Afghanistan Illegal Drug Trade Network

Backstory/Problem:

Profits from the cultivation and sales of poppy crops turned into opium and heroin have largely been responsible for funding insurgent activities in Afghanistan. Afghanistan produces 84% of the world's heroin supply, and money made from the sales of illegal drugs have paid insurgent fighters, bought weapons, and in general have been responsible for adding to violence in the country. Additionally, much of this opium and heroin makes its way to consumer markets in Western Europe and the United States particularly, fueling the illegal drug trade, adding to violence in these areas among traffickers, and supplying illegal drug users. Among many other reasons, these make it imperative to trace and understand main routes that illegal drugs traverse from places like Afghanistan, Myanmar, and more into primary consumer regions like Europe and the United States, and most importantly to increase understanding of the trade in order to maximize the use of limited resources to counteract and interdict as many drugs as possible.[i]

The goal of this project is to be able to formulate and describe this illegal drug trade network in order to inform and help define interdiction strategies- specifically looking at the best locations to allocate resources to combat drug trafficking. Other goals are to provide a means by which different data sets regarding trade routes can be inputted in order to compare changes over time to the network, and thus to view the effects of different interdiction and anti-trafficking strategies.

Network Description:

To build the network in terms of nodes and edges, data was used from the United Nations Office on Drugs and Crime. Network nodes were major transit points/locations, and edges were defined as routes between the nodes if illegal drugs traveled between the nodes. The capacities associated with the edges were the amounts of drugs known to be transited between the nodes. Figure 1 shows main routes with drug flow amount averages from 2002-2008. This data was combined with information on drug consumption and trade in some major European Countries such as Germany, Italy, France, and the United Kingdom, so as to provide more insights into the illicit trade within Europe. The initial amounts of drug flows out of Myanmar and Afghanistan serve as the initial supply amounts.

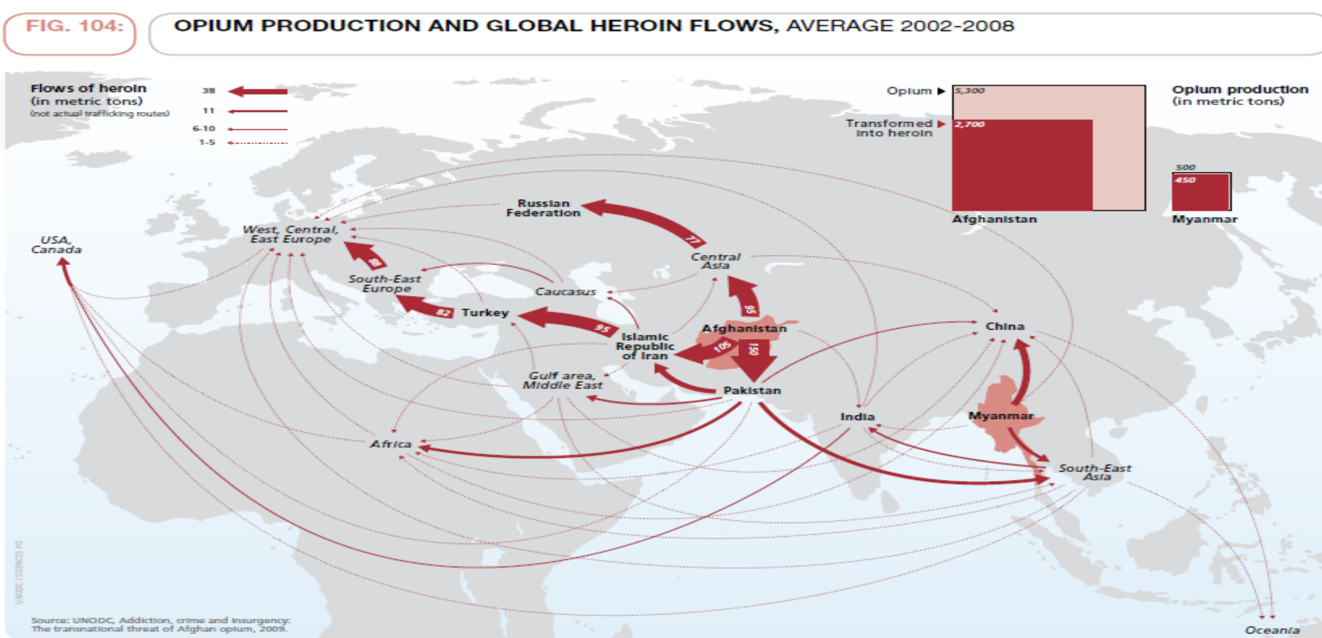

Figure 1: Average Opium Production and Global Heroin Flows 2002-2008[ii]

Research Questions:

- Assuming interdiction teams will be 100% effective in stopping the flow of drugs out of Afghanistan and Myanmar, what are the optimal routes on which to place a roadblock given 1-10 teams? Given these teams, what is the expected flow of drugs across the network?
- How does the flow of drugs across the network change if the amount of drugs that can be captured on each path is dependent on the length of the route and the number of teams that can be put on each path? For example, how does being able to dedicate two times more resources to interdicting drugs on one path change the result? Under these assumptions what are the optimal paths on which to allocate resources? How many interdiction teams should be placed on each path to minimize flow across the network given a varying number of available interdiction resources?
- How do the results change if the addition of a second interdiction team on an arc is only half as effective as the first team?

Mathematical Model: Max-Flow Interdiction Algorithm.

$$\min_{x,\mathrm{w}} \max_{v,y} \; v - \sum_{(i,j)} dijyij(xij + 0.5 * wij)$$

$$s.t. \quad \sum yis - \sum ysi = -v$$

$$\sum yit - \sum yti = v$$

$$\sum yia - \sum yai = 0$$

$$yij \leq uij$$

$$0 \leq yij$$

Analysis:

Initially running a Max-Flow Interdiction Algorithm, preliminary baseline results were obtained as to where to optimally place interdiction teams, given the assumption that placing an interdiction team would be 100% effective in stopping the flow of drugs on the route. These initial results were achieved by implementing a penalty value of d_{ij}=1.1 for transiting an interdicted path.

These results were built upon to more realistically model actual interdiction methods by introducing varying probabilities of interdiction on each path. A probability of interdiction value became the penalty for moving heroin across an interdicted route. Longer distance arcs were assigned a higher probability of interdiction, as it was assumed more drugs are likely to be intercepted along longer routes. This penalty was based on great circle distances, and initialized using a constant value representing a guaranteed probability of interdiction given a team was placed on the route. Scenarios were modeled assuming this guaranteed interdiction amount of both 10% and 50%.

$$Probabilty\ of\ Interdiction = 0.1 + \frac{\left(1.5^{(Distance/1000)}\right)}{50}$$

In order to model varying interdiction strategies, the model was run three times, each time using a different scenario. The first scenario allowed only one interdiction team per edge. The second scenario allowed up to two interdiction teams of equal strength per edge. The final scenario was similar to the second but with the addition of a second interdiction team on an edge being only half as effective as the first. The results of these scenario's for both 10% and 50% guaranteed probability of interdiction are summarized in Figures 2 and 3 below.

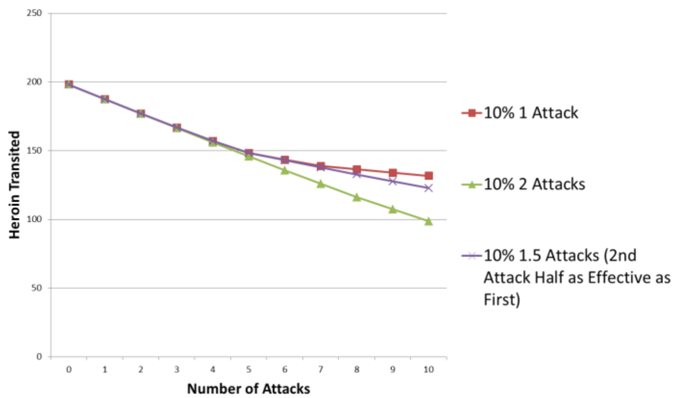

Figure 2: 10% Probability of Interdiction Per Edge

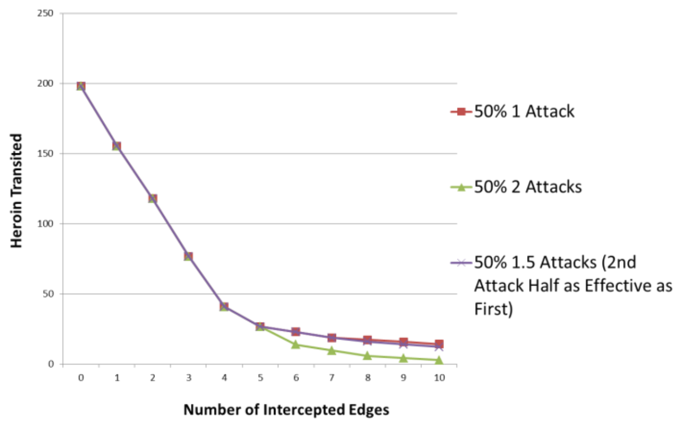

Figure 3: 50% Probability of Interdiction Per Edge

Conclusions/Future Work:

Figure 2 shows that the amount of total heroin that makes it through the network unimpeded barely differs across all three scenarios for up to 5 total teams. When two equally effective interdiction teams are allowed per edge, the benefits of each additional team are nearly linear. For the other two scenarios, the amount of heroin they can seize decreases substantially beyond 5 total teams allowed.

Figure 3 shows similar results assuming a guaranteed 50% probability of interdiction. In this case, the amount of total heroin that makes it through the network unimpeded barely differs across all three scenarios, but for up to 4 total teams. Additionally, for all three scenarios, the amount of heroin seized decreases substantially beyond 4 total teams allowed.

There is a great amount of room for future work and expansions of this model. For example, one area of future work might include more detailed modeling of drug traffickers' best responses when interdiction teams are placed on arcs. This could include creating new nodes and edges representing new routes smugglers might take should other routes become too risky and unprofitable. A second area for future work might include increasing the granularity of the model. Currently, network edges only represent distributions between nodes, not physical routes or intermediate nodes between the main nodes modeled. Identifying more intermediate nodes along the routes and more closely modeling actual transit routes (overland, sea, air) would provide more resolution to the results as well.

Sources:

Background on the Drug Routes from Central Asia to Europe, Geopium.org, http://geopium.org/196/the-drug-routes-from-central-asia-to-europe

Crime-Areas/Drugs, Interpol.Int, http://www.interpol.int/Crime-areas/Drugs/Heroin

Global Afghan Opium Trade, A threat Assessment 2011. United Nations Office on Drugs and Crime, http://www.unodc.org/documents/data-and-analysis/Studies/Global_Afghan_Opium_Trade_2011-web.pdf

Heroin: Data and Analysis. United Nations Office on Drugs and Crime .http://www.unodc.org/documents/data-and-analysis/tocta/5.Heroin.pdf

Illicit Drug Trends in Central Asia, United Nations Office on Drugs and Crime, http://www.unodc.org/documents/regional/central-asia/Illicit%20Drug%20Trends_Central%20Asia-final.pdf

Opiate Flows Through Northern Afghanistan and Central Asia. United Nations Office on Drugs and Crime. http://www.unodc.org/documents/data-and-analysis/Studies/Afghanistan_northern_route_2012_web.pdf

World Drug Report 2010, United Nations Office on Drugs and Crime, http://www.unodc.org/documents/wdr/WDR_2010/World_Drug_Report_2010_lo-res.pdf

World Drug Report 2011, United Nations Office on Drugs and Crime, http://www.unodc.org/documents/wdr/WDR_2011/World_Drug_Report_2011_lo-res.pdf

World Drug Report 2012, United Nations Office on Drugs and Crime, http://www.unodc.org/documents/wdr/WDR_2012/World_Drug_Report_2012_lo-res.pdf

ENDNOTES

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[i] Global Afghan Opium Trade, A threat Assessment 2011. United Nations Office on Drugs and Crime.
[ii] Heroin: Data and Analysis. United Nations Office on Drugs and Crime. http://www.unodc.org/documents/data-and-analysis/tocta/5.Heroin.pdf.