"Criminal Money Transfer"

Operations Research II Final Project

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Introduction:

In the modern day World there are still many 'currencies' that hold value and can be exchanged for goods. Most of the time currency is thought of as a clean crisp dollar bill but in the underbelly of society currency can take on all kinds of strange shapes and forms. I want to specifically focus on gangs who are typically known for creating a single commodity such as in some instances marijuana. These gangs then have to exchange marijuana for other goods and services. Now this is where things get tricky because marijuana is illegal and every time the gang makes an exchange using this marijuana they are taking on a risk that they could get caught by the police or some other authority.

In some instance some exchanges are far more risky for the gang in this situation for example if the police have been working undercover trying to purchase marijuana for cash, that would imply that the exchange of marijuana for cash would be more inherently risky than perhaps exchanging the marijuana directly for food because everyone knows that police don't go undercover selling bananas. But this alternative brings some other issues into play. Perhaps the exchange rate for marijuana is $10 per 1 unit marijuana and a banana costs $2 per banana giving an effective exchange rate of 5 banana per unit of marijuana. But directly exchanging the marijuana for the bananas the banana seller will only trade 3 banana per unit of marijuana. Is it worth it?

Problem:

I want to address this question of taking risk into account during these exchanges. Lets note first that Gangs are all different with different fundamental properties. The two properties that I am interested in here for this problem is the gangs internal risk adversity and the gangs strength of attachment to wealth. Taking these two quantities into account can help me provide a method of decided which choice to make and how much profit should a gang forgo to maintain a risk level that is acceptable to their preferences.

Basic Problem:

So the basic set of the problem goes as follows;

Consider that You have n commodities with exchange rates e(i,j), the exchange rate from commodity i to j and with "risk rate" of r(i,j), the "risk rate" from commodity i to j. Explaining the "risk rate": one can think of this quantity as the probability that our criminal gang gets "caught" when moving money from currency i to j. So now the idea is that as a gang we need to move our wealth across currencies to meet the demands of being a gang for example, treating some kind of desirable drug as a currency, we could want to find the "best sequences of exchanges" to acquire that drug. And I will answer the question of what the "best" way is given 2 specific quantities about the gang, one the amount of "value" they want to retain and the amount of risk that they are willing to take on during the acquisition of the "currency".

Assumptions:

For sake of simplicity I am assuming that the gangs have all of their money stored in a single currency, assuming that there is no arbitrage in the system, that the chances of getting caught at each transaction are independent.

Solution:

Suppose we have a gang that has currency i and needs to convert to currency j who has a minimum value of V and a maximum risk of R.

In order to work with this problem I used a directed graph allowing the vertices to represent the state of money and the edges to represent the tuple containing the exchange rate and the risk rate from i to j for the corresponding edges in the graph.

So now that we have this graph we can consider how to choose this best method of obtaining the best path. We want to get the amount of j that we need with the least i while still being under our set risk tolerance. We can then form the problem into an optimization problem subject to the constraints set by the graph and the risk tolerance constraint.

Let a path be expressed as so Pi = [(e(i,1),r(i,1)) , (e(a,2),r(a,2)), …. , (e(n,j),r(n,j))]

First off given a path from i to j to calculate the value we can multiply the exchange rates together. For the risks we want to find the probability that we get caught ever we first find the probability we never get caught which would be (1 - r(i,1))*(1- r(1,2))*.....*(1-r(n,j)) then in order to find the probability we get caught at all we and subtract that from 1.

We can use a dynamic program to work through the graph so that we can choose the correct path. The subproblem will be Paths(Graph, current, end, previous) which will return a list of triples with the following structure with an element corresponding to each path from current to end nodes in the graph G.

[(list of nodes traveled to for path), the probability of not getting caught on this path, value of path]

and the recursion will work as follows

The base cases will be

Paths(Empty Graph , c, e, p) = the empty set
Paths(G , current , current , p) = [(current, 1 , 1)]
if current has no neighbors in G then Paths(G, c, e, p) = the empty set

and the recursive relationship

Paths(G , c , e , p) = For each Neighbor(current)
add c to front of each path generated from
Paths(G-c,ith Neighbor , e,c)
Then bundle all of those paths together

Describing this process in words; To find all the paths from i to j along with the associated risk and value of those paths.

First we start i and what we do is that we look at all of the neighbors of i. At this stage three things can occur; first i could have no neighbors and in that case there are no paths from i to j, second i could in fact be equal to j and in that case you are done the only path is just i, or third i could have neighbors so in this case for each neighbor we are going to walk to that neighbor on the path and remember the node that we walked from. Then what we are going to do is for each neighbor we are going to find all the paths from that neighbor to j in the same manner. So once all of these paths are found what we are going to is to add the node that we walked from that we remembered to all of the paths that were returned and that will result in a complete list of all the paths from i to j.

So once we implement this and get a complete list of paths from i to j in our graph it is easy to find the corresponding risk and value quantities for each path and we can create a table where each row contains a unique path from i to j and the corresponding risk and values for that path. So when asked by our criminal gang to find a way to safely (a r% chance of less of getting caught) turn our i into j while still maintaining v% of the maximum value that could be reached we can get all of the results that maintain that level of value and have a risk level that is acceptable and we can just pick the path with the largest v from this group that satisfies the rules the gang put on you.

Discussion:

Because I have yet to make any headway getting adopted into a large crime organization I choose to keep this discussion theoretical and was not able to acquire a dataset to test my algorithm on. But as far as analyzing the algorithm if correctly memoized will take O(n) time which is pretty nice. Under the assumptions of the model this would work great for gangs to correctly balance their profits and risk.

Some ways that this specific problem could be further analyzed would to look at the magnitude between the marginal risk and the marginal profits so that some bivariate function could be optimized so that the gangs are really optimizing their lifestyle. Another question could be that in fact a gang was producing 2 or more goods and they have many options of which goods to trade and how that would affect the acquisition of what the gang required.

Another possible issue with this analysis is that the exchange rates were assumed to be constant regardless of the amount of goods exchanged i.e. that if 1 banana was worth 1 unit beer then 10 banana are worth 10 units of beer. In order to adjust for this the values and risks could be treated as functions of this additional quantity parameter as opposed to simply looking for the best exchange rate.

Conclusion:

Despite some setbacks this semester with my group. I ended up really enjoying this project where definitely dynamic programming and graphs were my favorite topics and was really fun getting to work with these in my own kind of set up and environment. Perhaps if I were to do something differently I would perhaps try to apply this to groups that I could acquire actual data from and test out my solutions with the training set to see how I matched up with what groups actually used. Some adjustments to my assumption could make this a more valuable tool in the future and some additional analysis could broaden my solution to a larger group. But overall I feel like my solution is a valid abet a somewhat simple solution to this problem.