Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy

Charles F. Manski, John V. Pepper, and Yonette F. Thomas, Editors; Committee on Data and Research for Policy on Illegal Drugs, National Research Council

ISBN: 0-309-51891-1, 64 pages, 6 x 9, (1999)

This free PDF was downloaded from:
http://www.nap.edu/catalog/9441.html

Visit the National Academies Press online, the authoritative source for all books from the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council:

- Download hundreds of free books in PDF
- Read thousands of books online for free
- Purchase printed books and PDF files
- Explore our innovative research tools – try the Research Dashboard now
- Sign up to be notified when new books are published

Thank you for downloading this free PDF. If you have comments, questions or want more information about the books published by the National Academies Press, you may contact our customer service department toll-free at 888-624-8373, visit us online, or send an email to comments@nap.edu.

This book plus thousands more are available at www.nap.edu.

Copyright © National Academy of Sciences. All rights reserved.
Unless otherwise indicated, all materials in this PDF file are copyrighted by the National Academy of Sciences. Distribution or copying is strictly prohibited without permission of the National Academies Press <http://www.nap.edu/permissions/>. Permission is granted for this material to be posted on a secure password-protected Web site. The content may not be posted on a public Web site.

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy

Charles F. Manski, John V. Pepper, and Yonette F. Thomas, Editors

Committee on Data and Research for Policy on Illegal Drugs

Committee on Law and Justice
Committee on National Statistics

Commission on Behavioral and Social Sciences and Education
National Research Council

NATIONAL ACADEMY PRESS
Washington, DC 1999

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

NATIONAL ACADEMY PRESS 2101 Constitution Avenue, N.W. Washington, DC 20418

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. William A. Wulf are chairman and vice chairman, respectively, of the National Research Council.

This study was supported by Contract/Grant No. DC8C01 between the National Academy of Sciences and the Office of National Drug Control Policy of the Executive Office of the President. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

International Standard Book Number 0-309-06477-5

Additional copies of this report are available from National Academy Press, 2101 Constitution Avenue, N.W., Lockbox 285, Washington, DC 20055; (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area); Internet, http://www.nap.edu

Printed in the United States of America
Copyright 1999 by the National Academy of Sciences. All rights reserved.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

COMMITTEE ON DATA AND RESEARCH FOR POLICY ON ILLEGAL DRUGS

CHARLES F. MANSKI *(Chair)*, Department of Economics, Northwestern University
ALFRED BLUMSTEIN, H. John Heinz III School of Public Policy and Management, Carnegie Mellon University
RICHARD J. BONNIE, School of Law, University of Virginia
JEANETTE COVINGTON, Department of Sociology, Rutgers University
DENISE C. GOTTFREDSON, Department of Criminal Justice and Criminology, University of Maryland
PHILIP B. HEYMANN, Center for Criminal Justice, Harvard University
JOEL L. HOROWITZ, Department of Economics, University of Iowa
ROBERT J. MACCOUN, Richard & Rhoda Goldman School of Public Policy, University of California, Berkeley
MARK H. MOORE, John F. Kennedy School of Government, Harvard University
WILLIAM NORDHAUS, Department of Economics, Yale University
ROBERT H. PORTER, Department of Economics, Northwestern University
PAUL R. ROSENBAUM, Department of Statistics, University of Pennsylvania
JAMES Q. WILSON, Department of Political Science, University of California, Los Angeles

DARNELL F. HAWKINS (*Liaison*, *Committee on Law and Justice),* African American Studies, University of Illinois at Chicago

YONETTE F. THOMAS, *Study Director*
JOHN PEPPER, *Consultant*
KAREN AUTREY, *Senior Project Assistant*

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

COMMITTEE ON LAW AND JUSTICE

CHARLES WELLFORD (*Chair*), Center for Applied Policy Studies and Department of Criminology and Criminal Justice, University of Maryland
RUTH DAVIS, The Pymatuning Group, Inc., Virginia
DARNELL HAWKINS, Department of African American Studies, University of Illinois at Chicago
PHILIP HEYMANN, Center for Criminal Justice, Harvard Law School
CANDACE KRUTTSCHNITT, Department of Sociology, University of Minnesota
MARK LIPSEY, Department of Psychology and Human Development, Vanderbilt University
COLIN LOFTIN, School of Criminal Justice, State University of New York at Albany
JOHN MONAHAN, School of Law, University of Virginia
DANIEL NAGIN, H. John Heinz III School of Public Policy and Management, Carnegie Mellon University
JOAN PETERSILIA, School of Social Ecology, University of California, Irvine
PETER REUTER, School of Public Affairs, University of Maryland
WESLEY SKOGAN, Center for Urban Affairs, Northwestern University
CATHY SPATZ WIDOM, Departments of Criminal Justice and Psychology, State University of New York at Albany
KATE STITH, School of Law, Yale University
MICHAEL TONRY, School of Law, University of Minnesota

CAROL PETRIE, *Study Director*
MELISSA BAMBA, *Research Associate*
KAREN AUTREY, *Senior Project Assistant*

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

COMMITTEE ON NATIONAL STATISTICS
1998-1999

JOHN E. ROLPH (*Chair*), Marshall School of Business, University of Southern California
JOSEPH G. ALTONJI, Department of Economics, Northwestern University
JULIE DAVANZO, RAND, Santa Monica, California
WILLIAM F. EDDY, Department of Statistics, Carnegie Mellon University
WILLIAM D. KALSBEEK, Survey Research Unit, Department of Biostatistics, University of North Carolina
RODERICK J.A. LITTLE, School of Public Health, University of Michigan
THOMAS A. LOUIS, Division of Biostatistics, University of Minnesota
CHARLES F. MANSKI, Department of Economics, Northwestern University
WILLIAM D. NORDHAUS, Department of Economics, Yale University
JANET L. NORWOOD, The Urban Institute, Washington, DC
EDWARD B. PERRIN, Department of Health Services, University of Washington
PAUL R. ROSENBAUM, Department of Statistics, The Wharton School, University of Pennsylvania
FRANCISCO J. SAMANIEGO, Division of Statistics, University of California, Davis
RICHARD L. SCHMALENSEE, Sloan School of Management, Massachusetts Institute of Technology

MIRON L. STRAF, *Director*
ANDREW A. WHITE, *Deputy Director*

Copyright © National Academy of Sciences. All rights reserved.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Contents

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Preface

In October of 1997 the Office of National Drug Control Policy (ONDCP) of the Executive Office of the President requested the National Research Council (NRC) to convene a committee to study the data and research needed for national policy on illegal drugs. The Committee on Data and Research for Policy on Illegal Drugs, formed in early 1998 under the aegis of the NRC's Committee on Law and Justice and Committee on National Statistics, was given the charge to:

1. assess existing data sources and recent research studies that support policy analysis;
2. identify new data and research that may enable the development of more effective means of evaluating the consequences of alternative drug control policies; and
3. explore ways to integrate theory and findings from diverse disciplines to increase understanding of drug abuse and the operation of drug markets.

The committee began its work in spring 1998 and will, over a $2^1/_2$-year period, conduct a broad study of data and research to inform drug control policy.

The charge to the committee gives it substantial discretion on the conduct of the study. ONDCP did, however, make one specific request: that the committee, early in its work, assess two recent cost-effectiveness studies on cocaine control policy. The two studies—by RAND and the

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Institute for Defense Analyses (IDA)—have starkly different methodologies and conclusions and have drawn considerable attention. In connection with its work, the committee hosted a public Workshop on Cost-Effectiveness Studies in June 1998. At the workshop, authors of the two studies presented their work, responded to questions, and offered their general perspectives.

This report presents the committee's review and assessment of the RAND and IDA studies. The immediate purpose of the report is to evaluate the degree to which these two studies effectively inform cocaine control policy. In the longer term, the report sets a context for the committee's future deliberations about the data and research needed to support analysis and development of drug control policy.

Many people made generous contributions to the work of the committee. We thank the authors and presenters of the two reports, Susan Everingham, Jonathan Caulkins, Barry Crane, and A. Rex Rivolo, who attended the Workshop on Cost-Effectiveness Studies, answered our many questions, and provided background material. Also, we thank Christopher Sims of the Yale University Department of Economics, Jeffrey Grogger and Mark Kleiman of the University of California, Los Angeles, School of Public Policy and Social Research, Robert Moffit of the Johns Hopkins University Department of Economics, and John Geweke of the University of Minnesota Department of Economics for their theoretical and methodological insights.

We also thank Eugenia Grohman, associate director for reports of the Commission on Behavioral and Social Sciences and Education, for her ever-important editorial support and Karen Autrey, our senior project assistant, for her organizational assistance and logistical support.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their participation in the review of this report: David S. Cordray, Institute for Public Policy Studies, Vanderbilt University; Stephen Fienberg, Department of Statistics, Carnegie Mellon University; Arthur S. Goldberger, Department of Economics, University of Wisconsin; Joel B. Greenhouse, Department of Statistics, Carnegie Mellon University; Herbert Kleber, National Center on Addiction and Substance Abuse, Columbia University; Lester B. Lave,

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Graduate School of Industrial Administration, Carnegie Mellon University; Philip R. Lee, Institute for Health Policy Studies, University of California, San Francisco; Colin Loftin, School of Criminal Justice, State University of New York at Albany; Henry W. Riecken, Professor of Behavioral Sciences, University of Pennsylvania School of Medicine (emeritus); and Thomas C. Schelling, School of Public Affairs, University of Maryland.

Although the individuals listed above have provided constructive comments and suggestions, it must be emphasized that responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Finally, as we begin the major phase of work, on the broad questions of illegal drug policies, we are happy to welcome two new members: James C. Anthony, at the Department of Epidemiology, Johns Hopkins University, School of Medicine, and Charles O'Brien, at the Treatment Research Center, University of Pennsylvania. Their expertise are valuable additions for the committee's continuing work.

Charles F. Manski, *Chair*
Yonette F. Thomas, *Study Director*
Committee on Data and Research for
Policy on Illegal Drugs

Copyright © National Academy of Sciences. All rights reserved.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Executive Summary

The Committee on Data and Research for Policy on Illegal Drugs was formed in early 1998 in response to a request from the Office of National Drug Control Policy (ONDCP) of the Executive Office of the President to study the data and research needed for national policy on illegal drugs. The committee's first task, the subject of this report, was to assess two recent cost-effectiveness studies on cocaine control policy: one by RAND, *Controlling Cocaine: Supply Versus Demand Programs* (Rydell and Everingham, 1994), prepared for ONDCP and the U.S. Army, and one by the Institute for Defense Analyses (IDA), *An Empirical Examination of Counterdrug Interdiction Program Effectiveness* (Crane, Rivolo, and Comfort, 1997), prepared for the Deputy Assistant Secretary of Defense, Drug Enforcement Policy and Support, U.S. Department of Defense. The committee examined the assumptions, data, methods, and findings of the RAND and IDA studies.

The RAND study is best thought of as conceptual research offering a coherent way to think about the cocaine problem. The study documents a significant effort to identify and model important elements of the market for cocaine. It represents a serious attempt to formally characterize the complex interaction of producers and users and the subtle process through which alternative cocaine control policies may affect consumption and prices. The study establishes an important point of departure for the development of richer models of the market for cocaine and for empirical research applying such models to evaluate alternative policies.

However, the RAND study does not yield usable empirical findings on the relative cost-effectiveness of alternative policies in reducing co-

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

caine consumption. The study makes many unsubstantiated assumptions about the processes through which cocaine is produced, distributed, and consumed. Plausible changes in these assumptions can change not only the quantitative findings reported, but also the main qualitative conclusions of the study. Hence the study's findings do not constitute a persuasive basis for the formation of cocaine control policy.

The IDA study is best thought of as a descriptive time-series analysis of statistics relevant to analysis of the market for cocaine in the United States. The study makes a useful contribution by displaying a wealth of empirical time-series evidence on cocaine prices, purity, and use since 1980. Efforts to understand the operation of the market for cocaine must be cognizant of the empirical data. The IDA study presents many of those data and calls attention to some intriguing empirical associations among the various series.

However, the IDA study does not yield useful empirical findings on the cost-effectiveness of interdiction policies to reduce cocaine consumption. Major concerns about data and methods make it impossible to accept the IDA findings as a basis for the assessment of interdiction policies. Numerous problems diminish the credibility of the cocaine price series developed in the study, and an absence of information prevents assessment of the procedure for selecting interdiction events. The conclusions drawn from these data rest on the assumption that all time-series deviations in cocaine price from an exponential decay path should be attributed to interdiction events, not to other forces acting on the market for cocaine. This foundation is too fragile to support the study's conclusions or to serve as a basis for policy.

The process of scrutinizing the specifics of the RAND and IDA studies has helped the committee to frame the questions that it will now address in a broad study of how data and research may, in the future, better serve the objective of informing drug control policy.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

1

Introduction

BACKGROUND

Initiatives that address the major goals of U.S. drug control policy have commonly been conceptualized as either supply-control or demand-control activities. Supply-control activities include disruption of production in source countries, interdiction of drug shipments from source countries, and domestic law enforcement activities that aim to disrupt the marketing of drugs within the United States. Demand-control activities include prevention, treatment, and law enforcement activities that seek to reduce the prevalence, intensity, or harmful consequences of drug use among Americans.

Current drug control policy includes both supply-control and demand-control activities. The appropriate mix of such activities is the subject of a continuing debate, with both normative and empirical components. On the normative side, Americans vary in their moral judgment of drug use and in their concern with the collateral consequences of drug-control activities. On the empirical side, Americans vary in their assessment of the effectiveness of prevention, treatment, domestic enforcement, and foreign interdiction activities in reducing the availability of drugs. The continuing debate about drug control policy manifests itself in many ways, among which is an annual battle within the federal government on the allocation of funding across different drug control activities.

The lack of a strong body of data and research to inform policy on illegal drugs has long impeded the development of well-grounded judg-

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

ments about the effectiveness of alternative drug control activities (Moore, 1990). Against this background, a body of scientific work on the operation of drug markets began to take form during the 1990s. Researchers sought to understand the empirical relationship between drug use, drug production, and the street price of drugs. Some studies sought to compare the effect of alternative cocaine control strategies, including source country eradication and enforcement programs, interdiction efforts, local criminal justice programs, sentencing schemes, and treatment programs (Crane, Rivolo, and Comfort, 1997; Caulkins et al., 1997; Everingham and Rydell, 1994; Rydell and Everingham, 1994). Other studies sought to evaluate alternative heroin control strategies (e.g., Weatherburn and Lind, 1996; Caulkins, 1995b; White and Luksetich, 1983).

THE RAND AND IDA STUDIES

Of the limited research to date, the studies of cocaine control policy performed at RAND by Rydell and Everingham (1994) and at the Institute for Defense Analyses (IDA) by Crane, Rivolo, and Comfort (1997) have drawn unique attention in the ongoing struggle over federal funding of drug control activities. The RAND study has been used to argue that funding should be shifted toward drug treatment programs and away from activities to reduce drug production or to interdict drug shipments. For example, in a 1995 statement to the Subcommittee on National Security, International Affairs, and Criminal Justice, Committee on Government Reform and Oversight, U.S. House of Representatives (1996:61), Lee Brown, then director of the Office of National Drug Control Policy (ONDCP), stated:

> Let me now talk about what we know works in addressing the drug problem. There is compelling evidence that treatment is cost-effective and provides significant benefits to public safety. In June 1994, a RAND Corporation study concluded that drug treatment is the most cost-effective drug control intervention.

The subsequent IDA study, which was undertaken in part as a reanalysis of the RAND findings, has been used to argue that interdiction activities should be funded at present levels or higher. In a 1996 hearing specifically devoted to the IDA study, "Review of the Internal Administration's Study Critical of Clinton Drug Policy and White House Suppression of the Study," chair William H. Zeliff began this way (Subcommittee on National Security, International Affairs, and Criminal Justice, Committee on Government Reform and Oversight, U.S. House of Representatives, 1998:1):

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

> We are holding these hearings today to review a study on drug policy, a study we believe to have significant findings, prepared by an independent group, the Institute for Defense Analyses, at the request of Secretary of Defense Perry in 1994. . . . [T]he subcommittee has questioned for some time the administration's strong reliance on treatment as the key to winning our Nation's drug war, and furthermore this subcommittee has questioned the wisdom of drastically cutting to the bone interdiction programs in order to support major increases in hard-core drug addiction treatment programs. The basis for this change in strategy has been the administration's reliance on the 1994 RAND study.

The RAND and IDA studies specify similar hypothetical objectives for cocaine control policy, namely reduction in cocaine consumption in the United States by 1 percent. Both studies predict the monetary cost of using certain policies to achieve this objective. Because they focus on the specified objective of a reduction in cocaine consumption, the two studies are called "cost-effectiveness" studies rather than "cost-benefit" studies, which would seek to evaluate the full set of consequences of alternative policies in comparable economic terms. And because both studies focus on real-world interventions rather than on interventions under ideal conditions, they are called "effectiveness" studies rather than "efficacy" studies[1] (see also National Research Council, 1979; Rossi and Freeman, 1993; Northridge et al., 1997).

The RAND study, which evaluates various demand-control and supply-control policies, reaches this conclusion (Rydell and Everingham 1994:xiii):

> The analytical goal is to make the discounted sum of cocaine reductions over 15 years equal to 1 percent of current annual consumption. The most cost-effective program is the one that achieves this goal for the least additional control-program expenditure in the first projection year. The additional spending required to achieve the specified consumption reduction is $783 million for source-country control, $366 million for interdiction, $246 million for domestic enforcement, or $34 million for treatment (see Figure S.3). The least costly supply-control program (domestic enforcement) costs 7.3 times as much as treatment to achieve the same consumption reduction.

[1]Effectiveness is a measure of the benefit resulting from an intervention for a given health problem under average conditions of use. This form of evaluation considers both the efficacy of an intervention and its acceptance by those to whom it is offered. It answers the questions: Does the practice do more good than harm to people to whom it is offered? Efficacy is a measure of the benefit resulting from an intervention for a given health problem under ideal conditions of use. It answers the question: Does the practice do more good than harm to people who fully comply with the recommendations (National Information Center on Health Services Research and Health Care Technology, 1998a, 1998b)?

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

The IDA study, which focuses on source-zone interdiction, reaches an entirely different conclusion (Crane, Rivolo, and Comfort, 1997:3):

> A rough estimate of cost-effectiveness indicates that the cost of decreasing cocaine use by one percent through the use of source-zone interdiction efforts is on the order of a few tens of millions of dollars per year and not on the order of a billion dollars as reported in previous research [the RAND study]. The differences are primarily attributed to a failure in the earlier research to account for the major costs imposed on traffickers by interdiction operations and overestimation of the costs of conducting interdiction operations.

The IDA study, thus, specifically rebuts a key finding of the RAND study.

The RAND and IDA studies use very different analytical approaches and data sources to reach their very different conclusions. Both studies were subjected to review before release, but neither was published in a peer reviewed medium. Both studies are unclassified reports available in the open literature. Since their publication, questions have been raised about the validity of the models of the drug market used in both studies. The capacity of even sophisticated analytic approaches to compensate for the limitations of the available data has been questioned by many researchers and policy analysts. Skepticism about the assumptions, data, and methods of one or the other study has been heightened because the two studies reach directly contradictory findings.

THIS REPORT

It is against this background that ONDCP requested the Committee on Data and Research for Policy on Illegal Drugs to assess the two studies. Because the assumptions, data, and methods of the RAND and IDA studies are so different, the committee decided that each study should be assessed in isolation from the other. Thus, the analysis of the RAND study in Chapter 2 makes no reference to the IDA study, and the analysis of the IDA study in Chapter 3 makes no reference to the RAND study. The two chapters have parallel formats, each beginning with a description of the assumptions, data, methods, and findings of the relevant study and then giving the committee's assessment of the study. The committee does not attempt to reconcile the very different findings of the two studies. Nor does the committee attempt to reach its own conclusions about the cost-effectiveness of alternative policies in reducing cocaine consumption.

IDA personnel advised that access to classified data is important if the IDA study is to be fully understood. In its work, the committee found that access to classified data would at most be relevant to assessment of one aspect of the IDA study—the selection of interdiction events for

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

analysis. Consequently, the committee formed a classified subcommittee to investigate this matter and, more generally, to explore whether access to classified data may be germane to the broader objectives of the committee. See the section "Selection of Interdiction Events" in Chapter 3 for discussion.

Although the RAND and IDA studies use different assumptions, data, and methods, the committee can and does apply the same broad criteria in assessing the two studies. Both studies use quantitative methods to draw conclusions from data and assumptions. In assessing each study, the committee evaluates the appropriateness of the data used, the plausibility of the assumptions imposed, and the logic of the methods by which data and assumptions are combined. In each case, the committee does not hold the study to a textbook standard of an ideal scientific analysis. The committee applied a necessarily looser and more pragmatic standard: Are the study's findings sufficiently credible that they should be given weight in the analysis and design of national drug control policy?

THE WORK AHEAD

The committee is now moving forward on its broad study of data and research to inform drug control policy. The process of scrutinizing the specifics of the RAND and IDA studies has helped the committee to frame the general questions that it will now address. Looking ahead, the committee plans to evaluate the knowledge presently and potentially available about the effectiveness of drug treatment programs, the economics of drug markets (e.g., substitution effects), and the effects of domestic law enforcement activities on drug use. The committee also plans to assess the data presently and potentially available on drug production, use, and prices. The committee's final report will address the broad issue of how data and research can, in the future, serve the objective of informing drug control policy.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

2

The RAND Study

ASSUMPTIONS, DATA, METHODS, AND FINDINGS

The RAND study, *Controlling Cocaine: Supply Versus Demand Programs* (Rydell and Everingham, 1994), develops a model of the market for cocaine in the United States and selects parameter values to make the model consistent with some empirical evidence. The study then uses the model to assess the cost-effectiveness of four alternative strategies for reducing cocaine consumption: source-country control, interdiction, domestic enforcement, and treatment of heavy users.

Modeling the Market for Cocaine: Qualitative Features

The RAND model seeks to explain the aggregate consumption of cocaine in the United States as the outcome of a long-run competitive market process in which the price of cocaine adjusts to balance supply and demand. The model has a complex detailed structure, but Figure 1 describes some of the essential qualitative features. The demand curve shows the quantity of cocaine that American consumers wish to purchase at any given price. The supply curve shows the quantity that producers would be willing to sell at any given price. The intersection of the supply and demand curves is the market equilibrium: the price at which the quantities demanded and supplied are equal, so that the market is in balance.

The downward sloping shape of the market demand curve reflects the usual economic assumption that the quantity of a product demanded

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

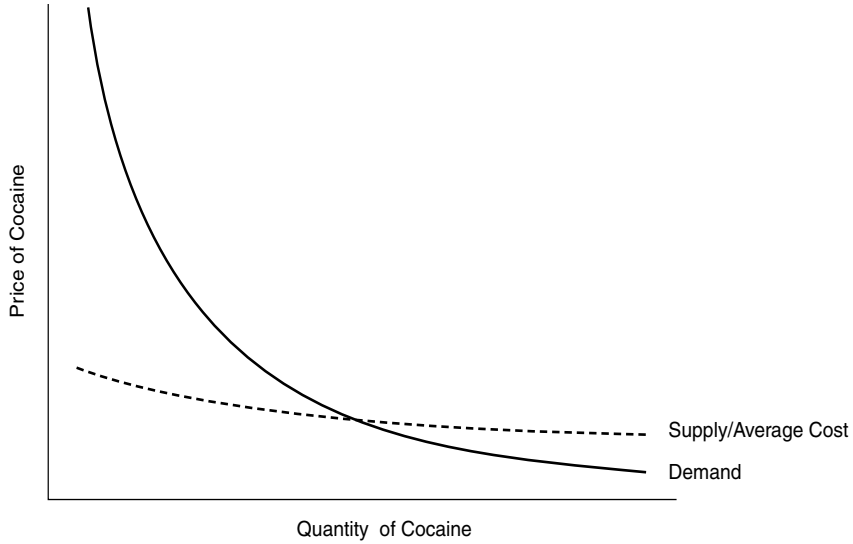

FIGURE 1 RAND model of long-run market supply and demand for cocaine in the United States.

varies inversely with its price. The unusual feature of Figure 1 is that the market supply curve also slopes downward. The RAND study bases its downward sloping supply curve on three assumptions. The first assumption is that the price at which a given quantity of cocaine is supplied to the market equals the average cost per unit of producing this quantity (Rydell and Everingham, 1994:53). This assumption is standard in the long-run analysis of competitive markets because free entry and exit of producers implies that profit must be zero for the marginal producer (Panzar and Willig, 1978). In this framework, the market supply curve in Figure 1 measures the average cost of producing any given quantity. The second assumption in the RAND study is that the resources used in the production of cocaine are available to producers at a constant price per unit, regardless of how much of these resources are used in the production of cocaine (pp. 52, 95). Hence, the marginal cost of producing an additional unit of cocaine does not change with the quantity produced. The third assumption is that supply-control policies generate production costs that grow at a slower rate than output (pp. 53, 95): As production rises, the ratio of seizures to the quantity of cocaine produced falls. Hence, the second and third assumptions together imply that average cost declines with quantity produced.

In the RAND model, cocaine control policies would reduce the con-

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

sumption of cocaine and increase its price. Source-country control, interdiction, domestic enforcement, and other supply-control policies would shift the average cost curve up, while leaving the demand curve unchanged. The result would be a new equilibrium with a higher price and lower consumption than would be observed in the absence of such policies. Drug treatment programs and other demand-control policies would shift the demand curve down, while leaving the average cost curve unchanged. The result again would be a new equilibrium with a higher price and lower consumption than in the absence of such policies. The RAND study does not specifically address the possibility that some cocaine control policies may affect both demand and supply. For example, domestic enforcement activities may reduce supply by disrupting the distribution of cocaine. They also may reduce demand by deterring cocaine purchases by incapacitating users and by making arrested users subject to mandatory treatment programs. The RAND study only entertains a limited form of incapacitation effects.

It is of interest to compare the qualitative predictions of the RAND model with those of models that make the usual assumption that supply curves slope upward. In models with upward sloping supply curves, supply-control policies would yield increases in price and decreases in consumption, and demand-control policies would yield decreases in price and decreases in consumption. Thus, from a qualitative perspective, the RAND model and models that assume upward sloping supply curves make common predictions about the effects of policy on consumption and about the effect of supply-control policies on price, but they make opposite predictions about the effect of demand-control policies on price.

Modeling the Market for Cocaine: Quantitative Features

Qualitative analysis does not carry one very far toward the objective of assessing the cost-effectiveness of alternative policies in reducing cocaine consumption. To make predictions about the magnitudes of policy effects, it is necessary to specify particular shapes for the demand and supply curves and to specify how these curves shift with changes in cocaine control policy.

The RAND study accomplishes this in two steps. First, it posits demand and supply models with specific functional forms. The demand model describes a dynamic process of cocaine use, with some individuals moving over time between no use, light use, and heavy use. The quantity of cocaine by the persons in a use category, as well as the transitions between categories, are assumed to be sensitive to prices (pp. 74-76). The model assumes that light and heavy users have the same constant price elasticity of demand. That is, given a 1 percent decrease in price, the

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

study assumes that the quantity of cocaine demanded by light and heavy users always increases by the same constant percentage. Similarly, the model assumes that the rates of transitions between categories have the same absolute constant price elasticity. That is, given a 1 percent decrease in price, it assumes that the inflow of users into higher consumption categories always increases by the same percentage and that the outflow always decreases by the same percentage. The model does not specify how nonprice variables, such as criminal sanctions on users, affect the demand for cocaine.

The supply model describes a multistage process of cocaine production and distribution, from the growing of coca leaf in source countries to the retail marketing of cocaine in the United States. Production costs at each stage are assumed to equal the sum of the value of inputs, processing costs, and costs generated by cocaine control policies.

The demand and supply models have several free parameters. The second step in model specification is to select values for these parameters. The values in the RAND study were chosen in part to make the model consistent with available data and the findings of previous empirical studies and in part on the basis of educated guesses. Formal statistical methods were not used to estimate parameter values, to describe their uncertainty, or to evaluate the sensitivity of the model's predictions to the parameter values assumed.

Table 1 displays the key parameters, the range of values entertained for them, and the sources of information used to choose this range. The "elasticity of market demand" parameter measures the sensitivity of quantity demanded to price. The RAND baseline analysis assumes that the price elasticity of demand equals –0.50: that is, a 1 percent increase in price generates a 0.50 percent decrease in the quantity of cocaine demanded, by both light and heavy users. This choice for the elasticity parameter was motivated by reference to empirical analyses of other psychoactive substances, namely, cigarettes and alcohol. The price elasticities of demand for cigarettes and alcohol have been estimated to lie between 0 (which means that changes in price have no effect on demand) to nearly –2.0 (which means that a 1 percent change in price generates a 2 percent drop in quantity demanded) (Manning et al., 1991). Most analyses find that the elasticity lies between 0 and –1.0. Given this range of estimates, the RAND study argues that a price elasticity of demand for cocaine of –0.5 is a "reasonable" assumption (p. 75). To assess the sensitivity of findings to this assumption, the study entertains values between –0.38 and –0.75.

The "elasticity of market supply" parameter measures the sensitivity of quantity supplied to price. The RAND supply model requires that the average cost curve in Figure 1 be downward sloping; hence, the study

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

TABLE 1 The Values of Selected Supply and Demand Market Parameters Used in the Simulations Reported in the RAND Study

Parameter	Low	Baseline	High	Sources
Elasticity of Market Demand[a]	–0.38	–0.50	–0.75	Extrapolated from previous studies on cigarettes and alcohol, as reported in Manning et al. (1991)
Elasticity of Market Supply[a]	–2.7	–3.6	–6.6	Educated guess
Drug Treatment Effects[b]				TOPS data as
In-treatment	79.0%	79.0%	79.0%	reported in
Post-treatment	9.9%	13.2%	16.5%	Hubbard et al. (1989)
Supply-Control Policies				
Elasticity of processing cost with respect to seizures	0.22	0.44	0.66	Crawford and Reuter (1988)
Productivity of additional control budget dollars	0.70	0.80	0.90	Educated guess

NOTE: The parameter values in the table are found in Rydell and Everingham (1994): Table 3.1 (p. 20), Table E.1 (p. 96), and Table F.1 (p. 107).

[a]The percentage change in quantity demanded or supplied that results from a 1 percent increase in price. The elasticity of supply is not constant for all prices, but is instead an estimate based on "runs of the cocaine-control model" (p. 96).

[b]These values are weighted averages of treatment effectiveness for residential and non-residential programs.

entertains only negative values for the supply elasticity parameter. The baseline analysis assumes that the price elasticity of supply equals –3.6, implying that a 3.6 percent decrease in the quantity supplied requires a 1 percent increase in average costs (Table E.1). This choice is based on a "rough appreciation of discussions and general reading about the cocaine supply process" (p. 71). For purposes of sensitivity analysis, the study entertains values ranging from –2.6 to –6.6.[1]

[1]In the RAND model, the average cost function does not have the constant-elasticity form. That is, the price elasticity of supply varies with average costs, and there is no single price elasticity of supply that applies for all prices. These elasticity measures are estimates based on "runs of the cocaine control model" as reported in Table E.1 in the RAND study (p. 96). The estimates are derived by varying a parameter, which regulates the fraction of seizure costs associated with the relative (as opposed to the absolute) size of the seizure. As this fraction increases from 0 to 1, seizures become increasingly related to total production, and the supply curve becomes increasingly elastic.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

The RAND model uses two parameters to measure the effectiveness of drug treatment programs that seek to reduce cocaine consumption by heavy users. The programs are assumed to have both an *in-treatment* and a *post-treatment* effect on drug use. The in-treatment effect measures the degree to which cocaine use decreases during the period that a person is undergoing the treatment program. The baseline analysis assumes that 79 percent of heavy users stop consuming cocaine while in treatment (p. 20). The post-treatment effect measures the effect of treatment on the rate of transition of heavy users into the light use and no-use categories. The baseline analysis assumes that treatment programs cause 13.3 percent of treated heavy cocaine users to desist from heavy use after treatment (p. 20).

These choices for the two treatment effect parameters are motivated by reference to statistics from the Treatment Outcome Prospective Study (TOPS) reported in Hubbard et al. (1989). TOPS collected program and client interview follow-up data in various treatment programs in 10 cities. The data include information on residential and nonresidential and public and private treatment programs. However, the programs studied primarily treated heroin users, not cocaine users.

The final set of parameters in Table 1 are intended to measure the effectiveness of supply-control policies. In the RAND supply model, each stage of cocaine production may be subjected to control activities, which affect costs of production. Supply-control activities impose direct costs on producers through product seizures and financial penalties, and they impose indirect costs as producers seek to avoid seizures and penalties. It is assumed that the costs imposed by control activities are additive at each stage of production. That is, a dollar increase in average cost at any stage of production leads to a dollar shift upward in the industry average cost curve shown in Figure 1.

The RAND study assumes that increases in the budget for supply-control activities generate additional seizures of cocaine and that seizures increase production costs. There are two key parameters. The "productivity of additional control budget dollars" measures how increases in the supply-control budget translate into additional seizures. The model assumes that increases in the supply-control budget lead to higher seizures, but with diminishing returns. As this parameter ranges from 0.70 to 0.90 in the RAND sensitivity analysis, "additional budget" is assumed to be increasingly effective in yielding seizures. The range of values entertained for the parameter is based on a "rough appreciation of discussions and general reading about the cocaine supply process" (p. 71).

The other parameter is the "elasticity of processing cost with respect to seizures," which measures how seizures affect the cost of cocaine production. In the baseline analysis, the elasticity of the processing cost with

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

respect to seizures is assumed to equal 0.44, implying that a 1 percent increase in seizures increases the unit cost of production by 0.44 percent. This number comes from the Simulation of Adaptive Response (SOAR) model, which explored how processing costs increase as producers seek to avoid sanctions (Crawford and Reuter, 1988).

Cost-Effectiveness Findings of the RAND Study

With the market model fully specified, the RAND study is able to evaluate the relative cost-effectiveness of demand-control and supply-control policies, given the current allocation of resources.[2] The primary criterion used is the cost of achieving a specified reduction in U.S. cocaine consumption, namely, a 1 percent reduction in the 15-year discounted value of consumption. The RAND study also estimates the cost of achieving a 1 percent reduction in the number of users, as well as the cost of achieving both a specified reduction in drug-related crimes and an increase in productivity. One policy is deemed to be more cost-effective than another if the RAND model predicts that it achieves the objective at lower cost.

The central finding of the RAND study is that treatment of heavy users, a demand-control policy, is much more cost-effective than all three of the supply-control policies considered—source-country control, interdiction, and domestic enforcement. In the baseline analysis, the least costly supply-control policy is domestic enforcement. The study predicts that spending on domestic enforcement, which in the RAND model acts to increase the average cost of production and reduce consumption by those who are arrested, would have to increase by $246 million to reduce cocaine consumption by 1 percent; in contrast, spending on treatment of heavy users would have to increase by only $34 million. Thus, the cost of achieving a 1 percent reduction in consumption through domestic enforcement is predicted to be 7.3 times the cost of achieving the same reduction through treatment of heavy users. The costs of achieving this reduction through source-country control and interdiction policies are predicted to be even higher, 23.0 and 10.8 times the cost of treatment, respectively.

[2] In 1992, the base year for the RAND study, the United States spent nearly $13 billion on cocaine control programs. Approximately 93 percent of the total was spent on supply-control activities, with the largest fraction devoted to domestic enforcement. According to the RAND report (pp. 4 and 70), nearly $9.5 billion was spent on domestic enforcement, $1.7 billion on interdiction, $0.9 billion on source-country control, and $0.9 billion on treatment.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

While the quantitative conclusions of the RAND study depend on the specific parameter values chosen, the basic qualitative conclusion does not vary across the range of parameter values considered in the sensitivity analyses performed; see Table 1. The study finds that, in all cases, the cost of achieving the target consumption reduction through supply-control policies is at least twice the cost of achieving it through treatment of heavy users (Table F.9, p. 110).

ASSESSMENT

The RAND study develops a potentially useful framework for understanding the functioning of the market for cocaine at a high level of aggregation. It reports a serious effort to describe the behavior of producers and users and the manner in which cocaine-control policies may affect consumption and prices. The study is innovative and sophisticated in comparison with previous analyses of cocaine control policy.

These positive features notwithstanding, the RAND study makes many unsubstantiated assumptions about the processes through which cocaine is produced, distributed, and consumed. Plausible changes in these assumptions outside the range examined in the sensitivity analyses may change the main qualitative conclusions of the study, not just the quantitative findings reported. The central finding—that treatment of heavy users is much more cost-effective in reducing cocaine consumption than are supply-control policies—depends on assumptions that are too questionable to guide the formation of cocaine control policy.

The rest of this chapter details the committee's main concerns: the RAND estimates of effects of drug treatment programs, the models of cocaine supply and cocaine demand, and the study's efforts to evaluate the model posed. It is important to stress that these concerns do not lead the committee to conclude either that the RAND findings are necessarily incorrect or that alternative conclusions should have been drawn. Rather, the committee concludes that the findings reported in the RAND study—both quantitative and qualitative—are not persuasive. The main contribution of the RAND study is conceptual rather than empirical: The study produces a potentially useful framework for thinking about the operation of the market for cocaine, it does not yield usable findings on the relative cost-effectiveness of alternative policies in reducing cocaine consumption.

Estimates of Effects of Drug Treatment Programs on Cocaine Use

As described above, the RAND study uses two parameters—measured in-treatment and post-treatment effects—to quantify the effective-

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

ness of treatment programs in reducing cocaine use. The values chosen for these parameters influence the cost of achieving reductions in cocaine use through treatment programs. Having credible values is essential to the RAND finding that treatment is cost-effective relative to supply-control policies. Unfortunately, the data and inferential methods used to select the parameter values displayed in Table 1 seem inappropriate.

The TOPS Data

The RAND study bases its estimates of treatment effectiveness on the Treatment Outcome Prospective Study (TOPS). TOPS is a study of drug abuse treatment effectiveness that included more than 11,000 patients in 41 treatment programs in 10 cities between 1979 and 1981 (Hubbard et al., 1989; Rydell and Everingham, 1994).[3] Samples of patients were followed 1 year, 2 years, and 3-5 years post-treatment (Fletcher, Tims, and Brown, 1997).

TOPS focused largely on treatment effectiveness for heroin users, specifically, those in methadone maintenance settings. Hubbard et al. make only the most general distinctions between types of treatment, and the programs observed were those in operation in the period 1979-1981. These years were well before the cocaine epidemic of the 1980s, when cocaine became widely available and inexpensive, and prior to the appearance of the crack form of cocaine. Moreover, there are many differences between the treatments available for heroin addiction and for cocaine addiction (O'Brien, 1997). Most notably, there is no current medication for cocaine comparable to methadone with its well-documented ability to reduce heroin use. Hence, it is not clear that the TOPS data provide information relevant to the evaluation of current treatment programs for heavy cocaine users.

Inferential Problems

Even if the TOPS data did accurately characterize cocaine treatment programs for heavy users, the RAND interpretation of the data is open to

[3]TOPS is one of three comprehensive studies of drug abuse treatment effectiveness sponsored by the National Institute on Drug Abuse (NIDA). The first study was the Drug Abuse Reporting Program (DARP), which assessed more than 44,000 clients in 52 treatment programs from 1969 to 1973. More than 50 treatment programs were included in the sample, and a subset of those studied were revisited 6 and 12 years post-treatment (Institute of Medicine, 1996). The DARP was followed by the TOPS, which was followed in 1989 by the Drug Abuse Treatment Outcome Study (DATOS). The intent of DATOS is to provide information on the effectiveness of drug abuse treatment in typical, stable programs (Fletcher et al., 1997).

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

question. Depending on the process by which users are selected into treatment programs and the determinants of dropout from such programs, the RAND interpretation of the data may make treatment programs seem more or less cost-effective than they actually are.

Consider, first, the parameter measuring in-treatment effects. This parameter is taken to be the fraction of TOPS sample members who desist from drug use while participating in their treatment programs. No comparison group is invoked to predict what fraction would have desisted in the absence of treatment. Instead, it is assumed that, in the absence of treatment, all TOPS sample members would continue their pre-TOPS use patterns.[4] To assess the validity of this assumption requires knowledge of the process by which cocaine users are selected into treatment programs. The assumption is reasonable if users are randomly drawn into treatment. But to the extent that users enter treatment programs voluntarily, it is reasonable to think that people who choose to enter treatment programs tend to be motivated to desist from drug use. In contrast, to the extent that users are mandated into treatment by the criminal justice system, it may be that people who enter treatment programs tend not to be so motivated.[5] Thus, observed declines in drug use during the period of treatment may reflect the characteristics of people who seek or are coerced into treatment, not the effects of treatment programs. The true in-treatment effect may be much lower or higher than the estimate in the RAND study.

Next, consider the parameter measuring post-treatment effects. To evaluate this parameter, the RAND study compares the post-treatment average drug use of members of the TOPS sample who completed their treatment programs with the post-treatment average drug use of TOPS subjects who began treatment but dropped out within 3 months. This comparison is appropriate under the assumption that people who drop out of their treatment programs are similar, on average, to people who complete treatment. Suppose, however, that treatment dropouts are more predisposed to drug use than are those who complete treatment. If dropouts are more severely addicted or less motivated or have fewer social supports than those who complete treatment, then the observed differences in post-treatment drug use of dropouts and completers may reflect differences in the characteristics of these two groups, not the effect

[4]For those not in treatment, the RAND study formalizes a dynamic model of initiation, intensification, and desistance.

[5]The leverage of the criminal justice system may provide an incentive for the coerced participants to reduce consumption while in treatment, so observed declines in drug use may reflect the effects of coercion rather than the effects of treatment participation per se.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

of treatment programs. The people who complete their treatment programs may be those who are more likely to reduce their drug use, whether or not they receive treatment. The true post-treatment effect may be smaller than estimated by RAND, or even zero.[6] Or, if dropouts are less predisposed to drug use than are those who complete treatment, the true effect may be larger than estimated by RAND.

The RAND study asserts that its baseline estimate of post-treatment effects may understate treatment effectiveness for another reason: "To the extent that treatments lasting less than three months have some effect, the calculation underestimates the effectiveness of cocaine treatments" (Rydell and Everingham, 1994:89). This assertion may have merit if TOPS dropouts are an appropriate comparison group for TOPS completers. However, the appropriateness of using TOPS dropouts as a comparison group for TOPS completers is not addressed in the RAND study. There is no discussion of the attributes of the two groups prior to treatment and no attempt to account for any pretreatment differences that may exist. The study does not even consider whether, for example, dropouts and completers had the same drug use patterns prior to treatment.

Even if the in-treatment and post-treatment parameters are evaluated correctly in the RAND study, these values pertain only to people of the TOPS sample, that is, only to people who actually were enrolled in treatment during the period of TOPS data collection. Expansion of treatment programs from their historical levels to the higher levels contemplated in the RAND study may require reaching out to groups of drug users who have neither sought treatment nor been coerced by the criminal justice system into receiving treatment.[7] These groups may be much more or much less susceptible to successful treatment than are the members of the TOPS sample: it is simply not known.

At heart, the committee's concern about the RAND interpretation of the TOPS data is that the RAND study disregards well-understood, fundamental problems that arise in attempting to infer treatment effects from observational data on treatment outcomes in heterogeneous populations: see, for example, Campbell and Stanley (1963), Cochran (1965), Cook and Campbell (1979), Manski (1995), Rosenbaum (1995), and Manski and Nagin (1998). Many empirical studies have found a strong statistical

[6]The true effect could even be negative, if treatment has a deleterious effect on some clients.

[7]To the extent that people who enter treatment programs are placed there by the criminal justice system, expansion of treatment programs may require expansion of domestic enforcement activities. However, entry into treatment may be limited by the availability of space in existing programs.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

association between drug use and such variables as school dropout and delinquency: see, for example, Elliot, Huizinga, and Menard (1989), Elliot and Voss (1974), and Mensch and Kandel (1988a, 1988b). It is well appreciated that these statistical associations do not by themselves imply that school dropout or delinquency induces drug use, nor vice versa. For example, Anglin and Hser (1990:407) state in a review essay: "By the end of the 1970s, however, it had become generally recognized that pre- and post-treatment studies were subject to serious methodological shortcomings." Yet the RAND study, without substantiation, assumes that statistical associations between treatment and drug use in the TOPS data imply real treatment effects.

The sensitivity analysis reported in the RAND study does not satisfy the committee's concerns; it only varies the post-treatment effectiveness parameter, leaving the in-treatment parameter fixed at the baseline value of 79 percent. The study observes that, even if one of the two treatment effect parameters were set equal to zero, the other parameter (fixed at its baseline value) would suffice to show that treatment programs are more cost-effective than are supply-control policies (Rydell and Everingham, 1994:xv, 20). The RAND report does not, however, evaluate the sensitivity of findings to joint changes in the values of the two treatment parameters. Clearly, if both parameters are zero, treatment would be an ineffective means of reducing consumption.

Modeling the Supply of Cocaine

The committee has several substantive concerns about the RAND model of the market supply of cocaine. Questionable aspects of the model include the assumption of a downward sloping industry average cost curve, the assumption of an additive process by which control activities affect production cost, the use of seizures to measure the extent of control activities, and the assumption that the market for cocaine equilibrates by price alone. In each case, the assumption tends to downplay the cost-effectiveness of supply-control policies.

Shape of the Average Cost Curve

Inferences on the effects of supply-control policies depend critically on the assumed shape of the average cost curve. The RAND supply model, described above, assumes that price equals the average cost of cocaine production, that the marginal cost of production is constant, and that the level of seizures grows at a slower rate than the quantity of cocaine produced. Together, these assumptions imply that the industry

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

average cost curve is downward sloping. Yet there is no compelling case for any of these three assumptions. We consider each in turn.

Price Equals Average Cost According to the RAND report, substantial monetary profits are earned in each of the six stages of production. The assumption of the RAND model is that the market for cocaine is competitive; hence, the profits exactly compensate producers for the risks they take and the processing costs they incur. If, on the contrary, some profits are economic rents that more than compensate for costs and risks, then the industry average curve will be upward sloping (see, e.g., Bresnahan, 1989).

Constant Marginal Cost The assumption of constant marginal cost is plausible only if all of the factors of cocaine production and distribution—the land for growing coca leaf, the skilled labor and chemicals used in producing cocaine from coca, the dealers who market the drug, etc.—are available in perfectly elastic supply to the cocaine industry. This is a strong assumption, contrary to the usual idea that resource constraints make production in an industry increasingly more costly with each additional unit produced. If there are resource constraints relevant to the production of cocaine, the cocaine average cost curve slopes upward, if all else is equal.

Supply-Control Policies Impose Fixed Costs In the RAND model, industry average cost declines as a consequence of an unsubstantiated assumption about the effects of supply-control policies. Such policies are assumed to generate seizures that increase less, proportionally, than output. Hence, the average cost of production falls as production rises.[8] Suppose, to the contrary, that the fraction seized rises with production: then the fraction of production making it to market may not increase with the level of production; it may decrease. If so, the average cost of production increases with production.

Changes in any of the three RAND assumptions could easily generate an upward sloping market average cost curve for cocaine. A sensitivity analysis can explore the range of plausible assumptions, but the RAND sensitivity analysis only entertains downward sloping curves. This matter is of potential consequence for assessment of the cost-effectiveness of

[8]The simplest version of this model, which is considered in the appendix to this report, occurs when supply-control policies impose fixed costs on producers. In this case, the level of seizures does not vary with the amount of cocaine produced so that the average cost of production falls with the total output.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

alternative policies, but the complexity of the RAND model makes it impossible to judge the implications from the report itself.

The most satisfactory way to judge the implications would be to reprogram the RAND model to permit upward sloping average cost curves and then to perform new sensitivity analyses. This is not a feasible activity for the committee, but we did find it feasible to formulate and analyze a relatively simple model that expresses the main features of the RAND model. This model is presented in the appendix; it can be used to assess how the cost-effectiveness of supply-control policies varies with the assumed shape of the average cost curve that determines industry supply.

The analysis in the appendix indicates that the RAND assumption of a downward sloping average cost curve restricts the responsiveness of equilibrium cocaine consumption to the intensity of supply-control activities. Consider, for example, the setting of Figure 2, which is based on the market model in the appendix. The figure describes an initial condition in which the equilibrium consumption of cocaine is point A. The aggregate demand curve is downward sloping. Two different baseline average cost curves are shown, both of which are consistent with this equilibrium. Consistent with the RAND model, baseline average cost 1 indicates a negative relationship between the quantity supplied and the market price. In contrast, baseline average cost 2 is positively sloped. The figure also portrays the two baseline average cost curves shifted upward, reflecting a higher intensity of supply-control activities that increase

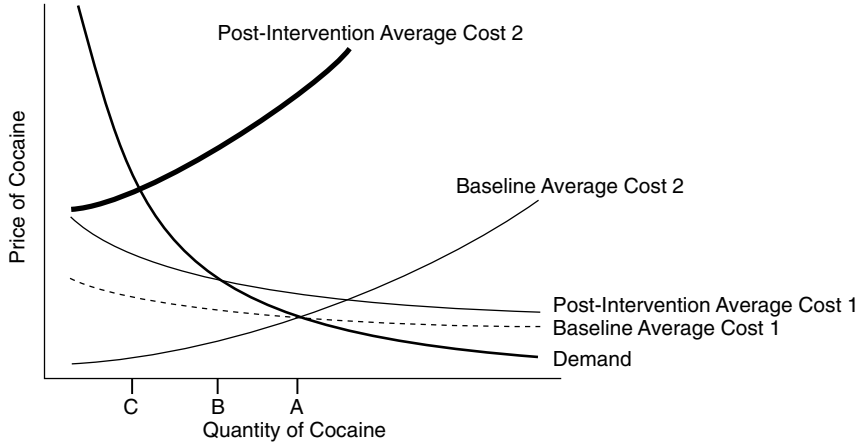

FIGURE 2 Simulated effects of added seizures given upward and downward sloping average cost curves. NOTE: See text for discussion and see appendix for a formal presentation of the model.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

seizures by a fixed amount. The two shifted curves are labeled post-intervention average cost 1 and 2.[9]

What is the effect on equilibrium cocaine consumption? If the operative average cost curve is downward sloping, as assumed in the RAND report, the new equilibrium consumption of cocaine is point B. If the operative average cost curve is upward sloping, the new cocaine consumption is point C. Thus, given the model presented in the appendix, the responsiveness of consumption to the increased intensity of supply-control activities will be understated if the market average cost curve is incorrectly assumed to be downward sloping.[10]

Supply-Control Policies and Average Production Costs

A major issue in assessing supply-control policies is the way that disruptions at different stages of the cocaine production and distribution process generate increases in average production costs. The RAND study assumes that the mechanism is additive: that is, a dollar of cost added at any stage of the process implies a dollar increase in average cost. In contrast, a multiplicative model would assume that a given percentage increase in cost at one stage of the process will be passed through proportionally at each later stage. Suppose, for example, that coca base costs $1 per gram in the supplying country but that this amount of coca base transformed into cocaine costs $100 per pure gram when distributed in the United States. Under the additive model, increasing the source-country cost of coca base to $2 per gram would increase the cost of cocaine distributed in the United States to $101 per gram. Under the multiplicative model, the cost of cocaine in the United States would increase to $200 per gram.

The choice between these two models has clear consequences for the assessment of supply-control activities. In the additive model, supply-control activities at early stages of the cocaine production process have only additive effects on average production costs. In the multiplicative

[9]The baseline case supposes that seizures equal 0, while the post-intervention case supposes that seizures equal 0.5. Under both average cost 1 and 2, the baseline equilibrium outcome is A (price = 1.0, quantity = 1.0). Under average cost 1, the post-intervention outcome is B (price = 1.64, quantity = 0.78). Under average cost 2, the post-intervention outcome is C (price = 2.57, quantity = 0.62).

[10]A particularly revealing case occurs when the demand curve is perfectly elastic. That is, suppose the demand curve is horizontal. In this extreme case, a downward sloping average cost curve implies that interdiction would increase the equilibrium quantity consumed. In contrast, an upward sloping supply curve would imply that consumption would fall.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

model, such activities obviously have much larger effects. The RAND study, by assuming the additive model, strongly restricts the potential sensitivity of cocaine market outcomes to source-country control and interdiction relative to what it would be under the multiplicative model.

The committee does not find compelling evidence in favor of either model. Caulkins and Reuter (1998) finds some evidence for a multiplicative model of the cocaine market and rejects an additive model. The question of pass-through of raw materials costs into the costs of final products has been studied much more extensively in some legal markets for which extensive wholesale and retail data are available. Such markets include foods and fuels, where the cost of the raw material (wheat or crude oil) is a small fraction of the cost of the final product (say, shredded wheat cereal or unleaded premium gasoline). Studies of the effect of fluctuations of raw materials costs on final product costs have tended to reject both the additive and multiplicative models in favor of a hybrid model, one in which fluctuations in raw materials costs are passed through more than additively but less than multiplicatively (see, e.g., Okun, 1981).

From a theoretical perspective, there are no persuasive reasons to argue for either the additive model or the multiplicative model. Some elements of non-raw-material costs are likely to be sensitive to raw material costs including insurance costs in legal markets and risk premiums in illegal markets. Other elements, such as transport costs, may be independent of the cost of the raw material. Overall, neither the pure multiplicative nor additive model need hold.[11]

Seizures as a Measure of Supply-Control Activity

The measure used to characterize the intensity of supply-control activities can influence findings on the cost-effectiveness of such activities. In the RAND study, the primary measure of supply-control activities—source-country controls, interdiction, or domestic enforcement—is the amount of cocaine that is seized. The study justifies use of this measure by asserting that seizures and supply-control activities are monotonically related and, hence, that seizures appropriately measure the intensity of supply-control activities (Everingham and Rydell, 1994:62).

[11]A theoretical model yielding a hybrid result supposes that each stage of production has a monopolistic firm that marks up the price over marginal cost. If the marginal cost at each stage includes raw materials as well as other prime costs (such as labor and fuel), then the retail cost will be a complex compounded markup of raw material and other prime costs.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Seizures, however, may not accurately measure the intensity of supply-control activities. There are some policies that may successfully disrupt supply without seizing any cocaine whatsoever. In fact, it is easy to imagine situations in which increasing control activities increases production costs while reducing seizures. Consider, for example, interdiction activities that aim to restrict the transport of cocaine to the United States, say, by interception of shipments in the Caribbean. Such policies may deter producers from attempting to make shipments. If so, seizures may fall as the intensity of supply-control activity rises.

Nonprice Effects of Supply-Control Activities

The RAND model assumes that supply-control activities affect the drug market by raising production costs and, hence, equilibrium drug prices. The operation of illegal markets, such as that for cocaine, however, may be more complicated than the operation of the simple legal markets in competitive models of market equilibrium. In such legal markets, price movements may suffice to balance supply and demand for the good or service. In illegal markets, however, both drug producers and consumers must reckon with important nonmonetary aspects of participation in the drug market. The relevant nonmonetary factors may include search costs and fear of stigma or imprisonment. The RAND study abstracts from these considerations and assumes that price movements suffice to equilibrate the market for cocaine. Yet important supply-control activities, particularly local law enforcement, act primarily by raising the nonmonetary costs of participation in the drug market. In this respect, as in the others discussed above, the RAND analysis may underestimate the cost-effectiveness of supply-control activities.

Modeling the Demand for Cocaine

The committee's concerns about the RAND model of demand for cocaine fall into two categories. First, accepting the RAND model's form, there is the matter of what value to use for its price elasticity parameter. Second, there are a host of reasons to question whether a demand model of the RAND type suffices to characterize the effects of control policies on cocaine use.

The Price Elasticity of Demand

The value of the price elasticity parameter used in the RAND study has important consequences for the study's findings on the cost-effectiveness of supply-control policies. To restate a point made above, the RAND

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

model assumes that supply-control policies affect the drug market by raising average production costs and, hence, equilibrium drug prices. The magnitude of the associated reduction in drug consumption is determined by the price elasticity of demand. The more negative this elasticity is, the less steeply sloped the demand curve is, and the more effective are supply-control policies in reducing cocaine consumption.

Figure 3 presents several possible supply and demand elasticities. The initial condition of equilibrium consumption of cocaine is point A. The baseline average cost curve is downward sloping, as assumed in the RAND model. Two different demand curves are shown, both of which are consistent with this equilibrium. The steeper demand curve has price elasticity –0.5, and the less steep one has elasticity –1.0. The figure also portrays a new average cost curve, shifted upward, reflecting a higher intensity of supply-control activities.

What is the effect on equilibrium cocaine consumption? If the operative demand curve is the one with elasticity –0.5, the new equilibrium consumption of cocaine is point B. If the operative demand curve is the one with elasticity –1.0, the new cocaine consumption is point C. Thus, the responsiveness of consumption to the increased intensity of supply-control activities is sensitive to the elasticity of demand.

There is a substantial literature on the price elasticity of demand for psychoactive substances, particularly for legal substances, such as alcohol

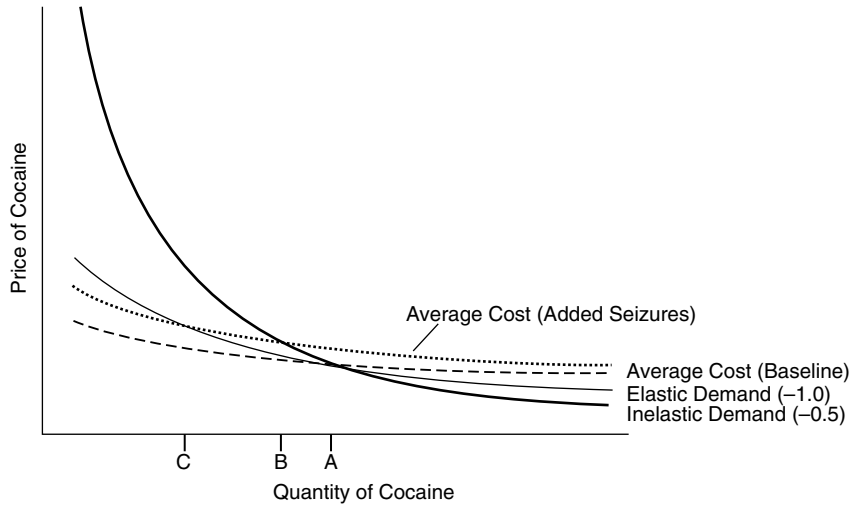

FIGURE 3 Simulated effects of added seizures given elastic and inelastic curves.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

and tobacco. The literature for illegal substances is much less well developed. For some time, the conventional wisdom was that the demand for illegal substances is relatively price inelastic. Reflecting this belief, the RAND study chose a baseline value of –0.50 and performed a sensitivity analysis entertaining values between –0.38 and –0.75. Recent studies, however, suggest that the demand for cocaine may actually be much more price elastic, perhaps –1.0 or even more negative (see Caulkins, 1995b; Grossman et al., 1996). If the price elasticity of demand is, in fact, less than –0.75, the RAND analysis understates the cost-effectiveness of supply-control activities.

The Complex Response of Cocaine Consumption to Prices

The RAND demand model, with its single price elasticity of demand parameter, abstracts from much of the complexity of the behavior that determines cocaine use. As noted above, supply-control policies may affect cocaine use by altering the search costs, stigma, and other nonmonetary factors relevant to current and potential cocaine users. In this section, we call attention to some of the complexity of the response of cocaine consumption to prices.

The RAND study assumes that light and heavy users of cocaine share the same sensitivity to price, in the sense that their consumption changes by the same percentage given a specified percentage change in price. This may be a justifiable simplifying assumption for an exploratory analysis, but it does not seem justifiable for a study that purports to draw strong policy conclusions, as does the RAND study. The addiction process may imply that price affects desistance from drug use differently than the way it affects initiation. The effects of price on initiation and intensification of drug use may be quite different as well. It is commonly thought that light drug users are more price sensitive than are heavy users, whose addiction drives behavior. However, heavy drug use may require such sufficient expenditure that income effects become prominent, which would imply strong sensitivity to price changes. For all of these reasons, it seems unlikely that a single price elasticity can adequately characterize how cocaine use responds to the price of cocaine.

Another simplification in the RAND model of the demand for cocaine is the absence of any consideration of cross-price elasticities with respect to other psychoactive substances, both legal and illegal. Some experts believe that there is strong complementarity across substances, that lowering the price of one drug stimulates demand for other drugs; others believe that different drugs are substitutes, that lowering the price of one drug tends to reduce the use of other legal or illegal drugs (see Kleiman, 1992; Rasmussen and Benson, 1994; Zimmer and Morgan, 1997). The

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

committee does not have the information to reach a judgment on these alternative perspectives, but it is clear that understanding patterns of complementarity and substitution among drugs is essential to understanding the effects of control policies on drug use.

Evaluating the Reliability of the Model

The RAND study formulates and applies a model of the cocaine market in the United States that is complex in some respects and simplistic in others. The model imposes a large set of unsubstantiated assumptions. When assessing the study, the committee conscientiously tried to focus on substantive issues that might arguably change the qualitative findings reported. As discussed above, plausible changes to the RAND assumptions about the effectiveness of treatment programs and the shapes of the demand and average cost curves might well modify or possibly even negate the study's findings. Hence, the committee concludes that the findings lack sufficient persuasiveness to be used as a basis for policy formation.

A general methodological concern is that the RAND study offers no systematic approach to evaluation of the model, or its various elements, as a description of the actual cocaine market. Common approaches to model evaluation include the performance of statistical tests of individual equations or of the entire model, assessment of the accuracy of out-of-sample predictions, and comparisons of the predictions of the model with those of other models of the same phenomena.

The sensitivity analyses reported in the RAND study are limited in scope and, in any case, do not take the place of efforts to evaluate the model empirically. It is troubling that the study makes no attempt to check the predictions of the model against the historical record. For example, the study makes no attempt to use the model to interpret the substantial decline in the domestic price of cocaine without any consequent increase in the consumption of cocaine that occurred during the 1980s.

CONCLUSIONS

The RAND study is best thought of as conceptual research, offering a coherent way to think about the cocaine problem. The study documents a significant effort to identify and model important elements of the market for cocaine. It represents a serious attempt to formally characterize the complex interaction of producers and users and the subtle process through which alternative cocaine control policies may affect consumption and prices. The study establishes an important point of departure for

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

the development of richer models of the market for cocaine and for empirical research applying such models to evaluate alternative policies.

However, the RAND study does not yield usable empirical findings on the relative cost-effectiveness of alternative policies in reducing cocaine consumption. The study makes many unsubstantiated assumptions about the processes through which cocaine is produced, distributed, and consumed. Plausible changes in these assumptions can change not only the quantitative findings reported, but also the main qualitative conclusions of the study. The study is also seriously deficient in its use of the Treatment Outcomes Prospective Study (TOPS) data to estimate the effectiveness of cocaine treatment programs. Hence, the findings of the RAND study do not constitute a persuasive basis for the formation of cocaine control policy.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

3

The IDA Study

ASSUMPTIONS, DATA, METHODS, AND FINDINGS

The study by the Institute for Defense Analyses (IDA), *An Empirical Examination of Counterdrug Interdiction Program Effectiveness* (Crane, Rivolo, and Comfort, 1997), couples time-series data on cocaine prices and consumption in the United States with a narrative description of contemporaneous interdiction events to assess the cost-effectiveness of interdiction activities in reducing cocaine consumption. The analysis has three steps. First, a time-series index of the price of cocaine in the United States is developed. Second, this price series is associated with various time-series measures of cocaine use and juxtaposed against eight specific interdiction events. The IDA study concludes that interdiction activities generate increases in price, which in turn generates decreases in consumption. Third, the study uses its findings to examine the cost-effectiveness of interdiction activities. In particular, the cost of reducing domestic consumption by 1 percent is evaluated.

A Cocaine Price Series

The cocaine price series developed in the IDA study is based on data from the Drug Enforcement Administration's System to Retrieve Information from Drug Evidence (STRIDE). The STRIDE database contains detailed information on the quantity, price, purity, and purchase location of cocaine transactions made in undercover DEA operations since 1980.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

For each transaction, a price per pure gram of cocaine is computed: that is, the ratio of the purchase price to the amount of pure cocaine received. These data on price per pure gram are then sorted by the date of purchase and divided into batches of 100 transactions each. Within each batch, the median price per pure gram is determined. This median price per pure gram is the measure used throughout the IDA study to index time-series changes in cocaine prices in the United States.

The IDA price series aggregates the prices paid for the purchase of a wide range of quantities of cocaine, from less than 1 gram to more than 30 grams. The IDA study observes that the price paid per pure gram tends to decline substantially with the quantity purchased, with the price per pure gram at the retail level (i.e., 0-10 grams) being nearly four times that at the wholesale level (i.e., 30 grams or more). However, the IDA study argues that the price series for different quantities of cocaine move proportionately over time so that when retail prices rise, there is a proportional rise in wholesale prices (Crane, Rivolo, and Comfort, 1997:II-10-13). Accordingly, the IDA study forms a single "street-price" index that combines STRIDE transactions at all quantities (pp. II-18-19).

The Price Elasticity of Demand for Cocaine

With the price series in hand, the IDA study turns to the substantive questions of the effect of prices on consumption and the effect of interdiction activities on prices. To measure the sensitivity of demand to prices, the IDA study presents estimates of the time-series association between its street-price index and measures of cocaine use obtained from four different sources. As shown in Table 2, the four data sources measure cocaine use among emergency room patients, arrestees, workers, and patients in treatment centers. Although these data sources provide no

TABLE 2 Estimated Price Elasticities of Demand in the IDA Study

Usage Data Set	Estimated Price Elasticity of Demand	Population Surveyed
DAWN (Drug Abuse Warning Network)	–0.71	Emergency room admittances
	–0.64	Arrestees in 23 cities
SBCL (SmithKline Beecham Clinical Laboratories)	–0.51	American workers
TEDS (Treatment Episode Data Set)	–0.73	Patients in cocaine treatment centers

SOURCE: Estimates reported in Crane, Rivolo, and Comfort (1997:Table III-1).

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

information on quantities of cocaine consumed and although they concern only particular subpopulations of potential users, the IDA study argues that they provide measures of cocaine use that are "logically linked" (p. III-2) to consumption and thus provide insight into the price elasticity of demand.

The IDA study uses its street-price index and the four data sets to estimate how the number of users varies with street prices, and it interprets the findings as estimates of the price elasticity of the demand for cocaine. The four estimates displayed in Table 2 range from –0.51 to –0.71. Given these estimates, the study concludes that the conventional wisdom value of –0.5 constitutes a "reasonable estimate of the price elasticity of demand" (p. III-9). Thus, a 1 percent increase in the price is assumed to result in a 0.5 percent decline in the quantity demanded.

Effect of Interdiction Events on the Price of Cocaine

The centerpiece of the IDA empirical analysis is its juxtaposition of the street-price time series against the onset of eight major drug interdiction events identified by the historian of the U.S. Army Southern Command. Figure 4, which replicates Figure IV-1 of the IDA study, displays the price series and information on the initiation of these interdiction events. In this figure, each circle indicates the median value of 100 consecutive individual transactions; the solid line is derived from a nonparametric fit to these data. The data show that the basic downward trend in cocaine prices is interrupted by an abrupt and lasting change in 1989 and by a number of short-lived upward "excursions" that appear from time to time. The IDA study attributes these interruptions to the eight interdiction events, stating "the sudden change in the price decay rate and each of the short-term excursions are shown to follow the initiation of major interdiction activities, primarily in the source zone nations, and are thus to be causally connected" (pp. 1-2). For example, the sudden and lasting change in the price decay rate that occurred in 1989 is attributed by the IDA study to the interdiction activities and infrastructure developed by the Bush Administration's "war on drugs."

Cost-Effectiveness of Interdiction

The IDA study uses the structural change to the cocaine market that it identifies as having occurred in 1989 to examine the overall cost-effectiveness of interdiction activities. Figure 5, which replicates Figure IV-5 of the IDA report, displays an extrapolated trend curve for the street price of cocaine. This trend curve is computed under the assumption that price follows an exponential path over time. Note that the line fits the data well

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

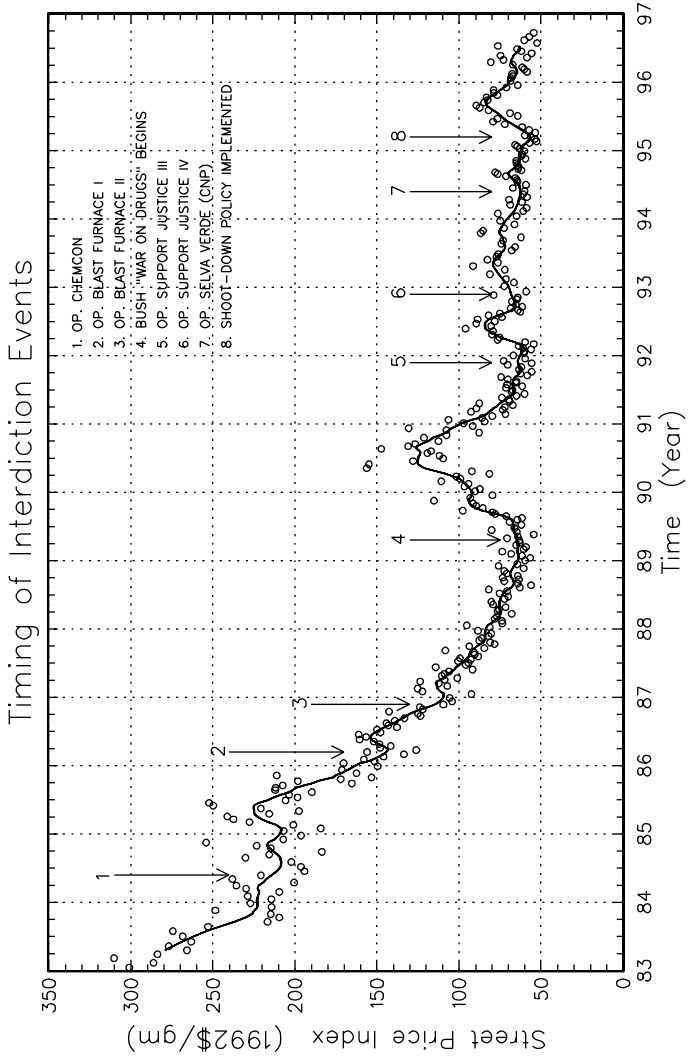

FIGURE 4 Price history of the U.S. cocaine market with superimposed time markers showing the timing of all major source-zone interdiction events since 1980. SOURCE: Crane, Rivolo, and Comfort (1997:Figure IV-1).

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

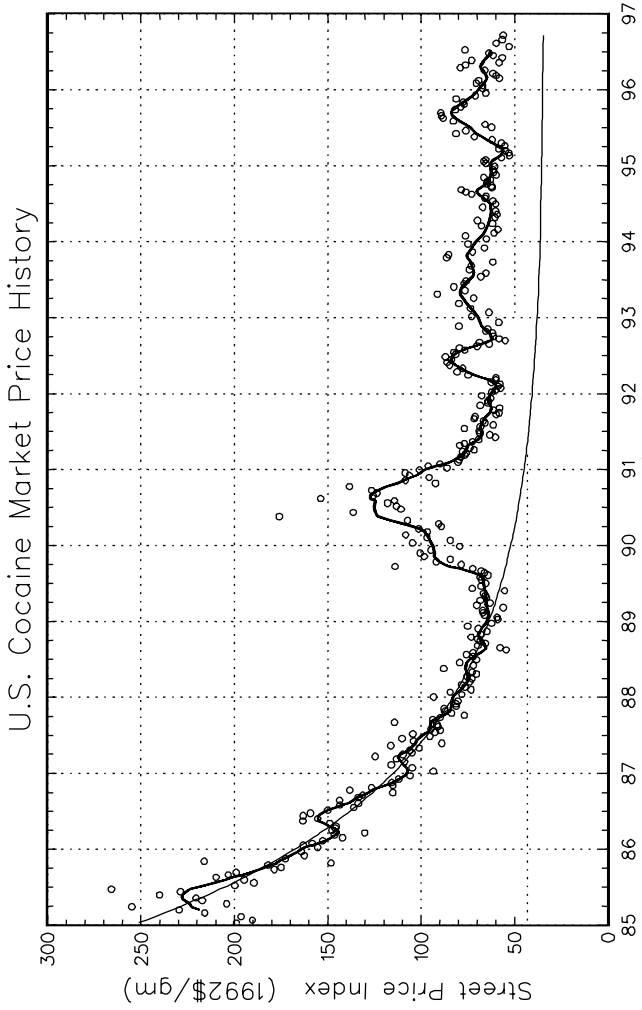

FIGURE 5 Street-price index of cocaine since 1985. SOURCE: Crane, Rivolo, and Comfort (1997:Figure IV-5).

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

from 1983 to 1989, but that actual street prices lie above the trend line after 1989. The IDA study asserts that in the absence of interdiction activities, especially the war on drugs, street prices would have continued to follow the exponential path after 1989. Therefore, the argument continues, the difference between the actual street price series and the trend curve "is an overall measure of the efficacy of the entire interdiction effort in the transit and source zones" (p. IV-15). By this measure, interdiction activities raised street prices at least 60 percent, from about $35 per gram to $55 per gram.

The final step in the IDA chain of reasoning combines the study's finding on the price effect of interdiction events with the conventional price elasticity of demand estimate of –0.5 and with data indicating that the U.S. government spends about $1-2 billion per year on all interdiction activities. According to the IDA report, interdiction activities increase street prices by 60 percent, which in turn results in a 30 percent reduction in the quantity of cocaine demanded. The study concludes that cocaine consumption falls by about 0.015 percent for every $1 million spent on interdiction activities. Hence, to reduce cocaine consumption by 1 percent, spending on interdiction would need to increase by $30-60 million (Crane, Rivolo, and Comfort, 1997:IV-15).

ASSESSMENT

The IDA study provides a wealth of information on the time series of cocaine prices, purity, and use in the United States since 1980. The study displays a set of detailed graphs that provide an informative summary of the primary, available time-series statistics. The study uses these statistics to conjecture an intriguing association between eight major interdiction events and short-term fluctuations in cocaine prices.

These positive features notwithstanding, the IDA study makes many questionable inferences about the effects of interdiction on the cocaine market in the United States. The primary shortcomings of the study are the conclusions drawn using the statistics presented. There are many plausible alternative interpretations of the price fluctuations found by the IDA study. It may be that the short-term price fluctuations in the IDA street-price series are artifacts of the STRIDE data acquisition procedures and are unrelated to substantive characteristics of the market for cocaine. It may be that the apparent long-term interruption to the price trend in 1989 was due to the destruction of the Medellin cartel by the Colombian authorities, rather than to the interdiction activities carried out during the war on drugs. With the exception of the 1989 interruption, none of the price changes that the IDA study attributes to interdiction events was

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

large, and none of the price changes lasted longer than approximately 1 year. Thus, even if one accepts IDA's interpretation of the data, the effects of interdiction are small and temporary.

The committee's major concerns about the data used in the IDA study include the development of the price series and the procedure for selecting interdiction events. Even if one accepts the IDA data at face value, the committee has deep reservations about the inferential methods used to relate price fluctuations to intervention events. And, even if one accepts the IDA data and inferential methods, the committee notes that the study at most shows that interdiction events have temporary effects on cocaine prices. Each of these concerns is detailed in the rest of this chapter.

The committee concludes that the main contribution of the IDA study is to provide descriptive time-series statistics on the domestic cocaine market. The study's findings on cost-effectiveness are not persuasive because they are based on data and inferential methods of questionable validity. One cannot reasonably infer the cause of an event from time-series data without accounting for other factors that might influence that event. It may be that the observed relationship between price fluctuations and interdiction events is causal, but the IDA study does not support this conclusion.

The IDA Price Series

The STRIDE price data are essential to the IDA analysis. The IDA findings on the effectiveness of interdiction rest critically on the proximity in time between interdiction events and upward excursions in the IDA street-price series. It is not clear whether the purported excursions are real or are artifacts of the STRIDE sampling process, of the IDA procedures transforming the STRIDE data into a price series, or even of random sampling error.

The STRIDE Data

Beginning in 1971, the Drug Enforcement Administration (DEA) has used the STRIDE data to provide information on seizures and undercover purchases of illegal drugs made in the course of DEA operations. The STRIDE data give the locations and dates of seizures and undercover purchases and measure the quantity and purity of the drug.

The STRIDE data on undercover purchases of cocaine are potentially useful to the study of the cocaine market because they reflect actual market transactions. However, these data pertain to transactions of many different quantities of cocaine of varying purity. Hence, the data obtained

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

from different transactions must somehow be standardized if they are to be comparable (Office of National Drug Control Policy, 1998; Caulkins, 1995b; Frank, 1987).

A vexing problem for analysis of the STRIDE data is that the observed transactions do not constitute a random sample of cocaine transactions. The sampling process that generates the STRIDE data is not well understood. The IDA study asserts that the nonrandomness of the STRIDE sample of cocaine prices and the resulting concern about the unrepresentative nature of the sample do not matter if the STRIDE sampling process is "approximately stationary in time" (p. II-3). The study does not adequately explain what it means by this assertion, provide evidence that the assertion is valid, or explain how the validity of the assertion would eliminate concerns about the nonrandom nature of the sampling process.

Among analysts of the cocaine market, there seems to be agreement that the STRIDE data satisfactorily describe long-term trends in cocaine prices, such as the drop by approximately a factor of six in the period 1983-1990 (Riley, 1996; Caulkins, 1994, 1995b; DiNardo, 1993). Most of the IDA analysis, however, is concerned with short-term price fluctuations, not with long-run trends. Even if the STRIDE data describe long-term trends satisfactorily, they may not accurately describe short-term fluctuations. It may be, for example, that short-term variations in the geographical distribution or quantity distribution of the cocaine purchases made by undercover agents produce short-term fluctuations in STRIDE prices of the magnitudes reported by IDA for the 1992-1997 period. In the absence of information on the DEA's purchasing strategy, it is impossible to know the extent to which the short-term price fluctuations identified by IDA are artifacts of changes in undercover purchase patterns and the extent to which they describe real changes in cocaine prices.

The Street-Price Index

Even if the STRIDE data did describe a random sample of cocaine transactions, the street-price index developed in the IDA study would be highly suspect. The IDA street-price index is the median price per pure gram for batches of 100 DEA purchases that occur at about the same time. The IDA argument that prices across different purchase quantities may be aggregated rests largely on the apparent proportional movements in prices for different quantities that occurred in the period of the war on drugs. Visual scrutiny of the graphs displayed in the IDA study does not, however, indicate clear co-movements of this type during other periods. Moreover, the study does not carry out any formal statistical procedures

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

to evaluate the degree of co-movement among the price series for different purchase quantities.[1]

Even if the IDA study is correct in claiming that prices at different quantities move proportionally over time, the aggregation of prices per pure gram into a street-price index remains problematic. Variation over time in the quantity-distribution of nationwide cocaine purchases can yield variations over time in the IDA street-price index even if the price per gram at each purchase quantity is constant over time. The IDA study asserts that "care was taken to ensure that no major changes in the purchase volume distribution have occurred over the period of interest" (p. II-19), but no details are given. The study does not specify what is meant by "major changes" nor what "care was taken."

The IDA study aggregates cocaine prices to reduce the statistical variability in the price series (II-18, 19). However, the procedure used in the IDA study to construct a street-price index makes it difficult to assess the validity of the study's findings on the association between interdiction events and short-term price fluctuations. It would have been better to construct a weighted price index in which the weights reflect variations over time in the nationwide quantity distribution of purchase quantities and variations over time in the DEA sampling process. In the absence of more convincing evidence about the co-movements of the price series across different quantities, an even better alternative would have been to separately analyze price series for different quantities and geographical strata.[2]

It should be noted that the IDA study's procedure for constructing a price index for cocaine does not conform to standard approaches. Standards for constructing retail and producer price indexes have been developed by scholars and by the Bureau of Labor Statistics of the U.S. Department of Labor over many years. The standards are incorporated in such measures as the consumer price index (CPI) and the producer price index (PPI). The IDA study does not draw on this body of knowledge.

[1]The IDA study interprets its apparent finding of proportional movements in prices for transactions of different quantities to be evidence for a "fractal" model of the supply of cocaine, which implies a constant multiplicative relationship between prices at various stages of the production process.

[2]There is substantial variation of cocaine prices across geographic regions (Caulkins, 1995a). The IDA study essentially ignores this variation except to note that "source zone interdiction operations generally affect the U.S. market as a whole" (II-19). Again, no details are given.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Purity as a Measure of Product Quality

A common problem in the construction of price indices is how to appropriately account for variations in product quality. The IDA study identifies cocaine quality with DEA laboratory measurements of purity and measures price as price per pure gram.

This procedure is sensible if one assumes that the participants in market transactions of cocaine have full knowledge of the purity of the product they are buying or selling. This assumption may be reasonable with respect to wholesale transactions of cocaine, but it is questionable with respect to retail transactions. It is especially questionable whether the consumers of cocaine, who may engage in many small transactions with different sellers and who do not ordinarily have access to laboratory equipment, are perfectly aware of the purity of the product they are purchasing in any given transaction.

If consumers do not know the purity of the product they are purchasing in given transactions, the demand for cocaine need not vary with price per pure gram in the simple downward sloping manner of classical demand analysis. Consumer behavior when presented with seller's offers of cocaine would depend on what the consumers know about purity. Do they know the distribution of purity of the cocaine offered by a particular seller? Do they only know the distribution of purity of all the cocaine that comes to market? Do they misperceive the distribution of cocaine purity? If the distribution of purity varies over time, what is the process by which consumers learn about these variations? Answering these questions is important to the analysis of the demand for cocaine and to the construction of appropriate price indices.

Sampling Error

Even if the STRIDE data did provide a random sample of transactions and an appropriate price series were formed from these data, a statistically valid analysis of the price series would require due attention to sampling error. The IDA study reports that cocaine prices are highly variable across transactions even within quantity strata (p. II-18). Nevertheless, the study provides no statistical measures, such as standard errors or confidence intervals, to describe the precision with which its street-price series is estimated. In the absence of such measures, it is impossible to interpret the price fluctuations that appear in Figure 4. Do these fluctuations reflect real variations in cocaine prices or are they simply the consequence of sampling error? The IDA study provides no information that would enable a reader to answer this most basic question.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Selection of Interdiction Events

A serious difficulty in interpreting the IDA study is the dearth of information provided on the eight "major" interdiction events whose occurrence is juxtaposed against the time series of street prices. The study does not describe the criteria used to select these events. Without this information, interpreting the relationship between interdiction activities and street prices is problematic. The only information revealed in the IDA study is that the historian of the U.S. Army Southern Command identified 10 major actions. Two of these actions were not included in the analysis because "further examination has shown that these operations were not, in themselves, major operations in the source zone" (p. IV-4). What does it mean to be a "major" action? Are actions deemed to be "major" ex ante, or are they so deemed ex post if they are observed to be sufficiently successful?

In an effort to obtain answers to these questions, the committee requested data from and a briefing by IDA personnel on any and all information pertaining to the selection of interdiction events. The classified briefing was held in December 1998: present were the IDA authors of the study and other IDA personnel; officials from the U.S. Department of Defense, the Drug Enforcement Administration, the White House Office on Drug Control Policy, and the Central Intelligence Agency; and members of the committee's classified subcommittee. However, neither the written materials nor the oral briefing provided answers to the committee's questions: what criteria were used for classifying events as "major" and whether such classification was made prior to or after an event. As noted above, one cannot interpret the relationship between interdiction activities and the time series of street prices without that information.

Whatever the IDA criteria may be, the committee's central concern remains that the IDA study only examines the possible effects of eight specific interdiction events and not of interdiction activities in general. At worst, if interdictions are classified as major events on the basis of ex-post realizations of street prices, the observed associations are meaningless. At best, focusing on only eight events implies that the IDA study reveals the effects of the eight events identified. The study does not offer evidence on the overall effects of interdiction activities on the cocaine market. The effects of the many "nonmajor" actions that consume most of the interdiction budget remain unknown.

Inferential Problems

The IDA study uses its cocaine street-price series coupled with time-series information on domestic cocaine use and major interdiction events

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

to draw inferences about the responsiveness of demand to changes in prices and about the responsiveness of prices to interdiction activities. The inferential methods used are appropriate only under extremely rigid assumptions about the behavior of cocaine demand, supply, and prices over time.

The IDA analysis attributing price changes to interdiction events and evaluating the cost-effectiveness of interdiction in reducing cocaine consumption implicitly assumes that the demand curve relating quantity of cocaine to price was fixed during the entire 1983-1996 period examined. That is, the study assumes that the quantity of cocaine consumed in the United States would have remained constant during this period if no changes in cocaine prices had occurred.[3] The analysis also implicitly assumes that supply-control activities other than interdiction remain constant over time. Going even further, the IDA study assumes that the time series of cocaine prices would follow an exponential path if it were not for the mediating influence of intervention events.

None of these extremely strong assumptions is substantiated in the study, and none of them has a priori plausibility. The failure of any one of them might be enough to overturn the study's major findings.

Attribution of Price Fluctuations to Intervention Events

The IDA study asserts without substantiation that all deviations in price from the exponential decay path shown in Figure 5 should be attributed to interdiction events. The study maintains that there are no other plausible causes of observed price fluctuations (Crane, Rivolo, and Comfort, 1997:IV-5, IV-10).

One obvious potential source of price fluctuations is time-series variation in the demand for cocaine. It seems likely that the demand for cocaine has changed over time. During the period of the IDA study, attitudes toward cocaine consumption changed, the mix of light and heavy users changed, and the penalties for cocaine possession changed. Any of these factors would probably shift the demand for cocaine and, hence, might have caused price fluctuations.

Another obvious source of price fluctuations is variation in the supply of cocaine for reasons other than interdiction activities. The IDA

[3]Moreover, this assumption is essential to the empirical analyses of the price elasticity of demand reported in the IDA study. If the assumption is incorrect, the IDA analysis actually estimates a mixture of supply and demand curves, not a pure demand curve. The committee does not pursue this matter here because the IDA study ultimately uses the conventional elasticity value of –0.5, not any of its own estimates.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

study attributes the large price increase in 1990 to the war on drugs, but as noted above it may have resulted from the dismantling of the Medellin cartel by the Colombian government. In addition, the study attributes the price excursion observed in 1995 to the initiation of an aircraft shoot-down policy in Peru, but the timing makes it likely that other factors were at work as well. Figure IV-2 of the IDA study shows that the quantity of coca base being transported across the air bridge from Peru to Colombia had been decreasing steadily for more than 2 years before the Peruvian government began shooting down aircraft, and the decrease accelerated sharply approximately 6 months before the shoot-down policy went into effect. The price of Peruvian coca base also decreased sharply 6 months before initiation of shoot-downs (Figure IV-3). The timing of these events makes it implausible that the shoot-down policy is the sole factor for the price excursion identified as occurring in the United States in 1995.

Time-series variations in domestic enforcement activities may also have generated price fluctuations. Many important changes in domestic enforcement policy occurred during the same periods as the eight interdiction events that are the focus of the IDA study. The Crime Control Act of 1984 established tougher penalties for drug-related offenses. The 1986 and 1988 Anti-Drug Abuse Acts increased domestic law enforcement efforts as well as demand reduction programs. In the latter part of the 1980s, the number of people sentenced to prison for drug-related offenses increased substantially (see Beck and Gilliard, 1995; Beck and Blumstein, 1999; U.S. Sentencing Commission, 1998).

The IDA study makes essentially no attempt to substantiate its assertion that interdiction events have been the only source of fluctuations in the price of cocaine in the United States. The price-series data alone simply cannot reveal whether the prices fluctuations that the study attributes to the eight interdiction events should so be attributed or were instead due to other contemporaneous changes in market supply or demand.

The Exponential Price Path

The analysis that attributes price fluctuations to interdiction and the subsequent analysis of the cost-effectiveness of interdiction in reducing cocaine consumption rely on acceptance of the exponential price path displayed in Figure 5. By construction, the fitted exponential path closely tracks the decline in cocaine prices in the 1980s. The extrapolated path lies below the realized price series after the abrupt change that occurs in 1989. In fact, it is not known why cocaine prices decreased sharply before 1989 nor why they became relatively stable in the 1990s. There is no reason to believe that the natural path of prices is exponential. The expo-

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

nential path and its extrapolation after 1989 are speculative and, in the absence of corroborating evidence, should be disregarded. In particular, there is simply no basis for assuming that in the absence of interdiction activities the street price of cocaine would have fallen to $35 per pure gram, as the IDA study asserts.

Duration of Price Excursions

The price excursions evaluated in the IDA study appear to be small in magnitude and short lived. None of the price changes that the IDA study attributes to interdiction events come close to the magnitude of the unexplained six-fold drop in price that took place between 1983 and 1990, presumably despite vigorous enforcement action. Furthermore, the price excursions identified in the IDA study are all temporary. The study argues that some of the interdiction events had short durations, but others were sustained efforts to which the cocaine production process eventually adjusted. That is, the price increased for some time but eventually decreased again.

Consider, for example, the implementation in 1995 of the shoot-down policy over the Peruvian-Colombia air bridge. Figure IV-2 of the IDA study indicates that shipments on the air bridge did not recover by the end of the observation period in mid-1996, but the street price of cocaine did return to its pre-shoot-down level. According to the IDA study, the production process may have adapted after about a year; alternatively, the price may have fallen in 1996 because of the takedown of the Cali cartel leaders (p. IV-3).

The cost-effectiveness estimates reported in the IDA study do not account for possible dynamic relationships between prices and events. Cocaine producers whose shipments are interrupted by interdiction activities have an incentive to develop alternative supply sources and shipment routes. The cost-effectiveness estimates in the IDA study implicitly assume that no good alternatives are available, so that the supply curve is close to vertical. This may perhaps be a reasonable short-run assumption, but it is highly questionable as a long-run assumption.

CONCLUSIONS

The IDA study is best thought of as a descriptive time-series analysis of statistics relevant to analysis of the market for cocaine in the United States. The study makes a useful contribution with a wealth of empirical, time-series evidence on cocaine prices, purity, and use since 1980. Efforts to understand the operation of the market for cocaine must be cognizant of the empirical data, and the IDA study presents many of these data and

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

calls attention to some intriguing empirical associations among the various series.

However, the IDA study does not yield useful empirical findings on the cost-effectiveness of interdiction policies to reduce cocaine consumption. Major flaws in the assumptions, data, and methods of the study make it impossible to accept the IDA findings as a basis for the assessment of interdiction policies. For example, the conclusions drawn from the data rest on the assumption that all time-series deviations in cocaine price from an exponential decay path should be attributed to interdiction events, not to other forces acting on the market for cocaine. Numerous problems diminish the credibility of the cocaine price series developed in the study, and an absence of information prevents assessment of the procedure for selecting interdiction events.

Copyright © National Academy of Sciences. All rights reserved.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Appendix

Cocaine Markets and Supply-Control Activities

This appendix presents a formal model of supply and demand for cocaine and uses the model to investigate how supply-control activities may affect market outcomes. The model described here seeks to express in a relatively simple fashion many of the essential features of the RAND model, while abstracting from much of that model's complexity. In one important respect, the model described here explores territory outside the domain of the RAND model: It permits the average cost function that determines industry supply to be upward sloping rather than downward sloping. With this elaboration, it is possible to investigate the sensitivity of the RAND findings to plausible variations in the shape of the average cost curve.

BASIC ELEMENTS OF THE MODEL

The basic elements of the model include a demand function specifying the quantity of cocaine demanded at any given price, a cost function specifying the cost of producing any given quantity of cocaine, and a market-clearing mechanism explaining how consumers and producers interact to determine the equilibrium quantity and price of cocaine. As in the RAND model, supply-control activities are measured through the magnitude of seizures of cocaine production.

On the demand side, let p denote the price variable and let D(p) be the quantity demanded as a function of price. On the supply side, let X denote the magnitude of cocaine seizures and let q denote the cocaine

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

production that escapes seizure. Thus, q + X is total industry production. Let C(q + X) denote the total cost of producing this amount of cocaine. Let Q be the equilibrium quantity of cocaine that escapes seizure and let P be the equilibrium price.

As in the RAND study, assume that equilibrium price equals the average cost of cocaine production, measured as total cost divided by the amount of cocaine that escapes seizure. Thus,

$$(1) \quad P = C(Q + X)/Q.$$

The equilibrium quantity that escapes seizure equals the quantity demanded at the equilibrium price. Thus,

$$(2) \quad D(P) = Q.$$

Combining these two conditions yields

$$(3) \quad D[C(Q + X)/Q] = Q.$$

Solving this equation for Q yields the equilibrium consumption of cocaine as a function of the magnitude X of seizures. Given specifications for the demand function D(•) and the cost function C(•), one may use (3) to study how cocaine consumption responds to variations in seizures.

SPECIFICATION OF THE DEMAND AND COST FUNCTIONS

As in the RAND study, assume that demand has the constant-elasticity form

$$(4) \quad D(p) = ap^b, \text{ where } a > 0 \text{ and } b < 0.$$

In a departure from the RAND study, assume that the cost function has the power-function form

$$(5) \quad C(q + X) = c(q + X)^d, \text{ where } c > 0 \text{ and } d \geq 1.$$

The average cost per unit of production that escapes seizure is then

$$(6) \quad A(q, X) = c(q + X)^d/q.$$

The RAND study essentially assumes the special case of (5) and (6) in which d = 1, implying constant marginal costs and downward sloping average costs. Here we entertain the possibility that d > 1, implying that

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

marginal cost increases with production. Inspection of the derivative of the average cost function (6) with respect to q shows that the average cost function is downward sloping when $q < X/(d - 1)$ but upward sloping when $q > X/(d - 1)$.

ANALYSIS OF MARKET EQUILIBRIUM

Given equations (4) and (6), the equilibrium condition (3) becomes

$$(7) \quad a[c(Q + X)^d/Q]^b = Q.$$

The goal is to determine how the equilibrium quantity Q varies with magnitude X of seizures. However, the easiest way to study the equilibrium condition is to solve (7) for X as a function of Q. This yields

$$(8) \quad X = [Q^{(b+1)}/ac^b]^{1/db} - Q = gQ^{(b+1)/db} - Q,$$

where $g = (ac^b)^{-1/db}$.

If the demand elasticity b is in the range $-1 \le b \le 0$, the right side of equation (8) is a decreasing function of Q. In particular, the right side of (8) decreases from ∞ to $-\infty$ as Q rises from 0 to ∞. This implies that there is a unique equilibrium, with the equilibrium consumption Q being a decreasing function of seizures X. If $b < -1$, there may be multiple equilibria, as the first term on the right side is increasing in Q and the second is decreasing. Henceforth, we assume that b is in the range $-1 \le b \le 0$, as is done in the RAND study.

HOW COCAINE CONSUMPTION VARIES WITH SEIZURES

Equation (8) reveals how equilibrium cocaine consumption Q varies with magnitude X of seizures. Under (8), the derivative of X with respect to Q is

$$(9) \quad \partial X/\partial Q = g[(b + 1)/db]\, Q^{\{[(b+1)/db]-1\}} - 1.$$

Hence, the derivative of Q with respect to X, evaluated at a specified value of Q, is

$$(10) \quad \partial Q/\partial X = (\partial X/\partial Q)^{-1} = \{g[(b + 1)/db]\, Q^{[(b+1)/db-1]} - 1\}^{-1}.$$

The complexity of the expression on the right side of (10) shows that it is not a simple matter to characterize the quantitative response of co-

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

caine consumption to seizures. The magnitude of the derivative $\partial Q/\partial X$ depends on the shape of the demand function as controlled by the demand elasticity parameter b, on the shape of the cost function as controlled by the power-function parameter d, and on the composite parameter g, as well.

We wish to focus here on the role played by parameter d, determining the shape of the cost function. For this purpose, it simplifies matters to choose certain values for the other parameters. In particular, suppose that b = –0.5 and that a = c = 1. The value b = –0.5 is the RAND baseline value for the demand elasticity. Setting a = c = 1 implies that g = 1. With these choices for (a, b, c), equations (8) and (10) reduce to

$$(11) \quad X = Q^{-1/d} - Q$$

and

$$(12) \quad \partial Q/\partial X = -\left(Q^{-(d+1)/d}/d + 1\right)^{-1}.$$

Observe that setting X = 0 in equation (11) yields Q = 1 as the equilibrium consumption of cocaine for all values of the parameter d. Evaluating the derivative (12) at the point Q = 1 reveals how consumption falls as seizures rise above zero. The result is

$$(13) \quad (\partial Q/\partial X)_{Q=1} = -d/(d+1).$$

Thus, the response of cocaine consumption to seizures increases with the value of d. Under the RAND assumption that d = 1, consumption of cocaine responds least to seizures. The derivative value $(\partial Q/\partial X)_{Q=1} = -1/2$ that holds in this case implies that, as seizures rise from 0 equilibrium cocaine consumption falls by half the amount seized. In contrast, if the value of d is much larger than 1, then the derivative $(\partial Q/\partial X)_{Q=1}$ is close to –1, implying that equilibrium cocaine consumption falls by almost all the amount seized.

In the market simulation in Figure 2 (in Section 2 of report), the parameter d is set to 1 to produce the two downward sloping average cost curves and to 4 to produce the two upward sloping average cost curves. These values for d are selected to illustrate the sensitivity of predictions to the assumed shape of the average cost curve. The actual shape of the curve is unknown.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

References

Anglin, D., and Y. Hser
1990 Treatment of drug abuse. In M. Tonry and J.Q. Wilson eds., *Drugs and Crime*, Chicago: University of Chicago Press.

Beck, A., and D.K. Gilliard
1995 Prisoners in 1994. *Bureau of Justice Statistics Bulletin* (August). Washington, DC: U.S. Department of Justice.

Beck, A., and A. Blumstein
1999 Focus contributing to the growth in U.S. prison populations. *Crime and Justice* (in press).

Bresnahan, T.
1989 Empirical studies of industries with market power. In R.L. Schmalensee and R.D. Willig, eds., *Handbook of Industrial Organization*, Vol. 2. Amsterdam, The Netherlands: Elsevier Science B.V.

Campbell, D., and J. Stanley
1963 *Experimental and Quasi-Experimental Designs.* Chicago: Rand McNally.

Caulkins, J.P.
1994 *Developing Price Series for Cocaine.* Santa Monica, CA: RAND.
1995a Domestic geographic variation in illicit drug prices. *Journal of Urban Economics* 37.
1995b Estimating Elasticities of Demand for Cocaine and Heroin with Data from the Drug Use Forecasting System. Working Paper Series. H. John Heinz III School of Public Policy and Management. Carnegie Mellon University.

Caulkins, J.P., and P. Reuter
1998 What Price Data Tell Us About Drug Markets. Working Paper Series. H. John Heinz III School of Public Policy and Management, Carnegie Mellon University.

Caulkins, J.P., C.P. Rydell, W. Schwabe, and J.R. Chiesa
1997 *Mandatory Minimum Drug Sentences: Throwing Away the Key or the Taxpayer's Money?* Santa Monica, CA: RAND.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Cochran, W.G.
1965 The planning of observational studies of human populations. *Journal of the Royal Statistical Society* (Series A) 128:134-155.
Cook, T., and D. Campbell
1979 *Quasi-Experimentation: Design and Analysis Issues for Field Settings*. Chicago: Rand McNally.
Crane, B.D., A.R. Rivolo, and G.C. Comfort
1997 An Empirical Examination of Counterdrug Interdiction Program Effectiveness. Paper prepared for the Institute of Defense Analyses, Washington, DC.
Crawford, G.B., and P. Reuter
1988 Simulation of Adaptive Response: A Model of Drug Interdiction. N-2680-USDP. Santa Monica, CA: RAND.
DiNardo, J.
1991 Using STRIDE Data to Form a Regional Time Series for Cocaine Prices. Working Draft WD-5548-DPRC, Drug Policy Research Center, RAND, Santa Monica, CA (July).
1993 Law enforcement, the price of cocaine and cocaine use. *Mathematical and Computer Modelling* 17(2):53-64. (Reprint RP-192, RAND, Santa Monica, CA).
Elliott, D.S., D. Huizinga, and S. Menard
1989 *Multiple Problem Youths: Delinquency, Substance Use, and Maternal Health Problems*. New York: Springer-Verlag.
Elliott, D.S., and H.L. Voss
1974 *Delinquency and Dropout*. Lexington, MA: Lexington Books.
Everingham, S.S., and C.P. Rydell
1994 *Modeling the Demand for Cocaine*. Drug Policy Research Center. Santa Monica, CA: RAND.
Fletcher, B.W., F.M. Tims, and B.S. Brown
1997 Drug abuse treatment outcome study (DATOS): Treatment evaluation research in the United States. *Psychology of Addictive Behaviors* 11:230-243.
Frank, R.S.
1987 Drugs of abuse: Data collection systems of DEA and recent trends. *Journal of Analytical Toxicology* 11(Nov/Dec):237-241.
Grossman, M., F.J. Chaloupka, and C.C. Brown
1996 The Demand for Cocaine by Young Adults: A Rational Addiction Approach. Working Paper No. 5713. National Bureau of Economic Research, Cambridge, MA.
Hubbard, R.L., M.E. Marsden, J.V. Rachal, H.J. Harwood, E.R. Cavenaugh, and H.M. Ginzburg
1989 *Drug Abuse Treatment: A National Study of Effectiveness.* Chapel Hill, NC: The University of North Carolina Press.
Institute of Medicine
1996 *Pathways of Addiction: Opportunities in Drug Abuse Research*. Committee on Opportunities in Drug Abuse Research. Washington, DC: National Academy Press.
Kleiman, M.
1992 *Against Excess: Drug Policy for Results.* New York: Basic Books.
Manning, W.G., E.B. Keeler, J.P. Newhouse, E.M. Sloss, and J. Wasserman
1991 *The Costs of Poor Health Habits*. Cambridge, MA: Harvard University Press.
Manski, C.F.
1995 *Identification Problems in the Social Sciences*. Cambridge, MA: Harvard University Press.
Manski, C.F., and D.S. Nagin
1998 Bounding disagreements about treatment effects: A case study of sentencing and recidivism. *Sociological Methodology* 28:99-137.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Mensch, B.S., and D.B. Kandel
1988a Dropping out of school and drug involvement. *Sociology of Education* 61:95-113.
1988b Underreporting of substance use in a national longitudinal youth cohort: Individual and interviewer effects. *Public Opinion Quarterly* 52:100-124.

Moore, M.H.
1990 Supply reduction and drug law enforcement. In M. Tonry and J.Q. Wilson, eds., *Crime and Justice*, Vol. 13 (Drugs and Crime). Chicago, IL: University of Chicago Press.

National Information Center on Health Services Research and Health Care Technology
1998a Clinical Practices Guidelines Glossary. National Library of Medicine, Bethesda, MD. Available electronically: http://www.nlm.nih.gov/nichsr/hsrckey.html
1998b Introduction to Health Services Research Class Manual. National Library of Medicine, Bethesda, MD. Available electronically: http://www.nlm.nih.gov/nichsr/ihcm/hsrckey.html

National Research Council
1979 *The Rehabilitation of Criminal Offenders: Problems and Prospects*, L. Sechrest, S.O. White, and E.D. Brown, eds. Panel on Research on Rehabilitative Techniques. Washington, DC: National Academy Press.

Northridge, M.E., B. Levin, M. Feinlab, and M. Susser
1997 Editorial: Statistics in the journal—significance, confidence, and all that. *American Journal of Public Health* 87:1092-1095.

O'Brien, C.P.
1997 A range of research-based pharmacotherapies for addiction. *Science*. 278:66-70.

Office of National Drug Control Policy
1997 *The National Drug Control Strategy, 1998: A Ten Year Plan, 1998-2007*. Executive Office of the President, The White House. Washington, DC: U.S. Government Printing Office.

Okun, A.M.
1981 *Prices and Quantities: A Macroeconomic Analysis*. Washington, DC: Brookings Institution.

Panzar, J., and R. Willig
1978 On the comparative statistics of a competitive industry with inframarginal firms. *American Economic Review* 68(3):474-478.

Rasmussen, D., and R. Benson
1994 *The Economic Anatomy of a Drug War*. Lanham, MD: Rowman and Littlefield Publishers.

Riley, K.J.
1996 *Snow Job? The War Against International Cocaine Trafficking*. New Brunswick, NJ: Transaction Publishers.

Rosenbaum, P.R.
1995 *Observational Studies*. Springer Series in Statistics. New York: Springer-Verlag.

Rossi, P.H., and H.E. Freeman
1993 *Evaluation: A Systematic Approach*. Newbury Park, CA: Sage Publications, Inc.

Rydell, C.P., and S.S. Everingham
1994 *Controlling Cocaine: Supply Versus Demand Programs*. Drug Policy Research Center. Santa Monica, CA: RAND.

Subcommittee on National Security, International Affairs, and Criminal Justice
1996 *Hearing before the Committee on Government Reform and Oversight, U.S. House of Representatives*. Washington, DC: U.S. Government Printing Office.
1998 *Hearing before the Committee on Government Reform and Oversight, U. S. House of Representatives*. Washington, DC: U.S. Government Printing Office.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

U.S. Sentencing Commission
1998 *Federal Sourcebook of Federal Sentencing Statistics, 1998*. Washington, DC: U.S. Government Printing Office.

Weatherburn, D., and B. Lind
1996 Drug law enforcement policy and its impact on the heroin market. *Addiction*, 92(5).

White House Office of National Drug Control Policy
1998 *The National Drug Control Strategy: 1998*. Washington, DC: U.S. Government Printing Office.

White, M.D., and W.A. Luksetich
1983 Heroin: Price elasticity and enforcement strategies. *Economic Inquiry* XXI (October):557-564.

Zimmer, L., and J. Morgan
1997 *Marijuana Myths, Marijuana Facts*. New York, NY: The Lindesmith Center.

Copyright © National Academy of Sciences. All rights reserved.

Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy
http://www.nap.edu/catalog/9441.html

Addendum to page 30

National Research Council (1999) *Assessment of Two Cost-Effectiveness Studies on Cocaine Control Policy*. Committee on Data and Research for Policy on Illegal Drugs. Charles Manski, John V. Pepper, and Yonette F. Thomas, editors. Commission on the Behavioral and Social Sciences and Education. Washington DC: National Academy Press.

This table from the study by Crane, Rivolo, and Comfort is reproduced here for comparison with TABLE 2 on page 30 of this report. It depicts the original from which TABLE 2 is derived.

Table III-1 Summary of Price Elasticity Estimates for Various Indicators of Cocaine Usage

Usage Indicator	Best Estimate	95% Confidence Interval	Regression Coefficient
Dawn	0.63	$-0.86 < e < -0.50$	-0.71
DUF	–0.29	$-0.51 < e < -0.19$	-0.64
SBCL	–0.60	$-0.98 < e < -0.29$	-0.51
TEDS	–0.38	$-0.49 < e < -0.29$	-0.73

Source: Crane, B.D. A.R. Rivolo, and G. C. Comfort, 1997. An Empirical Examination of Counterdrug Interdiction Program Effectiveness. Paper prepared for the Institute of Defense Analyses (IDA), Washington DC.

Note: A different point of view regarding this report is expressed in comments received from some of the authors of the IDA and RAND studies. These comments are available to the public in the NRC public access file for this project. All references in this report to IDA's analysis or findings are based solely on the 1997 IDA report by Crane, Rivolo, and Comfort. All references in this report to RAND's analysis or findings are based solely on its 1994 report, *Controlling Cocaine Supply Versus Demand Programs* by authors C.P. Rydell and S.S. Everingham.

Copyright © National Academy of Sciences. All rights reserved.