Simulating the Afghanistan-Pakistan Opium Supply Chain

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ABSTRACT

This paper outlines an opium supply chain using the Hilmand province of Afghanistan as exemplar. The opium supply chain model follows the transformation of opium poppy seed through cultivation and chemical alteration to brown heroin base. The purpose of modeling and simulating the Afghanistan-Pakistan opium supply chain is to discover and test strategies that will disrupt this criminal enterprise.

Keywords: opium cultivation, heroin, drug smuggling, credit system

INTRODUCTION

The rampant cultivation of opium poppy impedes the diversification of the Afghan economy and associated rural skill building. Heroin strains health and law enforcement in the countries where the drug is used. In between the cultivation of opium poppy and the use of heroin, the supply chain requires drug trafficking and money laundering. The money generated through these illegal activities can be used to disrupt the ISAF (International Security Assistance Force) war efforts in Afghanistan and to fund terrorism. In short, it is imperative that the flow of opium-based drug money be disrupted.

In a situation as complex as the Afghan opium supply chain, any interdiction measures are bound to result in unintended consequences if the wider system is not taken into account. One means to model the local and global effects of an interdiction strategy is through an agent-based simulation. The purpose of developing an agent-based simulation of the opium supply chain is to provide a useful predictive tool. The primary goal is to develop models of adaptive decision-making in illicit cross-border supply chains and illicit economies. These models will be used in computer simulations to anticipate and predict the interactions within and between economic agents based on local incentives, constraints, and decision-making processes. The challenge of this research is to simulate how the decisions of these agents will adapt and evolve under different economic, political, and counter-terrorism scenarios. This modeling effort has begun with a focus on the foremost opium-producing region in the world, the Hilmand province of Afghanistan.

HILMAND CASE STUDY

The Hilmand (also spelled Helmand) province of Afghanistan produces 59% of Afghanistan's opium (United Nations Office on Drugs and Crime [UNODC], *Survey*, 2009). This province is an optimal climatic zone for many crops, although the soil requires high levels of fertilizer (Shairzai, Farouq & Scott, 1975). The southern portion of the province receives consistent irrigation from the Hilmand River regulated through the Kajaki dam and canals. Each fall, the farmers decide which crops to plant. In 2007, they planted the highest acreage of poppy yet recorded in Hilmand with 102,000 ha (UNODC, *Assessment*, 2009). However, the acreage dedicated to poppy has declined since then to 70,000 ha in 2009 due to production in excessive of world demand (UNODC, *Summary*, 2009).

Once a farmer decides to plant poppy, the opium supply chain is initiated. Opium tar is found in the seedpod of the poppy plant. To harvest the tar, vertical slits are made in the pod to allow the tar to ooze out. Each poppy seedpod requires successively deeper lances as the harvest continues, until no more tar is available. This labor-intensive process often demands that the farmer hire additional labor. The demand for labor has produced a class of itinerant harvesters who begin harvesting in Hilmand's lower elevations and travel to higher elevations as the crop ripens. Harvesters may be farmers, soldiers, or students from universities or madrassas who use the opportunity to earn money (UNODC, *Access to Labour*, 1999).

Traders purchase the raw or dried opium tar from farmers and their laborers who are paid in kind. Many transitory traders were originally livestock dealers. They moved into the opium trade when the devastating drought of 2000 killed most livestock across Afghanistan (Pain, 2006). Farm-gate traders offer the service of transporting the opium to other buyers where the taxes incurred through road travel as well as the risks of seizure or theft deter the farmer. Traders maintain a tightly knit network formed through kinship and ethnic ties, that follows traditional trade routes, and is organized with satellite phones (Pain, 2006).

Traders facilitate the movement of opium tar to processors. The crude heroin labs in Hilmand require nothing more than metal kettles to boil the opium along with precursor chemicals. In Marjah, a district of Hilmand, where in February of 2010 there was estimated to be hundreds of processing labs, the labs serve as a profitable alternative to growing opium. Processors earn around $10 a day compared with $5 in a cash-for-work program (Tassal, 2010). Usually, the output of a heroin-processing lab is brown heroin base. This form of heroin is smokable, but must be further refined and mixed with cutting agents to produce the injectable white heroin desired in the West. This degree of refinement is beyond the capability of most labs in Afghanistan, thus it is brown heroin that is smuggled out of the country (UNODC, *Survey*, 2009).

Although, due to space considerations, this paper will not detail the distribution portion of the supply chain, suffice it to say that Hilmand is situated ideally for smuggling. The province borders Pakistan's Balochistan region to the south and has a traditional trade route with Iran to the west. Because Hilmand lacks a strong governing presence, this border economy has a history of smuggling goods. Those who were historically gun smugglers have moved into the profitable opium trade. Unlike almost all other provinces in Afghanistan, Hilmand plays a key role in every step of the supply chain from cultivation to processing to trafficking.

THE OPIUM SUPPLY CHAIN

Supply chain modeling is a technique typically employed to improve the efficiency of logistical and business processes. However, the purpose of modeling the opium trade as a supply chain is to sustainably disrupt, not improve, the process. As in any supply chain modeling, the focus of the present model is on understanding product, financial, and information flows. Both the product flow, the transformation of poppy seed to heroin, and the financial flow, the movement of money through the system, is briefly described in this section.

The depiction of the information flow in the opium supply chain is reserved for the next section. As the goal of this model is to anticipate and predict agent behavior, information flow is the primary phenomenon of interest. Information flow is modeled as the timing and execution of agent decisions. The agents involved in the opium trade, like other illegal trades, must adapt quickly to law enforcement pressures (Kenney, 2007). Thus, the challenge is to model agent decision-making so as to capture adaptation when condition change.

Product Flow. The Hilmand opium supply chain begins with the planting of opium poppy and ends with the trafficking of heroin across the borders. Along this chain, poppy seed is transformed to opium tar, the tar to morphine base, and the morphine to heroin. The product conversions are tracked in Table 1.

TABLE 1. The process that transforms poppy seeds into heroin including delays and conversion amounts. The Hilmand data (derived from UNODC, *Survey*, 2009) shows that around 70,000 ha of land dedicated to poppy produced 584,000 kg of heroin worth around US$1.3 billion.

	GROW	HARVEST	REFINE	PROCESS
Products:	***papaver somniferum***	**opium tar** poppy seeds poppy oil leaves (fodder)	**morphine base**	**heroin base**
Inputs:	fertilizer		water, kettles, burlap, ammonium chloride	acetic anhydride, slaked lime, activated charcoal, sodium carbonate
Conversions:	0.45 kg seeds/ 0.40 ha (1 lb / 1 acre)	60,000-120,000 poppy plants / ha 120,000-275,000 opium-producing pods	10-100 mg opium/pod average: 80 mg opium/ pod 8-15kg dried opium/ ha	0.45 kg morphine / 0.31 kg heroin
Delay:	120 days	7 days	several days	1 day
Hilmand 2009:	69,833 ha	58.5 kg/ha 4 million kg opium	7:1 opium to morphine 584,000 kg morphine	584,000 kg heroin $1,284,800,000

Financial Flow. Tracking the value chain of an illegal resource is difficult. It would be ideal to track the farm-gate prices that farmers receive through the prices that intermediary traders receive up to the final sale price of heroin as it crosses the Afghanistan border. There are additional financial considerations beyond the price at which the opium products are bought and sold. Transit and protection costs are an important component of each intermediary leg. The Taliban escorts shipments along the smuggling routes. Each laboratory will pay between $590 and $1180 per month to the Taliban in escort costs (Tassal, 2010). Figure 1 presents a simplified accounting of costs to produce heroin based on data for the Hilmand province.

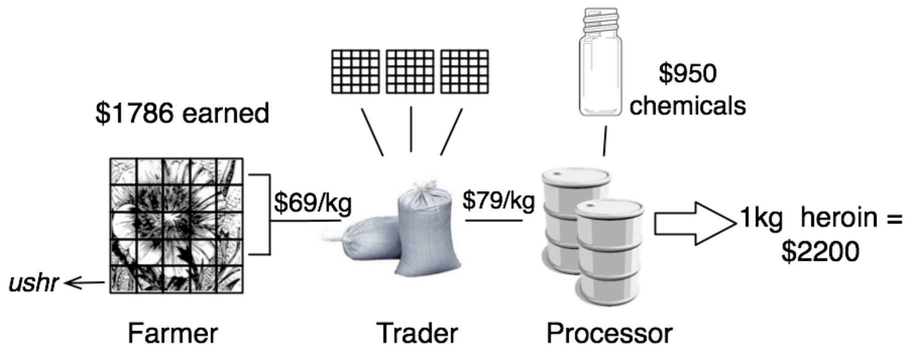

FIGURE 1. A simplification of the financial flow in Hilmand's opium supply chain. Farmers owe 1/5 of their harvest in *ushr* (an Islamic tax), the remaining harvest can be sold to a trader at the farm-gate. Given the average farm-gate price of $69/kg dried opium, an average Afghani opium-growing household earned $1786 in 2009 from the harvest. Traders engage in arbitrage, earning money by exploiting price differences between the farm-gate and bazaars. Acetic anhydride, an essential precursor chemical for heroin refinement, is a controlled substance that must be smuggled into Afghanistan significantly increasing its cost. Seven kg of opium plus $950 worth of precursor chemicals are required to produce 1 kg of heroin. In Hilmand, this amount of heroin is worth $2200. Across Afghanistan, the heroin to opium price ratio is 26:1. All data derived from (UNODC, *Survey*, 2009) and apply to Hilmand province in 2009 unless otherwise stated. Prices are in US dollars.

Supply chain models are often simulated using a system dynamics methodology. Here the factors of interest include inventories, desired inventories, number of items in transit, desired number of items in transit, current demand, and expected demand. The focus on stocks and flows glosses over the complicated decision processes used by those involved in the supply chain. In fact, some supply chain simulations exogenously include the supply chain actors' real-time decisions in a game-like format, rather than model those decisions in computer code (e.g., see the Beer Distribution Game, Sterman, 2000). In order to focus on the decisions of the opium supply chain actors, an agent-based approach is used instead. The next section describes the models of the decision processes of the agents.

AGENT DECISION MODELS

To model agent decisions, an understanding of the options available is necessary.

These options are both physically and culturally prescribed. For example, in the tribal agricultural societies, there are multiple ways to excuse debt besides currency or collateral. For example, farmers have been known to marry off young daughters to excuse a debt (Mansfield, 2006). The triggers that lead to a decision point are also both physically and culturally defined. For example, it is a combination of traditional growing seasons with the current and predicted weather that determine when a farmer plants his crops. Finally, the inputs that are taken into consideration are crucial to an accurate depiction of agent behavior.

The following sub-sections outline a sampling of the roles included in the model. For each role, a description and a representative decision are outlined. The agents in the opium supply chain may adopt one or more roles. Each role encompasses a set of decisions the agent will make given a trigger. Each decision has a number of potential options and the option chosen is dependent upon the state of one or more inputs at the time of the decision.

THE FARMER DECISION MODEL

The farmer role encompasses a few positions in the Afghan agricultural scene. We can describe these positions based on the amount of land owned or the arrangement under which land is temporarily obtained for farming. Large landowners own more than 100 jeribs of land. A jerib is a traditional unit of land measurement in Afghanistan equivalent to 1/5 of a hectare. Medium landowners own 10 to 100 jeribs, while small landowners own 1 to 10 jeribs. These are owner-cultivators. Additionally, landowners may allow sharecroppers or *bazgan* to farm some of their land in exchange for a portion of the final harvest. Landowners may also lease farmland to *Ijara* or tenant farmers for a period of years in exchange for a fixed amount of money or kilograms of crop per jerib.

The choice of which crops to grow is a complicated and important one for the farmer and his family. Drought, disease, anticipated crop prices, soil fertility, land available, laws and security, debt, and credit availability are all components of the choice. Crop choices can be segregated into four kinds: cereals grown mostly for domestic use, industrial crops for selling, horticulture used mostly for selling, and forage crops for animal fodder and soil health. For modeling purposes, these crops choices are represented by wheat, poppy or cotton, onion, and clover, respectively.

Decision: Should I Farm?

Trigger. The decision to farm occurs in the autumn. In Hilmand, the chosen crops of wheat, onion, poppy, and clover can be planted starting in September. Thus, the decision to plant must occur by September for farmer agents located in Hilmand.

Inputs. The decision to farm is based on land availability, soil health, water availability, and credit to debt ratios. If a farmer cannot gain access to land on which to plant, he cannot plant. Otherwise, he may choose not to plant if the soil is unfit, water is unavailable, or if there are better opportunities to provide for his family.

Options. This decision is restricted to two options, to farm or not to farm. If the farmer chooses not to farm, that ends all other farmer role decisions for the agent until the “should I farm?” decision is triggered next year.

For the opium supply chain, the most important farmer decision is that of deciding which crop to plant. One important interdiction avenue would be to change farmers’ valuations of each crop such that they simply choose not to plant poppy at all. For example, in 2008, Afghanistan wheat prices sharply increased rendering poppy a less desirable crop.

THE LABORER DECISION MODEL

Laborers are often farmers whose farms are not yet or have already been harvested. Thus, one agent can manage both a farmer and a laborer role. Most often laborers travel in kin-based groups to a bazaar where the local farms are in need of harvest. The experienced harvesters train and vouch for their inexperienced relatives. Farmers hire the laborers with a stringent oral contract that sets forth the duration of the harvest and the amount to be paid. The terms of the contract vary with the type of crop that will be harvested and the amount of labor available.

Decision: Sell opium now or later?

Trigger. After the harvest, the farmer usually transports the laborers back to the local bazaar. The laborers have been paid in a portion of the opium harvest and have the opportunity to sell that opium immediately at the bazaar.

Inputs. The decision to sell the opium is based on the immediate needs of the laborer and the current versus expected price of the opium. Usually, when the laborers arrive at the bazaar all local farms have been recently harvested, so the bazaar is flooded with opium and the price is low. The laborers would earn more by retaining the opium for sale at a later date, but this may be impossible if there are pressing needs for money or other goods.

Options. This decision is restricted to two options, to sell immediately at the bazaar or to maintain the opium in stock. The clearing of opium from stock is handled by a separate agent decision.

THE TRADER DECISION MODEL

The role of the trader is to buy farm crops, especially poppy, from the farmer at the farm-gate or bazaar. If the traders meet the farmer at the farm-gate, they save the farmer from the dangerous and expensive task of transporting the crops to market. Traders can be classified according to trading volume, seasonality, stock management, and geographical reach (Pain, 2006). The risks of trading include the up to 30% daily opium price fluctuations and the risk of theft and seizures. Additionally, inexperienced traders run the risk of buying adulterated product (Pain, 2006).

A trader may offer credit to the farmers in exchange for a fixed amount of a crop at the harvest, an advanced payment known as *salaam*. Opium is the preferred crop. A trader offers a cash advance that is half the current market price of opium. Given that advance payments are usually required during the opium off-season, the price of opium is high. The payments are repaid in opium immediately following the harvest, when opium prices are at their lowest.

Decision: Should I offer credit?

Trigger. Farmers most often require a *salaam* payment in the autumn prior to planting their crops or during the lean winter months. A farmer seeking advanced payment is the triggering event.

Inputs. The decision to offer credit is a classic risk calculation based on the likelihood the loan will be repaid. The best credit risks are those that own land, so that they may mortgage or sell all or a portion of the land to repay the debt. Farmers may also have to agree to sell household commodities to the trader for a portion of their market value should they default (Mansfield, 2006). For those without land, the threat of eradication or a drastic opium price decrease must be calculated.

Options. The trader is able to offer credit in any amount up to the full amount requested based on the determination of the amount the farmer will be able to repay should the opium harvest not go as planned.

Debt and access to informal credit is an important driver of opium cultivation. The Taliban ban on opium cultivation in 2001 left many farmers in debt. The price of opium soared because supply was low, leaving those with outstanding debt facing, in essence, a 1500% interest rate (Mansfield, 2006). The crop with the best return for repaying the debt was opium and many lenders refused to offer further credit for any crop other than opium poppy.

CONCLUSION: EVALUATING STRATEGIES

Once the agent decision models are entered into computer code and combined with a product flow and financial flow framework, the simulation can be populated with initial conditions. From this base simulation, intervention strategies can be tested and evaluated. One of the benefits of the agent-based approach is the ability to identify unintended consequences. For example, previously, the favored solution to Afghanistan's opium problem was the eradication of the poppy crop. This straightforward solution has the benefit of stopping the supply chain when it is easiest to catch---when the poppy is rooted to the ground. However, there are a number of unforeseen and unfavorable results of the eradication policy.

When poppy crops are eradicated, the farmer is often left in debt, as he borrowed money against the expected harvest. To get out of debt, the farmer's best option is often to cultivate even more poppy next season, as this is the crop with the highest return. Additionally, uneven eradication policies favoring those who live near roads and markets and those who cannot afford to bribe eradication teams results in further mistrust of the government and lends the Taliban, who may offer protection against eradication, a stronger hold.

The second unforeseen result of the eradication policy is that eradication increases worldwide heroin prices resulting in higher profits for those who sell the drug. Morphine base, a pre-cursor of heroin, stores well and is stockpiled and sold when the price increases.

Armed with the knowledge of how eradication, or any intervention, affects farmers, laborers, traders, and drug processors, decision-makers can better implement strategies to reduce the flow of money to the Taliban. Agent-based modeling provides an opportunity for the modeler to take an in-depth look at the problem and allows future users the chance to try out interventions in a consequence free environment.

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