Harvesting Terrorists

"You are under harvest"

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Deux motivations :

(a) la lutte anti-terroriste « aveugle » peut être contre-productive :

“Dear Obama, when a U.S. drone missile kills a child in Yemen, the father will go to war with you, guaranteed. Nothing to do with Al Qaeda,” a Yemeni lawyer warned on Twitter last month (New York Times, June 2012).

Not new in the political science literature…

(b) la dynamique du terrorisme est semblable à la dynamique des poissons :

“The guerrilla must move amongst the people as a fish swims in the sea.”
Mao Zedong (Tse Tung), *On Guerrilla Warfare,* (1937)

Pourquoi ?

➔ Intuition: To be effective, an underground organization needs a stream of money and information, new recruits, printing facilities, secret medical help for the wounded, transportation, places to hide, and the readiness of the surrounding population not to give its members away: tacit support.

➔ The guerrilla fighter is like a fish in the water, the water being the general population. Without the water, the fish dies (Mao Zedong)

“As a terrorist, I was keenly aware of the importance of public support. (…)”

Gush Shalom, *Water for These Fish: The Minds and Hearts of Palestinians*
New York Times, August 8, 1997

En résumé : le terroriste est un poisson, qu’il faut capturer avec des filets : mais plus la maille du filet est petite et moins la pêche est efficace.

Brief Overview

➔ We develop a model of capturing terrorists in a dynamic framework when the very act of killing or capturing them induces new recruit formation to the terrorists' cause.

➔ We adopt standard economic models of fishing to show that the discount rate, the cost of catching terrorists and the technology used, can affect optimal terrorism policy.

➔ We show conditions under which the model yields a "socially optimal" capture rate, and conditions under which no solution to the problem exists.

➔ The paper suggests that terrorism is a dynamic and long run problem and needs to be modeled using methods available in other disciplines such as resource economics.

Introduction

Important issue:

- ➔ How much resource to spend to control terrorism?
- ➔ The process of capturing or killing “terrorists” itself leads to the creation of new terrorists
- ➔ This is an issue mostly ignored in the literature on the economics of terrorism.
- ➔ As we show in this paper, this conversion to the cause has major implications for the control strategy that needs to be adopted to limit or control the number of terrorists in the population.

- ➔ In this paper, we develop a dynamic model for the harvesting of terrorists in an economy.
- ➔ The main innovation: the relationship between the harvest rate and the conversion of otherwise ‘productive’ people to the terrorist cause.
- ➔ When a solution exists, it is a steady-state, i.e., there will always be an “optimal” number of terrorists in the population.
- ➔ The policy implication of this rather simple exercise is quite profound and somewhat pessimistic. We can never eliminate terrorism from society; we can at best ‘contain’ their numbers.
- ➔ Against what George W Bush once said, that the United States will not stop until every terrorist is defeated.

- ➔ Casual empirical evidence from the last 10 years seems to suggest that in terrorist havens such as Afghanistan, Pakistan, Yemen, Somalia, terrorists continue to thrive, even though their networks have been decimated and a large number of them have been periodically captured or killed through government action.
- ➔ Le terrorisme a toujours existé. Il y a eu à toute époque dans une région du monde un mouvement d'insurrection contre le régime en place. Exemple des mouvements communautaires (basque, irlandais ou corse) : jamais vraiment éradiqués, atteignent un certain niveau d'équilibre dans la population, finissent par faire partie du paysage politique.

Literature on terrorism

(1) Papiers empiriques récents qui évaluent quantitativement les effets des politiques de lutte contre le terrorisme

- ➔ Bandyopadhyay, Sandler (2014), Journal of Public Economics.
- ➔ Mialon, Mialon, Stinchcombe (2012), Journal of Public Economics.
- ➔ Benmelech, Berrebi, Klor (2010), NBER Working Paper.

(2) Papiers en socio quantitative (méthodo : math appli-physique) qui étudient la dynamique propre de la population terroriste

- ➔ Gutfraind (2009), Studies in Conflict and Terrorism.
- ➔ Canals (2009), Mathematical and Computer Modelling.
- ➔ Udwadia, Leitmann, Lambertin (2006), Discrete Dynamics in Nature and Society.
- ➔ Gallam (2002), European journal of Physics B, (2003a,b) Physica A : théorie de la percolation.
- ➔ Hamilton and Hamilton (1983), International studies quarterly.

(3) Etude des conséquences du terrorisme sur Croissance Macro, Commerce Inter, FDI…

- ➔ Benmelech, Berrebi, Klor (2009), NBER Working Paper.
- ➔ Abadiea, Gardeazabal (2008), European Economic Review.
- ➔ Gaibulloev, Sandler (2008), Kyklos.
- ➔ Arin, Ciferri, Spagnolo (2008), Economics Letters.
- ➔ Mirza, Verdier (2008), Journal of Comparative Economics.
- ➔ Blomberg, Hess, Orphanides (2004), Journal of Monetary Economics.

(4) Articles théoriques, dimension normative : Quelle politique de lutte contre le terrorisme ?

- ➔ Sandler, Siqueira (2006), Canadian Journal of Economics.
- ➔ Notre papier : Cadre macro croissance, avec prise en compte des faits stylisés de (1) et (3) → coût pour l'économie du terrorisme, effet boomerang de la lutte anti-terroriste + hypothèse de (2) application à l'économie de la dynamique du terrorisme et du principe de contagion (phénomène d'épidémie)

The Model

- ➔ Total population N, constant.
- ➔ X number of terrorists in the population.
- ➔ At any given time, the number of terrorists killed or captured because of the policy is given by H.
- ➔ $H \leq X$
- ➔ $h = H / N$ Proportion of the population that is “harvested” by the policy.
- ➔ Conversion rate: $\alpha(h)$ where $\alpha'(h)>0$.

➔ Rate of change of the stock of terrorists in the economy:

$$\dot{X}(t) = -H + X(t) + \alpha(h)(N - X)$$

Over time, the population of terrorists increases naturally at the rate of unity, that is if there is no harvesting, the stock grows, like a renewable resource.

➔ Dividing both sides by the population *N* and simplifying yields

$$\dot{x} = -h + x + \alpha(h)(1 - x) \tag{1}$$

Simplify by normalizing in the form of $N = 1$.

➔ We can now develop the maximization problem of the planner who needs to devise an optimal harvesting policy for terrorists.

- ➔ Utility is derived from the number of good individuals $N-X$ which when normalized becomes $1-x$:

$$U(1-x), \text{ with } U'>0,\ U''<0.$$

- ➔ The unit cost of harvesting is given by $b>0$.
- ➔ $r>0$ the social discount rate.
- ➔ Infinite horizon problem of maximizing net surplus is given by:

$$\underset{\{h\}}{Max}\int_0^{+\infty} e^{-rt}\left[U(1-x)-bh\right]dt \qquad (2)$$

subject to (1) $\dot{x}=-h+x+\alpha(h)(1-x)$.

➔ The current value Hamiltonian is given by

$$H = \{U(1-x) - bh\} + \lambda[x - h + \alpha(h)(1-x)] \qquad (3)$$

$\lambda(t)$ the shadow price of the constraint ⇔social cost of a terrorist (negative).

➔ Differentiating with respect to the control variable, the harvest rate *h*:

$$b = -\lambda[1-\alpha'(h)(1-x)]. \qquad (4)$$

➔ Given that $\alpha'(h) > 0$, we must have $\alpha'(h) > \dfrac{1}{1-x}$.

➔ The next necessary condition for optimality is given by:

$$\dot{\lambda}(t) = r\lambda - \frac{\partial H}{\partial x}$$

which upon manipulation yields

$$\dot{\lambda}(t) = U' + \lambda\left[r - (1 - \alpha(h))\right].$$

➔ Specific functional forms: strict, concave utility function:

$$U(1-x) = \frac{(1-x)^{1-\varepsilon}}{1-\varepsilon}$$

➔ Absolute value of the elasticity of marginal utility: $0 < \varepsilon < 1$.

➔ Assume a strictly convex conversion function given by $\alpha(h) = \bar{\alpha}\frac{h^2}{2}$,

where $0 < \bar{\alpha} < 1$.

➔ First derivative of $\alpha(h)$ is given by $\alpha'(h) = \bar{\alpha}h$.

➔ Then the above problem becomes:

$$\underset{\{h\}}{Max} \int_0^{+\infty} e^{-rt} \left[\frac{(1-x)^{1-\varepsilon}}{1-\varepsilon} - bh \right] dt$$

subject to $\dot{x} = x - h + \bar{\alpha} \frac{h^2}{2}(1-x)$.

➔ The Hamiltonian:

$$H = \frac{(1-x)^{1-\varepsilon}}{1-\varepsilon} - bh + \lambda \left[x - h + \bar{\alpha} \frac{h^2}{2}(1-x) \right]$$

λ multiplier associated with the stock of terrorists.

➔ The first order conditions:

$$b = \lambda\left[\bar{\alpha} h(1-x) - 1\right]. \qquad (5)$$

and we must have $\bar{\alpha} h(1-x) - 1 < 0,$ which implies that

$$h < \frac{1}{\bar{\alpha}(1-x)}. \qquad (6)$$

➔ This condition says that: for the marginal cost of harvesting to be equal to the marginal social benefit of doing that, the rate of harvest must be bounded from above.

➔ The necessary condition with respect to the stock of terrorists gives:

$$\dot{\lambda} = r\lambda - \left[-(1-x)^{-\varepsilon} + \lambda\left(1 - \bar{\alpha}\frac{h^2}{2}\right)\right]$$

⇔

$$\frac{\dot{\lambda}}{\lambda} = \bar{\alpha}\frac{h^2}{2} - (1-r) - (1-x)^{-\varepsilon}\frac{\left[1-\bar{\alpha}h(1-x)\right]}{b} \qquad (7)$$

which yields the differential equation:

$$\frac{\dot{\lambda}}{\lambda} = \frac{\bar{\alpha}(1-x)}{1-\bar{\alpha}h(1-x)}\dot{h} - \frac{\bar{\alpha}h}{1-\bar{\alpha}h(1-x)}\dot{x}.$$

➔ Thus the dynamic system becomes:

$$\dot{h} = \frac{h}{(1-x)}\dot{x} + \frac{[1-\bar{\alpha}h(1-x)]}{\bar{\alpha}(1-x)}\left[\bar{\alpha}\frac{h^2}{2} - (1-r) - (1-x)^{-\varepsilon}\frac{[1-\bar{\alpha}h(1-x)]}{b}\right] \qquad (8)$$

$$\dot{x} = x - h + \bar{\alpha}\frac{h^2}{2}(1-x) \qquad (9)$$

Existence and Unicity

➔ To show that a steady state exists and is unique, substitute $\dot{x} = 0$ in (9):

$$\left(1 - x\right) = \frac{1 - h}{1 - \bar{\alpha}\frac{h^2}{2}} \qquad (10)$$

➔ The maximum value of *h* at the steady-state, using condition (6).

$$h < \frac{1 - \bar{\alpha}\frac{h^2}{2}}{\bar{\alpha}\left(1 - h\right)}$$

$$\Leftrightarrow \; \bar{\alpha}\left(1 - h\right)h - 1 + \bar{\alpha}\frac{h^2}{2} < 0.$$

➔ Second order polynomial $P(h) = -\frac{\bar{\alpha}}{2}h^2 + \bar{\alpha}h - 1.$

➔ Determinant of the polynomial $\Delta = \bar{\alpha}(\bar{\alpha} - 2) < 0$.

➔ The function *P(h)* is always negative, i.e., condition (6) is always satisfied at the steady state.

➔ Now, using (10) in (8) and assuming that $\dot{h} = 0$:

$$\bar{\alpha}\frac{h^2}{2} - (1-r) = \frac{1}{b}\left[\frac{1-h}{1-\bar{\alpha}\frac{h^2}{2}}\right]^{-\varepsilon}\left[1-\bar{\alpha}\frac{h(1-h)}{1-\bar{\alpha}\frac{h^2}{2}}\right]$$

➔ Consider $g(h) = \dfrac{1-h}{1-\bar{\alpha}\dfrac{h^2}{2}} \cong 1-x > 0$

$$➔ \bar{\alpha}\frac{h^2}{2} - (1-r) = \frac{1}{b}\left[g(h)\right]^{-\varepsilon}\left[1-\bar{\alpha}hg(h)\right] \quad (11)$$

➔ There will exist a steady state *(h***, x***)* if there exists a solution to this relation.

➔ Let us denote by *G(h)* and *K(h)*, respectively the LHS and the RHS of (11).

These functions are given by:

$$G(h) = \bar{\alpha}\frac{h^2}{2} - (1 - r)$$
$$K(h) = \frac{1}{b}\left[g(h)\right]^{-\varepsilon}\left[1 - \bar{\alpha}hg(h)\right] \qquad (12)$$

➔ There will exist a steady state (h^*, x^*) if there exists a solution to the following: $G(h^*) = K(h^*)$.

➔ We first study the function $G(h)$.

$$\lim_{h\to 0} G(h) = -(1-r) < 0 \text{ because } r < 1$$

$$\lim_{h\to 1} G(h) = \frac{\bar{\alpha}}{2} - (1-r).$$

➔ We need to make the assumption: $\frac{\bar{\alpha}}{2} > (1-r)$ combined with $0 < \bar{\alpha} < 1$

yields the inequality constraint :

$$1 > \bar{\alpha} > 2(1-r). \text{ Thus, } 1 > 2(1-r) \leftrightarrow 1-r < \frac{1}{2} \leftrightarrow r > \frac{1}{2}$$

➔ This implies that $G'(h) = \bar{\alpha}h > 0, \quad G''(h) = \bar{\alpha} > 0.$

➔ G is strictly increasing from a negative value $G(0) = -(1-r)$, when $h = 0$, to a positive value of unity, that is, $G(1) = \frac{\bar{\alpha}}{2} - (1-r) > 0$.

➔ Value of h for which $G(h) = 0$: $\underline{h}$. We have:

$$\bar{\alpha}\frac{h^2}{2} - (1-r) = 0 \rightarrow \underline{h} = \left[\frac{2(1-r)}{\bar{\alpha}}\right]^{1/2}. \qquad (13)$$

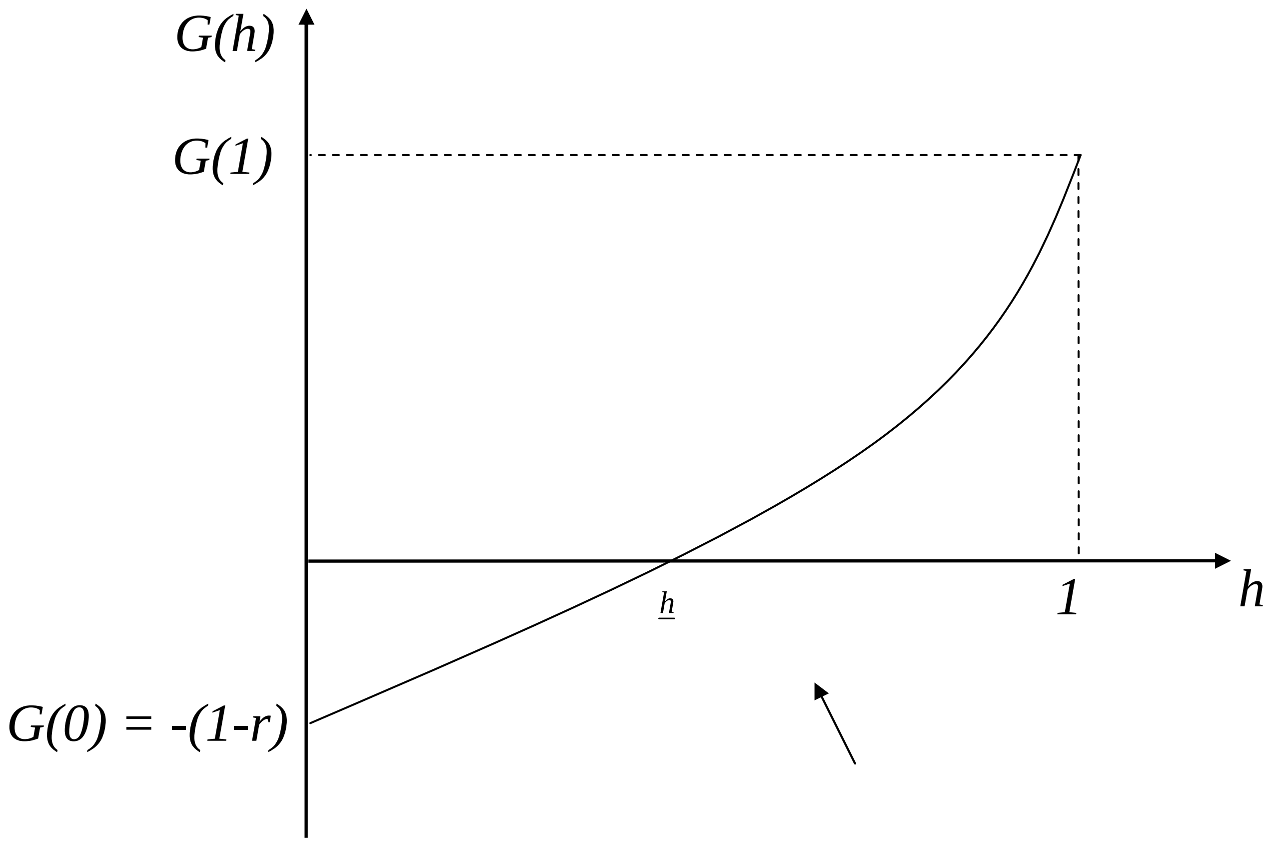

Fig.1: *graf of G(h)*

➔ Now let us look at the function $K(h)$.

$$K(h)=\frac{1}{b}[g(h)]^{-\varepsilon}[1-\bar{\alpha}hg(h)]>0.$$

$$\lim_{h\to 0}K(h)=\frac{1}{b},\quad \lim_{h\to 1}K(h)=+\infty$$

$$K'(h)=\frac{1}{b}[g(h)]^{-\varepsilon}\left[-\varepsilon\frac{g'(h)}{g(h)}(1-\bar{\alpha}hg(h))-\bar{\alpha}g(h)\left(1+h\frac{g'(h)}{g(h)}\right)\right]$$

➔ Define $\eta_{g/h}=-h\dfrac{g'(h)}{g(h)}>0$, which is the elasticity of $g(h)$, i.e. of the number of good citizens, with respect to the harvest rate, h. Then:

$$K'(h)=\frac{1}{bh}[g(h)]^{-\varepsilon}\left\{[\varepsilon+(1-\varepsilon)\bar{\alpha}hg(h)]\eta_{g/h}-\bar{\alpha}hg(h)\right\}\qquad(14)$$

➔ Value $\bar{h}$, s.t. $K'(\bar{h}) = 0$:

$$\varepsilon + (1-\varepsilon)\bar{\alpha}\bar{h}g(\bar{h}) = \frac{\bar{\alpha}\bar{h}g(\bar{h})}{\eta_{g/h}} \qquad (15)$$

➔ We therefore can conclude that:

if $\varepsilon + (1-\varepsilon)\bar{\alpha}\bar{h}g(\bar{h}) < \frac{\bar{\alpha}\bar{h}g(\bar{h})}{\eta_{g/h}}$, then $K'(\bar{h}) < 0, \quad and \quad h < \bar{h}$.

If $\varepsilon + (1-\varepsilon)\bar{\alpha}\bar{h}g(\bar{h}) > \frac{\bar{\alpha}\bar{h}g(\bar{h})}{\eta_{g/h}}$, then $K'(\bar{h}) > 0, \quad and \quad h > \bar{h}$

➔ If both of these conditions do not hold, $h = \bar{h}$. See Fig. 2.

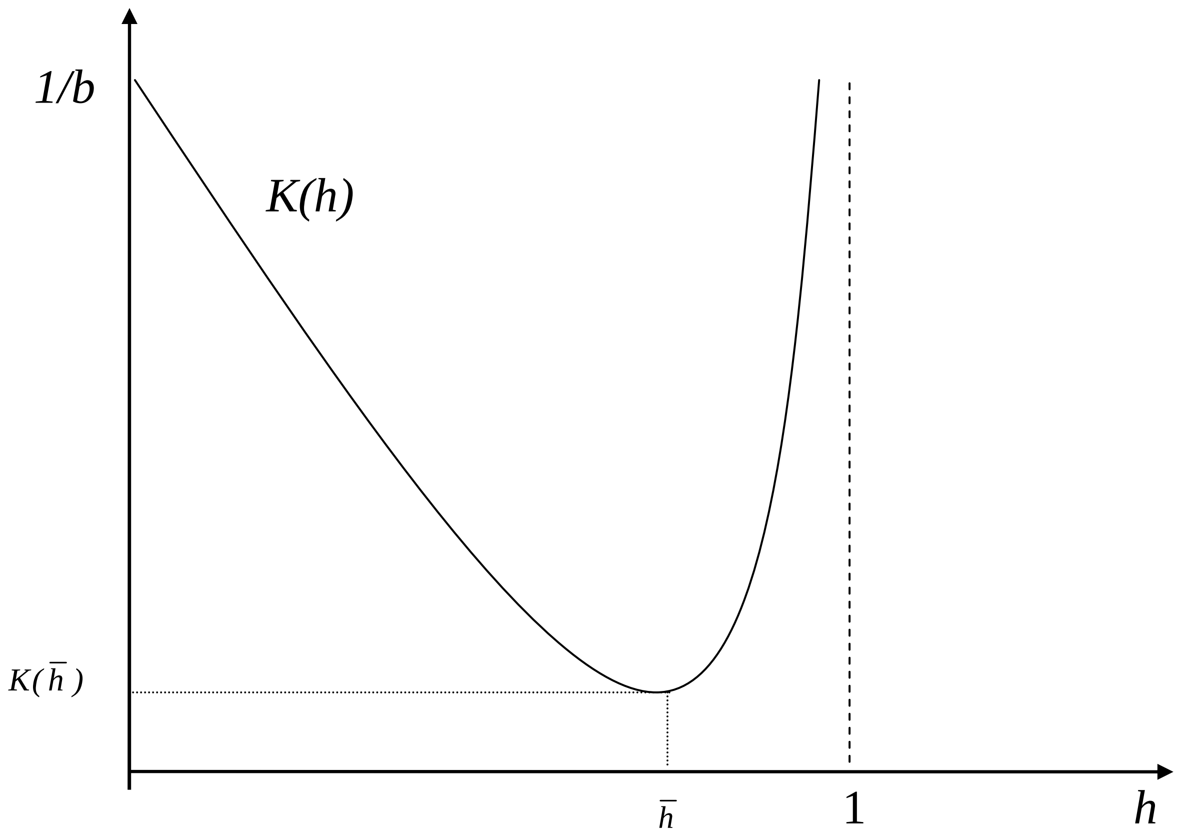

Fig. 2: *graf of K(h)*

➔ We can summarize our results in the following proposition:

Proposition 1: (i) If $K(\bar{h}) > G(\bar{h})$*, there is no solution to the above problem.*

(ii) However, if $K(\bar{h}) < G(\bar{h})$*, there will exist two steady-state solutions* $(h_1^*$ *and* $h_2^*) > \underline{h}$ *with* h_1^* *such that* $K'(h_1^*) < 0$ *and* h_2^* *such that* $K'(h_2^*) > 0$.

This is seen in Fig. 3.

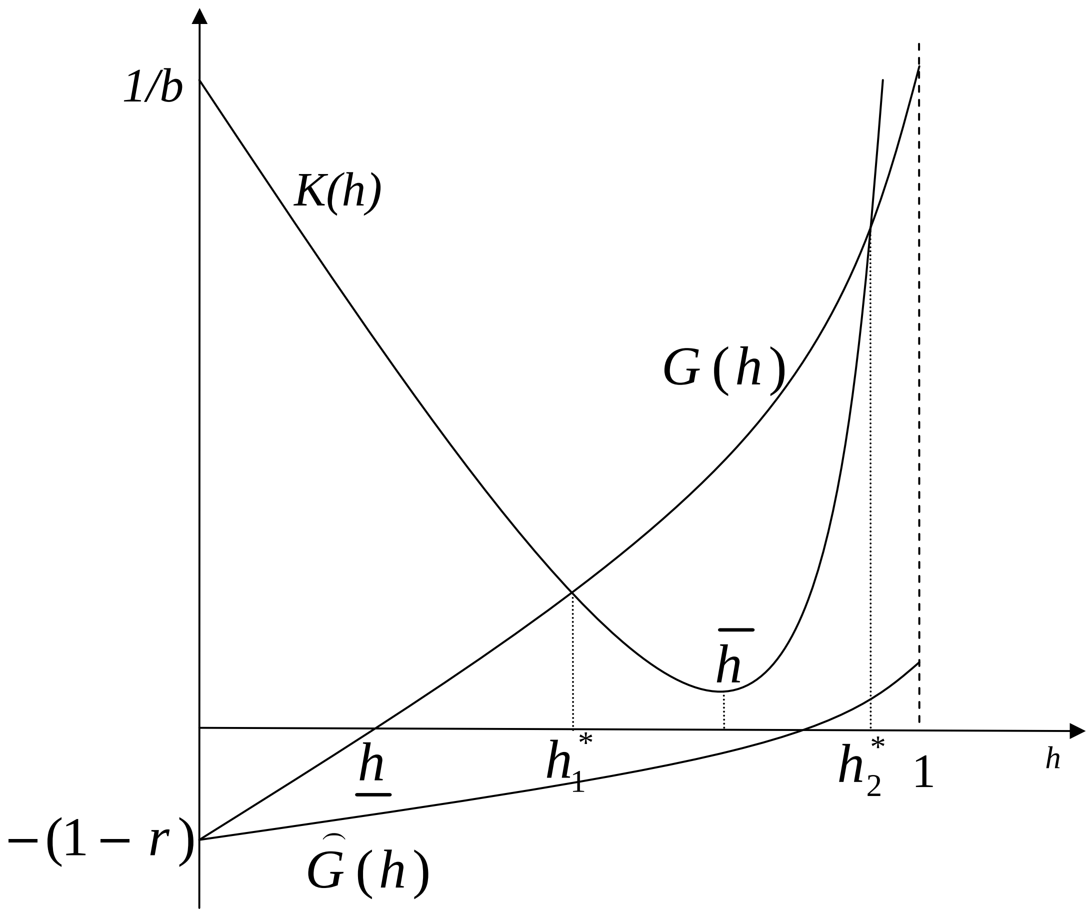

Fig.3. Two possible optimal harvest rates

Local Stability

➔ We analyze the stability of the solution by studying the components of the Jacobian matrix:

Proposition 2: The only solution which is locally stable is the one with K'(h)<0. To summarize, if $K\left(\bar{h}\right)<G\left(\bar{h}\right)$*, there will exist a unique stable saddle path solution of the problem set above. This saddle solution is such that* $K\left(h^{*}\right)=G\left(h^{*}\right)$ *with K'(h*)<0 and* $\left(1-x^{*}\right)=\dfrac{\left(1-h^{*}\right)}{\left(1-\bar{\alpha}\dfrac{h^{*2}}{2}\right)}$.

Conclusion

- ➔ We develop the idea that the population of terrorists in society can be "contained" through action by government.
- ➔ However, the technology for pursuing terrorists may itself affect the rate for formation of new terrorists.
- ➔ There is substantial empirical evidence to support this claim. For instance, the images from American prisons in Iraq, the barbed wire cages of Guantanamo Bay and the more recent civilian casualties from missile firings by unmanned drones have all been used by jihadi groups as a recruiting device.

- ➔ The paper uses standard economic models of fishing to show that the discount rate of the planner, the cost of catching terrorists and the technology used, can affect optimal terrorism policy.
- ➔ The key feature of the model is that enforcement technology plays a significant role in the formation of new terrorists in the population and thus leads to a growth in the population of terrorists. We show conditions under which there is a steady state of terrorists in the population.

➔ Although the model is extremely simple, we think that the empirical evidence in terrorism hotspots such as Afghanistan, Pakistan and the Middle East suggests that terrorism is a dynamic and long run problem and needs to be modeled using methods available in other disciplines such as resource economics.

Extension

1. Define a third category in the population: terrorist ie active, anti-terrorist ie pro-gov. and neutral or passive supporter. The rate of permeability between these 3 groups should be different; the impacts on the conversion should be also different whether the army harvests a passive supporter or an active terrorist, a pro-gov…Introduce a probability (a risk) of harvesting a passive supporter (instead of active terrorist)

2. Fight against terrorism by preventing conversion, like education, funding of public goods like schools, hospitals, roads, public infrastructures…