

### Seminar 7 – Terrorism Models

The paper Sandler, Todd and Arce, Daniel G. M., 2003, “Terrorism and Game Theory,” *Simulation and Gaming*, [http://www-rcf.usc.edu/~tsandler/Terror\\_Games.pdf](http://www-rcf.usc.edu/~tsandler/Terror_Games.pdf), contains a number of theoretical ideas on terrorism. Here I will touch on just one that I find the most interesting.

Consider the problem of a terrorist target. We can think of this as a particular country of a specific location such as 10 Downing Street. The target decides how much money,  $D$ , to spend on defensive measure. Suppose that the probability that the target will get hit with a terrorist attack is  $1 - aD$  where  $a > 0$ , the key point being that this probability is decreasing in defensive measures. If  $D > \frac{1}{a}$  then the probability formula gives a negative number. This is no problem. Then we just set the probability of an attack equal to zero. The interpretation is that if you make a target hard enough then there is a guarantee that it will not be attacked. However, achieving this result might be very expensive. Suppose the disutility of suffering a terrorist attack is  $P$  and that the people running the target can be modelled as having the utility function:

$$-(1 - aD)P - D^2 \quad (1)$$

This utility function is always negative but this is not a problem. The main point is indicates how the decision-maker trades off enhanced security against money. To maximize this utility function we get the first order condition:

$$aP - 2D = 0$$

which gives

$$D = \frac{aP}{2}$$

This result makes sense. The more it hurts to be subject to an attack the more the target would spend defending itself. Note that if  $P$  is large enough compared to  $a$  then this level of  $D$  would imply a negative probability of attack. In this case we reset  $D$  to equal  $\frac{1}{a}$  and the probability of an attack is zero. This will not happen as long as  $P < \frac{2}{a^2}$ . In other words, as long as the penalty for getting hit is not too large it will never be optimal to construct an impregnable defence.

Now consider two locations that are potential terrorist targets. These could be two countries, such as the US and the UK, or just two locations within a single country

such as the Statue of Liberty and the Golden Gate Bridge. Suppose there is a terrorist group that is determined to hit one of these two targets and is not considering other targets. Target  $i$  invests money  $D_i$  in defensive measure. The difference from the single-country case is captured by the different form that the attack probability takes. We assume, sensibly enough, that the terrorist will attack that weakest target. If this is target  $i$  then probability of success  $1 - aD_i$ . If the two targets defend themselves equally well then the terrorist group will select its target randomly by flipping a coin. This means that target 1 can reduce its probability of getting hit down to zero as long as 1 spends slightly more than 2 does and vice versa.

The only equilibrium outcome of this competitive interaction is for both targets to spend all the way up to the perfect defence  $\frac{1}{a}$ . To understand this, note first that the two targets must be spending equal amounts in equilibrium. If, say, 1 were spending more than 2 then the probability that 1 will get hit would be zero and would continue to be zero even if he cut back his defence spending a little bit. So unequal spending cannot be a stable pattern, therefore the two targets must be spending the same amount. If this equal amount is not  $\frac{1}{a}$  then either target could drop its probability of getting attacked down to zero by just spending infinitesimally more money on defence. In other words, with equal spending  $\frac{1}{a}$  both targets would want to gain a slight competitive edge by spending a bit more to divert the terrorists to the other target. So, again, this is not a stable pattern. The only equilibrium is where both targets are fully defending themselves with  $\frac{1}{a}$ .

The crucial point to understand is that this competitive outcome is actually sub-optimal. At a social optimum maximizes the two targets spend equally and maximize:

$$\frac{-(1-aD)P}{2} - D^2 \quad (2)$$

This is virtually identical to (1) except that in (2) the first term is divided by two to reflect that fact that when both targets are spending the same amount the terrorist will flip a coin to decide whom to attack. The solution is for each target to spend.

$$D = \frac{aP}{4}$$

This will be less than the perfect defence,  $\frac{1}{a}$ , whenever  $P < \frac{4}{a^2}$ . So we find that it is quite possible to get overspending on protection against terrorism.

At the competitive outcome both targets would be better off if they cooperated by reducing their expenditures. This is because of externalities running between the two targets. When target 1 protects itself more the terrorists are diverted to target 2. When target 2 defends itself more it diverts the terrorists to target 1. So the self-help efforts of

each target have a negative spillover onto the other target. In other words, this is an example of a “prisoner’s dilemma”.