Protection, Technological Transfer and Alliance against Terrorist Conflict

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ABSTRACT

This paper investigates the defensive measures of a government threatened by a terrorist organization. Some authors have studied only the alliance with a neighbouring country to protect from an external attack. This is the reason why our model focuses on a possible coalition with a terrorist group even if this cooperation is frowned upon by the international community. The second model deals with the protection technology. Indeed, the alliance between countries enables the transfer of such a protection. The example of the NATO justifies this analysis because of the Partnership for Peace (PfP). Then, we show that helping a threatened country leads to negative externalities due to this collaboration. The effects of the parameters differ, resulting in the optimal choice of the targeted country concerning its security.

Keywords: Conflict Resolution, Alliance, Protection.

1. INTRODUCTION

Terrorism is not a recent phenomenon. It concerns many countries across the world and is unfortunately still current. The attack which has the greatest impact on the population consciousness is certainly those of September 11th in the United States by Al-Qaeda. Actually, this date corresponds to the beginning of a new age in the way countries deal with terrorism. Today, even if Osama Bin Laden is dead (on May 6th 2011) and some terrorist leaders as well, the threat from this jihadist organization is not over. A feeling of fear and fright has been felt everywhere in the United States but also in the world and one of the many questions that remain unanswered is: how did such a powerful country fail to avoid this attack? Obviously, the terrorists display more and more sophisticated means to reach their objectives evading the vigilance of some countries but what is our real knowledge about terrorism. Today, it is quite clear that we were not well prepared to face terrorism. That is the reason why the causes and the consequences of terrorism (namely from an economic point of view) have to be analyzed with much more accuracy.

A unique definition of the terrorism?

There is not a unique form of violence: attacks suicides, hostage-taking, bomb attacks. This non-exhaustive list means that terrorism can take the most abundant and diverse forms. It is due to their socioeconomic, cultural, ideological or even political dimensions. Different techniques are used because the aim of these groups considerably differs. As the terrorist acts differently, it explains that the definition differs.

In France, the legislation (Penal Code Art. 421.1) defines it as "*an individual or collective undertaking the purpose of which is seriously to disturb public order through intimidation or*

terror". An act could be qualified as terrorist if it satisfies two criteria. On the one hand, it must implicate the committee of some specific offences such as voluntary attacks in life and in integrity of the person, kidnapping and sequestration or misappropriation of any means of transport. On the other hand, there must be a causal relation between the committee of these offences and the individual or collective undertaking.

The United State Code defines the term terrorism as a "*premeditated, politically motivated violence perpetrated against noncombatant targets by subnational groups or clandestine agents*".

The purpose is obviously not to give an exhaustive list of definitions but to have the point of view or the understanding of countries, international organization and authors.

It leads to consider the definition of the United Nations who recalls in the *United Nations Security Council Resolution 1566* in 2004 that:

> "*Criminal acts, including against civilians, committed with the intent to cause death or serious bodily injury, or taking of hostages, with the purpose to provoke a state of terror in the general public or in a group of persons or particular persons, intimidate a population or compel a government or an international organization to do or to abstain from doing any act, and all other acts which constitute offences within the scope of and as defined in the international conventions and protocols relating to terrorism, are under no circumstances justifiable by considerations of a political, philosophical, ideological, racial, ethnic, religious or other similar nature, and calls upon all States to prevent such acts and, if not prevented, to ensure that such acts are punished by penalties consistent with their grave nature.*"

The economists have their own definition. This concept is described by Enders and Sandler (2005) as "*the premeditated use, or threat of use, of extra normal violence by an individual or a subnational group to obtain a political objective through intimidation or fear directed at a large audience usually beyond the immediate victims. An essential aspect of this definition concerns the presence of a political objective that the terrorist acts or campaigns are designed to achieve*".

Even if these definitions seem different, there are yet common points such as violence, broader range than immediate victims whom it generates, the institution of a climate of fear and it is perpetrated in reference to a political, ideological or religious motivations. However, we must be careful with these "characterization" of terrorism. Indeed, for example, we should not merge terrorism, resistance and war. Current definitions do not allow differentiating them. The difference between these two first terms can seem vague. The resistance of French population during German occupation in the Second World War seems to be considered as terrorism for the Germans. But what is it for the groups of guerrilla? These groups accuse the countries of being themselves the terrorists. The qualifier "terrorist" changes according to the point of view of each camp. There are so many variables which come into the picture.

As a consequence, giving a precise definition is impossible. However, by specifying the type of terrorism, the definition becomes less controversial. Concerning the religious terrorism type, his objectives deal with morality and ideas. It resembles to the political terrorism but his

attacks are much more intense. His mission is to institute a religious theocracy. Political or ideological terrorism is aimed at the change of regime or at the overthrow of a government. They are represented by groups motivated by a radical ideology of extreme left or extreme right there. Regarding the separatist terrorism, the conquest of the territory is their first purpose.

Actions led in anti-terror struggle

According to the type of terrorism, motivations and purposes are different. However, means applied by the governments are similar towards these different terrorist organizations. To accomplish these attacks, the terrorist groups have to obtain a source of financing. Their resources come principally from two sources: on the one hand, thanks to organizations, countries and individuals, bringing them a financial contribution; on the other hand, by collecting funds through the illegal activities such as requests of ransoms during hostage-taking or during kidnapping, the traffic of drugs and all kinds of fraud. However, these resources can come just as well from lawful activities. These funds are intended for the purchase of weapons, for the planning of attacks but also for costs linked to the functioning of the terrorist network. Thus, the first purpose is not to accumulate the most possible funds. This money represents a means, and not finality.

In order to stop the terrorist actions, some measures are taken by the governments. Stopping the financing of these groups is one of the measures. There are other actions led by the states with the intention to fight terrorism. However, these measures are not always sufficient to neutralize these threats. We can differentiate four main ways used by the nations: 1) prevention through the information, 2) cooperation between countries, 3) legislative measures and 4) armed repressions. These measures can be as well independent as supplementary.

Prevention and information are especially useful before terrorist actions take place. Every nation has an intelligence service. For example, the SDAT in France, the Mossad in Israel, the MI6 in Great Britain and the CIA in the United States make up representative agencies and one of their objectives is the anti-terrorism fight. Their role is the detection and the repression of the terrorist activities. These goals are present on the world scale, notably with the international organization NATO (North Atlantic Treaty Organization). Indeed, intelligence service of each member has to share information about the terrorist threats according to the Istanbul Summit in 2004.

It leads precisely to focus on the nation cooperation through the cooperation formation. This NATO organization is one of the most-known. This one regroups currently 28 member countries and maintains links with 22 partner countries. The first function of this cooperation is to guarantee security in his member countries. The partnership for peace (PfP) was thrown in 1994. His purpose is to increase security and to diminish threats by establishing narrower relations between countries, notably thanks to information. Several summits took place to fix guiding principles for every member country as well as of objectives to be attained. The Washington Summit of 1999 was principally focused on PfP by reinforcing his role within the alliance. After attacks perpetrated by Al Qaeda, another Summit took place in Prague to avoid other such bloody attempts. The plan of action of the partnership against terrorism was set up and several measures were taken: improvement of the distribution of information between countries and intelligence services and cooperation reinforced on borders of member

countries. To continue the anti-terror struggle, the Summit of Istanbul in 2004 concentrated on two points: the development of new leading-edge technologies to improve the protection and the launching of a security program *via* the science. This program has for function to promote distribution and transfer of technology to help the allied countries. The mission of France is to detect and to cause the failure of chemical, biological, radiological and nuclear weapons. Scientists from Germany and Egypt do research on chemical and biological sensor system. Some countries such as Ukraine, France and the United States have collaborated on a "new generation of multi-energy X-ray scanners for anti-terrorism inspection". All these measures show the will of the international community to fight all kinds of threat. Besides, to lead to a situation of peace in the world, some alliances do not hesitate to collaborate together. NATO and the United Nations struggle together against terrorism, notably thanks to the distribution of information and to the installation of appropriate measures. This organization is not the only one fighting terrorism. To modelize this particular situation, we take the NATO as a representative organization. In other models, we can add the intelligence service and the police.

Review of the conflict literature

The literature on the war differs from the terrorist one because of his psychological dimension. Many books were written to try to understand terrorist logic, but especially to include the reasons why these individuals instigate suicide attacks. Marc Sageman (2008) gives information on Islamic terrorism and network of Al Qaeda. This author through his psychiatric and sociological training and his experience of the CIA brings us to a better understanding of their personality. To protect itself from these terrorist threats, a more economic literature appeared for about twenty year. Since the beginning of 1990's, many authors have looked into the question of anti-terror measures. The game theory is often used to study this phenomenon. The game theory considers strategic correlations between governments and terrorists, and these actors respect the rationality fundamental hypothesis of the game theory, where a player maximizes an objective subject to constraint. In this paper, we suppose that every player is rational. We could consider that a terrorist group is not, as mentioned in Baumann (2016).

The literature on models linked to terrorism is divided into two categories. First of all, models analyze the direct confrontation between a terrorist group and a government. Negotiation is useful for the study of case as the hijacking of planes or hostage-taking: Atkinson, Sandler, and Tschirhart (1987), Lapan and Sandler (1988), Selten (1988), Islam and Shahin (1989), Sandler and Scott (1987), Scott (1991), Shahin and Islam (1992) and Sandler and Enders (2002). These last were interested to the security which has a direct influence on the probability of failure of the terrorist attack. Extensions were made on this model by differentiating different possible targets: namely, the tourist and commercial areas.

Authors as Sandler and Siqueira (2002) and Sandler and Arce (2003) wondered about policies to apply in order to eradicate terrorist threat or only to counter it. The impacts of each strategy allow determining that a government has to lean on "defensive" strategies. These groups are composed in network. It is on this point that the literature on war differs.

There is a section of literature linked to the study of alliances. Lee (1988) studied the circumstances which encourage or not a country to act as a free rider in an alliance when it is

about retaliation towards a terrorist group. The country has the choice between applying retaliation on the terrorist group, making nothing or hosting this one. This last strategy dominates both first ones, leading to a prisoner's dilemma. Some countries do not have sufficient resources to protect themselves efficiently. Therefore, they can be encouraged to use an external help through allied support (Sorokin, 1994). Sandler (1999) modelled the formation of alliance to counter threats along borders. By forming an alliance with a neighboring country, these two countries save costs of protection linked to common border.

A country has many possibilities of strategies to struggle the terrorist threat. So, this paper deals with three realistic situations. The aim of this paper is to focus on terrorist groups located in foreign countries. Even if the cooperation with a terrorist organization is frowned upon by the international community, some countries rely on them, either by ideological motivation, or by pressure from terrorists. This paper deals with three models. The first analyses the optimum sharing out of the budget allocated in the defense of a directed country by a terrorist threat. This country makes arbitration between acquisition of weapon, alliance with a country or alliance with the terrorist group in question. Compared with the article of Sorokin (1994), this model enables to have a global vision of conflict and to consider a larger set of tools, available for all countries. The second puts the emphasis on the help brought by the neighboring country. We analyze especially the technological transfer allowing improving the security of the country. In the following section, we study the effects of the help coming from a country on the behavior of a terrorist group, notably on the probability of attack.

2. COOPERATION WITH A TERRORIST GROUP: SOLUTION OF SECURITY?

2.1. Strategies of the targeted country

When a country does not have enough information in anti-terror struggle, an obvious solution consists in a protection generally based on the acquisition of weapons. We consider that internal protection emanating from this country comes exclusively from these weapons. However, other alternatives or complements to this strategy are useable to the targeted country: forming an alliance with a country or cooperating with a terrorist group.

▪ The alliance with a neighboring country enables to improve the security of the country. However, the appeal to this alliance has financial counterparts. Indeed, the targeted country is compelled by his budget for his defense. It has to invest in his protection but his budget is not unlimited. It has to find fair balance if his uses this solution. This resort is very often used by countries. The distribution of information allows better knowledge of threat. Besides, the arrival of additional troops is a means of efficient dissuasion. Poor countries have a not competitive protection, implicating an ineffective security facing external threats. In exchange, for a weak contribution, they are entitled to call an external help. Let us take the example of the North Atlantic Treaty Organization (NATO): all members intervene in expenses linked to the common financing. The resources of NATO are intended for the interests of members. These costs are divided according to the capacity of payment of each. So, the sum for a poor country will not be excessive. These resources allow financing the civil and military budgets as well as the program of investment in the service of security.

▪The cooperation with the terrorist group allows avoiding a direct confrontation. Several cases can justify this cooperation: a country can be in keeping with the terrorist ideology and decides therefore to finance it. In the second case, the terrorist group threatens a country and gives it two options: either paying a ransom or suffering an attack. Agreeing to pay the request of ransom makes them less violent. However, by accepting the totality of ransom, it can encourage the terrorists to ask for a higher amount. The request of ransom is an important source of income for the terrorist groups. For example, Germany agreed to pay an 8 million dollar ransom for the liberalization of three of the nationals taken in hostage in Iraq in November, 2005. But France is the first country who pays ransom. In 2014, France payed $ 3 million for one hostage in Yemen. Other countries as USA refuse to pay.

▪The government can decide at the same time on an alliance with the neighboring country to improve his protection but also to cooperate with the terrorist group in order to attenuate the attack. The higher the degree of alliance with a country is, the more aggressive the terrorist group will be because the country prefers getting closer to an ally and, as a result, determined to use his protection instead of paying the ransom.

The country has to make arbitration between these different possibilities. The model serves for determining the desired degree of connection, as well as the level of protection.

2.2. The model of cooperation and negotiation

We consider a model of optimization under constraint where a country chooses to maximize his utility and thus his security, subject to his budget constraint. The targeted country #1 is threatened by a terrorist group k. However, this country #1 can receive help from the country #2 with the intention of improving his protection. This situation, illustrated by the figures 2.1 and 2.2, represents the cases of complete cooperation either with the border country or with the terrorist group.
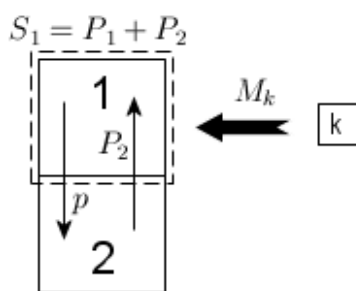
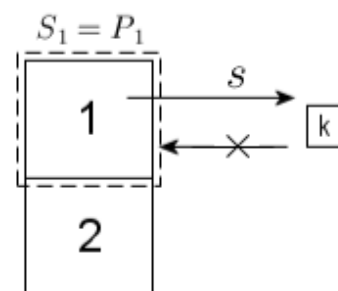

Figure 2.1: Total alliance with a border country

Figure 2.2: Total cooperation with a terrorist group

We assume that both countries are border but that only the country #1 is threatened. The country #2 is neutral but it is ready to help the country #1 in exchange for remuneration. The terrorist group is assumed to be located out of borders of both countries. By keeping this hypothesis, we do not

differentiate the internal security and the security on borders. Indeed, if a terrorist group is inside a country, it does not be confronted with all security set up. The terrorists are ready to abort the attack if the country pays ransom. However, sum asked for ransom can be much raised so that the country could not pay. We assume that the targeted country is not rather powerful to protect itself alone. In any case, it needs an external help.

The security of the country #1 is equal to the sum of the protection of this country to which is added the help coming from outside. This protection, noted P_1, depends on his cost C_1. This function is increasing and concave ($\frac{\partial P_1}{\partial C_1} > 0; \frac{\partial^2 P_1}{\partial C_1^2} < 0$).The protection P_2 of the second country has the same properties.

To improve his security, the targeted country can decide on a level of cooperation, noted *a*. According to this degree of cooperation, the country accepts a part of the protection of his ally. Help brought by this country is therefore of aP_2, with $0 \le a \le 1$. In exchange for this help, the beneficiary has to pay a sum *p* depending on the degree of cooperation, that is to say ap.

The total cooperation with the terrorist group leads to avoid an attack. However, if ransom *s* is too high, the government is not able to satisfy their request and thus it decides on a level of cooperation. The higher is this degree, the more the country will reduce tension between them. As a result, it reduces the intensity of the terrorist attack. The closer the government gets to the terrorists, the more it moves away from the border country: the level of cooperation with the terrorists is noted *(1-a)*. The amount of paid ransom is then $(1-a)s$. The intensity of the attack decreases with paid sum. Thanks to this ransom, the government avoids damage estimated at $(1-a)M_k$, where M_k indicate maximum terrorist damage.

For a political or ideological reason, it is possible that the priority of the terrorists is only the country #1, even if the country #2 gives his help and improves security. This model is only focused on the strategic decision of the first country. As a result, we assume that M_k, s, *p* and C_2 are exogenous variables. Endogenous variables are the level of cooperation wished by the country, *a* and *(1-a)*, as well as the sum allocated in the acquisition of weapon for aims of security, C_1.

Remark 1:
We could extend the model by considering the cooperation price p as an endogenous parameter. This price should be issue of a negotiation between the two countries. However, several bargaining solutions exist; Nash, Kalai-Smorodinsky, Equal-loss or egalitarian solutions. The choice of the solution is essential because the results are different and interpretation can obviously differ.

The utility function is given by:

$$U_1 = S_1 - M_k, \text{ with } S_1 = P_1 + aP_2 + (1-a)M_k$$

$$\Rightarrow U_1 = P_1 + aP_2 - aM_k$$

The resources of the country #1 are not unlimited. For each country, a budget is devoted to defense. This budget constraint is denoted by B_1. Resources cannot be negative; it is assumed that $B_1 \ge 0$. It is composed of the sum assigned to protection C_1, the sum allocated for an alliance with the border country (ap) and for cooperation with the terrorist group ($(1-a)s$):

$$B_1 \geq C_1 + ap + (1-a)s$$

The price to form an alliance is strictly positive ($p > 0$ and $s > 0$). The first country maximizes his utility, subject to his budgetary constraint:

$$\max_{C_1, a} U_1 = P_1 + aP_2 - aM_k$$

With respect to $B_1 \geq C_1 + ap + (1-a)s$

By determining the degree of alliance with the border country, we are able to deduct the level of cooperation with the terrorist group. To determine the equilibrium, we take back functions of protection such as Sorokin (1994) respecting the hypotheses of growth and of concavity (Figure 2.3): $P_1 = \ln(C_1 + 1)$ and $P_2 = \ln(C_2 + 1)$. To solve this constrained maximization problem, we use the Lagrangian function:

$$L(C_1, a, \lambda) = P_1 + aP_2 - aM_k + \lambda(B_1 - C_1 - ap - (1-a)s) \qquad (2.1)$$
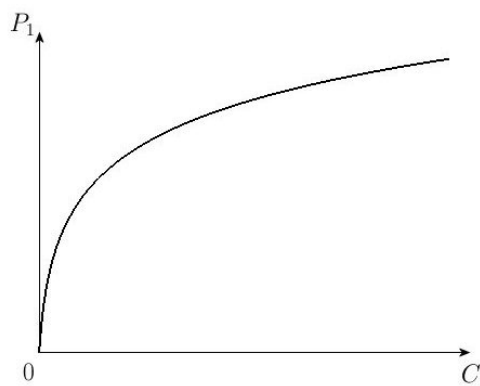

Figure 2.3: Protection function of the first country

At the equilibrium, we obtain the following results:

$$C_1^* = \frac{p - s}{\ln(C_2 + 1) - M_k} - 1 \qquad (2.2)$$

$$a^* = \frac{B_1 + 1 - s}{p - s} - \frac{1}{\ln(C_2 + 1) - M_k} \qquad (2.3)$$

$$(1-a)^* = \frac{p - B_1 - 1}{p - s} + \frac{1}{\ln(C_2 + 1) - M_k} \qquad (2.4)$$

From the equations (2.2), (2.3) and (2.4), we deduce the expressions of the other endogenous variables:

$$P_1^* = \ln\left(\frac{p - s}{\ln(C_2 + 1) - M_k}\right) \qquad (2.5)$$

$$S_1^* = \ln\left(\frac{p - s}{\ln(C_2 + 1) - M_k}\right) + \left(\frac{B_1 + 1 - s}{p - s}\right)(\ln(C_2 + 1) - M_k) - 1 + M_k \qquad (2.6)$$

$$U_1^* = \ln\left(\frac{p - s}{\ln(C_2 + 1) - M_k}\right) + \left(\frac{B_1 + 1 - s}{p - s}\right)(\ln(C_2 + 1) - M_k) - 1 \qquad (2.7)$$

2.3. Analyze

In this part, we study the effect of every parameter on the endogenous variables of this model. From these effects, we will be able to deduce conclusions as for the strategy of the targeted government.

2.3.1. Effects of the alliance price with a border nation

According to the value of exogenous parameters, decisions of the government are not the same. Several hypotheses have to be introduced to undertake the analysis. We assume that the price of alliance is increasing with the protection of the country #2. In other words, it means that the country #2 has better resources to undertake the acquisition of weapons and so to improve his protection. His resources are generated at the same time by his budget of defense but also by the allied contribution. Also, ransom is increasing with threat. If ransom is high but that threats and the group terrorists are weak, then this threat is not credible. We deduce that if $p > s$ then $P_2 > M_k$. Although we assume that ransom is too high to be paid by the government, we raise this hypothesis with the intention of differentiating all possible cases. Tables 2.1 to 2.4 sum up different effects of p.

	C_1	P_1	A	$(1-a)$	U_1
p	+	+	+	-	+

Table 2.1: If $p > s$ and $s > B_1$

	C_1	P_1	a	$(1-a)$	U_1
p	-	-	+	-	-

Table 2.3: If $p < s$ and $s > B_1$

	C_1	P_1	A	$(1-a)$	U_1
p	+	+	-	+	-

Table 2.2: If $p > s$ and $s < B_1$

	C_1	P_1	a	$(1-a)$	U_1
p	-	-	-	+	+

Table 2.4: If $p < s$ and $s < B_1$

We have to study four cases corresponding to these conditions in tables. The figure 2.4 enables to characterize four situations pointing out the strategy of the nation.
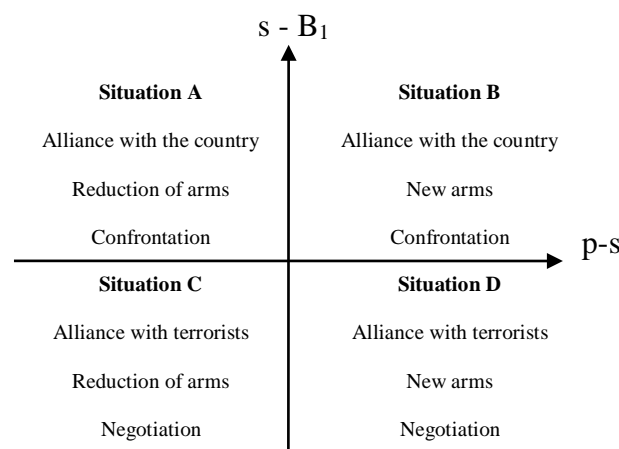

Figure 2.4: Decision of the government

Situation A: The terrorist group is powerful. A government is not able to pay the ransom in the totality. This country has to decrease his spending investing in arms in order to keep the foreign help coming from his ally. The increase of the alliance price, synonym of a better efficiency, is compensated by the lowering in arms. It is the case of Austria, member of NATO (military expenditure: 0.7% of GDP)

Situation B: The country wants to increase the alliance with the foreign country (even if his price grows) and his spending in internal protection to the detriment of the coalition with the terrorist group. As a consequence, the terrorists earn less money and their wrath is greater. They will launch a more violent attack. However, the government acts like this because his security, coming mainly from the outside, is such that it enables to neutralize this attack. The country #2 raises his price in order to improve his protection quality and efficiency. Israel, a de facto member of NATO, spends about 5% of his GDP to protect the country.

Situation C: The conflict is resolved thanks to the negotiation. The will of the country is to have peace. Hence, his spending in arms decreases. Qatar finances some jihadist groups in Iraq and Syria. His military expenditure is low: 2 % of GDP.

Situation D: The government is able to pay the totality of the ransom. It leads to avoid being attacked. The foreign help is useless, whatever his efficiency. The rest of the budget is bound to the acquisition of arms in order to keep a minimum level of internal protection. For example: Saudi Arabia with military budget of 10% of his GDP.

2.3.2.   Effects of the cooperation price with the terrorists

We notice previously that the government has the intention to ally with a border country as long as it is not able to pay the totality of the ransom. Concerning this payment, the reasoning is the same: the country wants to negotiate as long as it cannot get the wholeness of the foreign protection, because the attack cannot be neutralized by his security.

However, if the alliance price p is greater than the ransom, an increase of it leads to a higher threat, because the terrorist group disposes of more resources. A more intense threat feeds fear of the country which wants to form a coalition with the terrorists so as not to be subject to high damage. His relation with the other country will be distant. The ransom is higher. To pay it, it has to diminish his spending in arms.

When the amount of the ransom is greater than the price to join the alliance with the country #2, the government pitches on the negotiation. So the spending allocated to the outside help is assigned to the ransom and the acquisition of arms. The outside protection is substituted by the internal one. These effects are summarized by the tables 2.5 and 2.6.

	C_1	P_1	a	$(1-a)$	U_1
s	-	-	-	+	-

Table 2.5: If $p > s$

	C_1	P_1	a	$(1-a)$	U_1
s	+	+	-	+	+

Table 2.6: If $p < s$

2.3.3. Effects of resources and threat

It is obvious that resources have positive effects on the targeted country. It enables to justify some hypotheses concerning the choice of the cooperation (tables 2.7 and 2.8).

	a	$(1-a)$	U_1
B_1	+	-	+

Table 2.7: If $p > s$

	a	$(1-a)$	U_1
B_1	-	+	+

Table 2.6: If $p < s$

The country joins the side where the price is the greatest, synonym of strength. If $p > s$, then the additional resources are used in order to be close to the ally; inversely if $p < s$.

Concerning the terrorist threat, effects on his utility differ according to some conditions.

$$\frac{\delta U_1}{\delta M_k} = \frac{s - B_1 - 1}{p - s} + \frac{1}{\ln(C_2 + 1) - M_k} \quad (2.8)$$

If $p < s$ and $P_2 < M_k$, utility diminishes as terrorist threat grows. However, for $p > s$ and $P_2 > M_k$, utility increases as conflict intensifies. Indeed, no matter if the terrorist strength raises, the government knows that he could neutralize the attack thanks to the alliance with the country #2. His utility is greater because it forecasts that the terrorists have to use the major part of their resources in vain, to organize a violent assault. This utility goes down from the moment where the protection of the second country is not efficient anymore ($P_2 < M_k$).

3. OPTIMAL STRATEGIES OF THE GOVERNMENT: PROTECTION OR INVESTING IN TECHNOLOGY?

We notice that the protection is not effective in some cases. This is the reason why some countries use other defensive measures. We analyzed previously that a country can benefit from the help of the other countries or it can negotiate directly with terrorists in order to avoid being the target. These groups employ more and more sophisticated means. Consequently, the protection is sometimes obsolete. In regards to this phenomenon, the governments react and

adapt to this evolution. The research in the technological field enables a better detection as well as a better security against the terrorist assaults. This section points out the effects of a technological transfer on the decision-making of a government.

3.1. The model of technology transfer

We consider a model of optimization under constraint where a country maximizes his utility subject to his budgetary constraint. As previously, only the nation #1 is threatened by the terrorist group *k*. The country #2 develops a technology allowing improving his protection and to fight efficiently against the terrorist attacks. We suppose that only this second country has the necessary competences and resources to invest in such a research. This government is ready to send his innovation in exchange of a payment. The cost of technological transfer is supposed to be included in this payment. The technology can take several forms: state-of-the-art technology transfer such as detectors of nuclear weapons or simply knowledge allowing making the protection more efficiently and enabling to produce much more sophisticated weapons.

The motivation of the country #2 in order to sell a part of his technology is numerous:

- First of all, it can want to improve the security and to keep peace in his border countries in order to avoid that the threat propagates until it. Consequently, his interest is to give help to the nation in difficulties.

- The economic aspect is considerable. Besides the fact of selling his innovation, this nation has probably trades with his nearby countries. It is not to his advantage to trade in a risked zone. Moreover, selling a part of his research allows it to realize profitable investment, which is very expensive. Then, the cost of research decreases.

The government #1 has several strategies to face the attack of the terrorist group. It has the choice between buying a part of the technology and buying arms in order to improve his protection. His protection function P_1 does not only depend of his cost C_1, but also of the technology which has been bought. The total technology developed by the second country is designated by T. This nation can practice a high price of selling, so the first country can buy a certain percentage of it. We denote *d* as the degree of wanted technology, where $0 \leq d \leq 1$.

We keep the hypotheses of the previous section. The protection function is growing and concave with respect to his cost: $\frac{\partial P_1}{\partial C_1} > 0$; $\frac{\partial^2 P_1}{\partial C_1^2} < 0$. However, this function is growing and convex with the technology, justifying the innovation is necessary in the context of conflict: $\frac{\partial P_1}{\partial T} > 0$; $\frac{\partial^2 P_1}{\partial T^2} > 0$. This is the reason why some countries invest nowadays in the research and development. Research leads to some advantages such as the improvement of the protection, and to some inconveniences like the high cost. The innovation is an important key to protect itself from a terrorist attack, denoted M_k.

The utility function is the difference between the protection of the targeted country and the damages caused by a terrorist assault. It represents the undergone losses if the attack succeeds. The utility of the first country is given by: $U_1 = P_1 - M_k$.

The government is constraint by his budget B_1, supposed to be positive. The unit price to acquire a percentage of technology is designated by p. Knowing that the country buys dT, this one has to pay pdT. Consequently, the budget of the first country consists of the amount assigned to the protection C_1 and the bought technology pdT.

$$B_1 \geq C_1 + pdT$$

The government has for objective to maximize his utility under his budget constraint in order to determine his optimal strategy:

$$\max_{C_1,d} U_1 = P_1 - M_k \text{ with respect to } B_1 \geq C_1 + pdT$$

So as to have the equilibrium, we have to specify the protection function:

$$P_1 = (\gamma_1 + dT)^{\omega} C_1^a, \text{ where } \gamma_1 \geq 1, \omega > 1 \text{ and } 0 < a < 1$$

The parameters γ_1, ω and a are exogenous. They are defined to guarantee the previous hypotheses. They are linked to the protection.

To solve this constrained maximization problem, we use the Lagrangian function:

$$L_1(C_1, d, \lambda_1) = (\gamma_1 + dT)^{\omega} C_1^a - M_k + \lambda_1(B_1 - C_1 - pdT) \quad (3.1)$$

At the equilibrium, we obtain the following optimal values given by the equation (3.2) and (3.3):

$$d^* = \frac{B_1 - \dfrac{a}{w} p\gamma_1}{pT(\dfrac{a}{\omega} + 1)} \quad (3.2)$$

$$C_1^* = \frac{a}{a + \omega}(B_1 + p\gamma_1) \quad (3.3)$$

From these equations (3.2) and (3.3), we deduce the optimal values of the other endogenous variables of this model:

$$P_1^* = \left(\frac{p\gamma_1 + B_1}{p(\dfrac{a}{\omega} + 1)}\right)^{\omega} \left((\frac{a}{a + \omega})(B_1 + p\gamma_1)\right)^a \quad (3.4)$$

$$U_1^* = \left(\frac{p\gamma_1 + B_1}{p(\dfrac{a}{\omega} + 1)}\right)^{\omega} \left((\frac{a}{a + \omega})(B_1 + p\gamma_1)\right)^a - M_k \quad (3.5)$$

3.2. Analyze

Through the variations of the various parameters, we shall determine their effects on the optimal strategies of the government.

3.2.1. Effects of the sale price of the technology

If the price to acquire a percentage of technology is higher, then the government increases his spending in arms. It is due to the fact that the bought part decreases. Consequently, the utility decreases also caused by a less effective protection. Indeed, the government has less technology. The effects are represented in the table 3.1.

	$d*$	C_1*	P_1*	U_1*
p	-	+	-	-

Table 3.1: Effects of the sale price

3.2.2. Effects of the budget

It is obvious that a raise of the resources improves the utility of the government. It is possible to acquire more weapons while increasing his degree of cooperation with the other country. His protection is thus strengthened because it has a more important technological quantity.

	$d*$	C_1*	P_1*	U_1*
B_1	+	+	+	+

Table 3.2: Effects of the budget

3.2.3. Effects of the protection parameters

These coefficients have the same effects on the variables of the model [Table 3.3]. If one of both increases, it improves logically the protection. If this one becomes more and more efficient, the appeal to the technology will make lesser, without giving up it. It will always remain necessary as long as the protection does not allow it to neutralize the attacks. The degree of acquisition of technology is weaker so giving more resources to the government to buy more weapons. The amount resulting from the difference between these degrees is thus transferred towards the cost of protection: $p(d^1 - d^0) = +\Delta C_1$

	$d*$	C_1*	P_1*	U_1*
γ_1, a	-	+	+	+

Table 3.3: Effects of the protection parameters

3.2.4. Effects of the technology

Now, if the technology is more and more successful [Table 3.4], the government decides to have it much more to the detriment of his protection. With a minimum of protection but a high technology, this one is able to counter the threat thanks to a more effective security. The coefficient ω is directly connected to the technology.

	$d*$	C_1*	P_1*	U_1*
ω	+	-	+	+

Table 3.4: Impacts of the protection parameter linked to the technology

4. THE INFLUENCE OF THE HELP COMING FROM THE ALLY: NEGATIVE EXTERNALITY?

Until then, we have supposed that the terrorist group threats only one country. However, if a nation helps a targeted one through an alliance or a technological transfer, then the terrorist attack can be unsuccessful on account of this foreign help. The terrorists will be incited to target as well the nation having given his helping hand. In this section, we analyze mainly the impacts of an alliance on the behavior of a representative terrorist group, notably through the determination of the probability of being attacked.

4.1. Optimal strategies of the both countries.

We point out the reasons for which a weak country resorts to the foreign help before. The preceding sections concentrate on the making-decision process of one nation. The decision of a nation has repercussion on the strategic choice of other countries, but also on the choice of the terrorist group. A country, having suffered a war, will need an international help to stabilize the country and to his reconstruction. Foreign troops will be sent to complete these missions. A war can draw away the emergence of terrorist groups. Protests against the government could grow leading to the creation of terrorist groups, either moderates or hard-liners. Reasons are numerous: they do not agree with the national policies and they want to overturn the political regime in place, or it is due to religious reasons. These groups will not accept willy-nilly that foreign countries come to interfere in their country. They would order the withdrawal of troops otherwise they would appoint assassination attempts as well on the present troops as in the helping nation.

We take back the case of the technological transfer between two countries. The strategies of the nation #1 are the same, i.e. either to increase his protection by the acquisition of arms (strategy C_1) or to buy a certain quantity of technology coming from the neighboring country (strategy T). This technology is supposed to be divisible and quantifiable. The second country has two strategies: he can produce arms or/and invest in advanced technology level at $\overline{T}$ (where $\overline{T} \geq T$).

Remark 1: In order to simplify the model and the equations, the quantity of bought technology is equal to T instead of dT as in the previous section. Then, the percentage of innovation is equal to $T/\overline{T}$.

The utility of each country is equal to the protection minus the damages brought about the attempts. The utility function is given by:

$$U_i = P_i - M_k \quad \forall i = 1,2$$

The budget of countries is not unlimited. This budget constraint B_i is supposed to be positive. The unit price necessary for the getting of a unit of technology is given by p. The unit cost of technological research is noted h. The budget for the country #1 is composed of sum allocated in protection C_1 as well as bought technology (pT). Concerning the second country, his budget includes costs to acquire weapons (C_2) and the cost of technological research ($h\overline{T}$), in which is deducted the remuneration coming from the sale of the innovation. The cost h and the price p are exogenous in this model. It is assumed that the cost h is greater than the sale price ($h > p$): the nation #1 has no financial or human capacities to produce such a technology. Indeed, if this price is superior to the cost of innovation, the weak country will not be able to benefit from it. The purpose of the country #2 is not to produce technology to sell it more expensive. Technology is first of all a means to protect it efficiently. Nevertheless, having the opportunity to give in a part of his scientific knowledge, this government is able to generate additional resources.

$$B_1 \geq C_1 + pT$$
$$B_2 \geq C_2 - pT + h\overline{T}$$

Each country maximizes his utility subject to his budget constraint. The utility function is equal to the protection minus the terrorist threat:

$$\max_{C_1,T} U_1 = P_1 - M_k \ with \, respect \, to \ B_1 \geq C_1 + pT$$
$$\max_{C_2,\overline{T}} U_2 = P_2 - M_k \ with \, respect \, to \ B_2 \geq C_2 - pT + h\overline{T}$$

The protection functions are defined as follow:

$$P_1 = (\gamma_1 + T)^w C_1^a, \quad where \ \gamma_1 > 1, w > 1 \ and \ 0 < a < 1$$
$$P_2 = (\gamma_2 + \overline{T})^v C_2^b, \quad where \ \gamma_2 > 1, v > 1 \ and \ 0 < b < 1$$

The country #2 is ready to help the neighboring country against some sum. This sum allows it to invest even more in technology and to improve security. So, the first country can hope to suffer no damage thanks to technological assistant and to have a situation of peace in the zone of both countries. If the terrorist group thinks that the first country is too well protected, he will turn to the second country and also look at his protection. The terrorist group will compare the protection of both countries and attacks the one where the attack probability is the greatest. Figures 4.1 and 4.2 summarize the situations with which are confronted both governments. If the country #2 does not help, the probability of being attacked is almost nil because his protection will be better than the one of the country #1.
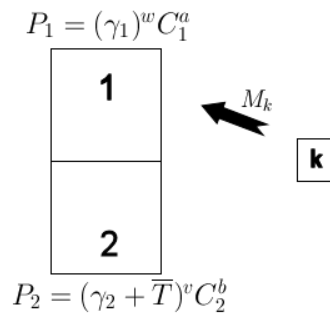
$$P_1 = (\gamma_1)^w C_1^a$$

Figure 4.1: No technological transfer: $T = 0$

If the help is substantial and allows having a more efficient security, then the terrorist group has the choice between the two targets.
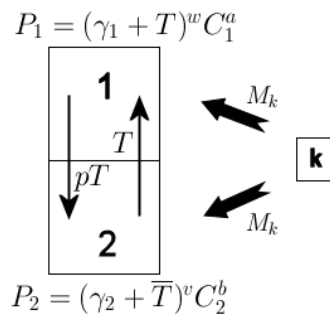
$$P_1 = (\gamma_1 + T)^w C_1^a$$

$$P_2 = (\gamma_2 + \overline{T})^v C_2^b$$

Figure 4.2: Technological transfer ($0 < T \leq \overline{T}$)

The Lagrangian function enables to determine the optimal strategies for each country:

$$L_1(C_1, T, \lambda_1) = (\gamma_1 + T)^w C_1^a - M_k + \lambda_1(B_1 - C_1 - pT) \quad (4.1)$$
$$L_2(C_2, \overline{T}, \lambda_2) = (\gamma_2 + \overline{T})^v C_2^b - M_k + \lambda_2(B_1 - C_2 + pT - h\overline{T}) \quad (4.2)$$

The best response functions of the country #1 and #2 are given by the equations (4.3) and (4.4). These equations lead to determine the quantities of total technology and bought technology which maximize their utility (equations 4.5 and 4.6).

$$C_1 = \frac{ap}{w}(\gamma_1 + T) \quad (4.3)$$

$$C_2 = \frac{bh}{v}(\gamma_2 + \overline{T}) \quad (4.4)$$

$$T^* = \frac{B_1 - \dfrac{ap\gamma_1}{w}}{p(\dfrac{a}{w} + 1)} \quad (4.5)$$

$$\overline{T}^* = \frac{B_2 - \dfrac{bh\gamma_2}{v} + pT}{h(\dfrac{b}{v}+1)} \quad (4.6)$$

The technology produced by the second country depends of the technology bought by the first nation. We can deduce the quantity of weapons and the total technology at the equilibrium from the equation (4.5).

$$C_1^* = \frac{a}{a+w}\left(\gamma_1 p + B_1\right) \quad (4.7)$$

$$C_2^* = \frac{b}{v+b}\left(\gamma_2 h + B_2 + \frac{B_1 - \dfrac{ap\gamma_1}{w}}{(\dfrac{a}{w}+1)}\right) \quad (4.8)$$

$$\overline{T}^* = \frac{B_2 - \dfrac{bh\gamma_2}{v} + \dfrac{B_1 - \dfrac{ap\gamma_1}{w}}{(\dfrac{a}{w}+1)}}{h(\dfrac{b}{v}+1)} \quad (4.9)$$

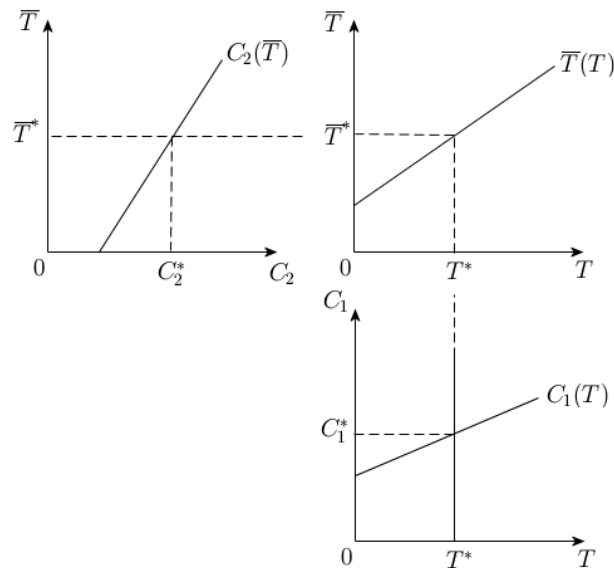The process is summarized in the figure 4.3:

Figure 4.3: Determination of the equilibrium

Consequently, we obtain the following values for the utility and the protection functions given by the equations (4.10) to (4.13):

$$P_1^* = \left(\frac{p\gamma_1 + B_1}{p(a/w+1)}\right)^w \left(\frac{a(\gamma_1 p + B_1)}{a+w}\right)^a \quad (4.10)$$

$$U_1^* = \left(\frac{p\gamma_1 + B_1}{p(a/w+1)} \right)^w \left(\frac{a(\gamma_1 p + B_1)}{a+w} \right)^a - M_k \quad (4.11)$$

$$P_2^* = \left(\frac{\gamma_2 + B_2 + \dfrac{B_1 - \dfrac{ap\gamma_1}{w}}{(1+a/w)}}{h(1+b/v)} \right)^v \left(\frac{b}{v+b} \left(B_2 + \gamma_2 h + \frac{B_1 - \dfrac{ap\gamma_1}{w}}{1+a/w} \right) \right)^b \quad (4.12)$$

$$U_2^* = \left(\frac{\gamma_2 + B_2 + \dfrac{B_1 - \dfrac{ap\gamma_1}{w}}{(1+a/w)}}{h(1+b/v)} \right)^v \left(\frac{b}{v+b} \left(B_2 + \gamma_2 h + \frac{B_1 - \dfrac{ap\gamma_1}{w}}{1+a/w} \right) \right)^b - M_k \quad (4.13)$$

4.2. Decision on the choice of the target

In the presence of technological transfer (figure 4.2), the terrorist group has some reasons to want to commit an attack in one of these countries. Only the first nation was threatened by the terrorist organization in the case where it does not benefit from the foreign help. But in the case of an alliance and more particularly because of this help reinforcing the protection of the country in trouble, the terrorists consider that this helping nation interferes in a conflict which does not concern it. As a consequence, a probability of being attacked will be attributed to each country: α_1 and α_2 designate respectively the attack probability for the country #1 and #2. If we assume that there is not a probability of any attack, then:

$$\alpha_1 + \alpha_2 = 1 \quad (4.14)$$

The utility function of the terrorist group depends on the chosen target. We assign U_k^i as the utility function if the terrorist group attacks the country i (for $i = 1,2$):

$$U_k^1 = \alpha_1(M_k - P_1^*) \quad (4.15)$$
$$U_k^2 = \alpha_2(M_k - P_2^*) \quad (4.16)$$

The terrorist organization is different between launching an attack on the two targets in the case where:

$$U_k^1 = U_k^2 \quad (4.17)$$

From the equation 4.14 to 4.17, we obtain the probability of being attacked for each country:

$$\alpha_1^* = \frac{M_k - P_2^*}{2M_k - P_1^* - P_2^*} \quad (4.18)$$

$$\alpha_2^* = \frac{M_k - P_1^*}{2M_k - P_1^* - P_2^*} \quad (4.19)$$

4.3. Analysis of the effects concerning the price and the cost of the technology

The increase of the sale price has several negative effects. The government #1 is unable to pay a too high price. It decreases his quantity of bought technology by substituting it for a greater quantity of weapons. As a consequence, the government has fewer resources. So it is reflected in the quantities of technology and the production of weapons. The quantities of weapons go down as well as the investment in technological research. Both combined effects lead to a less efficient protection of both countries, making them more vulnerable facing the terrorist threat. The country #2 does not therefore have interest in issuing a too high selling price. Effects on probability to be attacked are indeterminate due to these two opposite effects. It is confirmed if we study the effects of the acquisition of technology on probability of being attacked for the second country ($\frac{\partial \alpha_2}{\partial T}$). We lead to an indecision resulting from these two effects. Consequently, the technological transfer can turn out to be dangerous for the country #2. Improving the security of the neighboring country constitutes a negative externality. Indeed, if the terrorist group considers that the first country is too well-protected, he will turn to the second nation.

All the effects of the sale price are represented in the table 4.1:

	$C_1{}^*$	$P_1{}^*$	T^*	$\overline{T}{}^*$	$C_2{}^*$	$P_2{}^*$	$U_1{}^*$	$U_2{}^*$	α_1	α_2
p	+	-	-	-	-	-	-	-	?	?

Table 4.1: Effects of the sale price

The cost of technological innovation has effects only on the second country. If the unit cost of the technological creation is too high, this one substitutes technology for the creation of weapons. As a result, his protection will suffer. There is no effect on the country #1 because it does not affect the selling price according to our hypotheses, where we assumed that h and p were exogenous. The probability to attack the country #2 increases because he has to spend more; in order to keep the same level of security. According to the country #1, it buys technology to the same price. If the country #2 has a protection more efficient than the country #1, then the gap of security level will diminish.

	$\overline{T}{}^*$	$C_2{}^*$	$P_2{}^*$	α_1		α_2	$U_2{}^*$
h	-	+	-	+		-	-

Table 4.2: Effects of the technological cost

5. CONCLUSION

The analysis of the terrorist phenomenon has mainly been studied since 1990's and has been accentuated after the September 11th attack. This event impressed the population of western countries. These people became conscious of the real risk coming from the terrorist groups. This date has a psychological impact. The conflict resolution, the consequences of the terrorism on the economy and the psychology of a terrorist make up the main points of the terrorist literature. Knowing which strategies to adopt towards a terrorist group is certainly the main purpose of the major part of the literature dealing with the terrorist conflict.

Currently, Todd Sandler is one of the main contributors in the economic analysis of the terrorist threat. Through the game theory he describes several cases of conflict which government is confronted: kidnapping resolutions, optimal formations of alliance, analysis of policies and so on. The modelling of these situations enables to have a better approach of the issue and maybe more "tools" to resolve conflicts.

In this article, we lead an analysis on policies to be adopted to face up this type of conflict. Most authors limit their analysis to the cooperation between states. However, the appeal to an alliance with a terrorist group is completely possible and should not be neglected, even if it can seem ideologically inappropriate for the most part of countries. The first model concentrates on the determination of the optimum strategies of the government when it has to decide to which camp to turn: either forming an alliance with another country with the intention of getting a better protection, or forming an alliance with the terrorist group through a request of ransom with the intention of attenuating the attack. It is sometimes useful to meet terrorists' requirements if the help brought by the neighboring country is not efficient. It explains why some poor countries prefer paying ransoms to avoid conflicts if the cost of entrance in alliance is too high. In spite of this exogenous price, we could consider it as an endogenous parameter in a further analysis at the end of a negotiation process between these two countries. However, if we take the case of NATO, the cost is proportional in capacity of payment to make easier the entrance of these countries. However, it would be interesting to follow in dynamics and to see if the negotiation with the terrorist group is always preferable. Over the years, the government will collect a more massive weaponry while if it pays the request of ransom, his protection will be less and less efficient. The terrorist group could become more and more demanding on frequency and sum of ransoms. However, further to the attacks of September 11th, governments searched immediate solutions to resolve the terrorist problem, what justifies this static analysis.

The second section concentrates more particularly on the problems of the technological transfer. The determination of optimum value for the acquisition of weapon and the desired degree of technology allowed studying the effects of different variables such as the coefficients of protection, the budget but especially the selling price and the quantity of developed technology. This model introduces alternatives to the government but limited to the decision-making of a single country. This is the reason why the third section includes in the analysis the second country, seller of technology. It confirmed the presence of negative externality for the second country. A better protection for the country requiring an assistant can draw away an increase of probability to be attacked for this country selling his technology.

This paper explains why some countries cooperate with terrorist groups. Now we can categorize the countries into four groups. We understand why some countries, such as USA, don't pay ransom. We only focus on foreign terrorists. To improve this model in a next paper, we have to consider more general approach and include the terrorist group location (inside/outside country), *n* countries and endogenous variables (price of a cooperation and ransom) who can be determined by negotiation process (Nash and Kalai Smorodinsky solutions).

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