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# Terrorism and Game Theory: From the Terrorists' Point of View

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ABSTRACT

This paper investigates the interplay between two distinct terrorist cells of the same terrorist organization using game-theoretic models. It will discuss the economic consequences of terrorism and provide a literature review. Much of the available literature focuses on national policies and the effects such policies have on terrorists' behavior. The approach taken here differs in that the primary focus is on terrorists' behavior. By studying decisions terrorists make and understanding why they make them, better counterterrorism policies can be developed.

## I. INTRODUCTION

The September 11, 2001 terrorist attack on the World Trade Center and Pentagon (9/11) marked a watershed moment in world history. This unprecedented and unprovoked attack shook the American public and affected international markets. Despite the absence of 9/11-style attacks in recent years, terrorists still exist and want nothing less than to inflict mass casualties on Americans. In the words of Al Qaeda spokesman Suleiman Abu Gheith:

> We have not reached parity with them. We have the right to kill 4 million Americans—2 million of them children—and to exile twice as many and wound and cripple hundreds of thousands. Furthermore, it is our right to fight them with chemical and biological weapons, so as to afflict them with the fatal maladies that have afflicted the Muslims because of the [Americans'] chemical and biological weapons.[1]

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To accomplish this feat, terrorists continually improve their techniques, competing with one another to see who can execute the next 9/11.[2]

Economic tools can be applied to understand the root causes of terrorism so that future tragedies are averted. One of the economic tools used to analyze terrorist activity is game theory. Game-theoretic models are ideal for capturing the essence of interaction between terrorists and counterterrorism agencies. Such models elucidate terrorists' motivations by considering the decisions they encounter. Numerous papers focus on the decisions of nation-states and the reactions of terrorists; however, few, if any, papers focus on the decisions of terrorists and the corresponding reactions of nation-states. The purpose of this paper is to develop game-theoretic models to illustrate possible scenarios terrorist cells encounter. Terrorist cells are active players in these models, and nation-states are passive players responding with either changes in military allocation from opposing states or terrorist reinforcement from supporting states. Understanding the interactions described within these models is essential for developing better counterterrorism policies.

"Terrorism" is a difficult word to define, in part because deeming an act "terrorism" depends subjectively on whether a person sides with the attackers or their victims.[3] One definition of "terrorism is the premeditated use, or threat of use, of extranormal violence to obtain a political objective through intimidation or fear directed at a large audience."[4] A key part of this definition is the political objective, without which similar attacks would be considered merely criminal.[5] Another critical part of this definition is extranormal violence.[6] Terrorists continually try "to outdo one another [with increasingly severe atrocities] in their competition for publicity, funding, recruits, and contacts."[7] For example, a street mugging perpetrated by an individual upset about government policies leading to the outsourcing of his job does not constitute terrorism.

Much of the literature using economic tools to analyze terrorist behavior focuses on the interplay between nations. This paper develops game-theoretic models focusing on the interactions between two separate terrorist cells who are members of the same terrorist organization. Before developing these models, this paper presents an overview of the consequences of terrorist attacks and a review of the literature that discusses how game theory can be used to study terrorism.

## II. Economic Consequences of Terrorism

In 2002, the Joint Economic Committee of the U.S. Congress described the costs of terrorism as the loss of human and nonhuman capital, uncertainty in consumer and investor behavior, retrenchment in specific industries or localities, increased costs of security ("terrorist tax"), and anti-terrorist expenditures crowding out more productive activity.[8]

Terrorist attacks take lives and destroy infrastructure. Besides the actual loss of life, the economy suffers from a loss in productivity associated with that life. The loss of infrastructure includes not only the property destroyed, but also cleanup and repair costs.[9] In addition, after a terrorist attack markets experience increased volatility and increased risk premiums due to public fear.[10] Demand decreases for risky assets and increases for safe assets as investors safeguard themselves from this increased volatility.[11] Generally when consumption and investment decline, it adversely affects the stock market.[12] Furthermore, some industries, such as airlines, tourism, and casinos, carry a disproportionate amount of the negative burdens associated with a terrorist attack.[13] Localities heavily associated with these industries, such as Detroit and Las Vegas, are affected as well.[14]

After a terrorist attack, security tightens as businesses safeguard themselves against another attack. The indirect costs for this increase in security are distributed throughout society in the form of travel delays, higher insurance, increased shipping costs, and slower mail deliveries.[15] The inefficiencies associated with this "terrorist tax" create a negative supply shock to all production.[16] Furthermore, there are declines in real rental on capital, productivity, and potential growth rates.[17]

Alberto Abadie and Javier Gardeazabal describe decreased Foreign Direct Investment (FDI) as another cost of terrorism.[18] Countries experiencing high levels of terrorism also experience lower returns on investment, resulting in a decrease in the stock of foreign investments.[19] Abadie and Gardeazabal write that although terrorism contributes to only a small portion of a country's economic risk, the effect on FDI is magnified.[20] For example, the 9/11 attack caused a 0.06% loss in total productive assets for the US economy, but from 2000 to 2003 FDI inflows decreased from 15.8% to 1.5% of the gross fixed capital formation in the U.S.[21]

## III. GAME THEORY AS A MODEL FOR UNDERSTANDING TERRORIST BEHAVIOR

Because of the interactions between terrorists and counterterrorism agencies, game theory is an ideal tool for understanding terrorist behavior. For example, the high number of airplane hijackings in the 1970s caused airports to increase their use of metal detectors, therefore increasing the relative cost of hijackings for terrorists.[22] As a result, terrorists switched from hijackings to kidnappings.[23] The high number of kidnappings caused governments to increase security measures for foreign diplomats, so terrorists replaced kidnappings with suicide bombings.[24]

Game theory can also be used to dictate policy for future events. Harvey Lapan and Todd Sandler use a simple model to describe when and if a government should concede to terrorist demands.[25] The common government policy, and one of the four pillars of U.S. terrorism policy, is "no concessions to terrorists." However, Lapan and Sandler note this policy is optimal only if governments adhere to it and terrorists have incomplete information regarding government credibility.[26]

Todd Sandler and Daniel Arce use game theory to describe what they call a "deterrence race" between two countries.[27] If the home country increases domestic deterrence efforts, the terrorists' costs associated with attacking the home country increase.[28] This poses a negative externality on the foreign country because the relative cost for terrorists to attack the foreign country decreases.[29] As a result, the foreign country must also increase deterrence efforts or face an increased likelihood of being attacked.[30] When the foreign country increases deterrence efforts, the home country must reciprocate because they now face an increased likelihood of being attacked since the foreign country is now more secure.[31] The reiterative nature of this scenario causes countries to overspend on deterrence efforts.[32] Sandler and Arce go on to describe how information sharing between the home and foreign countries can exacerbate the dilemma if deterrence efforts are not coordinated.[33]

Sandler and Arce also illustrate the advantage of cooperation through a game-theoretic model that uses two countries and a terrorist group to show a prisoner's dilemma.[34] In this model both countries, without cooperation, choose to deter terrorists, although the optimal choice is for both countries to cooperate and preempt.[35] Sandler and Arce investigate other scenarios where the desired outcome is contingent on both countries acting together.[36] For example, when the goal is for the allied countries to freeze terrorist assets, the desired outcome is achieved only when both countries choose to freeze assets.[37] If only one country freezes assets, the terrorists will divert their assets to the other country.[38] This scenario is a "weakest link" game.[39] Another scenario considered involves intelligence gathering and sharing.[40] If both countries infiltrate the same terrorist organization, not only are their efforts redundant, but they increase the risk of being discovered.[41]

## IV. MODELS

Much of the game theory literature focuses on games where terrorists are passive players, meaning that terrorist actions are determined by the active decisions of other players. The aim of this paper is to develop models where terrorists are active players and nations, whether supporting or opposing terrorists, are passive players. Developing such models will provide insight into terrorist behavior and lead to useful counterterrorism policy recommendations.

These models assume a decentralized terrorist organization where cells act independently. The two active players in these models (*A* and *B*) are distinct factions of the same terrorist group. Al Qaeda is a perfect example because Al Qaeda "has been moving towards decentralization ever since the invasion of Afghanistan, with isolated cells and loosely affiliated groups that have only a tenuous connection to the greater [Al Qaeda] hierarchy tapping into Bin Laden's 'franchise,' appropriating its ideological 'brand name' for their actions."[42] According to some experts, "Al Qaeda has autonomous underground cells in some [one hundred] countries," and has become "increasingly reliant on sympathetic affiliates" of other terrorist organizations.[43] These models also include two types of passive players, supporting and opposing nations. Supporting nations provide resources to terrorist cells based on each cell's relative merit. The opposing nations, whom the terrorists attack, determine military allocations based on terrorist activity.

FIGURE 1: SIMPLE GAME WITH TWO TERRORIST CELLS

| | | *B* Attack | *B* Do Not Attack |
|---|---|---|---|
| *A* | Attack | 5,5 | 4,1 |
| *A* | Do Not Attack | 1,4 | 0,0 |

The model shown in Figure 1 illustrates a game with two options for the terrorist cells, "attack" or "do not attack". In this game, an attack is assumed to succeed. The terrorists' net payout for an attack is +4, which includes +4 pride points, +1 resource point from supporting nations, and a cost of -1 for resources spent. The effect of a terrorist attack for the other cell is +1, which includes +2 pride points because they are members of the same team, and -1 resource point because supporting nations regard the attacking cell with higher merit and reallocate their support, taking away funds from the passive cell. The dominant strategy in this game is for both cells to attack. When attacking, a terrorist cell experiences a net utility increase of +4 because 5 > 1 and 4 > 0 (see Figure 1).

To develop a model accounting for the possibility of failed attacks, Figure 2 shows the short-term change in military allocation for the opposing nation based on the actions of the two terrorist cells. $m_A$ represents the percentage of the military used to suppress cell $A$, and $m_B$ represents the percentage of the military used to suppress cell $B$. This model assumes the opposing nation dedicates its available military force solely to suppress the two terrorist cells so that $m_A + m_B = 1$. Adhering to the game theory convention where players try to maximize their payoffs, the values in Figure 2 are all between -1 and 0 inclusive, so that a terrorist cell receiving 100% of the opposing nation's military attention has a payoff of -1 and a terrorist cell receiving 0% of the opposing nation's military attention has a payoff of 0.

When both cells attack, the opposing nation does not change its military allocations. Also, when both cells do nothing military allocations do not change. When one cell attacks and the other does nothing, the attacking cell ($\Delta m_A$ or $\Delta m_B$) attracts increased military attention lowering that cell's payoff. The non-attacking cell experiences an equal decrease in military attention, which increases its payoff (see Figure 2). Because this model represents the short-term, the opposing nation cannot change its overall military strength with reinforcements or withdrawals.

FIGURE 2: OPPOSING NATION'S SHORT-TERM MILITARY ALLOCATION FOR TWO TERRORIST CELLS

| | | *B*: Attack | *B*: Do Not Attack |
|---|---|---|---|
| *A* | Attack | $-m_A, -m_B$ | $-m_A - \Delta m_A, -m_B + \Delta m_A$ |
| *A* | Do Not Attack | $-m_A + \Delta m_B, -m_B - \Delta m_B$ | $-m_A, -m_B$ |

The dominant strategy for both cells in this game is "do not attack". To see this, consider when both cells attack. Either cell can improve its payoff by not attacking ($-m_A + \Delta m_B > -m_A$ or $-m_B + \Delta m_A > -m_B$) and when a cell decides not to attack, the attacking cell experiences a decrease in payoff ($-m_A - \Delta m_A < -m_A$ or $-m_B - \Delta m_B < -m_B$). If this cell also decides not to attack, payoffs change back to "attack, attack" payoffs ($-m_A$ or $-m_B$). Because a cell improves its payoff by not attacking, or at least does no worse, regardless of how the other cell plays, "do not attack" is the dominant strategy for both cells leading to a Nash equilibrium of "do not attack, do not attack".

In the long-term the opposing nation can change the total military force, used to suppress the terrorist cells, with reinforcements or withdrawals. Considering the size of the opposing nation's military strength and allocation among terrorist cells is important because there is a difference in a cell receiving 100% of the attention from a small platoon as opposed to 50% of the attention from an entire battalion. Figure 3 illustrates a long-term model similar to Figure 2, where $M$ represents the opposing nation's military strength as a fraction of their total military strength ($0 \leq M \leq 1$). In this model, any change in the opposing nation's military strength affects both cells because of their proximity to one another. Any terrorist attack causes an increase in $M$, represented by $\Delta M$. When both cells refrain from attacking $M$ decreases, which is represented by $-\Delta M$. Similar to the model in Figure 2, the optimal strategy for both cells in Figure 3 is "do not attack."

Changes in total military strength described in Figure 3 are consistent with the cyclical nature of terrorism and counterterrorism, as described by Joao Faria.[44] The cyclical nature of terrorist attacks is a result of cause and effect. When enforcement is low $M$ is small, therefore terrorists have lower costs associated with terrorist activities, and terrorist attacks increase. In response, governments increase their level of enforcement and $M$ increases, which increases the costs to terrorists and effectively decreases the level of terrorist activities. After the frequency of terrorist attacks declines, governments have less incentive to invest in enforcement, so $M$ decreases and the cycle repeats itself. These terror cycles are similar to predator-prey models described in ecology and biology.

FIGURE 3: OPPOSING NATION'S LONG-TERM MILITARY ALLOCATION FOR TWO TERRORIST CELLS

| | | *B*: Attack | *B*: Do Not Attack |
|---|---|---|---|
| *A* | Attack | $-(M + \Delta M) * m_A$, $-(M + \Delta M) * m_B$ | $-(M + \Delta M)(m_A + \Delta m_A)$, $-(M + \Delta M)(m_B - \Delta m_A)$ |
| *A* | Do Not Attack | $-(M + \Delta M)(m_A - \Delta m_B)$, $-(M + \Delta M)(m_B + \Delta m_B)$ | $-(M - \Delta M) * m_A$, $-(M - \Delta M) * m_B$ |

Combining the long-term model for military strength and allocation with the initial model, where attacks always succeed, creates a model that considers the possibility of failed attacks. As an intermediate model that does not consider the opposing nation's military strength, Figure 4 shows the payoffs associated with unsuccessful attacks. This model will be generalized and considered in an expected value formula for the final model.

FIGURE 4: PAYOFFS WITH UNSUCCESSFUL ATTACK POSSIBILITY

| | | *B* Successful Attack | Do Not Attack | Unsuccessful Attack |
|---|---|---|---|---|
| | Successful Attack | 5,5 | 4,1 | 3,-5 |
| *A* | Do Not Attack | 1,4 | 0,0 | -1,-6 |
| | Unsuccessful Attack | -5,3 | -6,-1 | -7,-7 |

Successful attacks retain the same payoffs as in Figure 1. Unsuccessful attacks result in -6 for the attacking cell: -4 shame points, -1 resource point because the cell loses merit in the eyes of the supporting nation, and -1 point for resources spent. An unsuccessful attack also gives the other cell -1 point: -2 shame points and +1 resource point since the supporting nation views this cell relatively more favorable than the unsuccessful cell.

The likelihood of a terrorist attack being successful depends on the military strength of the opposing nation. Figure 5 generalizes the previous model, with $M * m_T$ representing the opposing nation's military strength and allocation dedicated to preventing terrorist cell *T* (either *A* or *B*). This multiplier does two things. First, if $m_A > m_B$ then for a fixed *M* the multiplier indicates more military attention to cell *A* than cell *B*. Second, for fixed $m_A$ and $m_B$, a larger *M* indicates more military attention to both terrorist cells. The terrorists' probability of success *p* equals the attack's success rate without opposition multiplied by $(1 - M * m_T)$. Using this probability, the expected value of an attacking cell is: $V = p(pride + resources) + (1 - p)(shame - resources)$. The expected value for the other cell is: $v = p(pride\ free\ ride - resources) + (1 - p)(shame\ externality + resources)$. In this model *C* represents the resource cost for attacking.

FIGURE 5: GENERALIZED GAME BETWEEN TWO TERRORIST CELLS

| | | *B* Attack | Do Not Attack |
|---|---|---|---|
| *A* | Attack | $V - C + v$, $V - C + v$ | $V - C$, $v$ |
| | Do Not Attack | $v$, $V - C$ | 0,0 |

In this game the Nash equilibrium depends on the values for $V$ and $C$. If $V > C$, the dominant strategy for each cell is to attack, leading to the Nash equilibrium "attack, attack". To see this, one must start by looking at the "do not attack, do not attack" scenario. Because $V > C$ and $V - C > 0$, it is therefore advantageous for a cell to attack. Furthermore, because $V - C + v > v$, it is advantageous for the other cell to attack as well. Hence when $V > C$, both cells can be expected to attack. Conversely, when $V < C$ the dominant strategy for each cell is to not attack. To see this, one must start by looking at the "attack, attack" scenario. Because $V < C$ and $V - C < 0$, it is therefore advantageous for a cell to not attack because $v > V - C + v$. For the other cell, $0 > V - C$, therefore making it advantageous for them not to attack either. An interesting scenario occurs when $V = C$ in that all four possibilities are Nash equilibria because each cell's payoff depends solely on the other cell's action, not its own (see Figure 6).

FIGURE 6: GENERALIZED GAME BETWEEN TWO TERRORIST CELLS WHEN $V = C$

| | | *B* Attack | Do Not Attack |
|---|---|---|---|
| *A* | Attack | $v$, $v$ | 0, $v$ |
| | Do Not Attack | $v$, 0 | 0,0 |

## V. Remarks

At first glance, the implications of these models seem intuitive. The opposing nation can decrease the probability of a successful terrorist attack ($p$) by increasing its military strength. In addition, the equation $V = p(pride + resources) + (1 - p)(shame - resources)$ implies the opposing nation can decrease cells' utility for attacks by decreasing resources given by supporting nations, decreasing cells' pride felt for successful attacks, or increasing cells' shame from unsuccessful attacks (see Figure 5). In short, to decrease the frequency of terrorist attacks these models suggest increasing military strength to intercept resources from supporting nations and lower terrorist cells' attack success probabilities, as well as increasing "soft power" tactics to alter the pride and shame felt by terrorist cells and deter supporting nations from providing cells with resources.

The question is which of these counterterrorism strategies, increasing military strength or increasing "soft power" tactics, is more effective. The answer depends on the elasticity of *p, pride, shame,* and *resources*. For a simplistic example, in the equation: $V = p(pride + resources) + (1 - p)(shame - resources)$, would a $1 trillion investment be better spent increasing $p$, or collectively decreasing *pride* and *resources* while increasing *shame*? If the investment would increase $p$ by 20% or decrease *pride* and *resources* by 25% while also increasing *shame* by 25%, the investment would be better spent on "soft power" tactics because such investment would lower $V$ more than investing in military strength. Similarly, if the investment would increase $p$ by 30% or decrease *pride* and *resources* by 25% while increasing *shame* by 25%, the investment would be better spent on military strength.

Determining the elasticity of such factors is beyond the scope of this paper and could be the subject of future research. Future research might also investigate the effects of increased military strength on terrorists' attack opportunities–whether the probability of a successful terrorist attack increases or decreases when available targets increase, and whether or not this effect changes from the short-run to the long-run. The purpose of this paper is to offer reasons why the study of terrorism is important, provide a review of previous studies, and develop game-theoretic models from the terrorists' point of view. These models are far from complete, but they do provide insights into the interplay between terrorists and nation-states. The importance of terrorism studies is evident, and with further research, better policies can be implemented to mitigate the effects of terrorism.

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