RAND

# A Simple Economic Model of Cocaine Production



Michael Kennedy, Peter Reuter,
Kevin Jack Riley





National Defense Research Institute

The research described in this report was sponsored by the Under Secretary of Defense for Policy under RAND's National Defense Research Institute, a federally funded research and development center supported by the Office of the Secretary of Defense and the Joint Staff, Contract MDA903-90-C-0004.

Portions of this report were published as "A Simple Economic Model of Cocaine Production," by Michael Kennedy, Peter Reuter, and Kevin Jack Riley, in *Mathematical and Computer Modelling*, Vol. 17, No. 2, 1993, pp. 19–36, copyright 1993 by Pergamon Press PLC. Used by permission of Pergamon Press PLC.

**Library of Congress Cataloging in Publication Data**

Kennedy, Michael, 1949–
A simple economic model of cocaine production / Michael Kennedy, Peter Reuter, Kevin Jack Riley ; prepared for the Under Secretary of Defense for Policy.
p. cm.
"MR-201-USDP."
Includes bibliographical references.
ISBN 0-8330-1384-X
1. Cocaine industry—Andes Region—Econometric models.
I. Reuter, Peter, 1944– . II. Riley, Kevin Jack, 1964– .
III. United States. Office of the Under Secretary of Defense for Policy. IV. Title.
HV5840.A5K46 1993
363.4'5—dc20 93-17674
CIP



Published 1994 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
To obtain information about RAND studies or to order documents,
call Distribution Services, (310) 451-7002

RAND

# A Simple Economic Model of Cocaine Production

*Michael Kennedy, Peter Reuter,*
*Kevin Jack Riley*

*Prepared for the*
*Under Secretary of Defense for Policy*

| Accesion For | |
|---|---|
| NTIS CRA&I | ☑ |
| DTIC TAB | ☐ |
| Unannounced | ☐ |
| Justification ........ | |
| By ........ | |
| Distribution / | |
| Availability Codes | |
| Dist | Avail and / or Special |
| A-1 | |

**National Defense Research Institute**

**Approved for public release; distribution unlimited**

# Preface

This report describes an economic model of the cocaine trade and presents some conclusions derived from simulations using the model. This work was done as part of a broader project entitled "Andean Futures: A Comparative Political, Economic, and Security Assessment." The research was sponsored by the Under Secretary of Defense for Policy. It was conducted within the International Security and Defense Strategy Program of RAND's National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense and the Joint Staff.

This report should be of interest to those concerned with drug policy, particularly as it relates to efforts to control drug exports from foreign sources.

A shorter version of this study appeared under the same title in *Mathematical and Computer Modelling*.

# Contents

# Figures

# Tables

# Summary

This report describes a simple economic model of the cocaine trade. The purpose of the model is to represent the fundamental economic relations that determine the size of the cocaine trade, and to simulate the effects on the trade of policy initiatives or other changes in the surrounding environment.

The report begins by describing the policy setting and the variety of programs that have been used, or advocated, to control drug production overseas. It then presents a description of the structure of the model in equation form and estimates of the current state of the cocaine market that are used to parameterize the model. The results of a set of simulations of the model are then presented, and they lead to the following conclusions.

**"Crop substitution" programs will have a negligible impact on the world cocaine market.** As desirable for other reasons as improving economic conditions in Peru, Bolivia, and Colombia may be, those improvements will not lower cocaine supply. This is because cocaine traffickers can easily match and exceed any increased economic opportunity, resulting from a crop substitution program, that is presented to workers currently in the cocaine industry.

**The cost of compensating workers currently in coca or cocaine production if the cocaine trade is destroyed is relatively low.** About a five billion dollar investment in the economies of Peru, Bolivia, and Colombia would provide employment opportunities for all those currently producing coca leaf, coca paste, cocaine base, or cocaine at a wage equal to their current wage. This is because their current wage is rather low; the cocaine traffickers, who earn huge fortunes, could not be compensated by such investments, of course.

**Cocaine-supply attack strategies that seize and destroy 70 percent or less of production, without limiting the total level of production, will have little impact on the market.** If cocaine traffickers have the option of increasing gross production to make up for some percentage of their product being destroyed, and if that percentage is 70 percent or less, the increased cost of the higher gross production is low relative to the retail value of the cocaine that survives. Thus, the natural market reaction to such a production attack program would be to step up gross production, and the resulting increase in the retail price or decrease in overall consumption will be small. There will simply be more cocaine produced to ensure a relatively constant amount is supplied to the market.

**There is a relatively modest long-run impact on the standard of living of average workers in Peru, Bolivia, and Colombia as a result of changes in the size of the world cocaine market.** In particular, if there is a decrease in the size of the market due to law enforcement, or drug education and treatment, in the consuming countries, there will be only a small decrease in the average wage of workers in cocaine-producing countries. This is because employment in growing coca and processing it into cocaine is not a large percentage of total employment in these countries. Cocaine traffickers would suffer very large income losses, of course.

**The results of this study are insensitive to the data uncertainties concerning the cocaine market.** Data about the cocaine trade are hard to obtain due to the trade's clandestine nature. However, the results presented here hold up over a wide range of possibilities about the true nature of the market. No plausible variations in the data have been found yet that fundamentally change these results.

The results of this study suggest that the justification for increased overseas cocaine control efforts has to be found in claims other than that the efforts will reduce U.S. cocaine consumption in the long run. None of these results say that enforcement and crop substitution programs are without value. The results refer to the long run adaptations that the industry can make to various interventions. Enforcement programs may have substantial and valuable short-term effects. However, the results do provide a cautionary note about what can be expected in the long run even if the programs are implemented.

The Appendix presents two input-output (I-O) tables relating to the cocaine trade. The purpose of constructing the I-O tables is to gain insight into the structure, size, and operation of the cocaine trade, as well as to provide the database used in the construction of the simple model. The Appendix contains three main sections. The first section describes the cocaine production process; the second the data sources used; and the third the tables and analytic results.

Cocaine manufacturing is a simple process that requires relatively large amounts of labor and small amounts of capital. Cocaine production, before export to the United States, is international in scope, primarily involving transactions among the Andean nations of Peru, Bolivia, and Colombia (PBC). A large effort has been put into quantifying and describing the cocaine trade. Out of these efforts, data have emerged that provide a solid foundation for constructing the input-output figures. Because of the uncertainties associated with the data, the figures here should be regarded as presenting a lower bound on the size of the cocaine industry in PBC.

The figures themselves reveal that the cocaine industry makes a moderate contribution to regional GDP and provides relatively high labor income to the participants. However, in part because of price fluctuations, the industry may not provide as much economic profit as previously believed. Specifically, the cocaine industry:

- generates GDP that is 3–13 percent of national GDP in Bolivia, Colombia, and Peru;
- provides average annual incomes of $504–$2,039, which match or exceed local average wages;
- appears to suffer periods of low profitability, due to fluctuating prices.

# Acknowledgments

Jennifer Duncan provided valuable research assistance. The authors would also like to acknowledge helpful reviews by Victoria A. Greenfield, C. Richard Neu, and Jonathan Caulkins.

# 1. Introduction

For twenty years, programs aimed at reducing the production and export of illicit drugs in foreign countries have played a major role in the rhetoric of United States drug control policy. Their role in drug control budgets has been more modest, though not insignificant; in fiscal year 1991 these programs received about $500 million, out of a total federal drug control budget of $10.6 billion. They have been important, often dominant, in U.S. relationships with the Andean region and, at times, with Burma, Mexico, Pakistan, and Turkey.

The effort to control drug production overseas has generally been viewed as ineffective. Mexico, the most cooperative of the source countries, continues to produce record amounts of heroin and marijuana, while Asian opium production grows by leaps and bounds.[1] The production and export of cocaine from the Andean region, the primary focus of concern throughout the 1980s, continued almost unabated into the early 1990s.

Pessimism about source country control programs, as they are generally known, is fairly widespread.[2] Indeed, outside of official documents it is difficult to find the slightest sign of optimism. However, much of that pessimism reflects the failure of the United States to persuade the governments of the major cocaine and opium producers to implement the production control effectively. For both political and economic reasons (though mostly the former), the source country governments have been reluctant to take actions against an industry that has become regionally, and sometimes nationally, important. The (implicit) belief of program advocates is that, if the producer governments could be persuaded to seriously implement control efforts, these programs might substantially reduce the production of illegal drugs.

The argument of this study goes beyond that, at least for Andean cocaine production. It implies that the failure of source country control lies not so much in the difficulties of program implementation as in the basic structure of the drug industry. It seems unlikely that eradication, crop substitution, or any related effort aimed directly at coca growing and cocaine refining in Peru, Bolivia, and

---

[1]For example, total opium production, dominated by Burmese output, doubled between 1985 and 1990. See [1].

[2]Among recent prominent statements of this pessimism are [2] and [3]. For a more complex view, see [4].

Colombia will make a significant difference to total Andean cocaine production, though it may affect the share of cocaine production in particular countries within the region.

This report describes a simple equilibrium economic model of cocaine production. The purpose of the model is to represent the fundamental economic relations that determine the size of cocaine output, and to simulate the effects on cocaine production of policy initiatives or other changes in the surrounding environment.

The model includes representations of economic conditions in the primary coca and cocaine producing countries: Peru, Bolivia, and Colombia (hereafter, PBC). It simulates employment and output levels in the production of the four primary products in the cocaine trade: coca leaf, coca paste, cocaine base, and cocaine powder (CHCl). (These four products will be referred to hereafter as "cocaine products.") The model also simulates employment and output in the rest of the economy, and thus explicitly represents the competition for resources between the cocaine sector and the non-cocaine sector. Finally, the model includes a representation of the world market for cocaine.

In this report, the model will be used to analyze the impact of the following changes:

- A "crop substitution" program that improves the economic attractiveness of producing crops other than coca.
- More effective law enforcement in coca- and cocaine-producing regions, which either holds physical production of cocaine products below given levels or which increases the cost of producing them. The model also simulates the effects of these policies on the standard of living of the PBC population.
- Changes in the size of the world market for cocaine, particularly as they affect the economic situation in the producing countries. Changes can be downward. Thus, the model can simulate the effect on the PBC economies of successful anti-drug programs (whether domestic law enforcement or prevention/treatment programs) in the major consuming countries such as the United States.

Other kinds of policy interventions or changes in external conditions, such as closer economic integration of the PBC countries, could be analyzed in this framework. The model can be extended in several directions, each allowing different issues to be addressed.

Section 2 briefly describes the kinds of programs that have been used to control cocaine production and exports from the Andean region. Section 3 describes the structure of the model and presents the values of the parameters used. The results of model simulations are provided in Section 4. The concluding section summarizes the results of the analysis. An appendix in three parts describes the cocaine production process, details the data sources used, and presents the input-output tables for the cocaine trade and analytic results derived from them.

# 2. The Varieties of Control Programs

Four different classes of programs have been mounted to reduce the production and/or export of cocaine from the Andean region: crop eradication; crop substitution or alternative economic development; refinery destruction and seizure of drugs; and the investigation and prosecution of traffickers.[1] The model deals primarily with the first two of these programs, which are described here in more detail.

## Eradication

The United States has, in its dealings with the Andean source countries, given primary emphasis to persuading the host governments to eradicate coca fields through aerial spraying of herbicides [8]. The concentration of coca production in relatively few areas (the Upper Huallaga Valley in Peru and the Chapare and the Yungas in Bolivia) makes eradication a particularly attractive option, since the program would not face the difficulties presented in Mexico (the only country with an active program) of small, dispersed marijuana and opium poppy fields in remote and hidden locations [9]. Producer countries have never been enthusiastic about the prospects of wiping out the coca fields by force, citing a *host of environmental* (Peru) and political (Bolivia) concerns.

Nor is it feasible to try manual eradication, the staple of Mexican control efforts during the 1960s and early 1970s and still a major military activity there [10]. The large acreage now under coca cultivation and the difficulty of removing the entire plant by such methods work against this. Indeed, the term *plant* is a misnomer; the coca bush is actually a small tree that is very difficult to kill.

Though both Bolivia and Peru have occasionally announced plans to achieve ambitious eradication goals, the results have varied between disappointing and negligible. Total Bolivian cultivation has grown from an estimated 34,000 hectares in 1985 to 58,400 in 1990. Peru has also seen a large increase in coca cultivation from 1985 to 1990 (95,000 hectares to 121,000 hectares); the highest annual Peruvian eradication figure was only 5,100 hectares.

---

[1]For an overview of the control programs and their immediate effects, see [5] to [7].

Eradication, then, has been given rhetorical emphasis but has not been implemented in any substantial way in the Andean region. If it were adopted, a central question would be whether growers could make the same kinds of adaptations that were made by the Mexican marijuana and opium growers, namely remote dispersal and concealment.

For modeling purposes, eradication is equivalent to raising certain cost elements for growers. They will have to use more inputs (labor, land, and seed) to achieve the same expected output of coca each year; there will also be more uncertainty about what quantities they will be able to market. The more intense the eradication effort, the lower the farmers' expected production and the greater their uncertainty. The refiner of coca leaf will have to pay a higher leaf price to compensate the farmer for increases both in expected costs and in the risks of production. Eventually, that higher leaf price will increase the retail price of cocaine, reducing total demand and in turn the amount of leaf that refiners will seek to purchase. The feedback is thus through the impact of higher leaf production costs on the retail price. Of course, if eradication were complete (a far cry from the current level of effort) output would be directly affected. The modeling results below simulate both kinds of effects.

## Crop Substitution

Given the political obstacles to eradication and the highly coercive nature of other enforcement, the cocaine source countries have favored programs that try to make other, legitimate, crops more attractive to peasant farmers. Thus in Peru in the mid-1980s, the Agency for International Development (AID) had a $40 million development project in the Upper Huallaga Valley aimed at encouraging production of other crops at the same time that eradication efforts were being carried out in the area.[2] The project had to be abandoned after peasants, encouraged by the Sendero Luminoso (Shining Path) and other guerilla groups, destroyed highways and closed the valley to outside traffic.

The Bolivian government has been a particularly consistent and enthusiastic supporter of alternative development programs, having sought large sums from a consortium of developed nations to build infrastructure and provide extension services. For example, in 1987 Bolivia adopted a "Three Year Plan for the Struggle Against Narcotics Trafficking," with foreign governments providing $240 million out of the total $300 million cost of the program. The components of

---

[2] Attempts at crop substitution and regional development in Peru and Bolivia are described in a number of project documents, e.g., [11] and [12].

this program were increasingly stringent restrictions on where coca could be grown (for the traditional legal coca industry, serving primarily local leaf chewers) and a coca land buy-out scheme. Originally the scheme involved payments of $300 per hectare of coca removed from production; under protest from the farmers, this was raised in 1988 to $2,000. In the Chapare, farmers have been encouraged to use these payments to shift into growing citrus, beans, tea, bananas, and corn (see [15]). Thus it is clearly an economically based, rather than an enforcement-oriented, approach to reducing drug production, though it has usually been coupled with enforcement programs of various types.

One method of representing the crop substitution programs is as an infusion of capital to the non-coca agricultural sector, raising the productivity of land and labor in the production of legitimate crops other than coca. The response of the cocaine refining industry, taken as a whole, will be to raise the price that it pays for coca leaf, since the opportunity cost (i.e., what the peasant could earn with his land and labor in other activities) has gone up. That will entice some farmers to remain in coca production but will require that refiners raise the price at which they buy the product.

The model also considers a more general type of economic development program aimed at attracting labor from coca production, going into the non-farm sector. This corresponds to the Colombian government efforts to improve access to U.S. markets for manufactured goods and thus increase the attractiveness of industrial employment.

# 3. The Structure of the Model

This section describes the model structure. Included in the section are numerical characterizations of the 1989 cocaine trade. The model is calibrated so that these (1989) values are simulated as the base case. The alternative policy and other cases described in the next section are calculated from the base case. The data used in this model are presented more fully in the Appendix.

## One Country, One Product Model

Before describing the full-blown model, which includes three cocaine-producing countries and four stages of cocaine production, the simple logic of a one-country, one-stage-of-production model will be given. This is intended to clarify the logic behind the complete model. Equation numbers are given with an * to distinguish them from equations for the three country/four stage model.

In this simplest model, the cocaine-producing country allocates its total labor force (TL) between workers making cocaine [L(1)] and workers making other goods [L(0)].

$$TL = L(0) + L(1) \qquad (1^*)$$

Output of cocaine, Q(1), is produced by labor only at constant cost.

$$Q(1) = \frac{L(1)}{r} \qquad (2^*)$$

Other output, Q(0), is produced by workers and (exogenous) capital stock. A Cobb-Douglas functional form is assumed.

$$Q(0) = A\, L(0)^{(a)} K^{(1-a)} \qquad (3^*)$$

The wage of labor in the "other output" sector is determined by its marginal product.

$$w = A\, a \left[\frac{L(0)}{K}\right]^{(a-1)} \qquad (4^*)$$

The wage of workers is also equal to their reward in cocaine production. If P is the export price of cocaine, then:

$$w = \frac{P}{r} \qquad (5^*)$$

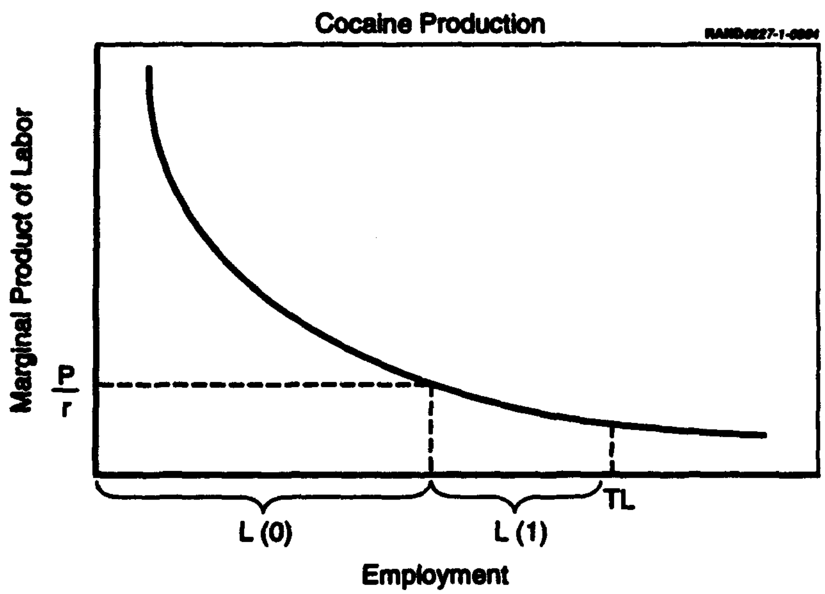
The cocaine-producing country is assumed to be a price taker in the cocaine market, so the wage of workers in the "other output" sector is equalized to the reward of producing cocaine. Combining equations (4*) and (5*):

$$\frac{P}{r} = A\,a\left[\frac{L(0)}{K}\right]^{(a-1)} \qquad (6^*)$$

Thus, L(0) and Q(0) are determined by the export price of cocaine, and as the export price (P) rises, workers leave the "other output" sector and produce cocaine. A rising supply curve for cocaine exports results. Algebraically, equations (1*), (2*), and (6*) can be combined to yield:

$$Q(1) = \frac{TL - K\left[\frac{\frac{P}{r}}{(Aa)}\right]^{\left[\frac{1}{(a-1)}\right]}}{r} \qquad (7^*)$$

Graphically, Figure 1 illustrates the market equilibrium. P/r is the market wage, at which L(0) workers are employed in producing "other output." The




SOURCE: Michael Kennedy, Peter Reuter, and Kevin Jack Riley, "A Simple Economic Model of Cocaine Production," *Mathematical and Computer Modelling*, Vol.17, No. 2, 1993, p. 23. Used by permission of Pergamon Press PLC.

**Figure 1—Determination of Equilibrium in the Simplest Model**

remaining workers, L(1) = TL – L(0), produce cocaine. As P rises, workers leave other-output production to produce cocaine. This leads to a rising supply curve. On the demand side, purchases of cocaine are assumed to be related to the retail price, which equals the export price (P) plus a markup (F).

$$Q(1) = f(P+F) \qquad (8^*)$$

Combining this with equation (7*) gives the market equilibrium price.

We now turn to the full multi-country/multi-sector model.

## Multi-Country, Multi-Sector Model

The three countries represented in the model are indexed by the variable i: Peru (1), Bolivia (2), and Colombia (3). Production of five kinds of output is represented in the model, indexed by the variable j.

Product 0 is literally all non-cocaine gross domestic product (GDP). It will be referred to as "other GDP" in the rest of this report. It includes both "measured GDP" and "informal sector output." The first is the conventional, reported GDP figure for the three countries. The second is the substantial level of production that is not included in measured GDP because of evasion of regulation or taxation. The total is referred to as "other GDP" because conceptually both are a part of GDP as generally defined.[1] "Other GDP" can be disaggregated in a second way, between "final other GDP" and "cocaine sector input." The second category is the production that is used as an intermediate product in the cocaine sector; the first category is production that is used to satisfy the conventional final demand categories of consumption, investment, and government spending.

Products 1 through 4 collectively are referred to as "cocaine products." The model simulates how the productive resources of PBC are allocated between cocaine products and other GDP.

| Index Variable (j) | Product |
|---|---|
| 0 | All other output (i.e., non-cocaine-product GDP) |
| 1 | Coca leaf |
| 2 | Coca paste |
| 3 | Cocaine base |
| 4 | Cocaine (CHCl) |

[1] Most of the production of the informal sector is of a legal kind of output, that is, of the same kinds of output that are produced and recorded in measured GDP. It is simply not reported to the authorities. For a comprehensive description of the informal sector in Peru, see [14].

The following economic variables are included in the model. Unless otherwise indicated, the index i runs from 1 to 3, and the index j runs from 0 to 4.

| Variable | Description |
|---|---|
| Q(i,j) | Output of product j in country i. |
| Q0(i,j) | Intermediate input of product 0 (other GDP) into production of product j in country i. |
| p(i,j) | Price of product j in country i. |
| L(i,j) | Labor employed in production of product j in country i. |
| TL(i) | Total employment in country i. |
| w(i) | Wage rate in country i. |
| K(i) | Capital stock in country i. |

Production of cocaine products requires both labor and intermediate inputs of other GDP; both of these requirements are assumed to be linearly related to production of cocaine products.

$$\begin{aligned} L(i, j) &= r(i, j)\, Q(i, j) \qquad i = 1\ldots3; \quad j = 1\ldots4 \\ Q0(i, j) &= c(i, j)\, Q(i, j) \qquad i = 1\ldots3; \quad j = 1\ldots4 \end{aligned} \tag{1}$$

Here r(i, j) is labor required for output of one unit of product, and c(i, j) is other GDP intermediate input required for output of one unit of product.

There is no formal representation of capital requirements for cocaine product production; these requirements are included in the intermediate input requirements. Thus, it is formally assumed that all capital goods used are fully consumed (and hence depreciated) in one year. Given the illegal nature of cocaine production, and thus the desirability of being able to move the location of production frequently, and the low level of sophistication in the production process, this is a reasonable approximation. This assumption is least tenable in coca growing, in which the plants live more than one year, so the labor that clears the land and plants the crop should be distinguished from the labor that harvests the crop. In the long-run analysis done here, this is not so important, but in short-run analysis (charting the path between long-run equilibria), it is important.

Tables 1 to 3 show base case values of cocaine product output, employment, and intermediate product use in the three countries. Table 1 includes legal output of 18,000 metric tons of cocaine leaf in Peru, and 10,000 in Bolivia. Table 2 includes legal employment of 35,000 workers in legal coca leaf production in Peru and

**Table 1**

**Base Case Output of Cocaine Products**

| Country | Product | | | |
|---|---|---|---|---|
| | Coca Leaf[a] | Coca Paste[b] | Cocaine Base[b] | Cocaine[b] |
| Peru | 155 | 1,177 | 325 | 16 |
| Bolivia | 78 | 720 | 232 | 81 |
| Colombia | 33 | 216[c] | 180 | 639 |
| Total | 266 | 2,113 | 736 | 736 |

[a]Thousands of metric tons.

[b]Metric tons.

[c]Columbian leaf is processed directly into base. Figure is imputed from processing ratios, but includes 19 metric tons of paste produced in Columbia from Peruvian and Bolivian leaf.

**Table 2**

**Base Case Employment in Cocaine-Related Production (thousands of workers)**

| Country | Product | | | | |
|---|---|---|---|---|---|
| | Coca Leaf | Coca Paste | Cocaine Base | Cocaine | Total |
| Peru | 300 | 75 | 20 | 5 | 400 |
| Bolivia | 240 | 50 | 15 | 35 | 340 |
| Colombia | 75 | 13 | 12 | 125 | 225 |
| Total | 615 | 133 | 47 | 165 | 960 |

**Table 3**

**Base Case Intermediate Input in Cocaine-Related Production (millions of dollars)**

| Country | Product | | | | |
|---|---|---|---|---|---|
| | Coca Leaf | Coca Paste | Cocaine Base | Cocaine | Total |
| Peru | 45 | 77 | 173 | 43 | 338 |
| Bolivia | 3 | 51 | 149 | 100 | 303 |
| Colombia | 2 | 8 | 14 | 1,295 | 1,320 |

31,000 in Bolivia. The sources for all data in these tables are provided in the Appendix.[2] The values of the r(i, j) and c(i, j) can be derived from these tables.

Production of other GDP is represented by a Cobb-Douglas production function.

$$Q(i, 0) = A(i)\ L(i, 0)^{a(i)}\ K(i)^{[1-a(i)]} \qquad i = 1\ldots3 \qquad (2)$$

Here the A(i) and a(i) are parameters. The a(i) must be between zero and one, and they are often referred tc as "labor's share" because they represent the share of national income that would accrue to labor if resources were paid their marginal products. This representation assumes that the same production function can be used for both measured GDP and informal sector output, and thus that labor and capital used in the two activities can be aggregated to determine total other GDP.

Final other GDP is defined as other GDP less cocaine sector input.

$$FO(i) = Q(i, 0) \quad - \sum_{j=1}^{4} QO(i, j) \qquad i = 1\ldots3 \qquad (3)$$

Here FO(i) is final other GDP in country i. Tables 4 to 6 show base case values of other GDP, employment in production of other GDP, and the parameters of the production functions for each of the countries.[3]

The sum of labor employed in all sectors equals total employment.

$$\sum_{j=0}^{4} L(i, j) = TL(i) \qquad i = 1\ldots3 \qquad (4)$$

Total employment is taken as exogenous in this model; i.e., neither labor force participation nor the unemployment rate are assumed to be affected by the factors that are varied in model simulation. In addition, the wage rate is

---

[2]The derivation of the figures in Table 3 is of special interest in interpreting the model. The value of intermediate input of other GDP into each stage of cocaine production is estimated as the value of production less wages, less the value of input of the intermediate cocaine product (zero for coca leaf). Thus this "intermediate input" includes both physical inputs and the value of any profits that accrue to cocaine traffickers, which are represented as their equivalent in "other GDP" goods and services.

[3]In Table 6, capital stock is assumed to be twice the level of other GDP, and the a(i) variables are derived as the ratio of the compensation-of-employees component of GDP to total GDP net of indirect taxes (compensation of employees, operating surplus, and consumption of fixed capital). These figures are reported in [16]. The assumption about the ratio of capital stock to recorded GDP is our interpretation of the stylized facts for these nations.

**Table 4**

**Base Case Other GDP**
**(millions of dollars)**

| Country | Final Other GDP [FO(i)] | Cocaine Sector Input[a] | Measured GDP[b] | Informal Sector[c] | Total Other GDP[d] [Q(i,0)] |
|---|---|---|---|---|---|
| | Activity | | | | |
| Peru | 24,062 | 338 | 18,400 | 6,000 | 24,400 |
| Bolivia | 4,357 | 303 | 4,160 | 500 | 4,660 |
| Colombia | 32,020 | 1,320 | 33,340 | 0 | 33,340 |

[a]From Table 3.
[b]From [16].
[c]From the statistical annex to [14] and [17].
[d]Columns 1 and 2 add to column 5. Columns 3 and 4 add to column 5.

**Table 5**

**Base Case Employment**
**(thousands of workers)**

| Country | Measured GDP[a] | Informal Sector[b] | Cocaine Production[c] | Total [TL(i)][d] |
|---|---|---|---|---|
| | Activity | | | |
| Peru | 7,224 | 2,200 | 400 | 9,824 |
| Bolivia | 1,906 | 210 | 340 | 2,456 |
| Colombia | 11,724 | 0 | 225 | 11,949 |

[a]Fom [27] (less estimated legal coca leaf employment).
[b]From [14] and [17].
[c]From Table 2.
[d]Columns 1, 2, and 3 add to column 4. Columns 1 and 2 add to L(i,0).

**Table 6**

**Base Case Values of Other Economic Variables**
**(capital stock in millions of dollars)**

| Country | [K(i)] | [a(i)] |
|---|---|---|
| | Variable | |
| Peru | 48,800 | 0.33 |
| Bolivia | 9,320 | 0.36 |
| Colombia | 66,680 | 0.46 |

assumed to be the same in the production of all output: all cocaine production, and both measured GDP and informal sector output.

The assumption that wages in the cocaine sector are no higher than in the rest of the economy reflects the lack of any systematic data on these wages. The existing, basically anecdotal evidence, indicates that wages are somewhat higher in the cocaine sector, as one would expect due to the risks in the production of contraband. While an interesting extension of this model would include a wage differential between the cocaine and non-cocaine sectors, the basic nature of the results would not change unless the proportionate differential were to rise drastically with higher enforcement, a possibility that will be briefly considered in the simulations of Section 4.

Production of cocaine follows a straightforward vertical processing system [18]. Coca leaf is processed into coca paste, which is processed into cocaine base, which is in turn processed into cocaine (CHCl). The term "intermediate product" will be used to refer to the product immediately preceding in the processing chain. Thus, coca leaf is the intermediate product for coca paste, coca paste is the intermediate product for cocaine base, and cocaine base is the intermediate product for cocaine.[4] When producing any given product, the intermediate product may be obtained from the country in which the production is done, or it may be imported.[5] In general, more than one ton of the intermediate product is needed to produce one ton of output.[6] The following variables are defined to characterize these relations.

| Variable | Description |
|---|---|
| s(i,k,j) | When product j + 1 is produced in country i, s(i,k,j) is the share of output made from intermediate product obtained from country k. i,j,k ∈ {1,2,3} |
| b(i,j) | Amount of product j of country i origin needed to produce one unit of product j + 1 (i.e., j is the intermediate product). |

The s variables are taken as exogenous in this model; i.e., the share of intermediate product supply by source country is fixed for each country-product

[4]Colombian leaf is mostly processed directly into base without an intermediate paste stage. In the model, a paste stage is artificially introduced for convenience, which does not affect the results at all. The parameters that determine the Colombian leaf-base relationship can be derived in a straightforward fashion from the two-stage process parameters presented here.

[5]According to intelligence estimates, of PBC, only Bolivia and Peru export intermediate products for further processing. See [19] for a description of the movement of intermediate products.

[6]Indeed, cocaine production results in a 500-fold weight reduction from the leaf stage. This reduction is a result of the low concentration of cocaine in coca plants; [20] reports average cocaine concentrations in coca plants ranging from 0.25 percent to 0.77 percent, depending on the variety cultivated (pp. 11–21).

combination. Modeling country shares as endogenous would be difficult because in addition to the least-cost-of-supply considerations that determine such shares in the legal world, there are also costs of changing clandestine distribution channels in the cocaine world. At any rate, the assumption of fixed s val·.es implies that the cocaine trafficking system in the model is more rigid, and less able to respond to changing supply availability, than is the system in the real world. A more flexible model would produce results more supportive of the conclusions than the present model, which assumes fixed patterns of supply channels. The b variables, which represent physical production coefficients, are also taken as exogenous.

Given these variables, the following relation holds:

$$Q(i,j) = \sum_{k=1}^{3}\left[Q(k,j+1)\, s(k,i,j)\, b(i,j)\right] \qquad i = 1\ldots3; \quad j = 1\ldots3 \qquad (5)$$

(In the model, the small amounts of legal coca leaf production mentioned earlier are also included as exogenous variables.)

Tables 7 and 8 show the values used for the s and b variables. Table 7 shows that Peru and Bolivia only process intermediate products made in their own country, while Colombia imports large amounts of intermediate product.

The model presented so far is sufficient to determine the state of the economies of PBC, given the level of cocaine (CHCl) production in each country. That is, if the levels of cocaine production, the Q(i, 4), are given, equation (5) determines the output levels of all other cocaine products. Equation (1) then determines employment in cocaine production in each country, and equation (4) determines employment in the other-GDP sector. Equation (2) then determines the level of other GDP in each country, and equation (3) determines the level of final other GDP in each country.

The wage rate in each country is equal to the marginal product of labor; i.e., it is assumed that the labor market operates competitively, so that workers receive a wage equal to their marginal contribution to output.

$$w(i) = \frac{\delta\, Q(i,0)}{\delta\, L(i,0)} = a(i)\, A(i)\left[\frac{K(i)}{L(i,0)}\right]^{[1-a(i)]} \qquad i = 1\ldots3 \qquad (6)$$

Table 7

**Shares of Intermediate Product Supply by Country[a]**

| Share values for j = 1, processing leaf into paste | | | |
|---|---|---|---|
| | Country Supplying Leaf (k = 1 . . . 3) | | |
| Country Producing Paste | Peru (k = 1) | Bolivia (k = 2) | Colombia (k = 3) |
| Peru | 1.00 | 0.00 | 0.00 |
| Bolivia | 0.00 | 1.00 | 0.00 |
| Colombia | 0.05 | 0.03 | 0.91 |
| **Share values for j = 2, processing paste into base** | | | |
| | Country Supplying Paste (k = 1 . . . 3) | | |
| Country Producing Base | Peru (k = 1) | Bolivia (k = 2) | Colombia (k = 3) |
| Peru | 1.00 | 0.00 | 0.00 |
| Bolivia | 0.00 | 1.00 | 0.00 |
| Colombia | 0.45 | 0.16 | 0.39 |
| **Share values for j = 3, processing base into cocaine** | | | |
| | Country Supplying Base (k = 1 . . . 3) | | |
| Country Producing Cocaine | Peru (k = 1) | Bolivia (k = 2) | Colombia (k = 3) |
| Peru | 1.00 | 0.00 | 0.00 |
| Bolivia | 0.00 | 1.00 | 0.00 |
| Colombia | 0.48 | 0.24 | 0.28 |

[a]The s(i,k,j) parameters: i = 1 . . . 3; k = 1 . . . 3; j = 1 . . . 3.

Table 8

**Conversion Factors for Stages of Cocaine Processing[a]**

| | Conversion Factor (j = 1 . . . 3) | | |
|---|---|---|---|
| Country | Leaf → Paste[b] (j = 1) | Paste → Base[c] (j = 2) | Base → Cocaine[c] (j = 3) |
| Peru | .115 | 2.9 | 1.0 |
| Bolivia | .092 | 2.8 | 1.0 |
| Colombia | .169 | 3.1 | 1.0 |

SOURCE: Appendix Table A.1.

[a]The b(i,j) parameters; i = 1 . . . 3; j = 1 . . . 3.

[b]Leaf → paste in thousands of metric tons per metric ton.

[c]In metric tons per metric ton.

Given the wage rate, the cost of producing all of the cocaine products can be determined by adding the labor costs and the prices of intermediate products. The price of cocaine products is equal to this cost.[7] (This relation is recursive, beginning with leaf price.) p(i, j) is the price of product j in country i; i = 1 . . . 3; j = 1 . . . 4. It is equal to labor cost, the cost of intermediate inputs of other GDP, and the cost of intermediate input of the appropriate cocaine product.

$$p(i,1) = r(i,1)\,w(i) + c(i,1) \qquad i = 1\ldots3 \qquad (7)$$

$$p(i,j) = r(i,j)\,w(i) + c(i,j) + \sum_{k=1}^{3}\left[p(k,j-1)\,s(i,k,j-1)\,b(k,j-1)\right] \qquad i = 1\ldots3; \quad j = 2\ldots4 \qquad (8)$$

These relationships give the internal price of cocaine in each country [p(i, 4)]. The world export price of cocaine is assumed to be a weighted average of these internal prices, in which the weights are the shares of each of the three exporting countries in total exports. Technically, this says that cocaine exporters are able to purchase cocaine at internal prices in the three countries that do not necessarily equalize, and thus that the exporters can capture the rents implicit in unequal prices. The landed price of cocaine in importing countries is assumed equal regardless of the country of origin of the product. It is reasonable that the "law of one price" is enforced internally in a marketing organization, rather than externally in a free market, for an internationally traded contraband commodity.

Finally, it is assumed that the shares of cocaine exports across the three exporting countries are exogenous. This is analogous to assuming that the shares of intermediate products obtained from the three countries for further processing are exogenous. This assumption imposes more rigidity on the cocaine market than probably exists in the real world; i.e., it implies that the market cannot react to an increase in the cost of producing cocaine in one country by decreasing that country's share in world exports. As in the assumption about intermediate good shares, this assumption is conservative with respect to the conclusions of the analysis; i.e., the conclusions would be supported more strongly by a model with less rigidity. The rigidity assumption has merit, however, in that it reflects the high cost of setting up marketing channels for a contraband product.

[7]Since the value of intermediate other GDP needed for production of cocaine products was derived as the difference between price and the value of intermediate cocaine products, it includes both the value of other GDP inputs physically used in production, and a value of other GDP equivalent to the level of pure profit in the cocaine trade.

Table 9 gives the base case (estimates of 1989) values of the prices of the cocaine products in the three countries, the average wage rate in the three countries, and the share of each country in cocaine exports. Table 9 implies an average export price for cocaine of $3,800 per kilogram.

The model as described so far can determine the export price of cocaine as a function of level of exports in the following way. Given any total level of exports, the cocaine export share parameters determine the level of export and production in each country.[8] It was described earlier how the levels of economic activity in each country can be derived from the cocaine production levels. Equations (6) to (8) then determine, for each country, the wage rate and the prices of cocaine products. The export price of cocaine is then calculated as the weighted average of the cocaine price in each country, with the export share parameters as the weights. What has been calculated is, in effect, a supply price relation for cocaine exports—for each level of exports, the model calculates the price that would be required to bring forth production of that much cocaine. To complete this part of the model algebraically, let P be the export price of cocaine; let e(i) be the export share of country i (i = 1 . . . 3); and let E be total exports of cocaine.

$$Q(i, 4) = e(i)\,E \qquad i = 1 \ldots 3 \qquad (9)$$

$$P = \sum_{i=1}^{3} \left[p(i, 4)\; e(i)\right] \qquad (10)$$

**Table 9**

**Base Case Values of the Price of Cocaine Products, Wage Rates, and Cocaine Export Shares**

| | Product | | | | Variable | |
|---|---|---|---|---|---|---|
| Country | Coca Leaf[a] | Coca Paste[c] | Cocaine Base[c] | Cocaine[c] | Wage Rate[b] | Cocaine Export Share |
| Peru | 2.0 | 0.35 | 1.60 | 4.5 | 0.86 | 0.03 |
| Bolivia | 2.5 | 0.35 | 1.68 | 3.3 | 0.78 | 0.11 |
| Colombia | 3.0 | 0.60 | 1.50 | 3.9 | 1.31 | 0.86 |

[a]Thousand dollars per metric ton.
[b]Thousand dollars per year.
[c]Thousand dollars per kilogram.

[8]As mentioned earlier, a small exogenous level of coca leaf production is included.

What remains for the model is the inclusion of a demand relation. The demand for exports, E, is a function of the retail price of cocaine in consuming countries. Let WP be the world retail price; it is the sum of the export price in PBC, P, plus an exogenous markup, which will be represented by the parameter F.

$$WP = P + F \tag{11}$$

$$E = C(WP)^{c} \tag{12}$$

The value of F is estimated to be $131,000 per kilogram, compared to $4,000 for P. Thus, the export price of cocaine in PBC is only 3 percent of the retail price of $135,000 per kilogram. The fact that the export price is such a small portion of the retail price to consumers is a strong driver of the conclusions of this analysis, as will be seen later. The high cocaine markup in the United States is due to three factors: (a) the higher enforcement risks faced by dealers in the United States, (b) the higher opportunity costs of labor, and (c) the fact that these risks are distributed over ever smaller quantities of drugs as cocaine moves down the distribution system.

(a) Notwithstanding concerns that the criminal justice system is failing to deliver sufficient punishment against drug dealers in American cities, the level of enforcement seems to be much higher here than in Bolivia, Colombia, and Peru. For example, Reuter, MacCoun, and Murphy [28] found that a street dealer in Washington in the late 1980s had a 22 percent probability of imprisonment in the course of a year; if imprisoned, the expected time served was 18 months. The risk of imprisonment for a PBC participant in the industry is likely to be an order of magnitude smaller.

Moreover, the United States also seizes a large fraction of the imported cocaine (between 25 and 35 percent) and perhaps as much as $1 billion per annum in assets generated by the drug trade, much of it from cocaine trafficking. These figures again are much larger than in the producer countries.

(b) The opportunity costs for labor in cocaine distribution are at least an order of magnitude higher in the United States. Reuter, MacCoun, and Murphy [28] found that the median legitimate hourly earnings of those involved in drug dealing were $7 per hour, about 20 times the figure for those working in the rural sector of PBC.

(c) Cocaine trafficking, after production, is essentially a brokerage business, with successive sellers handling smaller and smaller quantities. Whereas exporters and importers handle hundreds of kilograms in each transaction, the retailer handles only a few grams, a difference of four orders of magnitude. Yet the differences in expected prison time are only one order of magnitude. Thus, the retailers charge a great deal per gram for the risks they take, compared to participants at the upper levels of trade.[9] This is reflected in the absolute markup differences as cocaine moves along the distribution system. At the ounce level a pure gram sells for $45; the retail figure is $135, so that $90 (two-thirds of the price) is accounted for by the last two sales transactions.

The assumption of a fixed markup between the export price of cocaine in producing countries and the retail price to consumers plays a large role in determining the results. This assumption merits further discussion. The markup is the economic reward paid to smugglers, wholesalers, and retailers of cocaine for their work in the distribution system. It is presumed equal to the sum of: opportunity cost of their time; a premium to offset both their risk of legal sanctions and their vulnerability to theft and coercion from other illegal entities; monopoly profits that may accrue to established distribution organizations (and the costs they incur to deter potential entrants); the costs of the other goods and services (such as transportation equipment and storage) they purchase; and payments they make to evade law enforcement (which can take many forms). It is generally presumed that the opportunity costs of time are small relative to the total, although this is not essential to the argument.

Aside from monopoly profits, it is our judgment that all of these economic rewards will be primarily related to the quantity of cocaine sold rather than to its value. Thus, a reasonable first approximation is that the rewards are constant per quantity unit of business. A reasonable second approximation, in our view, is that the markup would increase as the quantity sold increases, both to attract more resources to the trade and to offset the increased visibility of higher volume. This second approximation would reinforce our basic conclusion of the ineffectualness of supply-side constraints in exporting countries, because the export price-increasing effects of these policies has a first-order effect of decreasing quantity demanded. The effect on monopoly rents is less clear, but standard non-competitive models strongly imply that a cost increase lowers per-unit profit. This should also decrease the resources required to deter entry.

A detailed quantitative model of the structure of the smuggling, wholesaling, and retailing industries is clearly needed to resolve these issues, but the qualitative arguments just given lead us to believe that our assumption of a fixed markup is conservative with respect to our results. We believe the most likely market response to an increase in the export price (thus a first-order dampening

[9]The higher-level participants make much larger incomes simply because they sell so much more of the product.

effect on consumption) would be a decrease in the markup, further weakening the impact of any export country policy. (The second-order impact of an exogenous decrease in demand would likely work the other way, decreasing the markup as well as the export price.)

The price elasticity of cocaine demand, c, is set at –0.5:[10] a 10 percent increase in the retail price reduces consumption by 5 percent. The coefficient C is set to 8,551, which produces demand of 736 metric tons at a retail price of $135,000 per kilogram. Seven hundred and thirty six tons is the estimate of 1989 exports of cocaine from PBC.

Equations (1) to (12) close the model and determine a unique price and quantity demanded of cocaine for each set of exogenous variables. Note that this analysis assumes that PBC are the only world exporters of cocaine; adding other producers would add little either analytically or for policy purposes, given the current dominance of PBC production and the finding of negligible effects from programs.

As a review of the model's structure, the solution algorithm will be described here. The algorithm begins with a guess of the quantity of cocaine exported. From equations (11) and (12) we can find the demand price. Equation (9) determines cocaine exports from each individual country, and equation (5) determines output of all stages of cocaine production. Equation (1) then determines employment in cocaine production, and equation (4) determines employment in the rest of the economy. Equation (6) determines the wage rate in the economy, and equations (7) and (8) determine the price of cocaine products in each country. Finally, equation (10) determines the supply price, that is, the price at which the amount of cocaine exports originally guessed in the algorithm will be forthcoming. If the supply price is above the demand price, the initial guess of quantity exported is adjusted downward, and vice versa. The algorithm continues until an export quantity is found at which supply price and demand price are equalized.

Before turning to our runs of the model under varying assumptions about exogenous variables and parameters, we describe the "stylized facts" about the cocaine trade implicit in the base case values of the variables. The low share of the export price in the consumer retail price has been noted already. Employment in the production of all cocaine products is 4 percent of total

[10]The literature contains no serious estimate of this parameter. We have chosen a value that is consistent with data on two other dependency-creating substances, alcohol and tobacco. For a review of estimates for these two substances, see [21].

employment in Peru; 13 percent in Bolivia; and 2 percent in Colombia.[11] (Note that this includes estimates of informal sector non-cocaine-related employment in Peru and Bolivia.) Income earned in cocaine product production is 2.5 percent of total income in Peru; 11 percent in Bolivia; and 4.8 percent in Colombia.[12]

A final word about the values of exogenous variables and parameters is in order. Data about the cocaine trade are problematic at best and arbitrary at worst; this is natural, given the desire of trade participants to disguise their activities. Sensitivity analysis of the model, too extensive to report in detail here, indicates that none of the conclusions to be drawn here are affected by reasonable changes in data values. The insights of this model appear to be robust with respect to considerable data uncertainty.

Models are simplifications; if they are to have content and to be transparent, they cannot address every possible change in policy or market conditions. One limitation of this model is that it deals only with long-term equilibria; it does not consider the path or timing of movement between equilibria.

---

[11]The numbers presented here represent full-time equivalent employees. The proportion would appear much higher if the total number of individuals involved in the cocaine industry either part- or full-time were to be compared to the labor pool.

[12]The concept of income earned from cocaine production here is based on the price of cocaine in the exporting country. This is particularly important for Colombia, which exports about 86 percent of all cocaine. If the markup on cocaine between Colombia and the port of entry to consuming countries is a factor of 5, and if Colombian nationals receive this markup, income earned from cocaine product production would be 21 percent of total income, most of it in smuggling revenues.

# 4. Results of Model Simulations

This section describes the results of using the model to calculate the impact on the cocaine trade of three kinds of changes in policy or other exogenous variables that affect the market. These changes are "crop substitution" policies; increased law enforcement and cocaine trade suppression in PBC; and changes in the cocaine market in consumer countries.

## Crop Substitution

As described in Section 2, one policy advocated to reduce cocaine exports to consuming countries is to provide those engaged in coca leaf growing with a more attractive economic alternative. The hypothesis is that leaf growers will then voluntarily quit coca leaf production, which results in a lower level of cocaine production. The policy is called "crop substitution" because the economic alternatives considered are generally agricultural, although its logic only depends on providing employment opportunities at a higher income than coca growing or cocaine-product processing provides. The policy would be implemented by investing in the growing countries, say by constructing new farms and providing farm equipment, supplies, and seed for new crops (the agricultural alternative), or by building new factories and ensuring raw material supplies (an industrial alternative).[1] This policy is represented in the model by

---

[1]One would also have to ensure markets for the output of these new enterprises; in particular, if the new enterprises were export-oriented, one would have to ensure that potential customer countries did not close their markets through protectionist measures. For this analysis it is assumed that the marketing potential of the output from the new investment is the same as that of the output from existing investments. This is represented in the model by assuming that the total factor productivity, A(i), associated with the new investment is the same as that associated with existing investments (capital stock). This implies that the new investment can simply be added to the original capital stock to derive a new capital stock, and the structure of the model is unchanged.

One could also do excursions in which the total factor productivity associated with the new investments is different. This would imply a change in the structure of the model. There would be two "other GDP" production functions like equation (2), one for the original capital stock and one for new investment. The equations would have different A(i) parameters. This generalization of the model would be straightforward.

In the same vein, one could consider a policy which, while not adding any new capital, improves the international marketability of "other GDP" (non-cocaine-related) output by lowering the trade barriers facing it. This could be represented in the model by an increase in A(i), or by disaggregating "other GDP" production into two sectors and increasing A(i) in only one of the sectors. (The structure of the model after implementing the second possibility would be like the one described in the paragraph above.) The results of improving the international marketability of "other GDP" (non-cocaine-related) output by lowering trade barriers would be the same as the results of increasing the capital stock.

an increase in the capital stock, K(i). Specifically, it was assumed that varying levels of investment (increases in the capital stock) were made in Peru and Bolivia (the primary growing countries), with the investment split between them in proportion to their existing capital stock. The model then simulated the effects of such a policy. Table 10 shows the results.

There is almost no effect on the world price of cocaine or on world cocaine consumption, despite a 60 billion dollar investment for improving employment opportunities in Peru and Bolivia. The reason is straightforward: Increasing the capital stock by 60 billion dollars represents a doubling. This increases the wage rate by a factor of 1.6, given the production functions we are using. The price of cocaine in PBC increases 12 percent, from $3,800 per kilogram to $4,300.[2] This represents a negligible increase in the world price of cocaine, and thus has effectively no impact on world consumption.

This result is remarkably strong and appears to be counterintuitive. Why would workers not be just as happy to migrate from drug production to legal enterprise if given the opportunity? The answer is that they would, but that the dynamics of the drug market frustrate the purpose of the capital-increasing policy. This is most readily seen by tracing the process by which Peru and Bolivia move from one economic equilibrium to another after the capital stock is increased.

**Table 10**

**Effect of Changing the Capital Stock in Peru and Bolivia**

| | Peru and Bolivia | | | | World Cocaine Market | | |
|---|---|---|---|---|---|---|---|
| Capital Stock ($ billions) | Wage[a] | Final Other GDP[b] | Other GDP Labor[c] | Cocaine Product Labor[c] | Output[d] | Export Price[e] | User Retail Price[e] |
| 60 (base case) | 0.84 | 28.4 | 11.6 | 0.74 | 736.37 | 3.82 | 135.00 |
| 70 | 0.94 | 31.6 | 11.6 | 0.74 | 736.14 | 3.90 | 135.08 |
| 80 | 1.03 | 34.7 | 11.6 | 0.74 | 735.93 | 3.98 | 135.16 |
| 90 | 1.11 | 37.6 | 11.6 | 0.74 | 735.73 | 4.05 | 135.24 |
| 100 | 1.19 | 40.5 | 11.6 | 0.74 | 735.53 | 4.13 | 135.31 |
| 110 | 1.27 | 43.2 | 11.6 | 0.74 | 735.34 | 4.20 | 135.38 |
| 120 | 1.35 | 45.8 | 11.6 | 0.74 | 735.16 | 4.26 | 135.45 |

[a]Thousand dollars per year. "Wage" is the average wage rate in Peru and Bolivia, weighted by employment share.
[b]Billion dollars per year.
[c]Millions of workers.
[d]Metric tons.
[e]Thousand dollars per kilogram.

[2]This increase is less than the wage increase because of the fixed (for this analysis) Colombian processing cost.

An increase in the capital stock means that there are now more factories and farms in Peru and Bolivia which can employ workers. As workers are hired away from the drug sector into these new enterprises, cocaine production will begin to fall. The fall in cocaine production will lead to an increase in the world price of cocaine (the stated intermediate goal of drug supply strategies), which will increase the profitability of cocaine production at the original wage rate. Given this increased profitability, those who manage cocaine product production and trade ("cocaine traffickers") will have a pure economic incentive to increase their wage offer for workers to come back to cocaine product production.[3]

This can most easily be seen through the concept of the "netback" from sales of cocaine on the world market to the PBC countries. Note that P, the export price of cocaine, can be written as a function of only the wage rates in the PBC countries and some exogenous coefficients. That is, combining equations (7), (8), and (10) leads to an expression of the form:[4]

$$P = P\left[w(1),\ w(2),\ w(3);\ e,\ r,\ s,\ b,\ c\right] \tag{13}$$

This will be written as P(w) for shorthand, to emphasize that the export price is determined when wages are determined, given the values of the parameters (which are held fixed in this analysis). Of course, one of the parameters held constant is the amount of other GDP used *as input per unit of cocaine* output. Intuitively, this simply means that the cost of producing cocaine depends on the cost of the labor that goes into its production at the various stages (plus the value of other GDP inputs). The netback (NB) can now be defined as:

$$NB = WP - F - P(w) \tag{14}$$

It is the world retail price of cocaine, less the world retail markup, less the price for procuring cocaine in PBC, which is itself determined by the labor cost of producing cocaine.

When NB is positive, as it would become if WP rose due to decreased production, there is an incentive to increase employment in cocaine product production to capture the netback as higher profit. Efforts to attract workers back—away from the new enterprises—will increase the wage rate, thus increasing P, and this effect will continue until the netback is again zero. (The netback is zero in equilibrium, as implied by equation (11).) At this point,

[3]The degree to which farmers are willing to move in and out of coca farming depends in part on their perceptions of risk as it relates to income. For a discussion of risk as it relates to Andean farming, see [24], [25], and [26].

[4]Here, "e, r, s, b, c" refers to the full arrays.

cocaine product employment and production have readjusted so that production equals demand at a (new, higher) world retail price that equals the (new, higher) PBC cost of producing drugs, plus the (old) retail markup. Since the labor cost of producing drugs, and indeed the export price, is such a small part of the world retail price, the percentage increase in the world retail price is small even if the increase in the wage rate is substantial, and so the decrease in production and consumption of cocaine is also small.

The crucial problem here is that any crop substitution strategy essentially puts the legal economy (embodied in the new farms or factories; i.e., the increased capital stock) in competition with the cocaine traffickers for the services of the labor force. The legal economy must make a more attractive offer to the workers than the cocaine trafficker does, and it generally has to do this by offering a higher wage rate.[5] The new capital stock, whose impact is analyzed in this modeling application, does indeed increase the wage rate in Peru and Bolivia by increasing worker productivity. This initially draws workers out of cocaine product production, which does lower cocaine exports. The problem is that the cocaine traffickers have the option of matching and exceeding the wage rate in the legal economy if they wish. Any decrease in cocaine exports, by increasing the world retail price, dramatically increases the profitability (netback) of replacing the workers who have left the cocaine product sector for the new legal enterprises, *even if the traffickers have to match or exceed the new higher wage rate.* In fact, matching any reasonable new higher wage rate is easy for the cocaine traffickers, because when they pass it on to the retail consumer, the resulting increase in the world retail price is so trivial that there is a negligible change in the level of consumption. As these results show, even if the new capital increases the wage rate in Peru and Bolivia by 60 percent, which would be an incredibly successful economic development program, there is no noticeable change in the level of cocaine exports. The retail price increases less than one percent; the world market shrinks less than one-half percent.[6] To repeat and emphasize, this is under the assumption that the entire increase in the wage cost of production is passed on to the consumer.

---

[5]It may well be that, because workers prefer not to work in contraband industries (due to either personal morality or fear of law enforcement), wages for those engaged in cocaine product production must in fact be higher than those in the legal economy. This higher level might be expressed either additively or multiplicatively. Such an adjustment to the model would not change the results presented here at all. At any rate, the evidence appears to be that workers in cocaine product sectors do not receive any substantial wage premium in PBC.

[6]It should be noted that this is a case where the rigidity in supply channels built into the model tends to cause the model to *overestimate* the effect of this policy on the world cocaine market. The model does not allow cocaine exporters to increase leaf production in Colombia (or anywhere else, for that matter) in response to the crop substitution program, and thus higher labor costs, in Peru and Bolivia.

Suppose that the economies of Peru, Bolivia, and Colombia could be transformed so that their wealth equaled, in per capita terms, that of the United States. (This would be a dramatically successful crop substitution program; more accurately, a very successful economic development program.) This would mean that, in the PBC economies, per-worker GDP would be $43,300 per year, and the average wage would be $28,900 per year (1989 U.S. figures). The PBC economies can be transformed in the model into ones like the U.S. economy with the following parameter changes:

$$K(1) = 1,070$$
$$K(2) = 270$$
$$K(3) = 1,290$$

$$A(1) = A(2) = A(3) = 9.1$$
$$a(1) = a(2) = a(3) = 0.67$$ [7]

Making just these parameter changes, the equilibrium of the model is:

$$E = 656$$
$$P = 39$$
$$WP = 170$$
$$w(1) = w(2) = w(3) = 29.0$$

Even this vast improvement in the economic situation in PBC, which has increased wages by a factor of almost 20, has only increased the world cocaine price about 25 percent, decreasing world cocaine use about 10 percent. Employment in cocaine product production in PBC has fallen from about one million to about 900,000. The increase in the capital stock in this case is $2,500 billion dollars, 50 percent of annual U.S. GDP. In addition, this case postulates that productivity in PBC has somehow increased by a factor of about 6.0 [represented by the changes in the parameters A(i)]. Once again, the relatively inelastic world demand for cocaine with respect to the export price in PBC has led to the market bidding up the export price of cocaine in PBC so that workers are induced to remain in cocaine product production even when economic opportunity in the non-cocaine economy is dramatically enhanced. This result should not be too surprising, however, given that there are large numbers of workers in the United States who voluntarily work in the drug industry despite the relative attractiveness of the open, legal economy in the United States.

---

[7] This is representative of values in developed countries such as the United States.

None of this is to say that a policy of increasing the capital stock of foreign countries to improve the economic conditions of their populations is a bad idea. This is the classical foreign aid paradigm, and it may provide high benefits to the United States in terms of stability of friendly countries and foreign relations in general. To the extent that such policies raise wages in poorer countries, they may have important positive results for the United States. They simply will not do much to discourage drug production.

An additional difficulty with the strategy of inducing workers in drug production to voluntarily switch to production of other commodities by increasing economic opportunity is precisely that *all* workers in the economy benefit from the increased capital. The wages of all workers are bid up as a result of the new economic opportunities, since all workers are eligible to work in the new enterprises. That is, the new enterprises set up with the increased capital will tend to attract not only those currently engaged in drug production, but also those currently engaged in non-drug production. What if opportunity for employment in the new enterprises could be restricted to only those engaged in drug production before the new capital appears? This seems to be an ethically and practically difficult policy to implement. It rewards those who chose to break the law in the past and would require an applicant to prove that he or she had been engaged in drug production before the new enterprise was built.

Simulations reported in Table 11 show the consequence of a policy that adds capital stock to Peru and Bolivia with the restriction that only those currently engaged in cocaine production can work in the new enterprises. The analysis simply assumes that this restriction can be enforced.[8] The wage rate, output, and employment results in Table 11 thus refer only to the workers currently engaged in cocaine product production.

In this case, an investment of five billion dollars increases the wage rate of the selected workers in Peru and Bolivia by about a factor of 2.7, and the export price of cocaine in PBC by about a factor of 1.4. This leads to a 0.5 percent decrease in world cocaine consumption. An investment of $35 billion increases the wage rate by a factor of 8.3, and an investment of $85 billion increases it by a factor of 15. The increase of the wage rate by a factor of 15 leads to a result about half way toward the case in which the economic situation of the entire PBC was improved to that of the United States: The world price of cocaine goes up about 10 percent; world cocaine use goes down about 5 percent.

[8]This case is equivalent in a modeling sense to one in which Peru's and Bolivia's labor force is 0.74 million, all of whom are engaged in cocaine product production when the new capital investment is made.

**Table 11**

**Effect of Changing the Capital Stock in Peru and Bolivia**
**(Restricted option, only workers originally in cocaine product industry affected)**

| | Peru and Bolivia | | | | World Cocaine Market | | |
|---|---|---|---|---|---|---|---|
| Increase in Capital Stock ($ billions) | Wage[a] | Final Other GDP[b] | Other GDP Labor[c] | Cocaine Product Labor[c] | Output[d] | Export Price[e] | User Retail Price[e] |
| 0 (base case) | 0.84 | 0.0 | 0.3 | 0.74 | 736.37 | 3.82 | 135.00 |
| 5 | 2.28 | 1.2 | 0.3 | 0.74 | 732.74 | 5.16 | 136.34 |
| 15 | 4.20 | 2.8 | 0.3 | 0.73 | 728.03 | 6.93 | 138.11 |
| 25 | 5.70 | 4.0 | 0.3 | 0.73 | 724.42 | 8.31 | 139.49 |
| 35 | 7.00 | 5.2 | 0.3 | 0.73 | 721.36 | 9.50 | 140.68 |
| 45 | 8.16 | 6.2 | 0.3 | 0.72 | 718.64 | 10.56 | 141.75 |
| 55 | 9.23 | 7.2 | 0.3 | 0.72 | 716.16 | 11.54 | 142.73 |
| 65 | 10.22 | 8.1 | 0.3 | 0.72 | 713.88 | 12.46 | 143.64 |
| 75 | 11.16 | 8.9 | 0.3 | 0.72 | 711.76 | 13.32 | 144.50 |
| 85 | 12.05 | 9.7 | 0.3 | 0.72 | 709.76 | 14.13 | 145.31 |

[a]Thousand dollars per year. "Wage" is the average wage rate in Peru and Bolivia, weighted by employment share.
[b]Billion dollars per year.
[c]Millions of workers.
[d]Metric tons.
[e]Thousand dollars per kilogram.

Dollar for dollar, investment in Peru and Bolivia is much more effective in inducing workers to voluntarily leave cocaine product production when employment in the new industry can be restricted to those previously in cocaine product production. For this policy to work, workers previously in non-cocaine product production must also be restricted from migrating to cocaine product production in response to the higher wages there. That is, the 0.74 million workers in cocaine product production in Peru and Bolivia in the base case must be isolated from the rest of the population, and none of the other 9 million workers in Peru and Bolivia can be allowed to work in either the new enterprises set up with the new capital, or in cocaine product production.

The difficulty in enforcing this policy can be seen in the tension that would result between the wage rates of the two groups. In the $85 billion investment case, the 0.74 million workers originally in cocaine product production are now earning about $12,000 per year, while the other 9 million workers are still earning (on average) only $840 per year. In summary, in order for the policy of increasing capital investment in Peru and Bolivia to have a noticeable effect on cocaine supply, the benefits of the investment must be concentrated on a very small part of the population, and it is difficult to see how this policy could be enforced. In particular, it is difficult to see how some of the 11.6 million workers who were originally not in cocaine product production could be kept from moving into that production, driving supply back up and the world cocaine price back down. Since the "netback" from cocaine production would be very high at a wage rate of $840, there would be very strong economic incentives to organize some of these 11.6 million workers into new cocaine product production.[9]

There is some good news associated with a policy of enhancing the capital stocks of Peru, Bolivia, and Colombia, but only as a measure to ameliorate the negative economic effects on these countries of a successful drug eradication policy. Let us first consider the effect on the economies of Peru, Bolivia, and Colombia of a complete elimination of cocaine production. This might result from a successful law enforcement program in PBC that discovered and destroyed all cocaine produced; a successful interdiction program on the part of consumer countries that stopped cocaine from getting to markets; or the elimination of demand for cocaine in consumer countries, due to change of drug choice by users, or successful elimination of drug use through education and treatment or law enforcement.

The first result would be the end of employment opportunities in cocaine product production, meaning that about one million workers, representing about 4 percent of employment in PBC, would have to turn to other economic activity. The results in the individual countries would vary dramatically. Cocaine product employment, as discussed earlier, is 4 percent of the total in Peru, 13 percent in Bolivia, and 2 percent in Colombia. The situation for Peru will be discussed first.

The model used in this study can simulate the economic effect of a complete loss of the cocaine market. In Peru, if all workers currently in illegal cocaine product production (400,000) found employment in legal production, and if the capital stock were unchanged at $48.8 billion, the model simulates a wage rate fall of about 2.5 percent, from $860 to $840 per year. Different functional forms for the production function (2) would lead to different numerical answers, but the general result that a moderate reduction in the wage rate would be sufficient to re-employ those workers currently involved in cocaine product production would hold as long as the proportion of employment currently in cocaine product production is a moderate fraction of total employment. An increase of

[9]Some simulations of the model were also done in which additional capital stock was given to Peru, Bolivia, *and* Colombia, again in proportion to their existing capital stock. For a given dollar amount of capital (investment) added, this policy had less effect on the cocaine market than one that simply focuses on Peru and Bolivia. This is because cocaine product employment is a lower percentage of the work force in Colombia than in the others, and also because Colombia has a relatively large existing capital stock compared to the others.

$1.8 billion in the capital stock would be necessary to maintain the wage at $860 in the face of an elimination of the cocaine trade.

In Bolivia, if all 340,000 workers currently in illegal cocaine product production found legal employment, and if the capital stock were unchanged at $9.3 billion, the wage rate would fall about 8 percent, from $780 to $725 per year. An increase of $1.2 billion in the capital stock would be necessary to maintain the wage at $780 in the face of an elimination of the cocaine trade. In Colombia, if all 225,000 workers currently in cocaine product production found legal employment, and if the capital stock were unchanged at $66.7 billion, the wage rate would fall about 1 percent, from $1,310 to $1,295 per year. An increase of $1.3 billion in the capital stock would be necessary to maintain the wage at $1,310 in the face of an elimination of the cocaine trade.

Thus, the model calculates that an increase of the capital stock (i.e., new investment) in PBC of less than $5 billion would compensate for the economic costs of the elimination of the cocaine trade, in the precise sense that the wage rate would be the same as it is today. Five billion dollars is a lot of money, but not enormous when compared to the annual U.S. anti-drug budget of about $10 billion. The simple analytics of this result are illuminating. If an x percent increase in employment is to be absorbed without a decrease in the wage rate, the capital stock must increase by x percent. Cocaine-related employment in PBC is about 4 percent of total employment; total capital stock in PBC is about $125 billion; $5 billion is about 4 percent of that.[10]

The results in this subsection can be summarized in two propositions. The answer to the question "How much foreign aid [investment in productive facilities] would be needed to maintain living standards in PBC if the cocaine trade were eliminated?" is "not much." Unfortunately, the answer to the question "How much foreign aid [investment in productive facilities] would be needed to induce those engaged in the cocaine trade to voluntarily work in the legal sector instead?" is "astronomical."

This analysis gives the general impression that cocaine-related production is not that important in the PBC countries. This impression is correct if two hypotheses embedded in our base case representation of the cocaine trade are correct: that employment in cocaine product production is a small part of total employment, and that wages (or economic returns in general) are about the same in cocaine product production as in other sectors. The (admittedly shaky) economic data

---

[10]These simplest results are only approximate because the three countries have different characteristics.

appear to support these hypotheses. Wages of ordinary production workers in the cocaine industry are not substantially above wages in the legal economy. This makes economic sense: Why should those who organize the cocaine trade pay any more than the going wage for labor, if government- and cocaine trade-imposed risks are modest?

This does ignore the vast fortunes that the few persons who organize the cocaine trade earn, since it only values cocaine production at $4,000 per kilogram, the export price. Given that the landed price of cocaine in the United States is about four times as high, there are very high incomes for shippers (smugglers) of drugs. If these persons are nationals of Colombia, the model is understating GDP in Colombia by 42 percent, all of it drug income.

Thus, excluding a small number of persons, income from cocaine product production is not a very high proportion of total income in PBC. That small number of persons excluded make large fortunes from the cocaine trade, which may have grave consequences for their ability and willingness to resist attempts to end the trade, but ending the trade would not have catastrophic consequences for ordinary workers. It would have moderate (and clearly unpleasant) negative consequences, on the order of 5 to 10 percent of total income. (Of course, income loss for cocaine product workers would be 100 percent until they found new employment, which could take many months, but almost certainly not many years.) Concomitantly, only a moderate increase in the capital stock of PBC would be needed to compensate workers for lost income from cocaine product production, on the order of five billion dollars, still a large influx of development capital. Compensating the large dealers and traffickers would be much more expensive, but presumably no one wants to do this anyway.

## Attacking Drug Production

Another approach to reducing cocaine supply is to find and seize the drugs before they can be marketed. As described in Section 2, this might involve destroying coca plants in the ground by uprooting them or spraying them with chemicals that kill them, or locating and seizing the finished product as it awaits transport out of PBC. Or it might involve seizing the product at the paste or base processing stage, or raiding the processing facilities frequently and effectively enough that production is deterred. There are two possible ways to represent the effect (and degree of success) of such a policy in the model, which lead to drastically different assessments of its impact. One way to represent the effect of a strategy that attacks cocaine product production is to assume that the policy can restrict production to a given absolute level, expressed in metric tons. The other is to assume that the strategy can find and destroy a certain percentage of what is produced, while the remainder is either successfully moved to the next processing stage or exported.

The analysis of a policy that works in the first way is very straightforward: Cocaine exports to the rest of the world will be equal to whatever level of production the drug attack strategy can enforce. Total cocaine consumption in the world will be reduced by the same amount that production is reduced, and the world retail price will rise accordingly (see Table 12).[11] Given the relatively inelastic demand for cocaine, the price increases are large. So, of course, are the rewards for potential increases in cocaine production in PBC. If the world export level is cut in half, the netback to any new production would be $400,000 per kilogram, over 200 times the estimated current cost of production.

Being able to restrict total production to a given quantity is a highly unlikely result. All of the necessary factors (labor, land, chemicals, and processing skills) are readily available; it is only their prices that might be increased through targeted programs. Hence, these quantity restriction results are presented essentially for theoretical purposes. It is much more likely that the result of a production attack strategy is not to limit the absolute amount of production, but instead to find and destroy a certain percentage of the drugs that are produced.

**Table 12**

**Effect on Cocaine Price of Restricting Cocaine Production**

| Total Cocaine Production[a] | World Retail Cocaine Price[b] |
|---|---|
| 735 (base case) | 135 |
| 700 | 149 |
| 600 | 203 |
| 500 | 292 |
| 400 | 456 |
| 300 | 810 |
| 200 | 1,823 |
| 100 | 7,293 |
| 50 | 29,172 |

[a]Metric tons.

[b]Thousand dollars per kilogram.

[11]The figures in Table 12 are easily derived from equation (12), taking E, total exports of cocaine, as exogenous. The effect of a drug supply attack policy that can constrain cocaine production in PBC to a given level is essentially to make that production an exogenous variable, at whatever level the policy is capable of enforcing.

This would be represented in the model by an increase in the r(i, j) coefficients that relate resources used for drug production (labor) to available output.[12] If the authorities can destroy a given percentage of the cocaine products produced, more labor must be employed to attain any given level of available output, i.e., output that can be further processed or exported. For example, if the authorities can destroy 50 percent of output produced, then employment of twice as many workers will result in the same amount of output available, since gross production will double while half of it is lost to law enforcement. By the same token, if the authorities can destroy 90 percent of output produced, the employment of ten times as many workers will result in the same amount of output available.

Table 13 shows results of model simulations assuming that a certain percentage of cocaine produced is seized and destroyed. That is, it is assumed that it is a given percentage of the final product (CHCl) which is seized and destroyed, after all intermediate processing has taken place. This is implemented by multiplying all r(i, j) coefficients by the inverse of one minus the percentage seized. The implications of other kinds of drug seizure policies, such as those that occur at different processing stages, could also be simulated with the model. Given

**Table 13**

**Effect of Cocaine Seizures**

| | Peru, Bolivia, and Colombia | | | | World Cocaine Market | | |
|---|---|---|---|---|---|---|---|
| Percentage of Cocaine Seized | Wage[a] | Final Other GDP[b] | Other GDP Labor[c] | Cocaine Product Labor[c] | Output[d] | Export Price[e] | User Retail Price[e] |
| 00 (base case) | 1.07 | 60.4 | 23.3 | 0.96 | 736.37 | 3.82 | 135.00 |
| 10 | 1.08 | 60.3 | 23.2 | 1.07 | 736.00 | 3.95 | 135.13 |
| 30 | 1.08 | 60.0 | 22.9 | 1.38 | 734.94 | 4.34 | 135.53 |
| 50 | 1.10 | 59.5 | 22.4 | 1.92 | 732.94 | 5.08 | 136.26 |
| 70 | 1.14 | 58.3 | 21.1 | 3.18 | 727.80 | 7.02 | 138.20 |
| 90 | 1.53 | 51.2 | 15.2 | 9.05 | 687.62 | 23.64 | 154.82 |
| 95 | 2.60 | 38.6 | 8.4 | 15.94 | 598.97 | 72.86 | 204.04 |
| 100 | 1.05 | 61.2 | 24.2 | 0.07 | 0.00 | — | ∞ |

[a]Thousand dollars per year. "Wage" is the average wage rate in Peru, Bolivia, and Colombia, weighted by employment share.

[b]Billion dollars per year.

[c]Millions of workers.

[d]Metric tons.

[e]Thousand dollars per kilogram.

[12]One might also include the c(i,j) in this formulation of the problem. However, since substantial parts of it represent profits to traffickers, it is excluded in this analysis.

percentage seizures at earlier stages will have less impact because fewer resources will have been expended on the product prior to seizure.

Table 13 shows that a policy that destroys a fixed *percentage* of production, rather than a fixed *level*, has relatively little impact until the percentage of cocaine destroyed reaches the 90 to 95 percent level. Even if 95 percent of all cocaine produced in PBC were destroyed, cocaine consumption worldwide would fall only about 20 percent, and world price would increase about 50 percent. However, the validity of the model at the 90 to 95 percent seizure range is doubtful since it shows massive shifts of the labor force into cocaine product production, over half the work force at the 95 percent level. There would obviously be social issues associated with such kinds of changes, and the applicability of this strictly market-oriented approach declines as massive changes in the legality of economic activity are simulated. The valid insight of the model is that moderately successful seizure rates, in the 30–70 percent range, have little effect on the world cocaine market because market forces simply induce more workers to enter cocaine product production to make up for the seizures. The cost increases implied at these seizure levels are small compared to the current market price.[13]

Interestingly, wages in PBC increase when drug seizure programs of this kind are effectively carried out. This is due to the inelastic nature of demand for cocaine, and is similar to the phenomenon that U.S. farm incomes increase when production is restricted, as it is by public policy.

## Changes in World Cocaine Demand

The model also allows examination of the effects of changes in the world demand for cocaine on the economies of PBC, a matter of considerable interest to PBC policymakers. The model can simulate these effects by parametrically shifting the world demand curve for cocaine. Specifically, the parameter C in equation (12) is multiplied by a a demand shift factor, and Table 14 shows the effect of this.

The impact on the economies of PBC is very slight, because this solution represents the long-run equilibrium of the economies, in which total employment is maintained at its original level. Workers simply migrate to or from the other

[13]One caveat is that this analysis does not take into account any additional increase in wages which might be needed to induce workers to enter drug production to compensate for a higher probability of arrest and punishment associated with a higher product seizure rate. Until the wage differential gets to around 100 (i.e., pay in cocaine production at 100 times pay in the legal sector), this phenomena has little impact, again because cost of production is such a low percentage of market price.

**Table 14**

**Effect of Shifting the Demand Curve: Long-Run Simulation**

| Demand Shift Factor | Peru, Bolivia, and Colombia: Wage[a] | Final Other GDP[b] | Other GDP Labor[c] | Cocaine Product Labor[c] | World Cocaine Market: Output[d] | Export Price[e] | User Retail Price[e] |
|---|---|---|---|---|---|---|---|
| 0.00 | 1.05 | 61.2 | 24.2 | .07 | 0.00 | — | — |
| 0.33 | 1.06 | 62.3 | 23.9 | 0.36 | 243.03 | 3.79 | 134.97 |
| 0.67 | 1.07 | 61.4 | 23.6 | 0.67 | 493.39 | 3.80 | 134.99 |
| 1.00 (base case) | 1.07 | 60.4 | 23.3 | 0.96 | 736.37 | 3.82 | 135.00 |
| 1.33 | 1.08 | 59.5 | 23.0 | 1.26 | 979.32 | 3.83 | 135.02 |
| 1.67 | 1.09 | 58.5 | 22.7 | 1.57 | 1,229.59 | 3.85 | 135.03 |
| 2.00 | 1.10 | 57.6 | 22.4 | 1.86 | 1,472.47 | 3.87 | 135.05 |

[a]Thousand dollars per year. "Wage" is the average wage rate in Peru, Bolivia, and Colombia, weighted by employment share.

[b]Billion dollars per year.

[c]Millions of workers.

[d]Metric tons.

[e]Thousand dollars per kilogram.

GDP (non-cocaine product) sector in response to world demand for cocaine, and the impact on wages is slight (plus or minus 2.5 percent in response to demand doubling or falling to zero).[14] The assumption that cocaine can be produced at constant cost in PBC means that prices do not rise very much when demand increases. The assumption that workers in cocaine product production can find alternate employment in the non-cocaine product sector (resulting in somewhat lower wages for all workers in PBC) means that cocaine prices do not fall very much when demand falls.

It is also of interest to do a short-run simulation, in which we assume that workers cannot migrate out of cocaine product production in response to a change in demand. Instead we assume that PBC cocaine product employment and thus cocaine production is constant. Table 15 shows the results of these simulations, which are dramatically different from those of the long-run simulations. Almost any backward shift in demand, coupled with constant cocaine production of 736 metric tons, reduces the world retail price to below the retail markup over the export price (the parameter F, set at $131), making the netback to PBC negative. This cannot occur, so a minimum price of $4.00 is assumed, and it is assumed that the cocaine that cannot be marketed at the world

[14]This is the average wage effect in the three countries combined. In Bolivia, which is the most dependent on the cocaine trade, the wage change is plus or minus 8 percent in response to demand doubling or falling to zero.

**Table 15**

**Effect of Shifting the Demand Curve: Short-Run Simulation**

| Demand Shift Factor | Wage Rate in Cocaine Product Production[a] | World Cocaine Price[b] |
|---|---|---|
| 0.00 | 0.00 | — |
| 0.33 | 0.35 | 135.00 |
| 0.67 | 0.72 | 135.00 |
| 1.00 (base case) | 1.07 | 135.00 |
| 1.33 | 28.80 | 238.80 |
| 1.67 | 65.70 | 376.50 |
| 1.83 | 80.30 | 452.10 |
| 2.00 | 109.40 | 540.00 |

[a]Thousand dollars per year.
[b]Thousand dollars per kilogram.

price of $135 is accumulated as unsold inventory. The wage in these decrease-in-demand cases is calculated as total revenue of cocaine exports divided by the fixed level of total cocaine product employment. In actuality there would presumably be some involuntary unemployment as well (and thus less inventory accumulation), so that some workers would actually receive more than this overall average wage, while some would receive nothing.

The netback to PBC, and the resulting rewards from cocaine production, jump dramatically with an increase in demand. This short-run equilibrium would presumably be short indeed, since the inducement to expand drug production is very high. The length of the short run is less clear in the demand decrease case. It depends on how soon workers come to believe that the downturn in the industry will be long lasting, how soon they migrate back to non-cocaine product production locations (if they have to), and how long they must search on average to find employment in the non-cocaine product sector.

This set of simulations was motivated by the following recent observations about the international drug industry. As a consequence of the assassination of a Colombian presidential candidate in August 1989 by drug interests, a crackdown on cocaine processing and shipping occurred in Colombia. This decreased the demand for coca leaf in Peru and Bolivia, severely depressing output and prices in those countries.

The final set of simulations presented in this report also represents changes in demand conditions outside the PBC area, but in this case changes in the retail markup, the variable F. This variable might be affected by the success of law enforcement in consuming countries in holding sellers at risk, thus affecting the reward that sellers are prepared to accept in return for working in cocaine marketing. Table 16 shows the results of parametrically varying the markup.

In these long-run simulations, the world price moves with the markup, and the export price of cocaine in PBC stays about constant. This is again because labor is assumed to be free to move between non-cocaine product production and cocaine product production, so that cocaine supply expands and contracts approximately as demand does. The assumption that there is constant average cost in cocaine product production is also important in determining the general nature of these results.

**Table 16**

**Effect of Changing the Retail Markup**

| | Peru, Bolivia, and Colombia | | | | World Cocaine Market | | |
|---|---|---|---|---|---|---|---|
| Retail Markup (F)[e] | Wage[a] | Final Other GDP[b] | Other GDP Labor[c] | Cocaine Product Labor[c] | Output[d] | Export Price[e] | User Retail Price[e] |
| 81 | 1.08 | 59.7 | 23.1 | 1.20 | 927.96 | 3.83 | 85.01 |
| 101 | 1.08 | 60.1 | 23.2 | 1.09 | 834.95 | 3.82 | 105.00 |
| 121 | 1.07 | 60.3 | 23.3 | 1.00 | 765.26 | 3.82 | 125.00 |
| 131 (base case) | 1.07 | 60.4 | 23.3 | 0.96 | 736.37 | 3.82 | 135.00 |
| 141 | 1.07 | 60.5 | 23.4 | 0.93 | 710.53 | 3.82 | 145.00 |
| 161 | 1.07 | 60.7 | 23.4 | 0.88 | 666.08 | 3.81 | 164.99 |
| 181 | 1.07 | 60.8 | 23.5 | 0.83 | 629.05 | 3.81 | 184.99 |

[a]Thousand dollars per year. "Wage" is the average wage rate in Peru, Bolivia, and Colombia, weighted by employment share.

[b]Billion dollars per year.

[c]Millions of workers.

[d]Metric tons.

[e]Thousand dollars per kilogram.

# 5. Conclusion

The following results have been derived from the model analyses presented here.

**"Crop substitution" programs will have a negligible impact on the world cocaine market.** As desirable for other reasons as improving economic conditions in Peru, Bolivia, and Colombia may be, an improved economy will not lower cocaine supply. This is because cocaine traffickers can easily match and exceed any increased economic opportunity, resulting from a crop substitution program, that is presented to workers currently in the cocaine industry.

**The cost of compensating workers currently in coca or cocaine production if the cocaine trade is destroyed is relatively low.** About a five billion dollar investment in the economies of Peru, Bolivia, and Colombia would provide employment opportunities for all those currently producing coca leaf, coca paste, cocaine base, or cocaine at a wage equal to their current wage. This is because their current wage is rather low; the cocaine traffickers, who earn huge fortunes, could not be compensated by such investments.

**Cocaine supply control strategies that seize and destroy 70 percent or less of production, without limiting the total level of production, will have little impact on the market.** If cocaine traffickers have the option of increasing gross production to make up for some percentage of their product being destroyed, and if the percentage is 70 percent or less, the increased cost of the higher gross production is low relative to the retail value of the cocaine that survives. Thus the natural market reaction to such a production attack program would be to step up gross production, and the resulting increase in the retail price or decrease in overall consumption will be small. There will simply be more cocaine produced to ensure a relatively constant amount supplied to market.

**Changes in the size of the world cocaine market have a relatively modest long-run impact on the standard of living of average workers in Peru, Bolivia, and Colombia.** In particular, if there is a decrease in the size of the market due to law enforcement or drug education and treatment in the consuming countries, there will be only a small decrease in the average wage of workers in cocaine-producing countries. This is because employment in growing coca and processing it into cocaine is not a large percentage of total employment in these countries. Cocaine traffickers would suffer very large income losses.

**The results of this study are insensitive to the data uncertainties concerning the cocaine market.** It is natural that data about the cocaine trade are hard to obtain due to its clandestine nature. However, the results presented here hold up over a wide range of possibilities about the true nature of the market. No plausible variations in the data have been found yet that fundamentally change these results.

The results are sensitive to assumptions about how prices in the production sector affect retail prices. If a 10 percent increase in the export price of cocaine were to raise retail prices by 10 percent, or by some significant fixed fraction of 10 percent, then the source country control programs might be more effective. This suggests the need for more refined analyses of the determinants of markups in the distribution of illegal drugs.

None of these results say that enforcement and crop substitution programs are without value. The results refer to the long-run adaptations that the industry can make to various interventions. Enforcement programs may have substantial and valuable short-term effects. However, the results do provide a cautionary note about what can be expected in the long run even if the programs are implemented.

This modeling approach has been useful in illustrating some of the key aspects of the cocaine market from the economic point of view. Despite the simplicity of the approach, insights have been derived that have policy relevance, and which are not now common wisdom. This encouraging beginning suggests that further work along these lines may be worthwhile.

# Appendix
# Statistical Portrait of the Cocaine Trade Using Input-Output Tables

## Introduction

Three nations, Bolivia, Colombia, and Peru, dominate the production of cocaine. Combined, these countries satisfy over 95 percent of the world's demand for cocaine. The division of labor and economic activity, however, is not evenly divided among the three countries. Colombia is by far the leading exporter of the final product, cocaine hydrochloride, referred to hereafter as cocaine. However, Colombia relies on Bolivia and Peru to provide it with the intermediate goods that it needs to produce and export cocaine. In addition, Peru and Bolivia export some cocaine directly to world markets.

The input-output (I-O) tables developed in this Appendix (Figures A.1 and A.2) track the cocaine production process from beginning to end. They describe the cocaine trade from two different perspectives. Figure A.1 follows the physical *flow of goods and services* used in the production of cocaine. As such, it is useful for identifying points in the production chain that are vulnerable to interruption, as well as providing a clearer picture of the path that cocaine takes before reaching retail markets in the United States and other countries. It includes such details as the amount of labor, chemicals, and equipment devoted to cocaine production. Figure A.2 provides a financial picture of the cocaine industry by presenting the physical flow of goods in value terms. It shows the revenues of the cocaine industry, the distribution of revenues among the participants in the production process, and the relative shares of cocaine GDP components.

This Appendix has three main sections. The cocaine production process is described in the first section, which includes a general description of the goods and services required at each stage of processing. The second section presents the data sources used to compile the I-O tables. The third section includes the I-O tables themselves and provides some key analytic results derived from the I-O tables.

# The Cocaine Production Process

## *Coca Leaf*

The production of cocaine is a simple process, both in terms of the inputs required and in comparison to the production of other psychoactive substances such as heroin [29]. Cocaine production begins in the intermontaine valleys and upper jungle regions of Peru, Bolivia, and Colombia (PBC). The conditions there are nearly perfect for farming the coca plant. Coca plants grow well in steeply sloped, poor quality soil. In addition, the coca plant tolerates a wide range in altitude, from sea level to 2,000 meters. Coca tolerates substantial rainfall, growing well in regions receiving 1,000–4,200 mm of annual precipitation [30]. The plants live as long as 30 years and can provide initial harvests in six months, mature harvests in as few as 18 months.

The coca plant has been a part of Andean culture for centuries. In addition to having mystical qualities ascribed to it, coca has been used to relieve fatigue, hunger, and altitude sickness [31]. In raw coca leaf the cocaine concentration is approximately .75 percent [20], though some varieties have substantially different concentrations. Some legal coca farming takes place in Peru and Bolivia to meet local non-cocaine demand, as well as to satisfy the small international market that exists for coca leaf.[1] *Coca farming is not legal in Colombia.*

Coca farming takes place in a few specific regions within PBC, though the amount of land devoted to coca farming could very easily be expanded by a factor of 50 or more. Coca farming is the most labor-intensive component of the cocaine production chain. In addition to clearing and preparing the fields for planting coca seedlings, coca farming may require periodic applications of insecticides and herbicides, as well as frequent weeding and pruning. Coca plants are often purchased as seedlings and transported to areas where full-scale production will take place. Once the coca plant has reached maturity for harvest, large amounts of labor are required to pick the leaves and transport them to local processing centers. The skills required for coca farming do not differ substantially from the skills required for licit agriculture, making coca a logical income crop for the agricultural laborers in the remote and rural sections of PBC. Throughout the farming phase, security is required to protect the farm locations against raids by local authorities, and bribes are often required to facilitate the uninterrupted cultivation and transportation of coca leaf.[2] The capital goods

---

[1]Coca leaf, for example, is used as a flavor additive in some cola products, after the cocaine alkaloids have been removed.

[2]In Peru, one of the more important groups to be paid off in the production process is the Shining Path. The Shining Path is a Marxist guerilla revolutionary group that uses the "taxes" it

needed at this stage of production primarily consist of farming implements and other cultivation tools.

### *Coca Paste*

The heart of cocaine processing is the release and concentration of the cocaine alkaloids from the coca plant. The alkaloids are more easily obtained in some varieties than in others. Peruvian and Bolivian leaf are preferred to Colombian leaf because the alkaloids are more readily extracted.[3] The initial release of alkaloids ma  the second stage of cocaine production. This stage is commonly referred to as paste production because the coca leaves are soaked in chemical solutions and mashed into a gray-white paste. Chemicals used to extract the alkaloids include sulfuric acid, kerosene, lime, and bicarbonate of soda. In addition, the paste-making process requires water and maceration pits made of cement or plastic. Water is essentially a free resource, and the remainder of these items, from the chemicals to cement, are readily available throughout the coca growing regions. Again, the labor skills required are not complex. Typically, the paste stage requires an individual with knowledge about the proper mix of processing chemicals, and adequate manual labor for mixing, mashing, packaging, and transporting the paste. Security becomes a more important element in the paste stage of production because paste output, unlike coca farming, is clearly intended to supply an illegal market.

### *Coca Base*

In the paste form, the cocaine alkaloids have been released from the coca leaves and are ready for further refinement. The next stage of production is the base stage, when processing impurities are removed from the coca paste and the cocaine alkaloids are further concentrated. Base production requires chemicals such as sulfuric acid, potassium permanganate, and ammonia. Variations of the process substitute acetic acid for sulfuric acid and ammonium hydroxide for ammonia. In addition, a third conversion recipe exists which relies solely on acetone to process the paste into base.[4] These conversion processes again require

---

levies on coca farming and cocaine trafficking to finance its military operations against the government of Peru. Despite the recent arrest of its leader, Abimael Guzman, the Shining Path remains a serious threat to Peru's current government. Thousands of deaths have been attributed to Shining Path operations, such as rural raids and urban bombings. See [38].

[3][20], p. 18.

[4]The recipes for processing coca leaf into cocaine vary slightly, depending on the region where the processing occurs and the type of leaf being processed. The general formulas described here are found in [32].

materials such as water and mixing containers, as well as simple drying and filtering equipment. This stage of production requires at least one worker with knowledge of chemical processing, as with the paste stage.

In the base stage of the production process, the transportation, security, and infrastructure requirements become more complex. Generally, base labs are remote from population centers and coca growing regions. The majority of coca base is shipped to Colombia for processing into cocaine. Hence, at the base stage more complex shipping arrangements, such as airstrips and overland trafficking routes, must be arranged. Transshipment to Colombia requires cross-border smuggling, a process which often entails bribing local police, and airport and customs officials. Also at this stage, the large networks of informants maintained to keep track of anti-narcotics law enforcement plans become more important as the trafficking becomes international in scope.

### *Cocaine Hydrochloride*

The final step in the production process is processing the base into cocaine hydrochloride, or cocaine, the purest and most marketable form of the product.[5] This process involves the use of equipment and chemicals similar to those used in the other stages of production. Sophisticated processing labs are often set up in remote regions of the countries. These well-guarded sites, while often sized to process large quantities of cocaine, are also designed to be both mobile and redundant. The mobility allows the processing to be moved rapidly to other locations in case of law enforcement interference. The redundancy of processing equipment ensures that even if one, or several, labs are shut down, processing capacity will not be crippled by losses.

After final processing into cocaine, the product is ready for shipment to the United States and other markets. At this stage transportation and security are major considerations. Transportation requirements include long-range aircraft, landing strips, intermediate transshipment points,[6] boats, radar, and fuel. Intelligence information, bribery, and security also take on new importance as the smugglers must now attempt to penetrate the anti-narcotics measures

---

[5]The intermediate products themselves can be consumed. Errors in processing that result in poor-quality base, and hence poor-quality cocaine, are increasingly consumed by residents of the producing nations. The various non-cocaine hydrochloride forms are often referred to as "bazooka" or "basuco." These forms of cocaine retain many of the pharmacologic properties associated with cocaine. Reference [18], p. 113, notes the history of such consumption. Reference [33] discusses the extent of cocaine product consumption in PBC.

[6]The Bahamas, Mexico, and Cuba are frequently mentioned as intermediate shipment points.

implemented by the United States. These transportation and security measures typically operate in reverse as well, since the traffickers smuggle cash and consumer goods back to South America. Finally, since most of these transactions take place in non-PBC currencies, elaborate money-laundering schemes are required to cleanse the money of its connections to the drug world.

## Data Sources

The previous section described the stages of cocaine production and the inputs used in these stages. This section explains how the data on the inputs and outputs were collected for this study. The data fall into three parts: the size of the trade, moving from one production stage in the industry to the next, and the prices and costs encountered along the way. The next three subsections address each of these areas.

### *Magnitude of Cocaine Production*

No definitive quantitative description of cocaine production exists. The traffickers naturally have an interest in keeping authorities from knowing the scope and organization of their operations. Nevertheless, accounts of cocaine production, divergent though they might be, do exist. One of the most comprehensive efforts at characterizing cocaine production is the *International Narcotics Control Strategy Report* (INCSR), which is published annually by the United States Department of State, Bureau of International Narcotics Matters. The report is used annually to certify that drug producing and drug transit nations are cooperating with the United States in its drug abatement efforts. More importantly, for the purpose of these tables, the document includes production estimates and conversion ratios, with updates on seizures, losses, and industry innovations. It is therefore the only regularly published document to combine estimates of the magnitude of production with analysis of production techniques, and as such, it was used as the primary source for information on the size and scope of cocaine production.

INCSR has major shortcomings. First, it is a document used in support of political decisions regarding narcotics assistance funds. While this does not automatically affect INCSR's results, it does mean that the reporters, whether U.S. or foreign officials, may have some incentive to bias the reporting process. Second, INCSR consistently reports some of the lowest estimates of coca farming and cocaine production.[7] Other observers and estimates depict much higher and more widespread levels of coca farming, implying higher levels of cocaine production. One reason behind this discrepancy may be that, because U.S. attentions and efforts are focused in Peru's Upper Huallaga Valley (UHV) and Bolivia's Chapare, the growth of production and farming outside these places is not well monitored.[8] INCSR is vague on the sources and methods used in compiling production information. While the estimates presumably come from intelligence sources, field interviews, and so forth, INCSR provides no details, making it difficult to assess the accuracy and robustness of the data; a critique of INCSR's Mexican estimates is contained in [9; Appendix]. INCSR was used as a conservative estimate of coca production for 1989.

The second important contribution that INCSR makes to the analysis is the publication of conversion ratios for the various stages of production. Publication of these ratios allows for easy calculation of cocaine production from acreage estimates. The conversion estimates, however, are subject to the same data concerns raised in the previous paragraph.

INCSR reports improvements in the efficiency of the various cocaine processing sectors from the early 1980s. The reported increases in processing efficiency may be due to both the accumulation of better information and real increases in efficiency.

### *Conversions*

The conversion process is at the heart of the cocaine industry. Table A.1 summarizes the rates at which the cocaine product advances from one stage to the next; each rate is subject to some uncertainty and variation. For example, different regions of the countries have soil properties and growing conditions which yield different amounts of coca per hectare, and different types of coca leaf yield different amounts of coca paste. We next describe the sources and assumptions that were used in constructing the conversion process ratio estimates.

---

[7]Reference [34] reports likely cultivation of 200,000 hectares in Peru, which implies production of 228,000 metric tons (mt) of coca leaf in Peru. This is nearly 50 percent more than the 155,000 mt reported by INCSR. Peruvian politicians have reported cultivation of up to 360,000 hectares, though these claims are thought to be exaggerated as a method of bargaining for more assistance. Laity [35] estimates total Peruvian cultivation in 1990 at 204,000 hectares. His analysis for the Upper Huallaga Valley in Peru is based on assessments of land use potential, labor force availability, and kerosene consumption.

[8]Indeed, some reports of cocaine production activity assert that farming is spreading to unmonitored regions in response to the concentration in the Upper Huallaga Valley: see, for example [6], and [7], pp. 6–10 and pp. 35–36.

Table A.1

Conversion Ratios in the Cocaine Production Chain

| INPUT: | One hectare of land | One metric ton of leaf | One metric ton of paste | One metric ton of base |
|---|---|---|---|---|
| OUTPUT:[a] | Leaf (mt): | Paste (kg) | Base (kg) | Cocaine (mt) |
| Bolivia | 1.5 | 10.8 | 357.1 | 1.0 |
| Colombia | 0.8 | — | 1.6[b] | 0.9 |
| Peru | 1.2 | 8.7 | 344.8 | 1.0 |

SOURCE: INCSR, 1989.

[a]Outputs weighted to reflect different processing ratios within country for regions and types of coca plants. Numbers rounded to nearest tenth.

[b]Colombian leaf is processed directly from leaf to base; amount entered in output base column reflects hectare:base ratio.

**Acreage to Leaf Conversion.** INCSR reports both hectares under cultivation and metric tons of coca produced. For purposes of constructing the input-output tables, the cultivation figures were used as the primary reference point. Hence, total production of coca leaf (in metric tons) is the product of the acreage under production and the average yield per hectare.[9] Although all three countries reported that small amounts of land were removed from production in 1989 as a result of eradication programs, these amounts were not netted out of the production figures because they were included in the INCSR report. In all three cases the amounts are too small to affect the results significantly, and there is substantial disagreement over whether the eradication is in any sense permanent.

Table A.1 clearly shows that a hectare of land in Bolivia produces a greater mass of leaf than a hectare of land in Peru. However, even within Bolivia itself, the land in the Chapare region is more productive than the land of the Yungas region.[10] Accordingly, the conversion rate presented in Table A.1 is the weighted average of the productivity of the two primary growing regions in Bolivia. In Peru and Colombia, land productivity is reported as uniform across growing regions.

**Leaf to Paste Conversion.** The differences in conversion ratios at this stage in the processing reflect the differences in the concentration and extractability of the

[9]Because of the way INCSR reports production figures, the Bolivian and Peruvian coca totals are calculated slightly differently. The general formula is: total leaf production = illegal leaf production + legal leaf production. For Peru, this is not a problem since legal and illegal leaf production are counted in separate categories. Except for Bolivia, INCSR does not list a licit consumption category, but rather lists domestic consumption of 10,000 mt of *illicit* coca. These 10,000 mt should be counted as legally consumed, and hence the formula for Bolivia is: total leaf production = (illegal leaf production − consumption of illegal leaf production) + consumption of illegal leaf production.

[10]1.6 mt of leaf/hectare/year in the Chapare, compared to 1.2 mt of leaf/hectare/year in the Yungas ([8], p. 113).

cocaine alkaloids in the coca leaves. One metric ton of Bolivian leaf,[11] which has a higher average alkaloid content than Peruvian leaf, yields approximately 10.8 kg of paste. In contrast, one metric ton of Peruvian leaf yields only 8.7 kg of paste. Because of the difficulty in extracting cocaine from Colombian leaf, coca grown in Colombia does not go through the paste stage; Colombian leaves are processed directly into base.

**Paste to Base, Base to Cocaine.** Once the alkaloids have been removed from the leaves, the conversion rates become nearly uniform across the three countries for the remaining two conversion steps. That is, Bolivian and Peruvian paste converts to base at nearly identical rates, and Bolivian, Colombian, and Peruvian base converts to cocaine in virtually the same proportions.

**General Comments on Conversions.** The yield at a given stage in the conversion process will be higher or lower, depending on the source of the intermediate product. For example, it takes less Bolivian leaf than Peruvian to make a ton of paste and this will hold regardless of where the leaf is processed. That is, the conversion ratios are embedded in the products themselves, and not in the technologies of the processing nations. The input-output tables preserve this fact. Hence, for example, Colombian processors will convert leaf at different rates, depending on whether it comes from Peru, Bolivia, or Colombia. Inputs are consumed at rates depending on the source of the intermediate goods, not the location of processing. For another example, if it takes more acid or water to release the cocaine alkaloids from Bolivian leaf than from Peruvian leaf, it will require more of these inputs no matter where the conversion of Bolivian leaf is carried out.

## *Prices and Costs*

**Prices.** Information on prices and revenues is just as scarce and contradictory as the information on outputs. Indeed, while overall price levels for each step in the production chain seem to have fallen substantially from the early 1980s, there is still tremendous variation for prices within the countries for each of the intermediate products for a given year. There are no obvious and consistent explanations for the volatility in leaf prices, for example. The Drug Enforcement Administration (DEA) tracks the movement in cocaine product prices, and has

[11] This is a composite metric ton of Bolivian leaf. According to INCSR, Bolivian leaf converts to paste at rates ranging from 75 kg leaf: 1 kg paste to 110 kg leaf: 1 kg paste. This might be due to the cultivation of different types and varieties of leaf in Bolivia. In the absence of information on the distribution of these conversion ratios, the linear average (92.5) was used. Peruvian and Colombian leaves, in contrast, are reported to convert at more uniform rates.

reported that leaf prices have fallen below the financial break-even point on a number of occasions.[12] What can be said with certainty, therefore, is that there is no one price for any given stage of the cocaine production process, but rather a range of prices. Averages of the INCSR ranges reported were used in constructing the I-O tables. As a result of using the average prices, some stages in the production chain appear to be money-losing activities. It is important to realize that unprofitability of production is likely to be a temporary phenomenon, and is perhaps specific to certain regions where price volatility is a more prominent and chronic problem.

The negative profits that result from using average prices have a direct bearing on the model. The model simulation logic requires non-negative value added in each sector, a result which cannot be obtained if the INCSR average prices are used. Therefore, the base simulation values of the model have prices above the observed prices for the base year to reflect a more normal price-cost relationship and to yield positive value added in each sector. By comparing Tables 3 and 9 in the text and Figure A.2 in this Appendix, the reader can see how much the assumed base values and prices differ from the observed 1989 values. Generally, the greatest differences in value added are found at the leaf stage, particularly in Bolivia, which grew a lot of leaf at a (temporarily) low prevailing price in 1989. The differences between observed and assumed value-added estimates narrow at each successive stage of refinement (paste, base, cocaine) because leaf constitutes a very small portion of intermediate input value, and because value added is heavily concentrated in the latter stages of production.

**Costs.** In addition to requiring prices for the outputs of cocaine production, the analysis also requires cost estimates for the inputs into the production process. Several authors have documented the costs involved in cocaine production. The primary resource on cost data has been Edmundo Morales [18]. The Morales work is based on extensive field interviews with Peruvian farmers and visits to coca-producing regions. In the course of completing his work, Morales became familiar with the production techniques and problems associated with the cocaine industry. He was able to document the process and accumulate cost information on every step in the process, and as such his work stands out as one of the very few available that describes the cocaine industry from the producer's point of view.

---

[12] DEA estimates that Bolivian farmers need to earn $30 per carga (100 pound bale) to break even. This is equivalent to $660 per metric ton. This figure is substantially below the estimates derived from this analysis.

Despite the detail and scope of the Morales work, it is not complete and consistent in its documentation. Morales cites many of the production costs, expressed in the local currency, without dates. This is problematic when the substantial inflation occurring in Peru in the 1980s is taken into account; it is difficult to express Morales' costs confidently and unambiguously in U.S. dollars. To address this problem, additional sources on production costs in the Andes were used. The first, *National Strategy for Alternative Development* (Presidency of the Republic of Bolivia, undated), analyzes economic conditions in Bolivia and includes an evaluation of the structure and impact of the cocaine trade. The second Bolivian source was the Cochabamba Ministry of Agriculture and Peasant Affairs, which published "DIRECO Coca Reduction Program—1988."[13] Together, the Morales, *National Strategy*, and DIRECO articles provided the cost and price information on the cocaine trade in Bolivia and Peru.

No independent information was available on the costs of processing in Colombia. Colombian processing consists of two parts: that of products imported from foreign sources, and that from domestically provided products. The costs for processing goods imported to Colombia were assumed to be the same as if the processing had occurred in Bolivia or Peru. In the absence of better information, there was no reason to assume that Colombia was a higher- or lower-cost processor of cocaine products. For goods of purely Colombian origin, the costs of processing were assumed to be a weighted average of the costs for the same stage of production in Bolivia and Peru. The weights were derived from the conversion factors reported in INCSR. As an example, a hectare of land in Colombia is reported to yield approximately 800 kg of leaf, but over 1 mt of leaf in both Peru and Bolivia. Thus, the chemical, labor, and other costs were assumed to be a linear function of the yield ratios. In any event, Colombia produces very little coca leaf of its own, and so errors in the cost assumptions are not likely to significantly distort the analysis.

The Morales, Government of Bolivia, and Cochabamba Ministry documents report the use of chemicals, transportation, labor, and equipment in the manufacturing of cocaine. None of these sources, however, addresses security. Security is defined to include protection of physical assets, bribery used to facilitate production, "taxes" paid to ensure cooperation of guerilla insurgents, and intelligence networks established to monitor law enforcement activity. These constitute a sizable cost in the production of cocaine. Risk is inherent in this type of activity, and in fact risk premia seem to account for the bulk of the markups in the later wholesale and retail stages of cocaine trafficking [36].

[13]Translated in [39].

Despite its importance in the production process, very little information on the subject of security costs exists. The only published estimate of security costs we are aware of appears in Lee [37], who estimates that security accounts for 10–20 percent of costs at each stage of production. This figure seems reasonable, and so a security factor of 15 percent of the intermediate good price was used in each stage of the process.

### *An Aside on the Accuracy of the Data*

How important is all of the uncertainty associated with the cost and revenue figures included in this document? While the uncertainty clearly indicates the desirability of better information, the paucity of cost data does not render the analysis irrelevant. The cost of raw coca leaf represents less than 13 percent of the wholesale export price and less than 1 percent of the street retail price. Table A.2 summarizes the absolute and relative prices of products in the cocaine chain. Moreover, the wholesale export price of cocaine represents less than 5 percent of the street retail price of cocaine. Hence, even a three-fold increase in the wholesale export price would have very little effect on the street retail price and consumption of cocaine. The cost components of cocaine production are more important in terms of their domestic effects on the cocaine-producing nations. Yet here again, the importance of data uncertainty is mitigated because even a doubling of cocaine production has a small impact on national accounts, as discussed in the main body of this study.

**Table A.2**

**Prices for Intermediate and Final Goods in the Cocaine Industry (prices in thousands of U.S. dollars)**

| Product[a] | Raw Price[b] | Kilogram Equivalent Price[c] |
|---|---|---|
| Coca leaf | 0.002 | 0.5 |
| Coca paste | 0.4 | 1.0 |
| Cocaine base | 1.7 | 1.5 |
| Cocaine wholesale in PBC | 3.9 | 3.9 |
| Import price in U.S. | 15.0 | 15.0 |
| Street retail price | 135.0 | 135.0 |

SOURCE: INCSR, 1989.

[a]Composite PBC prices used.

[b]Per kilogram.

[c]Kilogram Equivalent Prices reflect the value of a given intermediate good required to make one metric ton of cocaine.

# Input-Output Tables for Cocaine Production

## *Introduction to Input-Output Tables*

The I-O tables (Figures A.1 and A.2) show the economic activity relating to cocaine production in Bolivia, Colombia, and Peru. Four headings appear across the top of the I-O tables for each country: leaf, paste, base, cocaine. These are the outputs of the production process. In addition, three aggregate columns appear in the I-O tables: licit, illicit, and total. Licit use is the total amount of each product legally consumed in PBC or legally exported to other countries. Of the four cocaine products, only leaf has legal final consumption; there are no legal uses for paste, base, and cocaine.[14] Final illicit use is the amount of each good that was illegally consumed, processed, or exported in 1989. The total use column is the sum of legal and illegal use. It equals total production of each good.

The items listed down the first column in the I-O tables are the inputs used in the production of cocaine. Figure A.1, the Aggregate Physical Flow table, tracks the inputs used in cocaine manufacturing. The intersection of the Peruvian Leaf column with the Peruvian Leaf row shows that 580 metric tons (mt) of Peruvian leaf went into making 155,186 mt of leaf. This represents the amount of Peruvian leaf that was seized in Peru for 1989, and can be thought of as leaf used in the making of leaf. The intersection of the Peruvian Paste column with the Peruvian Leaf row is 135,326. This is the amount of leaf used to produce paste in Peru in 1989. The balance of the 155,186 mt of leaf was either shipped to Colombia for processing into paste (1,367 mt) or went into legal consumption in Peru (17,913 mt). There is no entry for the Peruvian Leaf column and the Bolivian Leaf row. This is because no Bolivian leaf was used as an input in the production of Peruvian leaf.

Farther down the first column the remaining elements in the production process appear. Intermediate goods are the products from the previous stage of production used in the current stage of production, expressed in value terms. Security, as previously discussed, is assumed to be a fixed percentage of the revenue generated by sale of the current stage of production. The Chemicals entry accounts for chemicals known to be used in the processing at a given stage. Water, though heavily used in all stages of production, is treated as a free resource. The transportation entry is an estimate of the cost associated with physically transporting the product from one area to another. In Peru and Bolivia, the vast majority of paste processed is also processed into base in

[14]There may be very minor legitimate demand for cocaine, for example, in the medical field. Such cocaine, however, would be refined from legal leaf sales, not purchased from cocaine traffickers.

| | PERU Leaf | PERU Paste | PERU Base | PERU Cocaine | BOLIVIA Leaf | BOLIVIA Paste | BOLIVIA Base | BOLIVIA Cocaine | COLOMBIA Leaf | COLOMBIA Paste | COLOMBIA Base | COLOMBIA Cocaine | Licit Use | Illicit Use | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PERU | | | | | | | | | | | | | | | |
| Leaf | 580 | 135,326 | | | | | | | | 1,367 | | | 17,913 | 137,273 | 155,186 |
| Paste | | | 941 | | | | | | | | 235 | | 0 | 1,177 | 1,177 |
| Base | | | | 16 | | | | | | | | 308 | 0 | 325 | 325 |
| Cocaine | | | | <1 | | | | | | | | | 0 | 16 | 16 |
| | | | | | | | | | | | | | | | |
| BOLIVIA | | | | | | | | | | | | | | | |
| Leaf | | | | | | 67,471 | | | | 682 | | | 10,000 | 68,152 | 78,152 |
| Paste | | | | | | 9 | 648 | | | | 72 | | 0 | 720 | 729 |
| Base | | | | | | | | 81 | | | | 151 | 0 | 232 | 232 |
| Cocaine | | | | | | | | | | | | | 0 | 81 | 81 |
| | | | | | | | | | | | | | | | |
| COLOMBIA | | | | | | | | | | | | | | | |
| Leaf | | | | | | | | | 203 | | 33,284 | | 0 | 33,284 | 32,487 |
| Paste | | | | | | | | | | | 19 | | 0 | 19 | 19 |
| Base | | | | | | | | | | | | 180 | 0 | 180 | 180 |
| Cocaine | | | | | | | | | | | | | 0 | 639 | 639 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Intermediate goods ($'000,000) | 1 | 271 | 329 | 27 | 0 | 85 | 227 | 136 | <1 | 4 | 138 | 989 | | | |
| Security ($'000,000) | 47 | 62 | 78 | 11 | 14 | 38 | 58 | 40 | 4 | 1 | 105 | 371 | | | |
| Chemicals ($ '000,000) | 7 | 24 | 57 | 9 | 1 | 11 | 30 | 31 | 2 | <1 | 36 | 325 | | | |
| Transportation ($'000,000) | 7 | 0 | 16 | 2 | 3 | 0 | 12 | 8 | 3 | <1 | 5 | 64 | | | |
| Labor (days '000) | | | | | | | | | | | | | | | |
| start-up | 60 | 15 | 4 | 1 | 49 | 10 | 3 | 7 | 15 | <1 | 2 | 45 | | | |
| annual | 301 | 76 | 20 | 5 | 245 | 50 | 15 | 35 | 76 | 1 | 12 | 224 | | | |
| Equipment ($'000,000) | | | | | | | | | | | | | | | |
| start-up | 28 | 3 | 11 | 1 | 30 | 1 | 5 | 2 | 14 | <1 | 6 | 20 | | | |
| annual | 28 | 3 | 11 | 1 | 30 | 1 | 5 | 2 | 14 | <1 | 6 | 20 | | | |
| Gross Output (mt) | 155,186 | 1,177 | 325 | 16 | 78,152 | 720 | 232 | 81 | 32,487 | 19 | 180 | 639 | | | |

**Figure A.1—Aggregate Physical Flow of Goods Related to Peruvian, Bolivian, and Colombian Cocaine Production (1989)**

| | PERU | | | | | BOLIVIA | | | | | COLOMBIA | | | | | TOTAL | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PERU | Leaf | Paste | Base | Cocaine | | Leaf | Paste | Base | Cocaine | | Leaf | Paste | Base | Cocaine | | quantity | value |
| Leaf | 1 | 271 | | | | | | | | | | 3 | | | | 155,186 | 310 |
| Paste | | | 329 | | | | | | | | | | 82 | | | 1,177 | 412 |
| Base | | | | 26 | | | | | | | | | | 493 | | 325 | 519 |
| Cocaine | | | | 1 | | | | | | | | | | | | 16 | 73 |
| | | | | | | | | | | | | | | | | | |
| BOLIVIA | | | | | | | | | | | | | | | | | |
| Leaf | | | | | | | 82 | | | | | 1 | | | | 78,152 | 95 |
| Paste | | | | | | | 3 | 227 | | | | | 25 | | | 729 | 255 |
| Base | | | | | | | | | 136 | | | | | 251 | | 232 | 388 |
| Cocaine | | | | | | | | | | | | | | | | 81 | 263 |
| | | | | | | | | | | | | | | | | | |
| COLOMBIA | | | | | | | | | | | | | | | | | |
| Leaf | | | | | | | | | | | <1 | | 23 | | | 32,487 | 23 |
| Paste | | | | | | | | | | | | | 7 | | | 19 | 7 |
| Base | | | | | | | | | | | | | | 244 | | 180 | 244 |
| Cocaine | | | | | | | | | | | | | | | | 639 | 2,474 |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| Intermediate goods ($ '000,000) | 1 | 271 | 329 | 27 | | 0 | 85 | 227 | 136 | | <1 | 4 | 138 | 989 | | | |
| Security ($ '000,000) | 47 | 62 | 78 | 11 | | 14 | 38 | 58 | 40 | | 4 | 1 | 37 | 371 | | | |
| Chemicals ($ '000,000) | 7 | 24 | 57 | 9 | | 1 | 11 | 30 | 31 | | 2 | <1 | 36 | 325 | | | |
| Transportation ($ '000,000) | 7 | 0 | 16 | 2 | | 3 | 0 | 12 | 8 | | 3 | <1 | 5 | 64 | | | |
| Labor ($ '000,000) | | | | | | | | | | | | | | | | | |
| start-up | 50 | 13 | 3 | 1 | | 37 | 8 | 2 | 5 | | 30 | <1 | 1 | 2 | | | |
| annual | 252 | 63 | 17 | 4 | | 187 | 39 | 12 | 27 | | 98 | 17 | 20 | 46 | | | |
| Equipment ($ '000,000) | | | | | | | | | | | | | | | | | |
| start-up | 28 | 3 | 11 | 1 | | 30 | 1 | 5 | 2 | | 14 | <1 | 6 | 20 | | | |
| annual | 28 | 3 | 11 | 1 | | 30 | 1 | 5 | 2 | | 14 | <1 | 6 | 20 | | | |
| Profit | -110 | -25 | -2 | 19 | | -207 | 72 | 37 | 12 | | -142 | -16 | -2 | 493 | | | |
| Price '000 (weighted) | 2 | 350 | 1,600 | 4,500 | | 1.21 | 350 | 1,675 | 3,250 | | 0.7 | 350 | 1,350 | 3,870 | | | |
| Gross Output (mt) | 155,186 | 1,177 | 325 | 16 | | 78,152 | 729 | 232 | 81 | | 32,487 | 19 | 180 | 639 | | | |
| Gross Value '000,000 | 310 | 412 | 519 | 73 | | 95 | 255 | 388 | 263 | | 23 | 7 | 244 | 2,474 | | | |

**Figure A.2—Aggregate Financial Table of Peruvian, Bolivian, and Colombian Cocaine Production (1989)**

coterminous or nearby locations. Hence, it is assumed that the transportation costs for within-country processing of paste to base are zero.[15]

The labor and equipment categories are subdivided into two separate components, start-up and annual, to reflect the need for labor services and equipment investment prior to to the beginning of production or conversion. Start-up labor is assumed to be fully depreciated over five years, indicating that a typical field or processing site must be replaced after that period. In contrast, the equipment used in the processing is assumed to be completely depreciated in one year, and it must therefore be replaced more frequently than production locations.

Land is essentially a free resource in the production of cocaine, and thus it is not represented in the I-O tables as a resource with cost associated with it. Land can be treated as a costless resource for a number of reasons. First, the state authorities, particularly in Bolivia and Peru, often encouraged settlement in remote regions by giving away land to migrants, or selling it at very low prices. Encouraged by these homesteading policies, unknown numbers of individuals migrated to the regions and expropriated land for themselves. Second, the recordkeeping associated with these remote regions has often led to disputes over title and ownership, making it easier for unscrupulous individuals to stake out claims to existing farmlands. Third, the state authority is often so weak in these remote regions that aggressive coca farmers can often farm land that the state never intended to give away with little fear of being caught. Coca farmers, for example, are now encroaching into state forest preserves. And finally, since there is virtually no use for much of this land other than coca farming at this point, the opportunity cost is essentially zero.

Unlike Peruvian and Bolivian leaf, Colombian leaf is not processed in four stages. Instead, Colombian leaf goes directly from the leaf stage to the base stage, bypassing the paste stage. Colombian leaf is of markedly poorer quality than the leaf grown in Bolivia and Peru, and it is more difficult to obtain the alkaloids from Colombian leaf. The I-O tables represent these facts. There are small amounts of paste manufactured in Colombia, all of it made from leaf imported from Bolivia and Peru. (However, for simplicity in conducting the analysis in the

---

[15] Transportation costs between the paste and base stages are assumed to be zero in Bolivia and Peru. However, it may be more accurate to consider leaf-to-paste and paste-to-base costs together. Typically, the transportation cost for moving leaf to a paste-processing site would be negligible, since much of that work is now carried out on the edge of coca farming locations. Base production, however, usually takes place at more centralized locations that serve several farms, and thus it should involve slight transportation charges. The zero transportation cost recorded for the paste-to-base stage also ignores the real cost of shipping very small quantities of leaf and paste to Colombia for processing. Without better information, it is impossible to be more precise about transportation costs. However, when considered in total, the transportation costs included do not seem unreasonable.

main body of this report, the four-stage process was artificially imposed on cocaine of Colombian origin.)

According to DEA officials and INCSR, traffickers have changed the way they process cocaine in the past decade. Formerly, most raw leaf was shipped from Bolivia and Peru to Colombia for processing into paste and the remaining steps of cocaine manufacturing. Since the mid-1980s, however, Bolivian and Peruvian traffickers have been increasingly processing up through the base stage domestically. Embedded in the I-O tables are the most recent data about the proportion of products that are processed in the various countries. Table A.3 summarizes the international flow of the various stages of cocaine-related products.

## *Aggregate Physical Flow of Goods Table: Data Highlights*

In Figure A.1, the Aggregate Physical Flow I-O table, five of the input items, intermediate goods, security, transportation, chemicals, and equipment, are measured in total dollars. Labor is measured in total days used. The output items (leaf, paste, base, cocaine) are all expressed in metric tons. Known internal losses such as domestic seizures and consumption have been netted from the total output figures, but external losses such as seizures occurring after export have not. Other internal losses, such as spoilage, theft, and misprocessing, have not been factored in because insufficient data were available to estimate their

**Table A.3**

**Percentage Flow of Cocaine Products Among Peru, Bolivia, and Colombia**

| Origin of Product | Amount of Product Processed in: | | |
|---|---|---|---|
| | Peru | Bolivia | Colombia |
| Leaf | | | |
| Peru | 99% | 0% | 1% |
| Bolivia | 0% | 99% | 1% |
| Colombia | 0% | 0% | 100% |
| Paste | | | |
| Peru | 80% | 0% | 20% |
| Bolivia | 0% | 90% | 10% |
| Colombia | 0% | 0% | 100% |
| Base | | | |
| Peru | 5% | 0% | 95% |
| Bolivia | 0% | 35% | 65% |
| Colombia | 0% | 0% | 100% |

SOURCE: INCSR, 1989.

magnitude. The grand total of 736 mt of cocaine therefore represents the maximum amount of cocaine that could have been produced from the conservative acreage estimates used, given the processing efficiency estimates.

**Labor.** Table A.4 shows that it takes 2.3 people working full-time for one year to produce one metric ton of coca leaf in Peru. In contrast, it takes 3.7 people to make one metric ton of leaf in Bolivia, and 3.0 people to produce one metric ton of leaf in Colombia. These figures imply that Peruvian farmers are 60 percent more productive in producing coca leaf than Bolivian farmers, all other factors being held constant. These figures are incomplete, however, because a metric ton of leaf from each country will yield different amounts of cocaine. When metric ton equivalents (MTEs) are compared, as they are in the second column of Table A.4, the productivity spread between Bolivia and Peru narrows considerably, and the gap between Colombia and the other two producers widens substantially. MTEs are the number of people required to produce enough leaf to make one metric ton of cocaine. In Peru, it takes 878 people working full-time to produce sufficient leaf to make one metric ton of cocaine, whereas 1,102 are required to work in Bolivia, and 1,502 in Colombia.

**Chemicals.** Producing 736 mt of cocaine requires over 53 million gallons of industrial chemicals, and perhaps a hundred times again as many gallons of water. When improperly disposed of, many of these chemicals are harmful to the environment. Yet proper disposal facilities are extremely rare in the isolated regions where much of the processing occurs. As a result, many streams and rivers, including the Huallaga River, one of Peru's largest, have all but died from chemical dumping.[16]

**Table A.4**

**Labor Requirements per Unit of Coca Leaf**

| | Labor-Years Required to Produce One Metric Ton of: | |
|---|---|---|
| | Raw Leaf | MTE (Leaf Equivalent of 1 mt Cocaine) |
| Peru | 2.3 | 848 |
| Bolivia | 3.7 | 1,102 |
| Colombia | 3.0 | 1,502 |

SOURCE: Figure A.1.

[16]For more on the environmental impact of the cocaine industry in PBC, see [7].

## *Aggregate Financial Table: Data Highlights*

In Figure A.2, the Aggregate Financial I-O table, all input items are expressed in dollars. In addition, all output items are also listed in value (dollar) terms, unless otherwise indicated. All of the other structural components of the table, such as treatment of internal and external losses, remain the same.

**Gross Domestic Product.** The cocaine industry generated nearly $3 billion in GDP in 1989.[17] Table A.5 shows the distribution of cocaine GDP between the three producing nations, and the share that cocaine GDP represents of legal national GDP. The largest source components of cocaine GDP, in order, are labor ($935 million, 34 percent of cocaine GDP), security ($760 million, 28 percent) and chemicals ($530 million, 20 percent).[18] Contrary to popular conviction, profit (in the true economic sense) accounts for a modest $129 million, or 4.7 percent of cocaine GDP; note that this does not include income from distribution within the United States.

**Labor.** The Aggregate Financial Table also reveals that the cocaine industry provides competitive legal *per capita* cocaine industry income levels. Table A.6 shows the income generated per person at each stage of production. The cocaine income levels compare favorably with the national *per capita* incomes reported for Bolivia ($780), Colombia ($1,310), and Peru ($860). More importantly, the legal national income figures listed here are aggregate across urban and rural economies. In fact, rural incomes are likely to be substantially lower than the national average income, and cocaine incomes are therefore likely to exceed average rural incomes. Thus, employment in the cocaine industry among rural

**Table A.5**

**Cocaine GDP**

| | Cocaine GDP[a] | Legal GDP[a] | Cocaine as % of Legal GDP |
|---|---|---|---|
| Peru | $ 0.69 | $ 24.4 | 2.8 |
| Bolivia | $ 0.55 | $ 4.6 | 13.4 |
| Colombia | $ 1.47 | $ 33.3 | 4.4 |

SOURCES: Figure A.2 and Table 4.
[a]Billions of dollars.

[17]This figure excludes the value of any operations conducted by PBC nationals beyond the wholesale export stage. Thus, any GDP generated by PBC residents in shipping to the United States is not considered here.

[18]The proportion of cocaine GDP returned to labor in Bolivia and Peru is substantially above the proportion of legal GDP returned to labor. This means labor is a more important component in the cocaine production process than it is in the legal production of goods. The returns to labor at the national level can be found in earlier sections of this report.

**Table A.6**

**Cocaine Industry Incomes**

| Stage of Production | Cocaine Incomes ($/year) | | |
|---|---|---|---|
| | Peru | Bolivia | Colombia |
| Leaf | 839 | 774 | 1,282 |
| Paste | 755 | 779 | —[a] |
| Base | 1,007 | 702 | 2,039 |
| Cocaine | 504 | 655 | 1,850 |

SOURCE: Figure A.2.
[a]Stage omitted in Colombian production process.

citizens would appear to provide excellent income compared to other local economic alternatives but not the large multiple of those alternatives that is sometimes claimed in the press.

In Bolivia and Peru, coca farming provides high income per hectare cultivated, compared to other agricultural crops. Coca farming yields labor income of over $2,500 per hectare in Peru, and over $3,300 in Bolivia. In contrast, a high-return legal crop such as coffee reportedly yields approximately $1,500 per hectare.[19]

**Profits.** Despite the drug industry's reputation for profitability, the Aggregate Financial Table, Figure A.2, shows some sectors within the industry making a loss. In fact, given the volatility of cocaine product prices in PBC, it is probably not uncommon for segments of production to be unprofitable at times. Table A.7 shows the product prices used in compiling the Input-Output Tables and the product prices needed to break even at prevailing input costs. Leaf prices are approximately 48 percent below the breakeven price. In contrast, paste prices are 6.5 percent above the breakeven point, base prices 2.4 percent above, and cocaine prices 18.4 percent above.

[19]Reference [37], p. 27, reports that coca in some cases provides over 90 times the income of local crops.

**Table A.7**

**Breakeven Prices in the Cocaine Industry (thousands of U.S. dollars per metric ton)**

| Product | Prevailing Price | Calculated Breakeven Price |
|---|---|---|
| Leaf | | |
| Peru | 2.0 | 2.7 |
| Bolivia | 1.2 | 3.9 |
| Colombia | 0.7 | 4.9 |
| Paste | | |
| Peru | 350 | 372 |
| Bolivia | 350 | 251 |
| Colombia | —[a] | —[a] |
| Base | | |
| Peru | 1,600 | 1,605 |
| Bolivia | 1,675 | 1,517 |
| Colombia | 1,350 | 1,370 |
| Cocaine | | |
| Peru | 4,500 | 3,360 |
| Bolivia | 3,250 | 3,100 |
| Colombia | 3,870 | 3,100 |

SOURCE: Figure A.2.

[a]Stage omitted in Colombian processing.

# References


1. National Narcotics Intelligence Consumers Committee, *Narcotics Intelligence Estimate*, Washington, D.C., annual.

2. Bruce Bagley, "Colombia and the War on Drugs," *Foreign Affairs*, Fall 1988.

3. Lee Rensselaer, "Why the U.S. Cannot Stop South American Cocaine," *ORBIS*, Fall 1988.

4. *Seizing Opportunities: Report of the Inter-American Commission on Drug Policy*, Institute of the Americas and the Center for Iberian and Latin American Studies, University of California: San Diego, June 1991.

5. Krishna Kumar, Ernest Carter, and Stan Samuelson, *A Review of AID's Narcotics Control Development Assistance Program*, USAID: Washington, D.C., 1986.

6. Committee on Foreign Affairs, U.S. House of Representatives, *Operation Snowcap: Past, Present, Future*, USGPO: Washington, D.C., 1990.

7. Committee on Governmental Affairs, U.S. Senate, *Cocaine Production, Eradication, and Environment: Policy, Impact, and Options*, USGPO: Washington, D.C., 1990.

8. *International Narcotics Control Strategy*, U.S. Department of State, annual.

9. Peter Reuter and David Ronfeldt, *Quest for Integrity: The Mexican-U.S. Drug Issue in the 1980s*, RAND: Santa Monica, CA, N-3266-USDP, 1992.

10. William Walker, *Drug Control in the Americas*, University of New Mexico Press: Albuquerque [revised edition], 1988.

11. "Plan de Ejecucion del Proyecto de Desarrollo Rural Integral del Alto Huallaga," USAID: Washington, D.C., 1981.

12. "Huallaga Valley Agribusiness and Marketing Study," IRI Research Institute: Stamford, CT, 1985.

13. *Final Report on the Evaluation of AID Project No. 527 0244; Development of Alto Huallaga Area*, Econsult: Lima, 1987.

14. Hernando de Soto, *The Other Path: The Invisible Revolution in the Third World*, Harper and Row: New York, 1989.

15. Testimony of Oswaldo Antezana Vaca Diez, Bolivian Ministry of Agriculture, before the Permanent Subcommittee on Investigations of the Committee on Governmental Affairs, U.S. Senate, September 27, 28 and 29, 1989. Hearing 101–311.

16. *National Accounts Statistics: Main Aggregates and Detailed Tables*, United Nations: New York, various years.

17. Samuel Doria Medina, *La Economia Informal en Bolivia*, undated.

18. Edmundo Morales, *Cocaine: White Gold Rush in Peru*, University of Arizona: Tucson, 1989.

19. *International Narcotics Control Strategy Report* (INCSR), 1989.

20. Timothy Plowman, "Coca Chewing and the Botanical Origins of Coca (*Erythroxylum Spp.*) in South America," *Cultural Survival Report #23: Coca and Cocaine*, Latin American Studies Program: Ithaca, NY, 1985.

21. W. Manning, E. Keeler, J. Newhouse, E. Sloss, and J. Wasserman, *The Costs of Poor Health Habits*, Harvard University Press: Cambridge, MA, 1991.

22. Peter Reuter and Mark Kleiman, "Risks and Prices: An Economic Analysis of Drug Enforcement," Michael Tonry and Norval Morris, eds., *Crime and Justice: An Annual Review of Research*, Vol. 7, pp. 289–340, University of Chicago Press: Chicago, IL, 1986.

23. Jonathan Caulkins, *The Distribution and Consumption of Illicit Drugs: Mathematical Models and Their Policy Implications*, unpublished PhD. dissertation, MIT: Cambridge, MA, 1990 (Chapter 3).

24. David L. Browman, "Agro-Pastoral Risk Management in the Central Andes," *Research in Economic Anthropology*, Vol. 8, 1987, pp. 171–200; "Andean Peasant Economics and Pastoralism," Department of Rural Sociology, University of Missouri: Columbia, 1987.

25. Michael Chibnik, "Double-Edged Risks and Uncertainties: Choices About Rice Loans in the Peruvian Amazon," *Risk and Uncertainty in Tribal and Peasant Economies*, Westview: Boulder, CO, 1988.

26. Robert E. Rhoades and Pedro Bidegaray, *The Farmers of the Yurimaguas: Land Use and Cropping Strategies in the Peruvian Jungle*, International Potato Center, Peru, 1987.

27. *Yearbook of Labor Statistics, 1988–1989*, International Labor Office: Geneva, 1989.

28. Peter Reuter, Robert MacCoun, and Patrick Murphy, *Money from Crime: A Study of the Economics of Drug Dealing in Washington, D.C.*, RAND: Santa Monica, CA, R-3894-RF, 1990.

29. Donald A. Cooper, "Clandestine Production Processes for Cocaine and Heroin," *Clandestinely Produced Drugs, Analogues and Precursors: Problems and Solutions*, DEA: Washington, D.C., 1989.

30. Marc J. Dourojeanni, "The Environmental Impact of Coca Cultivation and Cocaine Production in the Peruvian Amazon Basin," *Cocaine Production, Eradication, and the Environment: Policy, Impact, and Options*, Committee on

Governmental Affairs, U.S. Senate, USGPO: Washington, D.C., August 1990.

31. Catherine J. Allen, "Coca and Cultural Identity," John Murra, "Notes on Pre-Colombian Cultivation of Coca Leaf," and Herbert S. Klein, "Coca Production in the Bolivian Yungas in the Colonial and Early National Periods," *Cultural Survival Report #23: Coca and Cocaine,* Deborah Pacini and Christine Franquemont, eds., Latin American Studies Program, Cornell University: Ithaca, NY, 1985.

32. *Recipe Book: Cocaine Processing Techniques*, DEA: Lima Country Office, undated.

33. Scott MacDonald, *Mountain High, White Avalanche: Cocaine as Power in the Andean States and Panama*, Praeger: New York, 1989.

34. Marc Dourojeanni, "Impactos Ambientales del Cultive de Coca y la Produccion de Cocaina en la Amazonia Peruana," CEDRO: Lima, 1989.

35. James Laity, "The Coca Economy in the Upper Huallaga," USAID: Peru, 1989.

36. Peter Reuter, Statement Before the Subcommittee on Western Hemisphere Affairs, Committee on Foreign Affairs, U.S. House of Representatives, February 26, 1991, pp. 1–3.

37. Lee Rensselaer, *The White Labyrinth*, Transaction Publishers: New Brunswick, NJ, 1989.

38. Gordon H. McCormick, *The Shining Path and the Future of Peru*, RAND: Santa Monica, CA, R-3781-DOS/OSD, 1990.

39. "DIRECO Coca Reduction Program, 1988," Cochabamba Ministry of Agriculture and Peasant Affairs, translated in JPRS-DDD-89-043-L, October 20, 1989.