Opium in Afghanistan: Prospects for the Success of Source-Country Drug Control Policies*

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Abstract

Recent estimates suggest that in 2007, Afghan opiate production accounted for about 93% of the world's total. This paper presents a framework for estimating the potential for source-country drug-control policies to reduce this production. It contains a first pass at estimating the potential for policy to shift the supply of opium upward, as well as a range of supply and demand elasticities. The estimates suggest that meager reductions in production can be expected through alternative development programs alone (reductions are less than 6.5% in all but one of the specifications presented). They also suggest that substantial increases in crop eradication would be needed to achieve even moderate reductions in production (reductions range from 3.0% to 19.4% for various specifications). The results also imply that, all else equal, the cessation of crop eradication would result in only modest increases in opiate production (with estimates ranging from 1.6% to 9.6%).

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1. Introduction

In 2007, Afghan poppy cultivation produced an estimated 93% of the world's opium (UNODC 2007a). Poppy cultivation in 2007 was about 17% more widespread than in 2006, when the crop was estimated to have an export value of around $3.1 billion, an amount equivalent to 46% of Afghanistan's GDP (UNODC 2006a). Given an environment of international opiate prohibition, this high level of cultivation poses several policy concerns along two dimensions.

The first and most familiar concern relates to health problems associated with the use of heroin and other opiates, which are consumed by an estimated 16 million people worldwide (UNODC 2006b).[1] Other concerns relate to the narcotics industry's contribution to insecurity, instability, and corruption both within Afghanistan and along the trafficking chain. The narcotics industry has long been associated with insurgent, criminal, and terrorist groups (Kleiman 2004; Curtis 2002; Curtis and Karacan 2002; Berry et al. 2002), and Afghanistan has become an increasingly central part of this history during recent decades. Additionally, poppy cultivation and heroin processing pull economic resources into the black market. This complicates the emergence of a strong national government in that it both reduces the tax base and finances the warlords and militias with whom the government competes for control. Lastly, the presence of lucrative black market opportunities creates incentives for corruption within the government.

Skeptics of drug prohibition rightfully question the extent to which prohibition itself is responsible for these health- and security-related concerns. This work, however, is not directed at that line of questioning. Instead, it analyzes the potential effectiveness of efforts to suppress drug production when prohibition is taken as the given policy.

The analysis considers several of the key parameters that must be estimated for source-country drug-control policy to proceed in an informed manner. It should be noted at the outset that, in the study of this issue, data shortcomings and modeling complexities make it necessary to formulate a number of best guesses and approximations in order to arrive at policy-relevant estimates. This work is meant to provide some suggestive estimates of the potential for various source-county policies, and to outline a coherent framework for thinking about the issue. In light of the considerable uncertainty surrounding the estimates, I also show their sensitivity to changes in key parameters. Throughout the paper, attention is given to areas where improved data collection and methods may sharpen our understanding.

To summarize the results, small source-country demand elasticities drive estimates that are fairly pessimistic about the capacity for source-country policies to reduce opium production in the short run. Alternative development strategies, in particular, appear unable to shift the supply curve enough to have a meaningful impact on the quantity of opium demanded. Significant increases in source-country efforts would also be necessary to drive opium out of Afghanistan in the long run, as this would, all else equal, require sustaining prices well above those observed in other source-countries.

The paper proceeds as follows. After a review of the relevant literature in Section

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[1] See USDHHS (2006) for information regarding drug-related emergency room visits in the United States.

2, I outline a framework for analyzing drug-control policy in Section 3. In Section 4, I outline a model of the decisions farmers make when allocating land between poppy and alternative crops; I focus attention on the impact that source-country drug-control policies can have on the prices at which farmers would cultivate particular quantities of poppy. In Section 5, I then develop a range of estimates for the elasticities of supply and demand for opium at the source-country level. Finally, in Section 6, I bring Sections 4 and 5 together to estimate the equilibrium effects of manipulating policy-related variables.

2. Literature Review

2.1 Afghanistan's Rise in Global Opium Production

Afghanistan's rise to prominence in global opium production resulted from a variety of internal and external factors. Externally, Iranian, Pakistani, and Turkish crackdowns on opium production during the 1970's significantly reduced both regional and global supply (UNODC 2003c, 88). Internally, a quarter century of conflict, which began in 1979 with resistance to Soviet occupation, brought high levels of instability, which proved conducive to the rise of the narcotics industry. Several non-geopolitical factors have also made Afghanistan suitable for poppy cultivation. As a labor-intensive crop, poppy is suitable for agricultural regions in which there are few off-farm income opportunities and low capital-to-labor ratios (Misra 2004, 82). The absence of off-farm income opportunities is particularly noteworthy for Afghan women, who are generally prevented from working outside the home (UNODC 2000b; IRIN 2005). Afghanistan's soils, climate, and altitude have also made its poppy cultivation more productive than cultivation in other major opium-producing regions. While the major poppy-cultivating districts of Afghanistan frequently experience yields as high as 40-60kg per hectare, recent surveys in Myanmar and Laos report national yield averages of 9.5kg and 8kg per hectare, respectively (UNODC 2005b; UNODC 2005c).

2.2 The Determinants of Farm Level Supply

The United Nations, a number of Non-Government Organizations, and others have put a great deal of work into monitoring the cultivation of drug crops and assessing its causes on a qualitative level. Much fieldwork and data collection have gone into the UNODC's annual opium poppy surveys and its series of "Strategic Studies" on issues relating to Afghan opium. While these studies provide many valuable pieces of factual and conceptual information, their analyses are generally of a qualitative nature. The present study is, in part, meant to address the absence of work that incorporates these data into a more formal model of farm-level supply.

2.3 Retail Heroin Markets

The elasticity of demand at the retail level, an important aspect of the global market for heroin, has been estimated in several studies. Relevant papers include Saffer and Chaloupka (1995), Chaloupka, Grossman, and Tauras (1996), Caulkins (1995), and Bretteville-Jensen and Biorn (2003, 2004). These studies have generally yielded higher demand elasticity estimates than were previously assumed, with central estimates falling moderately above and below 1. Bretteville-Jensen and Biorn (2003) estimate distinct ranges of elasticities for dealers and non-dealers, finding that dealer-demand tends to be the less elastic of the two (with estimates in the range of 0.15-1.51 compared to 0.71-1.69). Their more recent work confirms this general pattern (Bretteville-Jensen and Biorn

2004). Using data on arrestees, Dave (2004) estimates a relatively low short-run participation elasticity of 0.09 (implying a long-run elasticity of about 0.18), providing further evidence that chronic users have less elastic demand than others.

2.4. Closed Modeling of Source-Country Drug Control Policy

Kennedy, Reuter, and Riley (1993) present a simple model of the world cocaine market in a rare closed-loop analysis of the economics of drug control policy. Their results, which are driven largely by the fact that source-country prices make up a small fraction of the prices observed in U.S. retail markets, are highly pessimistic about the potential efficacy of both source-country and interdiction policies. Rydell and Everingham (1994) extend this analysis by estimating the cost effectiveness of different forms of policy in terms of the expenditure required to reduce cocaine consumption by 1%. Their estimates suggest that, at least on the margin, drug treatment programs are far more cost effective than domestic enforcement, interdiction, and source-country policies. Source-country policies rank as the least cost effective of the four.

Two aspects of the model applied by Kennedy, Reuter, and Riley (1993) may make their results more pessimistic about source-country policies (at least with respect to cocaine) than is warranted. First, they treat the U.S. price as a world price rather than as one of many regional prices in a segmented world market. Since U.S. cocaine prices are significantly higher than prices in countries that are closer to source countries and/or have less stringent drug laws, their approach makes source-country prices appear to have a smaller impact on world retail prices than they actually do.

Second, they assume that source-country prices only have an additive impact on retail prices. This implies, for example, that if the price of a kilogram of heroin in Afghanistan rises from $1000 to $1100, the price in Europe will only rise from, say, $100,000 to $100,100. Hence a 10% increase in the Afghan price results in a mere 0.1% increase in the European price. This assumption has been a subject of dispute. A review of related literature by Rhodes et al. (2001) notes that, in the abstract, a linear model of the impact of source-country prices on retail prices could also take on a purely multiplicative form (where a doubling of the source-country price leads to a doubling of the price in retail markets) or, more likely, a mixed form with both an additive and a multiplicative element. This important issue will receive further attention in Section 5.[2]

Although these two factors would imply higher source-country demand elasticities in the context of Kennedy, Reuter, and Riley's study of cocaine, the demand-elasticity estimates in the present study of opiate production remain quite low. This is because source-country prices comprise an even smaller fraction of retail heroin prices than of retail cocaine prices.

3. Analytical Framework

The drug control policies examined here amount to efforts to shift the supply of Afghan opium upward. In general, analyzing the potential efficacy of such interventions requires estimating three parameters: the local supply elasticity, the local demand elasticity, and the extent to which particular interventions will shift the supply curve. Estimates of these parameters would allow the equilibrium effects of various policies to

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[2] As is more fully discussed in Section 5, a combination of economic intuition/theory and the limited empirical work suggest that multiplicative markups will be modest, but not entirely non-existent.

be estimated using a simple model like the following:

$$Q_D = Q_S \quad \textbf{(1)}$$

$$Q_S = C_1(P - \Delta P)^{\varepsilon} \quad \textbf{(2)}$$

$$Q_D = C_2 P^{\theta}, \quad \textbf{(3)}$$

where ΔP represents the extent to which policy can upwardly shift the price at which the initial equilibrium quantity is produced, ε represents the elasticity of supply, θ represents the elasticity of demand, and the constants C_1 and C_2 summarize other factors so as to fit the demand and supply curves to the initial equilibrium point.

One could imagine two potentially effective ways to analyze the demand for Afghan opium. The first, which is not used here, would be to attempt direct estimation of the demand elasticity using national price and production data.[3] The second method, used in the analysis below, highlights the global nature of the demand for Afghan opium, which is derived from demand in retail markets. It distinctly emphasizes two determinants of retail prices: the price paid in Afghanistan (the producing country), and the costs of transporting opiates to retail markets. The model, which is similar to Kennedy, Reuter, and Riley's (1993) model of cocaine production in South America, consists of four equations with four unknowns. In these equations, P_A represents the

[3] This approach was attempted briefly, using rainfall as an instrument to identify exogenous supply shocks. However, the results were imprecise and theoretically dubious, possibly due to the quality of the data, the limited number of observations, and the fact that poppy is less affected by rainfall during the growing season than other crops. Alternative strategies for directly estimating the source-country demand

price of opium in Afghanistan. P_R, for $R = 1, \cdots, n,$ represents the prices of opium in the n regional (meaning regions of the globe) retail markets that are supplied with Afghan opium. $Q_{D,R}$ represents the quantity of opiates demanded in each of the n regional retail markets, and $Q_{S,A}$ represents the quantity of opium supplied by Afghanistan. $\vec{x}$ is a vector of the non-price determinants of Afghan supply. α_R and β_R represent the costs of trafficking opiates from Afghanistan to a given region. C_R summarizes all factors other than prices that determine demand. ε_R represents the regional elasticities of demand to retail prices. The model looks like the following:[4]

$$\sum_{R=1}^{n} Q_{D,R} = Q_{S,A} \tag{4}$$

$$Q_{S,A} = f(P_A, \vec{x}) \tag{5}$$

$$P_R = \alpha_R + \beta_R P_A \tag{6}$$

$$\sum_{R=1}^{n} Q_{D,R} = \sum_{R=1}^{n} C_R P_R^{\varepsilon_R}. \tag{7}$$

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elasticity may produce more reliable results in future work.

[4] The four-equation structure of this model is uniquely suited for analysis of drug control policy because it separately highlights the focus of the three broad categories of intervention. Source-country control seeks to influence equation 5 by raising the price at which any given quantity will be produced. Interdiction seeks to influence equation 6 by raising the markup parameters, and hence the prices in retail markets, and demand-side control seeks to depress the quantity demanded at any given retail price. Since the current paper focuses on source-country control, I have chosen a general form for equation 5 and simplified forms for equations 6 and 7 for practical purposes.

Equation 4 is the equilibrium condition in which the quantity supplied equals the sum of the quantities demanded in each of the regions that consume Afghan opiates. Equation 5 states that the quantity supplied by Afghanistan is a function of the Afghan price and a vector of other factors. Equation 6 states the relationship between the Afghan price and the prices in the regional retail markets. Equation 7 states the relationship between the quantities demanded and the prices charged in the regional retail markets. Substituting equation 6 into equation 7 results in

$$\sum_{R=1}^{n} Q_{D,R} = \sum_{R=1}^{n} C_R (\alpha_R + \beta_R P_A)^{\varepsilon_R} . \qquad \textbf{(8)}$$

Given estimates for α_R, β_R, and ε_R, it is possible to derive an estimate of the price elasticity of demand for Afghan opium by plugging these estimates into equation 8.

The model assumes that the fraction of a regional market that is supplied by Afghanistan cannot obtain opiates from alternative source-countries. [5] This assumption of market segmentation is clearly unrealistic to some extent, but seems to hold reasonably well at least in the short run. Paoli, Reuter, and Greenfield (2006) document that segmentation can help to explain the world market's response to the Taliban's 2001 ban

[5] This assumption may apply better to the current global market for opiates than one might expect due to the extent of Afghanistan's dominance in the market. The UNODC estimates that Afghanistan produced about 87% of the world's opium in both 2004 and 2005, 92% in 2006, and 93% in 2007 (2007b, 2007a). Among the world's other opium-producing countries, Colombian and Mexican opiates tend to remain in the Americas, Myanmar (2nd in global production) has seen its production drop steadily over the last 10 years despite recent volatility in the Afghan market, as has Laos. In sum, the scope for large-scale substitution away from Afghan opium seems limited in the short run.

on opium production. Following the ban, Afghanistan continued to dominate world opium production despite three consecutive years during which Afghan prices exceeded those in Laos and Myanmar by more than $100/kg (that is, 2001-2003), suggesting that this short run may even extend for some time. Over a longer time horizon, market segmentation would break down as traffickers turn to farmers in other source countries and alter their trafficking routes in response to changes in Afghanistan. Hence, the demand for opiates in any one source country will be more elastic in the long run than in the short run. Consequently, this model will tend towards results that are: 1) overly optimistic about source-country drug control's ability to suppress the global market, and 2) overly pessimistic about its ability to drive production out of any one country.

4. Policy's Capacity to Shift the Supply Curve

4.1. The Model

Analyzing the potential for policy to affect a farmer's decision to cultivate poppy requires an understanding of the factors that determine the desirability of poppy relative to other crops. Principal among these are the net incomes available from growing alternative crops, the risks associated with each crop (in terms of both expected yields and expected prices), and farmers' relative tastes for cultivating various crops (of chief interest here being distaste towards poppy due to its illicit nature with respect to both Islamic and secular law). The analysis in this section proceeds largely through a presentation of stylized facts about the evolution of Afghan poppy cultivation, beginning in the 1990s (when poppy was neither illegal nor widely objected to on religious grounds) and continuing through the less stable last 7 years. These stylized facts are interpreted with the following model of farmer utility in mind:

$$EU = \sum_{i=1}^{n} p_i U[W, H_1 N_{1,i} + \cdots + H_m N_{m,i} + H_O N_{O,i} - M(H_O, N_{O,i})],$$

$$s.t., \sum_{j=1}^{m} H_j + H_O \leq T \text{ and } H_O, H_j \geq 0 \ \forall \ j. \qquad \textbf{(9)}$$

This model views farmers as gambling across $i = 1, \cdots, n$ states of the world that may emerge by the time crop revenues are realized post-harvest. The farmer begins the planting season with a stock of wealth, W. He has post-harvest utility determined by a function, U, with two arguments. The first is his initial wealth. The second consists of the net income earned from cultivating H_j hectares of each of the $j = 1, \cdots, m$ alternative crops at a profit of $N_{i,j}$ per hectare, plus the net income earned from cultivating H_O hectares of poppy at a profit of $N_{i,O}$ per hectare, minus a function, $M(H_O, N_{O,i})$, representing moral aversion to poppy cultivation. Each state, *i*, *is* expected to occur with probability p_i, and is associated with a unique set of prices, yields per hectare, labor requirements per hectare, wages, capital requirements per hectare, and capital costs for each crop. A farmer would seek to maximize expected utility by choosing the H_j and H_O subject to the constraint imposed by the land endowment, T.

This microeconomic model of farm-level decision making provides an explicit framework for thinking about how each of the major forms of source-country drug-control policy would influence the level of drug-crop cultivation. Efforts to increase alternative farm incomes would raise the N_j, likely by either increasing the expected yields from these crops, reducing costs (for example, reducing transportation costs by building roads), or by providing price supports. Improvements in alternative off-farm earning opportunities would result in decreases in the net incomes earned from cultivating all crops due to an increase in the opportunity cost of farm labor. (Such wage increases turn out to reduce poppy cultivation because poppy is far more labor intensive than common alternatives.) Crop eradication would raise the expected probability with which the net income from poppy would be negative (due to lost inputs and a yield of zero). Other sanctions could have a similar effect by, say, reducing the net income from poppy cultivation through fines. Finally, efforts to increase respect for the law or convince farmers that opium is anti-Islamic would increase the size of the moral aversion term.

Equation 9 provides a framework for thinking about how various policies would impact farmer decision making. The analysis proceeds by viewing stylized facts about Afghan poppy cultivation through the lens of such a model. A rigorous effort to write out and calibrate an explicit functional form would require a richer set of data than that used here. It would ideally follow a stochastic programming approach such as that used successfully by Maatman et al. (2002) to model farmer decision making in Burkina Faso. Such an effort would also need to incorporate insights about premiums for illicit activity (drawing on work in the economics of crime and other disciplines) if it is to convincingly account for morally-based aversion to poppy cultivation.[6]

[6] This microeconomic framework can be contrasted with the macroeconomic framework employed by Kennedy, Reuter, and Riley (1993). Their study of cocaine production employed a two-sector model of the source-country's economy in which a cocaine sector (where cocaine production increases linearly with the

4.2. Stylized Facts and Analysis

Early data gathering yields insights on poppy cultivation prior to its illegality. Afghanistan provides a unique opportunity for analyzing the impact of source-country policies because intensive data gathering began *before* poppy cultivation was outlawed and widely condemned on legal and religious grounds. This data collection began with the UNODC's first "Annual Opium Poppy Survey" in 1994. Since then, these surveys have provided province- and/or district-level price and cultivation data in each year. Early surveys (UNODC 1994a-1997a) also provide province-level price data for wheat, which I use when estimating a range for the elasticity of supply in Section 5. The Taliban did not forcefully ban poppy cultivation until the lead up to the 2001 harvest.

Data from valuable case studies (Assad and Harris 2003; FEWS NET 2003) and other studies which provide insights about key input requirements (Mansfield 2002;

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number of workers) competes for labor with an "Other Goods" sector. Although the general equilibrium nature of their approach has appeal, its implementation may miss some of the most important determinants of supply. In particular, by modeling the quantity supplied as a function of labor alone, they bypass the land-allocation decisions made by farmers. This has important implications for the supply response to source-country policies for two reasons. First, it will miss the fact that farmers, not day laborers, face the income risks associated with crop eradication. Second it will miss two major determinants of the slope of the supply curve, which are a) heterogeneity in the relative yields of poppy and alternative crops (which can differ significantly across areas of the country), and b) heterogeneity in the premium required as compensation for illicit activity (which is more relevant in the context of farmer decision making because the work of day laborers has not been the object of legal and religious condemnation as has the cultivation of poppy).

UNODC 2003c) make it possible to compare the net profits available from cultivating a hectare of poppy relative to a hectare of wheat. The focus of these case studies on wheat is unfortunate in terms of our knowledge about the relative input costs, prices, and yields for other alternative crops, but understandable given that wheat is far more intensively cultivated than all other crops in Afghanistan.[7]

Poppy's high labor intensity introduces a substantial discontinuity to the input-cost and net-profit functions. Poppy's high labor intensity emerges as an important determinant of poppy cultivation at the farm level. U.N. reports commonly cite an estimate that about 350 days of labor are required to cultivate a hectare of poppy relative to 41 days for wheat (see, for example, UNODC 2003c). Furthermore, an estimated 200 of the 350 days of labor required to cultivate poppy must take place during the 2-3 week harvest period. This implies a need for 10-14 individuals working full time on a hectare of poppy in order to complete the harvest during the appropriate time period.

Recent surveys also document that the typical poppy-cultivating farmer possesses a plot of about 2.7 hectares (UNODC 2005a) and has a family with 6 or 7 members, including those both too old and too young to work (UNODC 2005a). This implies that the farmer must hire itinerant labor during the harvest if he desires to devote a large portion of his land to poppy. This turns out to be important for two reasons. First, since

[7] The UNODC (2003c) notes that Afghan farmers devoted 2,534,000 hectares of land to cereal grains in 1999, of which 2,027,000 went to wheat. In that year, the next-most intensively cultivated category of crops was cultivated on slightly more than 7% of the land devoted to wheat. By comparison, opium poppy was cultivated on 91,000 hectares of land in 1999.

labor demand is high during the harvest, and since poppy harvesting requires more specialized skill than other forms of daily labor, poppy harvesters receive relatively high wages (UNODC [2004b] estimates that poppy harvesters receive $6.80 per day, while UNODC [2003c] provides estimates suggesting that day laborers typically receive $1-$2 per day). Second, although these wage increases directly affect the cost of itinerant labor and raise the opportunity cost of male household labor, this opportunity cost does not apply to the labor of household children and females. UNODC (2000b) summarizes the reason for this distinction, writing that "In Afghanistan, the livelihood choices of women are often limited by the practice of *purdah*…. Women often find themselves excluded from the limited off-farm and non-farm income opportunities that are currently available in Afghanistan, confining their productive role largely to on-farm income opportunities, including agricultural crops and livestock." Furthermore, "Previous fieldwork in Afghanistan has indicated that households do not attribute an economic cost to family labour" (UNODC 2000b).[8]

If one assumes that 3 or 4 members of a typical family of 6 or 7 are essentially opportunity-cost-free, and that the farmer works alongside the family's women and children, it follows that the labor constraint would be effective if the farmer cultivates more than about .34 to .42 hectares of poppy.[9] The fact that poppy-cultivating farmers

[8] Interested readers may enjoy further discussion of this and other societal issues in the installments of UNODC's "Strategic Studies" series.

[9] (200 person days of work per hectare) / (17 harvest days) ≈ 11.8 workers per hectare. (4 workers) / (11.8 workers per hectare) ≈ .34 hectares.

now devote an average of about .37 hectares of their land to poppy (UNODC 2006a) suggests that this constraint may play an important role in shaping cultivation decisions.

Opium price data suggest that before poppy cultivation was illegal, opium prices were not substantially higher than what one would expect based on the alternative income available through wheat cultivation. The available input requirement, input price, crop yield, and crop price data make it possible to estimate the threshold prices at which it would become profitable for our case-study farmer to devote different amounts of his land to poppy rather than wheat. The data (summarized in Table 1) suggest that the case-study farmer would have required an opium price of at least $25/kg[10] to cultivate poppy to the point of the labor constraint, and a price of $54/kg[11] to devote all of his land

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(5 workers) / (11.8 workers per hectare) ≈ .42 hectares.

[10] This number is calculated by using the data in Table 1 and the following formula:

$$P_O = (P_W Y_W - wL_W - K_W + w_{nh} L_{O,nh} + w_h 17 + K_O) / Y_O,$$

where P_O and P_W represent opium and wheat prices, Y_O and Y_W represent yields, K_O and K_W represent capital costs, w is the normal daily wage, w_{nh} is the non-harvest wage for poppy cultivation, w_n is the harvest wage for poppy cultivation, L_W is the labor requirement for wheat cultivation, and $L_{O,nh}$ is the non-harvest labor requirement for poppy cultivation. The harvest wage is multiplied by 17 in this case to account for the opportunity cost of the labor done by the farmer alongside his family (which is assumed to provide opportunity-cost free labor as described above). In words, this equation adds opium input costs to the net income from wheat, and divides this sum by the opium yield to identify the opium price at which it becomes more profitable to devote land to opium rather than wheat.

[11] This figure is calculated by plugging the data in Table 1 into the same formula as in footnote 9, but with the 17 days of the farmer's harvest labor replaced by the full harvest-labor requirement.

Table 1
Parameter Estimates and Sources

Parameter	Sources	Estimate
Land Endowment	UNODC 2005a	2.7 Ha
Opium Price ($/kg)	UNODC Surveys (1994a-2000a); UNODC 2003c	$39
Wheat Price ($/kg)	UNODC Surveys (1994a-1997a)	$0.20
Opium Yield (kg/hectare)	UNODC Surveys (1994a-2000a)	38.8
Wheat Yield (kg/hectare)	UNODC Surveys (1994a-2000a)	3815
Labor/Ha (Opium; non-harvest)	UNODC 2003c	150
Labor/Ha (Opium; harvest)	UNODC 2003c	200
Labor/Ha (Wheat)	UNODC 2003c	41
Capital/Ha (Opium)	Asad and Harris 2003; Mansfield 2002	$128
Capital/Ha (Wheat)	Asad and Harris 2003; FEWS NET 2003	$187
Non-Harvest Wage	UNODC 2004b	$1-$2
Opium Harvest Wage	UNODC 2004b	$6.80
Family Harvest Labor Days	UNODC 2004b	51-68
Opium Costs/Ha (w/o constraint)*		$468
Opium Costs/Ha (w/ constraint)		$1,585
Wheat Costs		$248
Price at which it becomes profitable to cultivate poppy up to constraint		$25
Price at which it becomes profitable to cultivate poppy beyond constraint		$54

* I assume that the household males are performing all labor necessary for cultivating wheat, and all non-harvest labor necessary for cultivating poppy. U.N. reporting on the role of women during the harvest suggests that although women typically have a full slate of household responsibilities, they are forced to work particularly hard during the poppy harvest (UNODC, 2000b). I think of the effort they exert during the opium harvest as being an effort that could not be sustained year round. Thus the women are not available for farm work during the remainder of the year (hence the opportunity cost of the standard daily wage), but they are nonetheless available as opportunity cost-free labor during the opium harvest (alternatively, assigning an opportunity cost of $1/day to this labor would raise the reported prices by about $5/kg). Also, I assume that the farmer himself is involved in the opium harvest along with the family's women and children. Thus the farmer's own labor during the harvest is included in the labor costs for poppy cultivation up to the constraint. This cost amounts to the harvest wage times the estimated 17 harvest days for a total of $115.60.

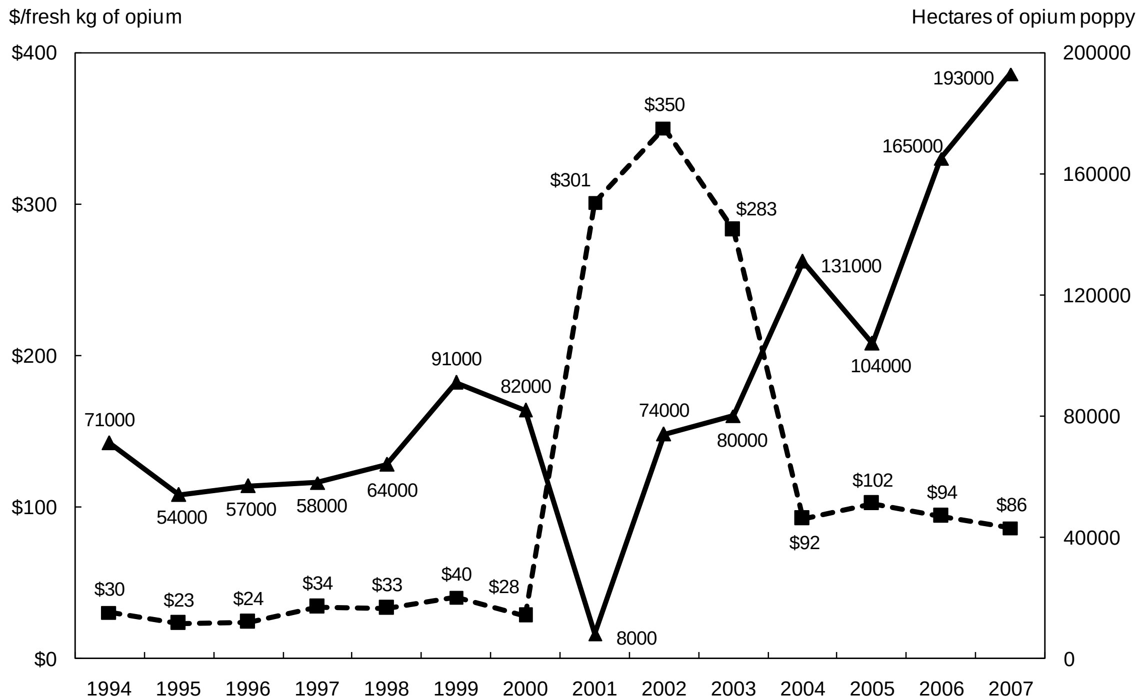
to poppy. The fact that opium prices averaged around $39/kg from 1994-2000 (in 2000 dollars) suggests that the labor constraint may have been a major determinant of the poppy cultivation decisions of many farmers. It also suggests that before poppy cultivation became illegal, traffickers could induce their desired opium production levels by offering prices that did little more than make poppy competitive in a strict dollar-for-dollar sense. There does not appear to have been a substantial drug-crop premium.

The poppy-cultivating environment changed dramatically in 2001, but farmers continued to devote similar portions of their land to poppy. Prior to the planting season for the 2001 harvest, the Taliban vowed to crack down on poppy cultivation, leading to a dramatic reduction in cultivation levels for that year. Unsurprisingly, there was also a dramatic increase in prices. Despite renewed threats of poppy crackdowns after the Taliban's fall, these price increases proved sufficient to bring cultivation and production back to their previous levels.

The paths of opium prices and poppy cultivation at the national level can be seen in Figure 1. I interpret these data under the assumption that farmers base their planting decisions for year t on the prices they received at the harvest in year $t-1$.[12] Together, this assumption and knowledge of the crop-eradication environment from 2000 to the present can feasibly explain the major shifts in both prices and cultivation levels during recent years. In short, the Taliban's threat of wide-scale crop eradication prior to the 2001 planting season induced a drop in cultivation from 82,000 hectares in 2000 to 8,000 hectares in 2001. Traffickers reacted by raising prices from $28/kg at the 2000 harvest to $301/kg at the 2001 harvest. Despite the continued threat of eradication on the part of the provisional Afghan government, this price was sufficient to bring cultivation back to a level of 74,000 hectares in 2002.

[12] This assumption is discussed more fully in Section 5 when I estimate a range for the supply elasticity.

Figure 1: National Opium Poppy Cultivation and Price Levels



Source: UNODC, 2006a

Since then, cultivation levels have increased substantially while prices have fallen moderately below $100/kg. It seems plausible that this has resulted from decreases in eradication expectations and respect for the law. As actual eradication efforts have taken place on a relatively small scale, farmers have likely revised their expectations down from initially high levels (that reflected the initially credible threat of wide-scale eradication) towards the true level of eradication.

Additionally, despite the high levels of prices in recent years relative to the 1990s, individual farmers still devote a relatively small fraction of their land to poppy rather than all or most of it. Hence, although it may now be “profitable” to hire itinerant labor to cultivate opium poppy beyond the labor constraint, this option is not desirable when the returns to cultivating poppy are adjusted for risk and for the drug-crop premium.

The last few years suggest that intensive crop eradication has the potential to raise opium prices into the $300-$350 range, but that current eradication levels are incapable of maintaining prices above $100. The UNODC (2006a) reports that it was able to confirm the eradication of 15,300 hectares of poppy in 2006, and that 165,000 hectares were ultimately harvested. This implies that about 8.5% of the initially-planted hectares were eradicated. With this level of eradication and a 2006 harvest price of $94/kg, poppy cultivation increased to 193,000 hectares in 2007, and the price went down moderately to $86/kg. In the absence of the opium ban and current level of eradication, conditions would be similar to the way they were during the 1990s. Hence, absent significant changes in input costs and input requirements, the price of opium would be expected to return to around $40/kg, where it stood in the 1999. I thus estimate that the current environment is capable of raising the price of opium by about $46/kg.

It also seems clear from the experience of 2002 and 2003, however, that heightened eradication expectations can lead to substantial price increases, as the price of opium averaged $350/kg at the 2002 harvest. Unfortunately, the need to model the drug-crop premium and its interaction with eradication risks complicates efforts to estimate the precise risk perceptions needed to raise prices to these levels. It may be that this would require enforcement levels that are not politically feasible for Afghanistan's government.

All else equal, a doubling (or tripling) of wheat revenues would increase opium prices by about $20/kg (or $40/kg). These numbers were calculated by taking the data in Table 1 and multiplying wheat revenues by 2 and 3 (so that $\Delta P_O = \Delta P_W Y_W / Y_O$). It appears that alternative crops other than wheat may hold the promise of even higher revenues, and hence be capable of increasing opium prices by more substantial amounts. For example, UNODC (2003c) suggests that revenues from black cumin may average around 6 times the per-hectare revenue available from wheat (although input costs are not reported). Such an increase in alternative incomes could potentially increase opium prices by $100/kg. However, the feasibility of such alternatives is not entirely clear. In some cases, it may be that such alternatives are not adopted due to either a lack of knowledge or to the limited presence of normal lending institutions.

All else equal, a doubling (or tripling) of alternative (non-harvest) wage-earning opportunities would increase opium prices by about $4/kg (or $8/kg). These price increases result from the fact that poppy cultivation is more labor intensive than wheat cultivation. The price increase equals $\Delta w(L_{O,nh} - L_W)/Y_O$, or the wage increase times the difference between the labor requirements for poppy and wheat, divided by the opium poppy yield. If the wage increase (of $1.50 or $3) also applies to harvest wages (including that by the family's women and children), the price increases would be larger, namely $12/kg and $24/kg.

The opium-price increases achievable through increases in alternative farm incomes and wages appear small. However, it should be noted that these increases may be magnified by interactions with the premium for cultivating a drug crop. This would be the case if the premium is realized, at least in part, as a preference for licit income as a multiple of illicit income.

The analysis in this section produces my estimates of the capacity for source-country policies to shift the opium supply curve upward. In the next section, I develop estimates for the source-country supply and demand elasticities. The methodologies used to derive these estimates are meant to look deeper into the causes of source-country supply and demand than one can go by simply tracking the movements of country-level quantities and prices over time. Nonetheless, the estimate ranges do contain the estimates one could derive with simple calculations using country-level data surrounding the supply shock caused by the Taliban in 2001.[13]

5. Supply and Demand Elasticity Estimation

5.1. The Elasticity of Supply

To estimate the elasticity of supply, I model the number of hectares cultivated in a district or province as being determined by prices from the previous year. This model is uniquely suited to agricultural settings for two reasons. First, the number of hectares cultivated and the market price are not subject to instantaneous adjustment, but are determined at discrete moments in time each year (namely the planting season and the harvest season). Second, since the determinations of quantity and price take place at different times during the year, it is possible to treat the harvest price as the price to which

[13] For example, the fact that in 2000 traffickers paid $28/kg for the produce of 82,000 hectares and in 2002, the year after the 2001 supply shock, paid $350/kg for the produce of 74,000 hectares, could suggest a demand elasticity estimate of the form $[\ln(Q_t)-\ln(Q_{t-2})]/[\ln(P_t)-\ln(P_{t-2})] \approx -.04$. Similarly, the fact that farmers cultivated 74,000 hectares in 2002 (in response to a 2001 price of $301/kg), and 80,000 hectares in 2003 (in response to a 2002 price of $350/kg), could be used to suggest a supply elasticity estimate of the form $[\ln(Q_t)-\ln(Q_{t-1})]/[\ln(P_{t-1})-\ln(P_{t-2})] \approx .52$. Performing this same calculation on year-earlier data results in an elasticity estimate of ≈ 0.94.

farmers are reacting when they make planting decisions.

As discussed in the previous section, many factors beyond the price of opium work to determine opium supply. Unfortunately, with the exception of wheat prices, data availability precludes the possibility of controlling for these other factors. I discuss the potential biases associated with these other omitted variables below.

I avoid the complications of crop eradication (and shifting attitudes towards the law) by basing my estimates on data for the pre-eradication time period of 1994-2000. Additionally, yields and input requirements would, to a large extent, be products of the underlying quality of the land. Consequently, expectations going into each year would remain essentially the same. Maatman et al. (2002) point out, however, that planting decisions are affected by rainfall early in the planting season, which is a determinant of yields. Resulting changes in yield expectations, as well as fluctuations in the prices of labor and capital (and in the prices of crop alternatives other than wheat), pose genuine econometric concerns, and would bring a negative bias to the estimates. Since these factors bring considerable uncertainty to the quality of the estimates, I present the effects of source-country policies assuming a wide range of supply elasticities, with allowance made for likely negative bias due to the failure to control for all supply determinants.

The regressions take the following forms, with the number of hectares cultivated with poppy taken as a function of either the previous year's price of opium alone, or as a function of the previous year's prices of both opium and wheat:

$$\ln(H_{O,t,i}) = \beta_0 + \beta_1 \ln(P_{O,t-1,i}) + R_i + T_t + \mu_{t,i} \quad \textbf{(10)}$$

$$\ln(H_{O,t,i}) = \beta_0 + \beta_1 \ln(P_{O,t-1,i}) + \beta_2 \ln(P_{W,t-1,i}) + R_i + T_t + \nu_{t,i}, \quad \textbf{(11)}$$

where R_i is a region fixed effect, T_t is a year fixed effect, and $\mu_{t,i}$ and $\nu_{t,i}$ are error terms.

From 1994-2000, the UNODC collected poppy-cultivation data at the district level, which can be aggregated to construct province-level observations. During much of this time period, the UNODC reported price data for both opium and wheat at the province level. I associate the prices from 1994-1999 with cultivation levels from 1995-2000. Since wheat prices were only reported from 1994-1997, specifications that include the wheat price only use poppy-cultivation data from 1995-1998. In some specifications, I have matched the province-level price data with province-level cultivation data and, in others, with the more detailed district-level cultivation data.

Results can be found in Table 2. Specifications 1 and 2 in both panels make use of all available observations. Specifications 3 and 4 restrict the sample to districts that cultivated at least 50 hectares (panel A) and provinces that cultivated at least 250 hectares (panel B). This is done because cultivation sometimes begins in a district (or province) on a small scale, then increases dramatically in the next year if the crop is fully phased in. Cultivation increases of this sort would, in effect, result from shifts of the district- or province-level supply curve rather than from movements in price.

The estimates suggest that district and province poppy-cultivation levels are fairly responsive to prices. The district-level estimates of the price elasticity range from 0.59 to 0.97. The province-level estimates range from .60 to 1.55. While the estimates seem plausible, they are not particularly precise. In my central estimates of the effectiveness of

Table 2

Estimates of the Price Elasticity of Hectares Cultivated

Panel A: Estimates using district-level cultivation data	(1)	(2)	(3)	(4)
ln (opium price)	0.59	0.97	0.77	0.87
	(0.52)	(0.81)	(0.37)	(0.55)
ln (wheat price)		-0.23		-0.05
		(0.57)		(0.34)
District Fixed Effects?	Yes	Yes	Yes	Yes
Year Fixed Effects?	Yes	Yes	Yes	Yes
No. of Observations	331	217	283	183

Panel B: Estimates using province-level cultivation data	(1)	(2)	(3)	(4)
ln (opium price)	0.88	1.55	0.60	0.83
	(0.59)	(1.12)	(0.38)	(0.77)
ln (wheat price)		1.16		0.41
		(1.00)		(0.78)
Province Fixed Effects?	Yes	Yes	Yes	Yes
Year Fixed Effects?	Yes	Yes	Yes	Yes
No. of Observations	38	27	33	22

Note: Standard errors are reported in parentheses beneath each point estimate. All standard errors are heteroskedasticity robust and allow for clustering at the district or province observation level as appropriate. In panel A, specifications 3 and 4 differ from specifications 1 and 2 in that observations are not included if the number of hectares cultivated with poppy was less than 50. Panel B is similar, but with a 250-hectare cut off for the province level.

source-country control, I use an elasticity of 1. I also show results with elasticities as low as .25 and as high as 2.

As a final note, these estimates are of elasticities at the province and district level as opposed to the national level. As poppy has expanded beyond the 5 most traditional poppy-cultivating provinces, there have been increases in national production which were not brought about by changes in price. Now that poppy has been cultivated in all of Afghanistan's provinces, however, changes in national cultivation will be more closely tied to the province- and district-level elasticities.

5.2. The Elasticity of Demand

The final key parameter of the market for opium in Afghanistan is the elasticity of demand. As noted in section 3, the demand for opium at the Afghan farm gate is derived from the demand for opiates in final consuming markets. It was observed there that an estimate of the elasticity of demand for Afghan opium can be derived by estimating α_R, β_R, and ε_R, and substituting equation 6 into equation 7 to produce equation 8.

Central to this method for analyzing the demand for Afghan opium is estimating the relative importance of the parameters in equation 6. In this equation, α_R is a fixed, additive markup, and β_R is a multiplicative markup that determines the potential effect of changes in the source-country price on the prices faced by consumers.

As discussed in Sections 2 and 3, Kennedy, Reuter, and Riley's (1993) analysis of cocaine production assumed that $\beta_R = 1$. This assumption, coupled with their use of the U.S. price as a world price, led them to implicitly assume a very low elasticity of demand at the source-county level.[14] The assumption that $\beta_R = 1$ implies that all trafficking costs are independent of the source-country price. This may be a reasonable approximation for many trafficking costs (for example, transportation costs, most personnel costs, and markups due to the risk of legal sanctions). Other factors, however, would be directly linked to the source-country price. For example, the opportunity cost of the financial

[14] Kennedy, Reuter, and Riley assume a retail price of $135,000, which consists of a $3,820 price at the source-country border and an additive markup of about $131,000. They also assume a retail demand elasticity of 0.5. These numbers imply that, for example, a doubling of the source-country price would increase the retail price by about 2.8%, resulting in a demand reduction of about 1.4% and implying a source-country price elasticity of about -0.014.

capital sunk into the heroin itself would be multiplicative.[15] Additionally, since illicit industries lack legally-binding contracts, high source-country prices may make it necessary to pay higher wages to personnel to dissuade couriers from stealing the product.

Empirical work on trafficking markups has not produced definitive estimates of the extent to which markups are additive and multiplicative. Several studies of cocaine prices use data from the U.S. Drug Enforcement Administration's (DEA's) System to Retrieve Information from Drug Evidence (STRIDE) program, which tracks the price of drugs at different quantity levels within the U.S. (as they proceed from wholesale to retail). Using these data, Caulkins and Padmin (1993) find evidence against a simple model that implies a fixed cost per transaction, suggesting that retail prices are not determined by a strictly additive markup structure. Caulkins (1994), using STRIDE data from 1977-1991, finds evidence that is consistent with a multiplicative model. Desimone (2006), on the other hand, using STRIDE data from 1985-2000, arrives at the opposite conclusion with essentially the same regression specification as Caulkins.[16] Using similar data, Rhodes et al. (2001) find that multiplicative markups are likely small, that estimates are sensitive to the use of various time trends, and that, in the case of heroin, it is difficult

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[15] This cost would take the form of the foregone risk-adjusted return, which, given the high-risk nature of heroin trafficking, would be compounded at a high rate.

[16] Desimone (2006) writes that this difference may be due to fundamental changes in the cocaine market from the earlier to the latter period, the fact that he has a larger sample, the fact that he uses a less restrictive outlier filter, or possibly differences in the ways that he and Caulkins standardized prices to reflect differences in purity levels. As Desimone did not have access to data from the late 1970s and early 1980s,

to identify a multiplicative markup at all.[17]

It should be noted that these studies apply directly to a small portion of the trafficking universe, namely the portion within a Western consuming nation with relatively strict drug laws. They tell us little, if anything, about the nature of markups along other portions of the trafficking chain. However, the absence of spikes in retail prices in response to substantial changes in source-country cocaine and heroin prices suggests that multiplicative markups from source-country to retail prices are modest.

Consistent with intuition and the available empirical work, I present results using a range of small to moderate values for β_R, namely 1, 3, and 5.[18] I then collect a set of heroin prices for the regions of the world that consume Afghan opium (see Table 3).[19]

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however, he reports that he was unable to attempt to replicate Caulkins' results directly.

[17] The 2006 *World Drug Report* (UNODC 2006b) provides annual data for U.S. and European heroin prices, making it possible to run naïve regressions of retail prices on source-country prices. The regression on U.S. prices suggests a multiplicative markup of about 4, while the regression on European prices suggests 2. These regressions include a time trend. The price of fresh opium is multiplied by 10 (to account for the amount of opium required to produce a kilogram of heroin), and the Afghan prices are lagged by 1 year (to allow for the time between the opium harvest and the arrival of heroin on retail markets).

[18] The high end of 5 is roughly derived from Caulkins (1994). Caulkins found evidence in favor of a multiplicative markup from the U.S. border to U.S. retail markets. The implied multiplier for this portion of the trafficking chain would have been between 4 and 5. Applying a multiplicative markup of 5 to all regional retail markups is, if anything, overly charitable towards source-country policies.

[19] These prices were obtained from two UNODC reports (2003c, Annex 7; 2004c, 366-368). These sources were chosen because the price observations are reported alongside an estimate of heroin purity

These prices come from 2001 and 2002. I associate heroin prices for a given year with opium prices from the previous year.

Next, I work through the following series of calculations. Given the known heroin prices from Table 3, I either work forward to estimate a 2002 price based on the known 2001 price, or backward to a 2001 price based on the known 2002 price. The difference between the 2001 and 2002 prices equals $\beta_R(3{,}010 - 280) \times I$.[20] This difference comes from three sources: the multiplicative markup, the difference between the cost of the opium required to produce 1kg of heroin in 2000 and 2001 ($3,010 and $280 respectively),[21] and an adjustment for interdiction, I. Interdiction effectively increases the amount of heroin that must be produced in the source country to deliver 1kg of heroin to retail markets. It thus magnifies the impact of increases in farm-gate opium prices. My interdiction adjustment of 1.316 is based on recent seizure data from UNODC (2006b).

The remaining calculations proceed as follows. I compute the log change in retail

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whenever purity information is available. I have restricted the data used to form my estimates to the observations for which there are purity estimates, and I have scaled all price estimates to coincide with a purity level of about 85%. These estimates are meant to capture the reality of increasing prices along the trafficking chain.

[20] This is subject to the constraint that the additive markup can never be less than zero.

[21] UNODC estimates (2005a) suggest that about 7kg of dry Afghan opium were required to produce 1kg of heroin. Unfortunately, UNODC's annual series on the average price of opium in Afghanistan reports the price of fresh opium. UNODC (2005a, Table 20) provides data suggesting that the price of dry opium tends to be around 140% of the price of fresh opium. My figures multiply the fresh prices by $7 \times 1.4 \approx 10$.

Table 3

Regional Price Data and Weights Used in Demand Elasticity Estimates (Prices in $/kg of heroin)

Region	Known 2001 Heroin Prices (US$)	Known 2002 Heroin Prices (US$)	Assumed Harvest Year	Assumed Afghan Heroin Price (US$)
Western Europe and North America	238000		2000	280
Eastern Europe	154500		2000	280
South and South East Asia	108200		2000	280
Central Asia		46400	2001	3010
Africa	38300		2000	280
Iran		26000	2001	3010
Pakistan		15500	2001	3010

	Opiate Weights	Heroin Weights
Western Europe and North America	0.158	0.207
Eastern Europe	0.195	0.211
South and South East Asia	0.401	0.352
Central Asia	0.025	0.035
Africa	0.072	0.101
Iran	0.095	0.039
Pakistan	0.055	0.056

Sources: UNODC (2003c, 172, 180, 191, and Annex 7; 2004c, 336-368; 2006b, 75).

Note: Prices are purity-level adjusted to approximate the price of a kilogram of 85% purity, which is the approximate purity of much of the heroin at the beginning of the trafficking chain. Prices for Western Europe and Eastern Europe are straightforwardly based on data from UNODC (2003c, Annex 7). Prices for South and Southeast Asia, Central Asia, Iran, Pakistan, and Africa are based roughly on data from UNODC (2003c), and the 2004 *World Drug Report* (UNODC 2004c). Data on purity levels are spotty in many cases. This makes it necessary to use a degree of discretion to ensure that the full set of prices captures the essential feature of increasing prices along the trafficking chain. Assumed Afghan heroin prices are simply ten times the national price for a kilogram of fresh opium in the assumed harvest year. The opiate and heroin weights are based on drug abuse statistics which can be found in UNODC (2003c), for Iran, Pakistan, and Central Asia, and the 2006 *World Drug Report* (UNODC 2006b).

prices between 2001 and 2002, then multiply these changes by a literature-based estimate of the retail elasticity of demand for heroin, namely -1 (see Section 2). This produces my estimate of the log change in the quantity demanded in each region. The elasticity of demand to the Afghan price is then the log change in quantity divided by the log change in the Afghan price.

The final step towards a cumulative demand elasticity involves establishing weights for the percentage of Afghan opium consumed in each region. I develop two sets of weights, both of which can be found in Table 3 and both of which refer largely to data from the 2006 *World Drug Report* (UNODC 2006b). One set of weights uses data on the number of all opiate users around the world, while the other set focuses on the number of heroin users. Estimates for the number of users in Iran, Pakistan, and Central Asia come from UNODC (2003c). I assume that Afghanistan supplies the opium used by all addicts in its neighboring regions, Africa, and Europe. I add one-third of all North American addicts to the number of users in Western Europe to account for Afghan opium consumed in the United States and Canada. I then add as many South and East Asian users as necessary to bring the total number supplied by Afghanistan to 80% of the world total. The heroin weights result in slightly smaller estimates than the opiate weights because heroin use is more concentrated in Western Europe, where the Afghan price is a relatively small fraction of the retail price.

The source-country demand elasticity estimates range from $-.022$ to $-.159$. My central estimates of the potential effects of source-country policies use an elasticity of $-.090$, and sensitivity to the entire range is reported.

A drawback of these estimates is that I cannot use region-specific estimates of β_R and ε_R. This is because past studies of these parameters have been based on U.S. and European markets. Similarly, the weights suffer from a lack of knowledge about the quantity of opiates consumed per user in each region. These shortcomings point to contributions that could be made by future studies of region-specific opium usage and by the production of a more comprehensive panel of retail price data around the globe.

6. Potential Policy Effects, Discussion, and Conclusion

The analysis conducted in the previous sections enables me to estimate the equilibrium effects of various levels and forms of crop eradication and alternative development. As outlined in Section 3, I produce these estimates by substituting values for ΔP, ε, and θ into equations 1 through 3. Using the national figures from the 2007 opium survey, I assume an initial equilibrium at a price of $86/kg of opium and a total of 193,000 hectares cultivated.[22]

The results, presented in Table 4, suggest that the source-country policies considered here have the potential to bring about limited (and, in most cases, quite small) reductions in opium production. The largest estimated effect is associated with

[22] The estimate of the number of hectares cultivated, which was a record high in 2007, does not significantly affect the results because they are reported as percent changes in cultivation. The assumed initial price has a moderate impact on the results for alternative development, and turns out to be most significant for the estimated effect of ceasing eradication altogether. This is because assuming an equilibrium price implicitly involves assuming the extent to which current eradication policy has raised the price above the levels observed during the 1990s.

increasing eradication enough to restore farmers' 2002 risk perceptions. The estimated reductions associated with this policy range from 3.0-19.4%, depending on the assumed supply and demand elasticities. Past experience suggests that the increase in eradication needed to bring farmers' risk perceptions to these levels would be substantial, and that the Afghan government may not be in a position to carry out such an effort. The benefits from such an effort would have to be weighed carefully against costs such as its possible impact on the loyalty of farmers to the national government versus Taliban insurgents. The high-end estimate of 19.4% results from assuming a multiplicative markup of 5, which likely provides an overly-optimistic assessment of the potential for source-country prices to impact retail prices.

Increases in alternative incomes appear to be incapable of producing meaningful reductions in poppy cultivation. If the incomes associated with wheat production were to triple, the estimates suggest that opium production would fall by only 0.8-5.3%. Even the introduction of new crops with revenues 6 times those from wheat would decrease poppy cultivation by only 1.7-10.8%. The decreases in poppy production attainable through increases in daily wages are smaller yet. A $3 increase in all daily wages is estimated to reduce poppy cultivation by 0.5-3.5%. Also noteworthy is that a cessation of eradication activities (which would allow the price of opium to return to around $40/kg as observed in 1999) would lead to an estimated production increase of only 1.6-9.6%.

These results suggest that, in the absence of substantially higher levels of crop eradication (which the government does not appear to be in a position to carry out), the

Table 4

Estimated Equilibrium Impacts of Various Source-Country Policy Outcomes

		Estimated % Change in the Number of Hectares Cultivated					
		Supply Elasticity = 1.0			Supply Elasticity = 0.25	Supply Elasticity = 1.0	Supply Elasticity = 2.0
Source-Country Policy	Estimated Supply Curve Shift (US$)	Demand Elasticity = -0.022	Demand Elasticity = -0.090	Demand Elasticity = -0.159	Demand Elasticity = -0.090		
Eradication							
Cease Eradication	-46	1.62	5.97	9.62	4.10	5.97	6.49
Eradicate 8.5%	0	0.00	0.00	0.00	0.00	0.00	0.00
Restore 2002 Risk Perceptions	264	-3.02	-11.64	-19.38	-11.10	-11.64	-11.75
Increases in Alternative Farm Incomes							
Double Wheat Income	20	-0.45	-1.74	-2.90	-1.45	-1.74	-1.80
Triple Wheat Income	40	-0.82	-3.19	-5.34	-2.73	-3.19	-3.28
New Crop with 6 x Wheat Income	100	-1.67	-6.45	-10.82	-5.83	-6.45	-6.58
Increases in Alternative Wage Opportunities							
$1.50 (applied to non-harvest only)	4	-0.10	-0.38	-0.63	-0.30	-0.38	-0.39
$3.00 (applied to non-harvest only)	8	-0.19	-0.74	-1.23	-0.60	-0.74	-0.77
$1.50 (applied to all labor)	12	-0.28	-1.08	-1.81	-0.89	-1.08	-1.12
$3.00 (applied to all labor)	24	-0.53	-2.05	-3.45	-1.72	-2.05	-2.12

Source: Author's calculations assuming simple forms for supply and demand and an initial price of $86/kg of opium.

prospects for large-scale, short-run reductions in poppy cultivation (and hence of the quantity of opiates on the global market) are fairly grim. To the extent that reductions are brought about, they would be concentrated in the areas closest to Afghanistan, which have relatively high demand elasticities with respect to the Afghan price. Reductions in European markets would be smaller since the Afghan price has a relatively small impact on European prices. U.S. markets would be even less affected since much of the heroin consumed in the United States comes from Mexico, South America, or Southeast Asia. Additionally, these reductions would likely be limited to the short run since other source countries would begin to replace Afghanistan over longer time horizons.

Significant increases in enforcement activities and alternative incomes would also be necessary to achieve the goal of pushing opium out of Afghanistan over the long run. Achieving this second goal, which would yield relatively little benefit in terms reducing global opiate consumption, would at minimum require sustaining Afghan prices at levels above those observed in other major source-countries. Such prices are achievable, as price data from 2001-2003 suggest, but not at current enforcement levels.

Progress towards either the goal of reducing the quantity of opiates on the global market or of pushing opium out of Afghanistan should be measured within a historical context. U.N. estimates suggest that Afghanistan produced 8,200 metric tons of opium in 2007 and 6,100 tons in 2006 (UNODC 2006a, 2007a). By comparison, the U.N.'s estimates for total global production in each of the previous 4 years are between 4,500 and 4,900 metric tons (UNODC 2007b). Meaningful reductions in the quantity of opiates on the world market would require depressing Afghan production below 3,500 metric tons (the estimated average for 2002 and 2003) rather than just reducing it on the margin from its high current level. This would be linked to reducing the hectares of poppy from the current level (around 193,000 hectares in 2007) to below 80,000 hectares (the level observed in 2003).

An additional form of source-country policy, which is not analyzed here since it does not target farmers directly, is source-country interdiction (for example, targeting heroin laboratories). Interdiction effectively increases the amount of opium that must be produced for a kilogram of heroin to get out of the country. If half of all opiates are interdicted, for example, input *requirements* would effectively double (since 2 kilograms of product would be needed to get 1 kilogram out of the country). Input *costs*, on the other hand, would more than double since doubling production requires moving up the supply curve. Interdiction can cloud our judgment of the effectiveness of policies that target farmers since it can result in increases in poppy cultivation even while reducing the quantity of opiates that leaves the country. UNODC (2007b) seizure data suggest that increases in interdiction over the past several years can help to explain why record high levels are poppy cultivation are being observed.

A word should also be said about the distributional effects of the policies that have been considered. Increases in farm incomes would improve the well-being of farmers across the board. By introducing a premium for involvement in an illicit activity, the poppy ban benefits the farmers who are least inclined to respect the law and harms law-abiding farmers who would otherwise have cultivated poppy on the basis of factors like relative yields. Crop eradication raises the premium for illicit activity (by giving the law credibility) and introduces an additional premium for risk. Eradication thus results in particularly large gains for those who disobey the law and get away with it, while imposing costs on those who disobey the law and are punished. As for those who are punished, it should be noted that since poppy is typically cultivated on a small fraction of any given farmer's land (about 1/7th), the loss in poppy income may be substantial relative to other income, but the loss in terms of alternative licit incomes is not particularly large.

As is apparent in Table 4, the results are far more sensitive to variations in the assumed elasticity of demand than in the assumed elasticity of supply. Additionally, it is the inelastic character of source-country demand that drives the small size of the estimated effects of source-country policy. This is significant, because although the methodology used to characterize source-country demand is more fully developed than those found in previous studies, estimates of many key factors could be substantially improved. In terms of data, the reliability of source-country demand elasticity estimates could be improved by more complete information on the prices, purities, and average levels of consumption-per-addict that prevail around the world. Analysis of regional retail demand elasticities (particularly for opiate consumers in Asia) is also needed. Additionally, and perhaps most importantly, the estimated demand elasticities are sensitive to the assumed markup structure, on which the literature does not agree.

Future work may also enrich our understanding of policy's ability to shift the supply curve. The data used and presented here are sufficient to make rough estimates of the potential impacts of alternative development and crop eradication policies, but complexities have hindered the development of a convincing, estimable model of their effects. The premium for engaging in illicit activity and its interaction with eradication and alternative incomes pose particularly notable difficulties. Insights from the economic analysis of crime and from other disciplines may provide opportunities for improvement Finally, the stochastic programming approach to modeling farmer decision making may deepen our understanding of how farmers respond to various forms of risk.

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