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Counterproductive Counternarcotic Strategies?

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# Counterproductive Counternarcotic Strategies?*

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**Abstract:** We model the economic incentives surrounding opium crop production in Afghanistan. Specifically, we examine the impact of eradication policies when opium is used as a means of obtaining credit, and when the crops are produced in sharecropping arrangements. The analysis suggests that when perfect credit markets are available, an increased risk of eradication will lead to less land being allocated to opium poppy. However, when opium is used as a means of obtaining credit, the effects of eradication are no longer clear-cut. Finally, under sharecropping arrangements, increased risk of eradication will make the tenants worse off, while landlords may benefit.

**Keywords:** Eradication, Informal credit markets, Opium, Sharecropping.

**JEL classification**: Q12

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Afghanistan is the leading producer of opium in the world. In 2010, Afghanistan accounted for 63% of the world's opium production (UNODC 2011). The high level of production has been of international concern not only due to the health problems related to its usage, but also due to its contribution to insecurity, instability, and corruption, both within and beyond Afghanistan's borders (Clemens 2007). An important part of the counternarcotic strategy to combat the production of opium in Afghanistan has been eradication of opium poppy. However, eradication of opium poppy is highly controversial. Advocates argue that a credible threat of eradication is necessary for farmers and landowners to refrain from opium cultivation, while critics argue that eradication is inefficient and often even counterproductive (Blanchard 2009). In addition, eradication often targets poor farmers who have few alternative sources of income. Indeed, the questionable success of eradication strategies calls for a closer examination of the economic incentives that are at play at farm level in the Afghan opium industry. Are there factors in the market structure surrounding opium crop production that affects the outcome of the eradication policies and cause the usual assumption of increased risk of eradication – lower levels of crop production – to be unfounded?

In this article, we consider two features that have been associated with Afghan opium crop production (Mansfield 2003):

- That opium can be used as a means of obtaining credit through advance sales of future harvest, and
- That the crops often are produced in sharecropping arrangements.

The purpose of this article is to develop a theoretical model to understand whether and, if so, how these circumstances can affect the outcome of opium eradication policies.

The reason for studying the effects of eradication under different credit and land tenure systems is that the formation of these systems in Afghanistan often differs from the perfect credit and land rental markets that are usually assumed when evaluating economic policy. In Afghanistan, as is often the case in areas where the environment is inherently risky and formal credit and insurance markets are limited, informal credit systems and sharecropping arrangements have become integral parts of the rural economy. In these credit and land rental systems, the opium poppy has, due to its favourable characteristics, come to play an important role both as a means of obtaining credit through advance sales of future harvest, and as a means to obtain land through sharecropping arrangements. It has been widely recognised that these roles are likely to influence the choice of what crops to cultivate (see e.g. Mansfield 2003). However, to the best of our knowledge, there has been no attempt to launch an in-depth investigation on the underlying mechanisms of how and when these circumstances affect the outcome of opium eradication.

The theoretical analysis presented in this article suggests that, when perfect credit markets are available, an increased risk of having the opium poppy eradicated will lead to less land being allocated to opium poppy production. Hence, when perfect credit markets are available, the eradication policies are likely to have the intended effect. However, if opium is used as a means of obtaining credit, the analytical results suggest that the outcome of an increased risk of eradication is no longer clear-cut: it will depend on how much opium is sold prior to harvest and on the degree of risk aversion. If the farmers are sufficiently risk-averse and all opium poppy crops are sold prior to harvest, the land allocated to these crops may actually increase. The analysis also indicates that, when the opium poppy is grown in a sharecropping arrangement, the tenant will unambiguously suffer losses from increased risk of eradication; on the other hand, under some circumstances, the sharecropping landlord may actually benefit from increased risk of eradication. These results indicate that ignoring the role of opium in the rural economy can lead to eradication policies having perverse outcomes.

This article relates to several strands of previous literature. Firstly, it relates to models of crime put forward in the seminal work by Becker (1968). In these models, crime is seen as an economic decision: a crime is committed if the expected utility of committing it outweighs the expected utility of using the resources in an alternative activity. Specifically this article relates to the models of crime where the choice of illegal crop production is addressed; in this regard the contributions by Ibanez (2010), Clemens (2008) and Willumsen (2006) are notable. Ibanez (2010) evaluates the effects of eradication and alternative development programs in Colombia and finds only modest responses in cultivation to the two policies. Clemens (2008) estimates supply and demand elasticities for opium and simulates the equilibrium effects of eradication in Afghanistan. He finds that, in order to achieve even modest decreases in opium production, substantial increases in opium eradication are needed due to low source-country demand elasticities. However, neither Ibanez (2010) nor Clemens (2008) take into account that, if the illegal crop can be used as a means to obtain credit or is produced in sharecropping arrangements, this can affect the outcome of eradication policies. Willumsen (2006), on the other hand, acknowledge the role of opium as a means of obtaining credit and studies whether the Afghan opium production is debt-induced.

Secondly, this article relates to the literature on sales of crop production in futures markets, where the first formalisation of the problem is presented by Stiglitz (1983).

Finally, this paper also relates to the theoretical models of sharecropping (see e.g. Singh 2000 for an overview). Of special interest in this regard is the contribution by Braverman and Stiglitz (1986) and their result that, in a sharecropping arrangement, a landlord may actually benefit from resisting technological innovation if the improved technology leads to a sufficiently large negative supply response on behalf of the tenant.

The main contribution of this article is to connect these different strands of literature in order to analyse the impacts of eradication policies, given the economic and institutional setting facing opium farmers in Afghanistan. The principal model developed in this article is a version of Becker's choice between legal and illegal activities, connected with Stiglitz's model of sales of an uncertain output of crops on a futures market on the one hand, and Braverman and Stiglitz's set-up of the sharecropping model on the other. Other aspects that influence the choice of illegal activities, such as social norms, morality, threats, violence and the legitimacy of authorities are left out of the analysis in order to keep the model as simple as possible.

In the next section, the institutional setting is described. The focus is on how opium is used as a means of obtaining credit and the methods used to eradicate opium in Afghanistan. In the subsequent section, we set up a number of theoretical models to study the outcome of opium eradication under different credit and land tenure systems. In the first theoretical model, we investigate how an increased risk of eradication affects the land allocated to opium poppy crops when perfectly functioning credit markets are available. In the second model, we investigate how the land allocated to opium poppy crops is affected by an increased risk of eradication when opium is the only means of obtaining credit. In the final model, we investigate how the costs and benefits for landlords and tenants, respectively, are affected by an increased risk of eradication. The article ends with a discussion of the results of these investigations, and of issues that are left for future research.

## Institutional setting[1]

Advance sales of future harvest and the formation of sharecropping arrangements are features that are commonly associated with agricultural markets worldwide. Advance sales of future harvest give farmers the opportunity to obtain credit and insure against future fluctuations in price, while sharecropping arrangements give stakeholders an opportunity to share risk and compensate for asymmetric information. In areas like rural Afghanistan, where formal credit and insurance are lacking, these kinds of credit and land tenure systems are especially important as a means of insuring against risk and smoothing consumption over time.

The opium poppy has, due to a number of specific features, come to play an important role in these markets of advance sales and sharecropping arrangements. The characteristics that make opium different from many other crops are that it –

- has a high value

- is light in weight, which makes it easy to transport from remote areas
- is non-perishable, which makes it easy to store
- is not as sensitive to local pests as many other crops
- can be grown at high altitudes, and
- is highly labour-intensive.

The fact that opium is easy to store and transport is likely to make it an attractive crop on which advances can be given, as this allows the buyer to spread risk between regions and over time. This characteristic is likely to be especially attractive, considering that many of the other markets for agricultural production in Afghanistan are likely to be shallow, which makes the risk for a local supplier of credit on future crop harvests extremely high. The high labour intensity in opium cultivation is also likely to make sharecropping an attractive arrangement as regards land tenure, as costs associated with monitoring wage labour would be high. These assumptions seem to be confirmed in the field. Mansfield (2003) and Mansfiled and Pain (2005; 2006; 2007) find that lenders often prefer to give advances on opium poppy rather than other crops. In addition it is concluded that opium plays an important role as a means for poor farmers to gain access to land: sharecroppers who are willing to grow opium are given preferential treatment by landlords.

In Afghanistan, agricultural credit known as *salaam* is usually given through a system of advance sales of future harvests. The system is essentially that farmers sell their crops prior to harvest, often at a price that is significantly lower than the market price. Once the crop is harvested, it is delivered to the lenders, who can resell it at a higher price on the market. Mansfield (2003) reports that, for many resource-poor farmers, advance sales of opium are their only means of obtaining credit during the winter season. It is also reported that many of these resource-poor farmers sell their entire crop prior to harvest in order to cover consumption needs and to buy agricultural inputs. The market structure surrounding opium-based salaam seems to differ from one geographical location to another. A field study of farm-gate opium traders (UNODC 1998) found that, in eastern Afghanistan, salaam was usually provided by shopkeepers; in the southern regions, salaam was provided by a range of different intermediaries in the opium trade. Generally, it seems that the opium trade in southern Afghanistan is more open and 'legitimate', and is characterised by numerous buyers and sellers. In the eastern and central provinces of Afghanistan, on the other hand, the opium trade seems to be more centralised, with fewer traders (Pain 2006; UNODC 1998). In the latest Opium survey from Afghanistan, the number of villages in which advances were given on opium ranged between 8-57% between provinces (UNODC 2011).

As is always the case with advance sales, there is a risk that the opium is never delivered to the lender, e.g. due to crop failures, eradication, or moral hazards. To limit the risk of default, salaam has often been found to be restricted to farmers that the lenders know (UNODC 1998). As regards the outcome when farmers are unable to deliver the opium, this is likely to differ from case to case. Lenders have reported that they either permit farmers to delay the delivery of opium until the following season (but then demand a higher amount), or they claim the loan amount back in cash within the same season (UNODC 1998). Irrespective of the timing of the repayment, farmers have reported that, in order to cope with an opium-denominated debt, they use a number of strategies ranging from the sale or mortgaging of their land, to marrying off their daughters (Mansfield 2006b). Opium-denominated debt is often mentioned as a driving force behind continued opium cultivation.

However, and of relevance to our modelling, the risk of undelivered opium also seems to be reflected in the advance price of opium received by the farmers. The dynamics of the price of opium-based salaam and the risk of opium poppy eradication can be seen in the patterns discerned through a series of field studies known as the *Driver Studies* (Mansfield 2003; 2004; 2005; 2006a; 2006b; 2007). In these studies, farmers' plans on what crops to grow during the season ahead as well as the underlying reasons for these plans were examined. In the first Driver Study, a large share[2] of the respondents had obtained opium-based salaam. In these deals, the price for the opium sold in advance was usually set to half the current market price. In the second Driver Study, the authors concluded that the system of advanced sales of opium harvest seemed to have been put under pressure due to a fear of eradication. They based this finding on the fact that the share of respondents who had taken this kind of credit had declined dramatically. The authors also reported that the advance price had fallen to 30–40% of the prevailing market price for those farmers who owned no land and, therefore, had been considered less creditworthy. For a comprehensive review of the literature and the linkages between opium and informal credit, see Pain (2008).

In respect of the eradication strategies themselves, their content in Afghanistan has varied over the years. The current programme was launched in 2004 and is based on forced eradication. In 2010, all opium eradication in the country was led by Governors (UNODC 2010). The methods used are mainly destruction by tractor, stick, animal plough, or all-terrain vehicles (UNODC 2009).[3] Thus, unlike the eradication policies pursued against coca farming in parts of Latin America, for example, the eradication of opium will only affect the opium crop per se and will not affect other crops grown on nearby land. This factor simplifies our subsequent modelling considerably.

## Theoretical models

In the following subsections, we investigate the effects of the eradication policy under different credit and land tenure systems in a number of theoretical models. In the first subsection, the effects of an increased risk of opium eradication on farmers' crop choices is examined in a situation when credit markets are perfectly available and the farmer can freely decide how to allocate land to different crops. In the second subsection, we present an analysis of whether these effects are altered when the only way to obtain credit is through advance sales of future opium harvest through the salaam system. In the third subsection, we present an investigation into how an eradication strategy affects landowners' profits and utility for tenants when opium is produced in a sharecropping arrangement.

### *Baseline: Perfect capital markets and rented land*

Assume that a farmer derives utility from consumption in two time periods according to the following:

(1) $V = U(x_1) + \rho U(x_2)$

where $U$ is the utility of consumption.,$x_i$ is consumption in time period *i* = 1, 2, and $\rho$ is a discount factor. It is assumed that the utility function is concave, meaning that $\frac{\partial U}{\partial x_i} = U_{x_i} > 0$ and $\frac{\partial^2 U}{\partial x_i^2} = U_{x_i x_i} < 0$. It is also assumed that the farmer can produce two goods: opium and another agricultural good. The only factor of crop production is land, $L$, which is fixed,[4] but it can be allocated freely to production of the two goods.[5] The rental cost of land is given by the price $w$. The production functions for opium and the other agricultural good can then respectively be written as $f_o(l)$ and $f_a(L-l)$.

Furthermore, it is assumed that the farmers face a risk that the opium crop production will be eradicated. Hence, the actual outcome of the such production is given as $\theta f_0(l)$, where $\theta = 1$ with probability $(1-\gamma)$, and $\theta = 0$ with probability $\gamma$. The price of opium is given by $P$ and the price of the other agricultural good is normalised to 1. The production and consumption decisions are assumed to be made at the beginning of the first period, and production realised in the second period. In the first period, the farmer can borrow at the interest rate $r$. Assuming that he borrows $x_1$, consumption in the second period is then given as follows:

(2) $$x_2 = \theta P f_o(l) + f_a(L-l) - x_1(1+r)$$

Hence, the farmer is assumed to choose how to allocate land between the two activities and consumption between the time periods in order to maximise the expected utility, given as follows:

(3) $$\begin{aligned} E(V) = U(x_1) + \rho(1-\gamma)U[&Pf_o(l) + f_a(L-l) \\ &- x_1(1+r) - wL] \\ &+ \rho\gamma U[f_a(L-l) - x_1(1+r) - wL] \end{aligned}$$

The utility in the second period differs according to good or bad outcomes. To distinguish between the different outcomes, we denote $U_g = U[Pf_o(l) + f_a(L - l) - x_1(1 + r)]$, i.e. the utility from second-period consumption when the opium has not been eradicated, and $U_b = U[f_a(L - l) - x_1(1 + r)]$, i.e. the utility from second-period consumption when the opium has been eradicated. As the income is larger in the former case, it follows that $U_{bx_2} > U_{gx_2} > 0$.

The first-order conditions are then given by the following:

(4) $$V_x = \frac{\partial E(V)}{\partial x_1} = U_{x_1} - \rho(1 - \gamma)U_{gx_2}(1 + r) - \rho\gamma U_{bx_2}(1 + r) = 0$$

(5) $$V_l = \frac{\partial E(V)}{\partial l} = \rho(1 - \gamma)U_{gx_2}(Pf_{ol} - f_{al}) - \rho\gamma U_{bx_2} f_{al} = 0$$

Equation (4) implies that, in optimum, the marginal utility of consumption in the first period is equal to the mean of the expected utility across the different states in the second period, weighted by the interest rate and the discount rate. This is an expected result, but it is mentioned here as it will be used as a point of reference in future models. Equation (5) can be reorganised to yield the following:

(6) $$\frac{(1 - \gamma)Pf_{ol}}{f_{al}} = 1 + \gamma\left(\frac{U_{bx_2}}{U_{gx_2}} - 1\right) > 1$$

This implies that, in optimum, because of farmers' risk aversion, the expected marginal revenue product of land is always higher for opium poppy than for the other agricultural good. To derive the effect of an increased risk of eradication, we totally differentiate the first-order conditions and use Cramer's rule (for a more detailed description of the calculations, see Appendix A). This gives the following:

(7) $$\frac{\partial l}{\partial \gamma} = \frac{U_{x_1x_1}\rho\big(U_{gx_2}(Pf_{ol} - f_{al}) + U_{bx_2}f_{al}\big)}{|D|} + \frac{Pf_{ol}(1+r)^2\rho^2\left((1-\gamma)U_{gx_2x_2}U_{bx_2} + \gamma U_{bx_2x_2}U_{gx_2}\right)}{|D|}$$

where $|D|$ is the Hessian determinant, which is positive from the second order conditions for maximisation. The signs of the numerators in the first and second terms are both negative. Hence, if the system has an interior solution, then $\frac{\partial l}{\partial \gamma} < 0$.

Thus, if a risk-averse farmer chooses how to allocate land between opium poppy and another agricultural good, and perfect credit markets are available, an increased risk of eradication will unambiguously reduce the land allocated to opium poppy. This result is intuitive and in line with expectations. Hence, under perfectly functioning credit markets, eradication is likely to have the intended effects of reducing or even eliminating opium poppy production. An important thing to note here is that, as it is assumed that all opium is lost in the case of eradication, there is no reason for the farmer to a priori increase the production of opium poppy crops to compensate for income losses in the bad state in the case of an increased risk of eradication. We now turn to the case when credit is obtained through advanced sales of opium.

*Imperfect capital markets and rented land*

In this subsection, we model a situation where there are no formal credit markets available to the farmer, and the only way to obtain credit is through advance sales of future opium harvest. Throughout this section, a number of assumptions need to be made about the lender/buyer and the market in which he operates. In the outline presented below we assume, that the lender/buyer is risk-neutral and operates in a fully competitive market. [6]

We also need to make assumptions about what happens if the opium poppy is eradicated before it is delivered to the lender/buyer. In this case, there are at least three possible ways to make the market clear in a two-period setting. The first option is that the borrower always pays back the borrowed amount to the lender/buyer. Given the above assumptions, this would imply that lenders face no increased risk due to eradication, and the advance price of opium differs from the harvest price only by the interest rate. This scenario leads us to the baseline model described above. The second option is to assume that, if eradication occurs, there is no way for the lender/buyer to get the borrowed money back. If this risk is anticipated by the lender/buyer at the time of providing the loan, the risk of eradication will be fully reflected in the advance price received on the opium. This would imply that the farmer 'pays' for the eradication through the lower advance price. The third option is a mixed case: some farmers are able to repay the loan if eradication occurs while others default. In this case, the risk of eradication will also be partly reflected in the opium's advance price.

In the models presented below, we follow the second option and assume that the risk of eradication is fully reflected in the advance price. The third option will entail an intermediate outcome between the perfect credit market scenario studied above and the scenarios studied below.

Now let us turn to the formulation of the lender's optimisation problem. We assume that, in the first period, i.e. prior to harvest, the farmer has the opportunity to sell opium to a lender/buyer at the price $P_1$. In the second period, the opium can be sold at a fixed price $P_2$. This price is assumed to be set on a world market that is sufficiently large not to be influenced by the risk of eradication; for simplicity's sake, this price is assumed to be non-stochastic. As it is assumed that the lender/buyer operates on a fully competitive market, the expected present value of the lender's/buyer's profit is 0, and there is no way for the lender/buyer to reclaim his money in case of opium poppy eradication, the lender's/buyer's expected profit can be written as follows:

(8) $$E(\pi) = \frac{P_2 q_{o1}^d (1-\gamma)}{(1+r)} - P_1 q_{o1}^d = 0$$

where $q_{o1}^d$ is the opium bought by the lender. A rearrangement of equation (8) gives:

(9) $$P_1 = \frac{P_2(1-\gamma)}{(1+r)}$$

Equation (9) implies that if the risk of eradication, $\gamma$, increases, the price of opium in the first period decreases. This result is in line with the findings in Mansfield (2004).

The model presented above could be seen as special case of a broader model where the lender/buyer has a limited amount of liquid assets to use on purchases of future harvests of different kinds of agricultural production. The special case would then occur when the profitability in advance purchases of opium is higher for every unit of opium bought in advance, compared with advance purchases of other crops.

Now let us turn to the farmer's optimisation problem. Assume that the farmer sells $q_{o1}^{s}$ units of opium in advance to buy $x_1$ units of the other agricultural good. This means that the budget constraint in the first period is given by the following:

(10) $$x_1 = q_{o1}^{s} P_1$$

In the second period, there are two possible outcomes for the farmer. If no eradication occurs, he can consume what he receives for the remaining opium crop production and the production of the other agricultural good, minus the land rental cost, expressed as follows:

(11) $$x_2 = P_2(f_o - q_{o1}^{s}) + f_a - wL$$

By inserting (9) and (10) into (11), the above expression can be rewritten to yield the following:

(12) $$x_2 = \left(P_2 f_o - x_1 \frac{(1+r)}{(1-\gamma)}\right) + f_a - wL$$

In the second possible outcome for the farmer, namely if eradication occurs, the second-period consumption is given by the following:

(13) $$x_2 = f_a - wL$$

Hence, the farmer maximises the expected utility, as given by –

(14) $$E(v) = U(x_1) + \rho(1-\gamma)U\left[P_2 f_0(l) - x_1 \frac{(1+r)}{(1-\gamma)} + f_a(L-l) - wL\right] + \rho\gamma U[f_a(L-l) - wL]$$

w.r.t. $x_1$ and $l$.

It should be noted that, as long as $P_2 f_o(l)(1-\gamma) < x_1 \frac{(1+r)}{(1-\gamma)}$, the farmer is overcommitted, in the sense that he sells more than the expected output. We assume that there is a limit for overcommitment, in that the farmer can never sell more of his opium poppy crop than he plants. This can be thought of as a situation where the lender/buyer and the farmer operate in the same village, so there is no option to sell more opium in advance than what is actually planted. For a theoretical model of collateral requirements by informal lenders with monitor advantages, see Boucher and Guirkinger (2007). The overcommitment constraint implies that the following inequality must then hold:

(15) $$P_2 f_o(l) - x_1 \frac{(1+r)}{(1-\gamma)} \geq 0$$

The solution to the model will differ depending on whether or not the overcommitment constraint is binding. In Case 1 below, we look at the model when the constraint is binding; in Case 2 below, we look at the model when the constraint is not binding. We end this subsection with Case 3, where it is assumed that the first-period consumption is restricted to a minimum level of consumption and, therefore, is totally inelastic.

Case 1

In Case 1, the entire opium crop produced is sold in advance. As mentioned in the preceding section, previous field studies have found that many Afghan farmers sell their entire opium crop prior to harvest in order to meet their consumption needs during the winter months. Hence, for some farmers, the assumption of an advanced sale of all opium crops seems reasonable.

In this case, an increased risk of eradication only enters the utility function through the advance price, since all of the opium is already sold when the potential eradication occurs; hence, there is no stochasticity in the utility function. The utility function can be written as follows:

(16) $$V = U\left(\frac{P_2(1-\gamma)}{(1+r)}\ f_o(l)\right) + \rho U[f_a(L-l) - wL]$$

which is maximised w.r.t. $l$. The first-order condition can then be written as follows:

(17) $$U_{x_1}\frac{P_2(1-\gamma)}{(1+r)}f_{ol} - \rho U_{x_2}f_{al} = 0$$

From equation (17), it follows that the marginal rate of substitution of consumption in the two time periods, $\frac{U_{x_1}}{U_{x_2}}$, is equal to the marginal rate of technical transformation in the production of the two crops, $\frac{f_{al}}{f_{ol}}$, weighted by the relative price of consumption in each time period, $\frac{(1+r)\rho}{P_2(1-\gamma)}$. Total differentiation of equation (17) gives the following:

(18) $$gdl + \left(-U_{x_1}\frac{P_2}{(1+r)}f_{ol} - U_{x_1x_1}\frac{{P_2}^2(1-\gamma)}{(1+r)^2}f_{ol}\ f_o(l)\right)d\gamma{=}0$$

where

$$g = U_{x_1}\frac{P_2(1-\gamma)}{(1+r)}f_{oll} + U_{x_1x_1}\left(\frac{P_2(1-\gamma)}{(1+r)}f_{ol}\right)^2 + \rho U_{x_2}f_{all} + \rho U_{x_2x_2}{f_{al}}^2$$

and

(19) $$\frac{dl}{d\gamma} = \frac{\frac{P_2 f_{ol}}{(1+r)}\left( U_{x_1} + U_{x_1 x_1} x_1\right)}{g}$$

The denominator in equation (19) is negative from the second-order condition for maximisation. The numerator can be rewritten as: $\frac{P_2 f_{ol}}{(1+r)}(1-R)$, where $R = -x_1 \frac{U_{x_1 x_1}}{U_{x_1}}$, can be seen as a measure of relative risk aversion. Thus, the sign of equation (19) will depend on the degree of risk aversion.

**Proposition 1:** If a risk-averse farmer sells his entire opium crop in advance on a competitive market where the lenders/buyers fully anticipate that some of the crop production will be eradicated, the effect of an increased eradication will depend on the degree of risk aversion. Thus, –

- if $R < 1$, increased risk of eradication will lead to a reduction in the land allocated to opium poppy.
- if $R > 1$, increased risk of eradication will lead to an increase in the land allocated to opium poppy.

Thus, in optimum, there are basically two contradicting forces at play when the risk of eradication increases and the advance price of opium declines. One direct effect works in the direction of lowered opium poppy production. This can be seen as a substitution effect, where the reduced profitability of opium crop production draws resources away from such production. There is also an indirect effect that works in the direction of increased production. This can be seen as an income effect that stems from the fact that when the risk of eradication increases, the expected income and food consumption is reduced. The reduced consumption increases the marginal utility of food in both periods, but as the food consumption is lower in the first period than in the second period, the marginal utility of food is increasing relatively more in the first period. The income effect therefore goes in the direction of higher first period consumption. Risk aversion is a measure of the curvature of the utility function; the higher relative risk aversion, the faster is marginal utility of food consumption increasing when consumption decreases. Thus, higher the higher relative risk aversion, the stronger is the income effect. The net outcome of the two effects will therefore depend on the degree of the farmer's risk aversion. If the farmer's risk aversion is low, the optimal response is to reduce the amount of land allocated to opium crops; if the degree of risk aversion is sufficiently high, the farmer will insure himself/herself against income losses by increasing the production of opium. This is interesting: it implies that the more risk-averse the farmer is, the more likely he is to act contrary to policymakers' intentions when the risk of eradication increases.

Case 2

In Case 2, the farmer keeps some of the opium to be sold after harvest at the price that is higher than the advance price. This implies that the expected utility function is given by equation (14). This situation can be seen as a combination of the two previous models described above: the opium that is kept for sale after harvest is directly subject to the risk of eradication, and the opium that is sold in advance is only affected by eradication through the price effect. The first-order conditions in this model are given by the following:

(20) $$V_x = \frac{\partial E(V)}{\partial x_1} = U_{x_1} - \rho(1+r)U_{gx_2} = 0$$

(21) $$V_l = \frac{\partial E(V)}{\partial l} = \rho(1-\gamma)U_{gx_2}[P_2 f_{ol} - f_{al}] - \rho\gamma U_{bx_2} f_{al} = 0$$

Note that the difference between equation (20) and equation (4) is that the trade-off in consumption is now only between the first period and the 'good' outcome in the second period.

Total differentiation and Cramer's rule (see Appendix B for details) give the following:

(22) $$\frac{\partial l}{\partial \gamma} = \frac{U_{x_1x_1}\rho[P_2 f_{ol} - f_{al}]\left(\frac{(1-\gamma)}{(1+r)} - R\right)}{|D|} + \frac{U_{bx_2}\rho f_{al}\left(U_{x_1x_1} + \frac{(1+r)^2}{(1-\gamma)^2}U_{gx_2x_2}\rho\right)}{|D|}$$

Here, $R$ is defined as $-x_1\frac{U_{gx_2x_2}}{U_{gx_2}}$ and can again be seen as a measure of relative risk aversion. As before, $|D|$ is the Hessian determinant, which is positive from the second-order conditions for maximisation. The numerator second term is negative, while the numerator in the first term will depend on the degree of risk aversion. Hence, if the farmer's risk aversion is low, increased eradication will lead to lower levels of opium crop production; if the risk aversion is sufficiently high, the effect is ambiguous.

**Proposition 2:** If a risk-averse farmer sells some of the produced opium in advance on a competitive market where the lenders/buyers fully anticipate that some of the crop production will be eradicated, the effect of an increased eradication will depend on the degree of risk aversion. Thus, –

- if $R < \frac{(1-\gamma)}{(1+r)}$, increased risk of eradication will lead to a reduction in the land allocated to opium poppy.
- if $R > \frac{(1-\gamma)}{(1+r)}$, the effect of increased risk of eradication on land allocated to opium poppy production is ambiguous.

Thus, when some opium is kept for sales after harvest, the outcome is similar to that when all opium is sold in advance. The outcome in Case 2 differs from Case 1 only in respect of the indeterminate outcome in the event of high risk aversion. As the opium that is kept for selling after the harvest is directly subject to the risk, it is not surprising that the substitution effect is relatively stronger in Case 2.

Case 3

We now turn to the special case when first-period consumption is totally inelastic. This could be thought of as a situation where the farmer is at borderline starvation levels of consumption in the first period, and only produces the amount of opium necessary to meet this consumption level. If the first-period consumption cannot be changed, the following equality must hold:

(23) $$\frac{P_2(1-\gamma)}{(1+r)}\, f_o(l) = x_1^{Min}$$

where $x_1^{Min}$ is the minimum level of necessary consumption.

Total differentiation then gives the following:

(24) $$\left(\frac{P_2(1-\gamma)}{(1+r)} f_{ol}\right) dl - \left(\frac{P_2}{(1+r)} f_o\right) d\gamma = 0$$

and

(25) $$\frac{dl}{d\gamma} = \frac{f_o}{f_{ol}(1-\gamma)} > 0$$

**Proposition 3:** If the farmer's first-period consumption is restricted by a minimum subsistence level, an increased risk of eradication will lead to an increase in the land allocated to opium crop production.

The intuition behind this result is that if the price of opium goes down and the farmer cannot reduce his consumption further, he has no choice but to grow more opium. This result is reasonable as long as the risk of eradication is sufficiently low; if the risk of eradication is sufficiently high, however, lenders/buyers are likely to provide advances on other crops instead.

*Imperfect capital markets and sharecropping arrangements*

We now shift focus and study the effects of eradication when opium is produced in a sharecropping arrangement. Instead of paying a land rental cost, the tenant shares the agricultural output with the landlord. We start by studying a situation where the tenant decides what share of the land to allocate to opium poppy crops and another agricultural product. Thereafter, we study a situation where the landlord has already decided that opium will be grown on a specific plot. These can be seen as extreme cases. In reality, the decisions on which crops to grow, and what shares to allocate to these crops, are likely to be determined through negotiations.

Consider the first situation where the tenant decides land allocation. We use the same models as described in the previous, but assume that instead of a land rental cost, the output share received by the tenant is denoted by $\alpha$ and the output share received by the landlord is denoted by $(1-\alpha)$. In practice, the shares in sharecropping can be seen as exogenous and as set by cultural norms or tradition. The tenant's expected utility is then given by the following:

(26) $$E(v) = U(x_1) + \rho(1-\gamma)U\left[\alpha P_2 f_0(l) - x_1 \frac{(1+r)}{(1-\gamma)} + \alpha f_a(L-l)\right] + \rho\gamma U[\alpha f_a(L-l)]$$

As long as the shares received from opium and the other agricultural product are the same, the optimal solution as well as the effect of eradication on land allocated to opium poppy production are analogous to those in the models described above. Note that, in optimum, the change in the tenant's utility caused by a change in the risk of eradication is given by the following:

(27) $$\frac{\partial E(v)}{\partial \gamma} = -\rho U_g - \rho x_1 \frac{(1+r)}{(1-\gamma)} U_{gx_2} + \rho U_b$$

As the income is always larger in the no-eradication outcome, it follows that $U_g > U_b$. Thus, the expected utility of the tenant will always decrease when the risk of eradication increases.

But what outcome can the landlord expect? The landlord is assumed to maximise the expected profit rather than the expected utility. The present value of the expected profit will be given by the following:

(28) $$E(\pi) = \frac{P_2(1-\gamma)}{(1+r)}(1-\alpha)f_o(l) + \frac{(1-\alpha)}{(1+r)} f_a(L-l)$$

The change in profit due to increased risk of eradication is given as follows:

(29) $$\frac{\partial E(\pi)}{\partial \gamma} = -\frac{P_2}{(1+r)}(1-\alpha)f_o(l) + \frac{(1-\alpha)}{(1+r)}[P_2(1-\gamma)f_{ol} - f_{al}]\frac{dl}{d\gamma}$$

The first term in equation (29) is negative, while the second is indeterminate.[7] Hence, the effect on the landlord's profit from an increased risk of eradication is ambiguous.

**Proposition 4:** Given the assumptions above, an increased risk of opium poppy eradication will always lead to lower expected utility for the tenant. However, the effect of increased risk of eradication on the landlord's expected profit is ambiguous.

We now turn to the situation where the landlord has already decided that only opium poppy crops should be grown on a specific plot. For simplicity's sake, we assume that the tenant sells his entire share in advance, while the landlord's share is sold after the harvest. We also assume that the only thing that the tenant can choose in this model is how much effort, $e$, to put into production. This is in order to have some choice variable for the tenant; otherwise, the problem would become trivial. The income received by the tenant is then given by the following:

$$Y = \frac{P_2(1-\gamma)}{(1+r)} \alpha\, f_0(e) \tag{30}$$

where $f_{oe} > 0$ and $f_{oee} < 0$. Assuming that the utility function is additively separable, the expected utility function is given as follows:

$$U = U\left(\frac{P_2(1-\gamma)}{(1+r)}\ \alpha f_0(e)\right) + V(e) \tag{31}$$

where $U(Y)$is the utility of consumption and $V(e)$ is the disutility of effort. It is assumed that $U_Y > 0$, $U_{YY} < 0$, $V_e < 0$ and $V_{ee} < 0$. The first-order condition can then be written as follows:

(32) $U_Y \frac{P_2(1-\gamma)}{(1+r)} \alpha f_{oe} + V_e = 0$

Total differentiation gives –

$$\left(U_{YY}\left(\frac{P_2(1-\gamma)}{(1+r)}\alpha f_{oe}\right)^2 + U_Y\left(\frac{P_2(1-\gamma)}{(1+r)}\alpha f_{oee}\right) + V_{ee}\right)de$$

(33) $$+\left(-U_Y\frac{P_2}{(1+r)}\alpha f_{oe} - U_{YY}\frac{P_2^2(1-\gamma)}{(1+r)^2}\alpha^2 f_{oe}\, f_0(e)\right)d\gamma = 0$$

Reorganising equation (33) gives the following:

(34) $$\frac{de}{d\gamma} = \frac{\frac{P_2}{(1+r)}\alpha f_{oe}(1-R)}{\left(U_{YY}\left(\frac{P_2(1-\gamma)}{(1+r)}\alpha f_{oe}\right)^2 + U_Y\left(\frac{P_2(1-\gamma)}{(1+r)}\alpha f_{oe}\right) + V_{ee}\right)}$$

where $R = -\frac{U''Y}{U'}$ is a measure of the relative risk aversion. Hence, the effect of eradication will depend on the degree of risk aversion. If $R > 1$, an increased risk of opium poppy eradication leads to more effort being directed towards opium poppy production. Note, again, that increased opium eradication will always reduce the expected utility of the tenant, i.e. –

(35) $$\frac{\partial U}{\partial \gamma} = -U'\left(\frac{P_2}{(1+r)}\alpha\, f_0(e)\right) < 0$$

The landlord's expected present-value profit can be described as follows:

(36) $$E(\pi) = \frac{P_2(1-\gamma)}{(1+r)}(1-\alpha)f(e)$$

while the change in profit from an increased risk of opium poppy eradication can be given by the following:

(37) $$\frac{\partial E(\pi)}{\partial \gamma} = -\frac{P_2}{(1+r)}(1-\alpha)f(e) + \frac{P_2(1-\gamma)}{(1+r)}(1-\alpha)f_{oe}\frac{de}{d\gamma}$$

Hence, again, the effect of an increased risk of eradication on the landlords profit is ambiguous. If an increased risk of opium eradication leads to an increased effort by the tenant, and the effort response is sufficient to offset the lower expected output, the landlord may actually benefit from increased eradication. If this is the case, the increased risk of eradication creates no incentive for the landlord to switch production to other agricultural crops in subsequent periods.

**Proposition 5:** Given the assumptions made above, an increased risk of opium poppy eradication will always lead to lower expected utility for the tenant. However, the effect of increased risk of eradication on the landlord's expected profit is ambiguous and will depend on the tenant's degree of risk aversion. For low levels of risk aversion, the landlord will lose; but if the tenant is sufficiently risk-averse, the landlord may actually benefit from increased risk of eradication.

**Discussion**

The eradication of opium poppy is highly controversial. Critics argue that the effect is limited and the human costs are high, while advocates argue that eradication is an important instrument for reducing opium poppy cultivation. To offer some insight into this debate, this article investigated how the role of opium in the rural economy affects the outcome of eradication policies. As this article is the first attempt to model the opium farmer's decision problem, we have used quite simple assumptions throughout. However, despite the simplicity of the model, it still gives some important insights into the underlying mechanisms at stake.

The analysis presented in this article suggests that, when perfect credit markets are available, an increased risk of eradication will lead to lower levels of opium poppy production. Hence, if credit markets were available, the eradication strategy would be likely to have the intended effect of lowering production. However, the assumption of perfect credit markets is unrealistic in rural Afghanistan. In this article, we try to build a model that incorporates some of the aspects of Afghanistan's credit market and, especially, the role of opium in this context. A number of field studies have found that, in opium poppy crop-growing areas in Afghanistan, cultivation has become an important way to obtain credit; for poor farmers, it is even sometimes the only way. It has also been found that many of the farmers sell their entire crop production prior to harvest to obtain credit for covering consumption needs during the winter season. The price received from these advance sales of opium seems to reflect the risk of eradication: the higher the risk of eradication, the lower the price that the farmer obtains on the advance sale.

When these aspects are taken into consideration, the results of this study indicate that the outcome of eradication policies are no longer clear-cut, but will depend on the degree of risk aversion. The higher the degree of risk aversion and the more opium that is sold in advance, the more likely it is that the eradication is counterproductive. This is something that is worth reflecting on when future counternarcotic strategies are designed.

Another aspect of Afghanistan’s rural market is that of sharecropping arrangements. The results from this study suggest that, if the tenants’ effort response is sufficiently large, the landlord may actually benefit from an increased risk of eradiation and thus, the landlord will have no interest in reduced opium poppy production. If this is the case, and landlords are influential in the villages, the scope of reducing opium by eradication is limited.

Eradication policies would be straightforward and have the intended effects on farmers’ incentives if credit markets and land markets functioned perfectly. If we remember that such perfection is not realistic, even our simple models indicate that the outcomes from eradication are difficult to predict.

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**Appendix A**

Total differentiation of the first-order condition described in (4) and (5) gives the following expression:

$$\begin{pmatrix} V_{xx} & V_{xl} \\ V_{lx} & V_{ll} \end{pmatrix} \begin{pmatrix} dx \\ dl \end{pmatrix} = -\begin{pmatrix} V_{x\gamma} \\ V_{l\gamma} \end{pmatrix} d\gamma$$

where –

$$V_{xx} = \frac{\partial^2 V}{\partial x^2} = U_{x_1 x_1} + (1-\gamma)\rho U_{g x_2 x_2}(1+r)^2$$

$$+ \gamma\rho U_{b x_2 x_2}(1+r)^2$$

$$V_{xl} = \frac{\partial^2 V}{\partial x \partial l} = -\rho(1-\gamma)U_{g x_2 x_2}(P_o f_{ol} - f_{al})(1+r)$$

$$+ \gamma\rho U_{b x_2 x_2} f_a (1+r)$$

$$V_{ll} = \frac{\partial^2 V}{\partial^2} = \rho(1-\gamma)U_{gx_2x_2}(P_o f_{ol} - f_{al})^2$$

$$+ \rho(1-\gamma)U_{gx_2}(P_o f_{oll} - f_{all}) + \gamma\rho U_{bx_2x_2} f_{al}^2$$

$$+ \gamma\rho U_{bx_2} f_{al}$$

$$V_{x\gamma} = \frac{\partial^2 V}{\partial x \partial \gamma} = \rho U_{gx_2}(1+r) - \rho U_{bx_2}(1+r)$$

$$V_{l\gamma} = \frac{\partial^2 V}{\partial l \partial \gamma} = -U_{gx_2}\rho(P_o f_{ol} - f_a) - \rho U_{bx_2} f_{al}$$

To understand how an increased risk of eradication, $\gamma$, affects the land allocated to opium, *l*, we use Cramer's rule to find that –

$$\frac{\partial l}{\partial \gamma} = \frac{U_{x_1x_1}\rho\left(U_{gx_2}(P_o f_{ol} - f_{al}) + \mathrm{U}_{\mathrm{bx}_2} f_{al}\right)}{\begin{vmatrix} V_{xx} & V_{xl} \\ V_{lx} & V_{ll} \end{vmatrix}}$$

$$+ \frac{P_o f_{ol}(1+r)^2\rho^2\left((1-\gamma)U_{gx_2x_2}U_{bx_2} + \gamma U_{bx_2x_2}U_{gx_2}\right)}{\begin{vmatrix} V_{xx} & V_{xl} \\ V_{lx} & V_{ll} \end{vmatrix}}$$

where the determinant is positive from the second-order conditions for maximisation.

**Appendix B**

Total differentiation of the first-order condition described in (20) and (21) gives the following expression:

$$\begin{pmatrix} V_{xx} & V_{xl} \\ V_{lx} & V_{ll} \end{pmatrix} \begin{pmatrix} dx \\ dl \end{pmatrix} = -\begin{pmatrix} V_{x\gamma} \\ V_{l\gamma} \end{pmatrix} d\gamma$$

where –

$$V_{xx} = \frac{\partial^2 V}{\partial x^2} = U_{x_1 x_1} + \rho U_{g x_2 x_2} \frac{(1+r)^2}{(1-\gamma)}$$

$$V_{xl} = \frac{\partial^2 V}{\partial x \partial l} = -\rho(1+r) U_{g x_2 x_2}[P_2 f_{ol} - f_{al}]$$

$$V_{ll} = \frac{\partial^2 V}{\partial l^2} = \rho(1-\gamma) U_{g x_2}[P_2 f_{oll} + f_{all}]$$
$$+ \ \rho(1-\gamma) U_{g x_2 x_2}[P_2 f_{ol} - f_{al}]^2 + \rho\gamma U_{b x_2} f_{all}$$
$$+ \rho\gamma U_{b x_2 x_2} f_{al}$$

$$V_{x\gamma} = \frac{\partial^2 V}{\partial x \partial \gamma} = \rho(1+r) U_{g x_2 x_2} x_1 \frac{(1+r)}{(1-\gamma)^2}$$

$$V_{l\gamma} = \frac{\partial^2 V}{\partial l \partial \gamma} = -\rho U_{gx_2}[P_2 f_{ol} - f_{al}]$$

$$- \rho(1-\gamma) U_{gx_2x_2}[P_2 f_{ol} - f_{al}] x_1 \frac{(1+r)}{(1-\gamma)^2}$$

$$- \rho U_{bx_2} f_a' = 0$$

The use of Cramer's rule gives the following:

$$\frac{\partial l}{\partial \gamma} = \frac{U_{x_1x_1}\rho[P_2 f_{ol} - f_{al}]\left(\frac{(1-\gamma)}{(1+r)} - R\right)}{|D|}$$

$$+ \frac{U_{bx_2}\rho f_{al}\left(U_{x_1x_1} + \frac{(1+r)^2}{(1-\gamma)^2} U_{gx_2x_2}\rho\right)}{|D|}$$

**Endnotes**

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[1] This section draws heavily on the work of David Mansfield, a leading expert in opium eradication strategies, as well as on reports produced by the United Nations Office on Drugs and Crime (UNODC) and the Afghan Research Evaluation Unit. For obvious reasons, few field studies in this area have been made and more research is needed in order to have a better picture of the market structure surrounding opium crop production in Afghanistan.

[2] Ranging from 63% in Nangahar to 16% in Badakhshan.

[3] At the international level, counternarcotic supply control strategies in source countries fall into four broad categories: eradication, alternative development, in-country enforcement, and interdiction. *Alternative development* refers to development of new alternative income sources that are financially attractive for the farmer. *In-country enforcement* targets refineries, stocks and business dealings. Finally, *interdiction* targets international trafficking and smuggling operations (Paoli et al., 2009).

[4] Owing to the fractured character of the Afghan countryside, with small plots of arable soil surrounded by rocky, untillable land, in practice the sizes of plots are often fixed by natural factors.

[5] If factor proportions are assumed to be constant, the input can be thought of composite land and labour input.

[6] The general result is not altered if the buyer/lender is assumed to have market power.

[7] In model 3.2.1, $(dl/d\gamma)$ is either positive or negative depending on the tenant's degree of risk aversion while the sign of $[P_2(1-\gamma)f_{ol} - f_{al}]$ is ambiguous, which can be seen from equation (17) when reorganised to yield $\frac{P_2 f_{ol}(1-\gamma)}{f_{al}} = \frac{\rho(1+r)U_{x_2}}{U_{x_1}}$. In

model 3.2.2, $(dl/d\gamma)$ is either negative or indeterminate depending on the tenant's degree of risk aversion while the sign of $[P_2(1-\gamma)f_{ol} - f_{al}]$ is positive, which can be seen from equation (21) when reorganised to yield $\frac{(1-\gamma)P_2 f_{ol}}{f_{al}} = 1 + \gamma\left(\frac{U_{bx_2}}{U_{gx_2}} - 1\right)$.