its mid-1980s peak for a decade, and measures of harm, such as the number of emergency room mentions of cocaine, continue to increase.

The persistence of high levels of cocaine consumption and the fact that cocaine control spending now exceeds $15 billion per year underscore the need to think carefully about the relative cost-effectiveness of available interventions. Four such interventions analyzed here are:

Source country control: coca leaf eradication and seizures of coca base, paste, and powder in source countries (primarily Peru, Bolivia, and Colombia);

Interdiction: cocaine and asset seizures by the U.S. Customs Service, Coast Guard, military, and Immigration and Naturalization Service;

Domestic enforcement: cocaine and asset seizures and arrests of drug dealers and their agents by federal, state, and local law enforcement agencies, plus imprisonment of convicted drug dealers and their agents; and

Treatment of heavy users: outpatient and residential treatment programs.

The first three are "supply-control" programs that raise the cost of supplying cocaine. Increased production costs raise retail cocaine prices, which in turn reduces consumption, partly by discouraging current consumption and partly by reducing initiation into and increasing desistance from cocaine use. (Domestic enforcement also reduces demand by incarcerating dealers who use.)

The fourth program—treatment—is a "demand-control" program that reduces consumption directly, without going through the price mechanism. Treatment reduces consumption in the short run, because clients largely cease use during treatment, and in the longer run, because not all clients resume use after treatment ends. Enforcement directed at users and drug prevention are also viable interventions but are not analyzed here.

To assess the cost-effectiveness of alternative control programs one needs to know how much is being spent on them and what benefits accrue from that spending. Determining current spending is a straightforward, albeit tedious, matter of piecing together official data from various

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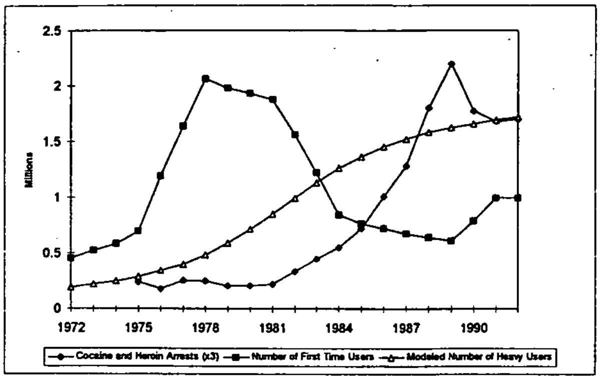

Figure 1. Trends in cocaine-related indicators.

agencies and levels of government (Rydell and Everingham 1994, p. 70–89). During 1992, the base year for this study, an estimated 13 billion dollars was spent in the United States on the four programs listed above, specifically: $0.9 billion on source country control, $1.7 billion on interdiction, $9.5 billion on domestic enforcement (all levels of government), and $0.9 billion on treatment (both public and private). The bulk of these resources go to domestic enforcement—drug arrests, jails, and prisons are expensive. Treatment has only a seven-percent share of this budget, even when privately funded treatment is included.

Measuring the benefits is more difficult. Data are insufficient to use recent trends as a natural experiment, and the programs produce a variety of effects. Supply-control programs generate cocaine seizures, asset seizures, and arrest and imprisonment of drug dealers. Treatment programs induce people to stop using cocaine. To be compared directly, these outcomes must be translated into a common measure of effectiveness. The next section presents a model which performs such a translation. Rydell and Everingham give a more detailed description of the model.

Quantitative models previously have been constructed for specific types of supply-side interventions including source country control (Kennedy et al. 1993), interdiction (Crawford and Reuter 1988), and local crackdowns (Caulkins 1990), but these studies did not compare different classes of programs. A rare exception is Reuter and Kleiman (1986), who compare all these supply-control programs in terms of their ability to raise price, although their estimates of program costs are very rough.

Many studies have found that treatment yields benefits (e.g., Anglin and Hser 1990) without comparing benefits to program costs. A few (Hubbard et al. 1989 and Gerstein et al. 1994) carefully consider both costs and benefits and conclude that treatment is cost-effective in an absolute sense, but they make no comparison to supply-control programs. Some authors have argued that treatment funding should be expanded relative to enforcement (e.g., Falco 1992), but they have not done so on the basis of any analysis that compares treatment and enforcement on a common outcome measure.

The closest comparable literature is a series of systems dynamics studies. Schlenger (1973) simulates varying mixes of voluntary treatment, court-ordered treatment, and sanctions for heroin users. Levin et al. (1975) compare different types of treatment, prevention, and local enforcement for heroin in a single community, but their policy prescriptions do not consider the resource allocation or cost-effectiveness questions addressed here. Gardiner and Shreckengost (1987) create a descriptive model of heroin supply and demand in order to estimate how much heroin enters the United States. Homer (1993) models the market for cocaine at the national level, but his goal is to make prevalence projections, not to evaluate interventions, let alone measure cost-efficacy. Hence, true to their name these studies took a systems perspective, and several modeled both supply- and demand-side interventions, but none answers the question addressed here.

1. THE MODEL

1.1. Modeling Strategy

Cocaine is a consumer good. It is produced, distributed, and sold in markets. The markets for cocaine are not identical to markets for licit goods; they are characterized by a high degree of uninsurable risk, the inability to enforce contracts in courts of law, and poor information. Nevertheless they are markets.

Hence, to model the effect of government interventions, one must first model the market for cocaine. The next two subsections model the demand curve and supply curve, respectively, as functions of the intermediate "products" of interventions. The subsequent subsection estimates how much of each intermediate product is generated per dollar spent on each intervention.

Together these three components yield a complete model. The production functions determine the amounts of various intermediate products (such as seizures and treatment) that are generated by a particular level of spending. Given these numbers, in principle one can simply plot the demand and supply curves, find their intersection, and observe the price and quantity consumed, thereby relating spending on interventions to the relevant outcomes.

In practice the model is a little more complicated. Interventions take effect over time, so the model must be dynamic. The production functions for the interventions depend on the number of users and amount of cocaine produced, so all components of the model must be solved simultaneously. The market clearing equilibrium must be found numerically, not graphically. Nevertheless, these complications do not change the basic structure of the model.

The model includes parameters which are known very imperfectly. As described below, sensitivity analyses show the results are robust with respect to this uncertainty.

1.2. Modeling the Demand Curve

A demand curve is not only a function of price, but also of consumers' tastes. If tastes do not vary, there is no need to address them explicitly, but sometimes they do. With addictive substances this variation takes a particularly pernicious form. Consumers' tastes for cocaine today depend on the amount of cocaine consumed in the past. This occurs for a variety of reasons, but the most salient are addiction and tolerance.

Hence, to model the demand for cocaine over time, one must keep track of the number of people who are using cocaine. Even this is not sufficient because not all users are alike. Many use cocaine in a controlled fashion not unlike the typical consumer of a nonaddictive good; others develop a taste for substantially greater amounts. In principle, one could differentiate among many levels of use. In practice, the data are meager, so we distinguish only between light and heavy users.

To model flows into and out of light and heavy use we begin with the simple, first-order difference equation model described by Everingham and Rydell (1994):

$$L(y+1) = [1-a-b]L(y) + fH(y) + I(y), \qquad (1)$$

$$H(y+1) = [1-f-g]H(y) + bL(y), \quad \text{where}, \qquad (2)$$

$L(y)$ = number of light users at the start of year y,
$H(y)$ = number of heavy users at the start of year y,
$I(y)$ = initiation into light use during year y,
a = average annual rate at which light users quit,
b = average annual rate at which light users escalate to heavy use,
f = average annual rate at which heavy users de-escalate to light use, and
g = average annual rate at which heavy users quit.

By fitting the model to historical data on prevalence, retention rates, and the fraction of users who are heavy users, Everingham and Rydell estimate that $a^* = 0.150$, $b^* = 0.024$, $f^* = 0.040$, and $g^* = 0.020$, where the asterisk denotes base year values; i.e., under base year conditions, 15% of light users quit over a year, 2.4% escalate to heavy use, and the rest stay light users. Similarly, 4% of heavy users de-escalate to light use, 2% quit, and the rest stay heavy users.

Initiation, $I(y)$, is not modeled as a function of the other variables. For the past, the observed initiation rates are used. For the future, we evaluate all interventions relative to the same baseline projection for initiation. The baseline starts with the observed 1992 level of 0.988 million new light users per year and linearly extrapolates the trend observed in the late 1980s so that initiation declines to half the 1992 level by 2007.

Various interventions affect the four flow rates. Treating heavy users, for example, increases the flows out of heavy use. In particular, let k_1 be the difference between the per capita average rates at which treated and untreated heavy users de-escalate to light use, k_2 the corresponding quantity for quitting from heavy use, and "t" the fraction of heavy users in treatment. Since we know the value of these quantities in the base year (1992, denoted by an asterisk), the dependence of the flow rates out of heavy use (f and g) on t can be written:

$$f(t) = f^* + k_1[t - t^*], \qquad (3)$$

$$g(t) = g^* + k_2[t - t^*]. \qquad (4)$$

Values for k_1 and k_2 were estimated from the Treatment Outcomes Prospective Study (TOPS) reported in Hubbard et al. The sum $k_1 + k_2$ is the proportion of heavy users treated who leave heavy use because of that treatment, namely 13.2%. The sum is divided across k_1 and k_2 in proportion to empirically estimated flow rates out of heavy use. The base year (1992) proportion of heavy cocaine users treated was estimated to be $t^* = 0.32$ as follows: 221,000 of the 606,000 public treatments in 1989 (34.8%) were for cocaine (Butynki 1990, p. 41–42). If 34.8% of the 390,000 private drug treatments (NIDA, 1989) were for cocaine, there were a total of 347,000 cocaine treatments in 1989. Real treatment spending increased by 54% between 1989 and 1992 (ONDCP, 1992), suggesting that 534,000 of the 1,688,000 heavy cocaine users in 1992 (Everingham and Rydell, p. 48), or 32%, received treatment.

Enforcement affects the flow rates indirectly through price. The overall responsiveness of consumption to changes in price (measured as the percent change in quantity divided by the percent change in price) is known as the elasticity of demand, $e < 0$. The elasticity of demand for cocaine is unknown. We set $e = -0.5$ because that is the central tendency of alcohol and tobacco elasticity estimates reviewed by Manning et al. (1991), but conduct sensitivity analyses with respect to this parameter.

The overall elasticity is made up of the short run impact on the demand of current users and the long run impact through reduced initiation and escalation, and increased de-escalation and desistance. Based on Becker et al.'s (1991) findings for cigarettes, we take the short run and long run components to be of the same magnitude. Hence, in the long run the number of users would decrease by about $e/2$% for every 1% increase in price. Making the elasticity of the inflow parameters $e/4$ and the elasticity of the outflow parameters $-e/4$ achieves this exactly in steady state and turns out to be a very good approximation in the dynamic model. So, if P denotes the market clearing price and we continue to denote the base year by *, the full approximations for the flow parameters are:

$$a = a^*\left[\frac{P}{P^*}\right]^{-e/4} = 0.150\left[\frac{P}{P^*}\right]^{0.125}, \qquad (5)$$

$$b = b^*\left[\frac{P}{P^*}\right]^{e/4} = 0.024\left[\frac{P}{P^*}\right]^{-0.125}, \qquad (6)$$

$$f = [f^* + k_1[t - t^*]]\left[\frac{P}{P^*}\right]^{-e/4}$$

$$= [0.040 + 0.088[t - 0.32]]\left[\frac{P}{P^*}\right]^{0.125}, \qquad (7)$$

$$g = [g^* + k_2[t - t^*]]\left[\frac{P}{P^*}\right]^{-e/4}$$
$$= [0.020 + 0.044[t - 0.32]]\left[\frac{P}{P^*}\right]^{0.125}. \quad (8)$$

Given these parameters, one can compute the number of light and heavy users over time. However, at any given time not all users are free to consume. Some are incarcerated; others are in treatment. It is assumed that incarcerated users consume a negligible amount (Harlow 1992) and that 73% of heavy users in outpatient programs and 99% of heavy users in residential programs stop using cocaine while in treatment (Hubbard et al.).

Consumption by users who are free to consume is affected by price through the short run elasticity of $e/2$. Hence, the demand curve can be written as:

$$C(y, P) = \left\{C_l^*\left[\frac{1 - j}{1 - j^*}\right]L(y) + C_h^*\left[\frac{1 - n - dt}{1 - n^* - dt^*}\right]H(y)\right\} \cdot \left[\frac{P}{P^*}\right]^{e/2}, \quad (9)$$

where

$C(y, P)$ = annual consumption of cocaine in projection year y, at price P,
C_l^* = annual consumption of cocaine per light user in 1992,
C_h^* = annual consumption of cocaine per heavy user in 1992,
j = incapacitation rate of light users due to imprisonment,
n = incapacitation rate of heavy users due to imprisonment, and
d = person-years off cocaine during treatment per user entering treatment.

1.3. Modeling the Supply Curve

The factors of production for cocaine (arable land, farm labor, precursor chemicals, smugglers, street dealers, etc.) are not scarce, and the technological barriers to entry are low. Hence, there is little reason to model explicitly the number of coca growers, smugglers, or dealers; when their services are needed, they are available. Likewise, enforcement cannot create shortages at the national level, so it is not necessary to model availability, per se. Rather, enforcement can be modeled as a "tax" which raises the cost of production and, thus, increases the price necessary to call forth any given market quantity.

Cocaine production proceeds in stages, and different supply-side strategies affect different stages. Based on availability of data and the nature of the policy choices, we distinguish between production (which is affected by source country control), transshipment (which is affected by interdiction), and domestic distribution (which is affected by domestic enforcement).

The quantity available from a given stage, N_i, (i = 1 for source, 2 for transshipment, and 3 for domestic), is just the amount available in the preceding stage minus the amount seized X_i:

$$N_i = N_{i-1} - X_i, \qquad i = 1, 2, 3, \quad (10)$$

where N_0 = gross production.

There are three categories of costs associated with each stage: (1) the cost of purchasing cocaine from the previous level; (2) sanctions imposed by enforcement; and (3) processing costs, including normal profits, precautions taken to avoid detection, and costs imposed by other market participants. The first is easy to model; the cost of cocaine is just the amount received times the price at the previous stage.

The principal enforcement sanctions are seizure of cocaine (already modeled by the X_i's), seizure of other assets, arrest, and incarceration. For each level, we assume that the relative mix of these four sanctions is constant and equal to the base year ratios. That is, we assume that the "technology" of enforcement at a given level is fixed. This allows us to parameterize source country control, interdiction, and domestic enforcement by the amount seized at each level. Sanction rates, such as the number of cell-years per ton seized, are computed from base year data.

We further assume that the dollar value of the sanctions imposed is linear in the amount of the sanction. For example, the losses due to incarceration are computed as the product of the number of cell-years sentenced times the cost of being incarcerated for one year. The valuations of those sanctions for domestic enforcement and interdiction are educated guesses taken from Reuter and Kleiman and Kleiman (1992) and adjusted for inflation. Costs in source countries are assumed to be one-third those in the United States reflecting lower wages and opportunity costs.

It is easy to compute the processing cost for the base year by subtracting the costs of the cocaine and the sanctions from total costs, but processing costs depend on enforcement levels. As enforcement increases, traffickers work harder to disperse and camouflage the product, relocate operations frequently, intimidate their employees into not cooperating with police, and so on. We know essentially nothing about the dependence of processing costs on enforcement, so we invented a parameter, h, which represents the elasticity of processing costs with respect to enforcement. Then the processing costs per unit, $K_i(X_i)$, are:

$$K_i(X_i) = K_i^*\left[\frac{X_i}{X_i^*}\right]^h. \quad (11)$$

Crawford and Reuter conclude that smuggling costs increase an average of 0.44 percent per one-percent increase in cocaine seized by interdiction, so we assume h = 0.44. The reader might be uneasy about applying a number generated from a study of interdiction to all three enforcement levels. Furthermore, the other two diminishing productivity parameters introduced below ("m" and "p") have even less empirical support. However, the policy results are very robust with respect to these parameters (Rydell and Everingham, Appendix F).

To relate prices at different levels we assume revenues at each stage just cover costs, so the price is the ratio of total costs to the amount of cocaine sold to the next level. This zero-profit condition might seem odd for so lucrative a business, but it is not a statement that net dollar revenues are small. Risk compensation and normal profits are considered to be costs. Thus, this zero-profit assumption (which is based on Reuter and Kleiman's "risks and prices" approach) merely implies that, on average, the high revenues are payment for the nonmonetary costs incurred, such as the high risk of being arrested, injured, or killed. These equations can then be summarized as:

$$P_i N_i = \left\{ P_{i-1} + K_i^* \left[\frac{X_i}{X_i^*} \right]^h \right\} [N_i + X_i] + S_i X_i, \quad i = 1, 2, 3. \tag{12}$$

Dividing the $i = 3$ equation through by N_3 gives the industry supply curve.

1.4. Modeling the Interventions

The modeling above relates intermediate products of interventions to outcomes. Next we need to determine how much of each intermediate product one can buy per dollar spent on each intervention. Constructing such "production functions" from detailed models of the mechanics of each intervention is daunting. We take a simpler approach. Base year data provide one point on the products vs. spending curve; we draw an increasing curve through that point which reflects some diminishing returns.

Treatment has diminishing returns because not all users are identical, and the treatment system has some ability to identify and treat first the easiest cases. We model this by assuming the fraction of treated users who need expensive interventions such as residential treatment, z, increases linearly in the fraction of all users who receive treatment.

Supply-control programs have two forms of diminishing returns. First, there are conventional diminishing returns associated with decreasing productivity as agencies become larger and more bureaucratic, as agencies are forced to hire less talented agents, and as fixed resources (such as military support) are used more intensively. We model these effects by introducing a parameter $m = 0.8$ so that:

$$X_i = X_i^* \left[\frac{B_i}{B_i^*} \right]^m, \quad i = 1, 2, 3, \text{ where} \tag{13}$$

X_i = seizures at level i, and
B_i = enforcement spending at level i.

The second form of diminishing returns arises because the amount seized depends not only on enforcement spending, but also on the amount shipped. If a given level of spending allowed one to inspect a certain fraction of all vessels and containers entering the United States, then the amount seized would be proportional to the amount shipped as well as to spending. Much enforcement, however, is not blind search, but intelligence driven. Indeed, if it took a fixed number of agent hours to develop a lead, the amount seized might be proportional to enforcement spending and independent of the amount of cocaine (provided seizures do not exceed production). The truth lies between these two extremes, so we model the cost per unit seized at level i, Z_i, as a weighted average of the two costing principles:

$$Z_i = Z_i^* \left\{ \left[\frac{N_{i-1}^*}{N_{i-1}} \right] p_i + [1 - p_i] \right\}, \quad i = 1, 2, 3. \tag{14}$$

There are essentially no data on the weights, p_i, but the results are not particularly sensitive to them, so we set $p_i = 0.5$ for all i. Note, this form of diminishing returns applies only to the search and investigative sides of enforcement; it costs the same amount to incarcerate a smuggler no matter how much cocaine is being smuggled.

Combining Equation (13), Equation (14), and parameters for the arrest processing and incarceration costs gives the production function for each level of enforcement.

2. RESULTS

2.1. Expressing the Impact of Interventions in Common Terms

The model describes the costs and effects of four policy interventions. In principle one should divide the benefits by their respective costs and call the intervention with the highest ratio the most cost-effective. However, we have not one outcome but a vector of outcomes (number of heavy users, spending on cocaine, number of people arrested, etc.) which evolves over time.

Different outcome measures are relevant for different goals. Reduction in the total number of users would be consistent with the use-reduction philosophy which has predominated in the United States. Reduction in the number of heavy users would be consistent with a health-oriented, harm-reduction philosophy. Reduction in cocaine spending would be most relevant for someone concerned about market-related crime and violence.

We report all these measures but focus on reduction in the quantity of cocaine consumed. Since heavy users consume much more than light users, tracking consumption is similar to tracking the number of heavy users, but it has the advantage of not entirely ignoring the number of light users. Also, consumption is closely related to total spending.

We examine the impact of changes over a 15-year time horizon. For summary comparisons the 15 annual outcomes need to be reduced to scalar measures. Keeler and Cretin (1983) show that monetary and nonmonetary consequences should be discounted at the same rate, so we use annualized values discounted at a real rate of 4% for all quantities. Thus, when we refer to "cocaine consumption per year" or "cocaine spending per year" we do not mean to imply that these quantities are constant over time. Rather, we are just using the annualized value to summarize results over 15 projection years.

Table I
Costs and Consequences of Reducing Cocaine Consumption by 1% Through Different Programs

	Source Country	Interdiction	Domestic Enforcement	Treatment
Cost of Reducing Consumption by 1% ($ million/year)	783	366	246	34
Cost Relative to treatment	23.0	10.8	7.3	1.0
Change in Number of Light users	−0.33%	−0.33%	−0.33%	−0.05%
Change in Number of Heavy users	−0.50%	−0.50%	−0.50%	−1.08%
Change in Price of cocaine	2.00%	2.00%	2.00%	0.30%
Change in Spending on cocaine	1.00%	1.00%	1.00%	−0.70%

Note: The costs are the additional control costs in the first projection year, which result in consumption decreases over 15 projection years that have a net present value equal to one percent of the first year's consumption. The percentages are the net present value of changes over 15 projection years relative to the first year's total.

2.2. Marginal Cost-effectiveness

We ran the cocaine-control model four times, each time augmenting one program's budget enough in the first projection year to reduce the net present value of cocaine consumption over the 15-year projection period by one percent of total consumption in the first projection year. (Table I, first row) Treatment wins hands down. Per unit reduction in consumption, source-country control costs twice as much as interdiction, interdiction costs one and one-half times as much as domestic enforcement, and domestic enforcement costs seven times as much as treatment. This result is not sensitive to either the length of the time horizon or the particular target reduction in consumption.

The short story behind the supply-control cost estimates is that money spent on supply control increases the cost to producers. These added costs get passed along to consumers as price increases, which in turn reduce consumption. For example, spending $246 million more per year on domestic enforcement increases the suppliers' costs by about $750 million, or two percent of the $37.6 billion spent annually on cocaine. If the elasticity of demand, e, is −0.5, this reduces consumption by one percent.

The short story behind the treatment estimate has two parts: (1) most users stay off drugs while in treatment, and (2) some users stay off drugs after treatment. The average treatment (a mixture of relatively inexpensive outpatient and more expensive residential treatments, and including partial as well as completed treatments) costs $1700, so $34 million pays for 19,000 treatments. The average treatment lasts 0.30 years and 80% of people in treatment are off drugs, so the in-treatment effect of 19,000 treatments is about 5,000 person-years less heavy cocaine use.

Thirteen percent of heavy users cease heavy use after treatment. Not all those departures are permanent, but during the 14 years following treatment, they generate an estimated present value of 20,000 person-years less heavy cocaine use. Heavy users consume about 120 grams per year, so the total of 25,000 person-years of consumption averted represents three metric tons or one percent of current annual consumption.

Table I reports specific estimates of the cost of achieving the cocaine reduction goal, relative cost-effectiveness on this measure, and the impact on other measures (number of light users, number of heavy users, price of cocaine, and spending on cocaine). Supply control looks even worse relative to treatment on other measures. Since supply control increases prices, it increases spending and, hence, the incentive for users to commit property crime and for dealers to commit violence to protect their revenue. Furthermore, part of the consumption reduction induced by driving up cocaine prices may be the result of substitution into other drugs. In contrast, because of polydrug use, treating cocaine users would tend to reduce consumption of other drugs.

2.3. Sensitivity Analysis

The results are most sensitive to two parameters: the price elasticity of demand (e) and treatment's effect on outflow from heavy use ($k_1 + k_2$). The first directly influences the effectiveness of supply-control programs. The second is the most important parameter governing the effectiveness of treatment. Table II shows how decreasing the elasticity of demand by 25% or increasing it by 50% affects the

Table II
Sensitivity of the Cost (in Millions of 1992 Dollars) of Reducing Consumption by 1% to Changes in the Elasticity of Demand

	Price Elasticity of Demand, e		
Control Program	−0.38	−0.50	−0.75
Source-country Seizures	1084	783	474
Interdiction	505	366	222
Domestic Enforcement	330	246	154
Treatment of heavy users	35	34	31
Dom. Enforcement/ Treatment	9.5	7.3	5.0

Table III
Sensitivity of the Cost (in Millions of 1992 Dollars) of Reducing Consumption by 1% to Changes in the Additional Outflow Due to Treatment

	Additional Outflow Due to Treatment (%)		
Control Program	9.9	13.2	16.5
Source-country Seizures	796	783	771
Interdiction	372	366	360
Domestic Enforcement	250	246	242
Treatment of heavy users	43	34	27
Dom. Enforcement/ Treatment	5.7	7.3	9.0

cost of reducing annualized consumption by 1%. Table III shows the effect of varying treatment outflow rates by 25%.

The bottom line in these tables is the ratio of the cost of domestic enforcement to the cost of treatment, for the given reduction in consumption. That ratio is always considerably greater than 1.0, implying that treatment is more cost-effective than domestic enforcement for these parameter values. Also, the ranking of the four interventions is invariant. Source country control costs more than interdiction, which costs more than domestic enforcement, which costs more than treatment.

We can also vary both parameters simultaneously. In Figure 2 the combinations of parameter values to the upper left of the diagonal line are those for which the most cost-effective supply-control program (domestic enforcement) becomes more cost effective than treatment. The solid dot gives the base values. The arrows leading out from the dot show the ranges considered in the sensitivity analysis above. That the entire cross formed by the arrows is so far from the threshold line shows that the conclusion, that treatment is the most cost-effective program, is very robust.

Note: treatment can beat enforcement even if the additional outflow rate due to treatment is zero. The reason is that about one-fifth of treatment's effect on consumption occurs during treatment (people reducing consumption while in treatment). The in-treatment effect alone makes treatment the better program unless the (absolute value of the) elasticity of demand for cocaine is almost 1.0!

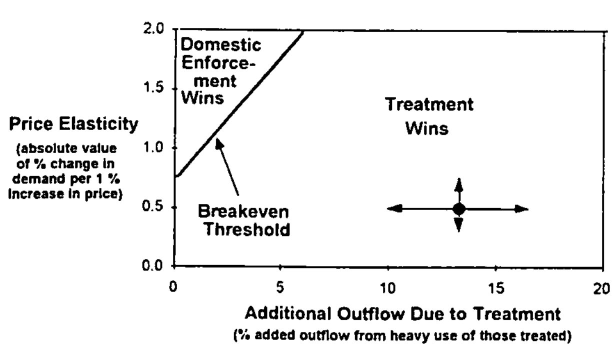

Figure 2. Threshold analysis of sensitivity with respect to key parameters.

Table IV
Defining Characteristics of Alternative Policies

	Current Policy	(A)	(B)	(C)	(D)
		Alternative Policies			
Cocaine Control Budgets ($ billion per year)					
Source country	0.87	0.65	0.65	0.65	0.87
Interdiction	1.71	1.28	1.28	1.28	1.71
Domestic Enforcement	9.47	7.11	7.11	7.11	9.47
Treatment	0.93	0.93	1.86	3.68	3.52
Total	12.98	9.97	10.90	12.72	15.57
Number of Treatments per Year (000)					
Outpatient treatment	430	434	610	627	600
Residential treatment	118	117	272	627	600
Total	548	551	882	1253	1200
Percent of Heavy Users Treated Each Year					
% treated	29	27	51	100	100

Note: Estimates are annualized values over 15 projection years using a 4% real discount rate. Dollar values are expressed in 1992 dollars.

2.4. Changing the Mix of Programs

Four (prominent) alternatives to current policy are:

- **Alternative A:** decrease all three supply-control program budgets by 25%.
- **Alternative B:** decrease supply control by 25% and double the treatment budget.
- **Alternative C:** decrease supply control by 25% and treat 100% of heavy users each year.
- **Alternative D:** treat 100% of heavy users each year without changing supply control.

Table IV describes each plan. A 25% reduction in supply control is of interest because the resulting savings could pay for treating all heavy users once per year. Treating all heavy users once per year is not a theoretical upper bound because someone who starts treatment, quits after a week, and then starts treatment again a few months later gets counted as two episodes of treatment. However, not every heavy user wants treatment, so it is also not obvious that even "100% treatment" is feasible. The reader can draw his or her own inference on that score.

We ran the model with each policy instituted and maintained over fifteen years (with the same initiation scenario as above). For each policy, we computed the annualized average cocaine consumption and plotted it against the average annual control cost in Figure 3. Points corresponding to the alternative policies are identified by their respective letter; the lines connecting the discrete policies represent intermediate policies.

Cutting supply control (moving from current policy to alternative A) saves money but increases consumption.

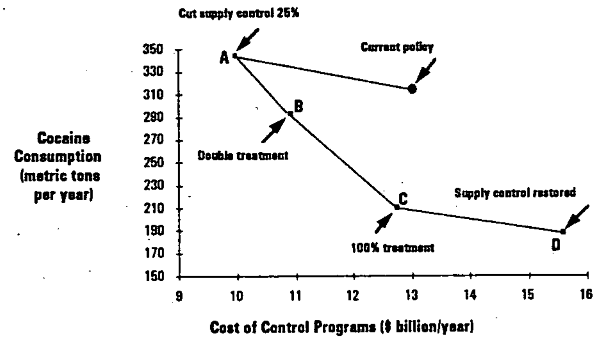

Figure 3. Effect of alternative policies on cocaine consumption.

However, if the savings are used to expand treatment, the setback in consumption is rapidly made up and then some. Further decreases in consumption are possible if treatment can be expanded to reach 100% of heavy users each year without reducing the supply-control budgets.

The point on the tradeoff curve horizontally left of the current policy shows that spending a small part of the supply control savings on treatment would hold cocaine consumption at the level obtained by current policy at considerably reduced cost. The point on the tradeoff curve straight down from the current policy identifies a plan with the same budget as current policy, but with considerably less cocaine consumption. Any place on the wedge between these points and current policy dominates current policy.

The figures above are annualized averages, but the time profile of the effect on consumption is different for different alternatives. Figure 4 shows that the difference between alternatives that do and do not expand treatment get larger over time. Figure 4 needs a strong caveat. That the projected consumption under current policy shows little change over the projection period is *not* a prediction. It is a consequence of the initiation scenario adopted for this analysis. Predicting initiation is beyond the scope of this analysis, but some assumption had to be made to get a reference point from which to measure the effect of changes in policy. Consequently, the reader should focus on the differences between the lines in Figure 4, not their absolute values. The differences, and other results in this paper, are robust with respect to the initiation scenario assumed.

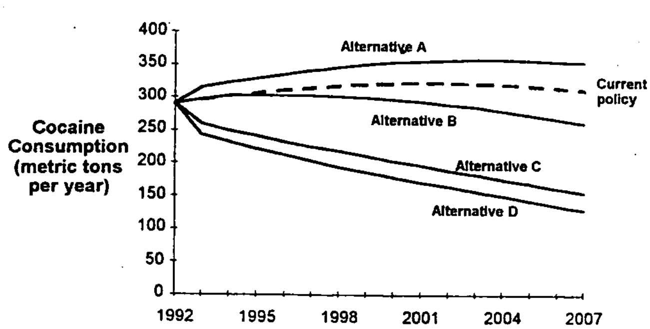

Figure 4. Changes in cocaine consumption over time under alternative policies.

3. DISCUSSION

This paper concludes that treating heavy users is more cost-effective than supply-control programs. Skeptics might wonder how this can be, given the high relapse rates from treatment. There are two explanations. First, treatment evaluations typically measure the proportion of people who no longer use drugs at some point after completing treatment, so they tend to under-appreciate the benefits of keeping people off drugs during treatment. This stands in ironic contrast to evaluations of criminal justice interventions that focus on incapacitation during the intervention and ignore the possibility of rehabilitation. Second, about three-fifths of those who start treatment stay in less than three months. Incomplete treatments do little to reduce consumption, which makes treatment look weak by traditional criteria. However, incomplete treatments also do not cost much, so they do not dilute the cost-effectiveness of completed treatments.

Treatment is not, however, a panacea because there is a limit on how much treatment can be done. Even treating every heavy user once each year would only reduce U.S. consumption of cocaine by half in 2007, and by less in earlier years (see Figure 4).

Although our model is rough, sensitivity analyses indicate that our qualitative conclusions are robust in the face of parameter uncertainty. So, if the results of this analysis are wrong, it is because of something substantial and structural in the modeling, not because of particular parameter choices. We hope that this analysis prompts others to develop similar models and to refine this one. Future efforts need to consider user sanctions (where deterrence must be modeled), prevention programs (where long time horizons are needed to assess the effects), and the relationship between efforts to control cocaine and efforts to control other drugs (primarily heroin, marijuana, and alcohol).

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