Game Theory Application on Terrorism  
JAN FUKA, ILONA OBRŠÁLOVÁ, PETR LANGÁŠEK  
Faculty of Economics and Administration  
University of Pardubice  
Studentská 95, 53210, Pardubice 2  
CZECH REPUBLIC  
jfuka@seznam.cz  ilona.obrsalova@upce.cz  petr.langasek@cez.cz  www.upce.cz

Abstract: This article reflects contemporary trends in research of international terrorism, and suggests the possibility of their application for Czech private sector. Method presented in this article is Game Theory, which is in recent years increasingly used in research and creating anti-terrorism strategies. Game Theory can rationally examine this phenomenon, and with the use of economic instruments offer new solutions.

Key-Words: terrorism, extremism, game theory, economics, security, strategy

1 Introduction
Most definitions of terrorism agree that this phenomenon is designated as an act of violence applied to achieve the aims through intimidation and fear. Who is terrorist? What is his motivation? Why is this topic devoted so much attention when the number of victims compared to deaths in traffic accidents or due to lack of food in the world is much smaller? Terrorism seems to be a phenomenon that significantly influences public opinion. The idea of irrational thinking terrorists moves toward deeper research of their motives and causes of conflict behavior and its modelling.

"Game Theory is becoming much more important in the study of economics of defence these days. Game Theory is also useful in study of conflict resolution, mediation, peacekeeping, and arms races and arms trade."

How can state or private entity effectively defend against a terrorist attack? How high are the costs associated with it? Is it advantageous to negotiate with terrorists or not? These and other questions that are related to fight against terrorism can be responded rationally by game theory (TH). "Current application of methods of Game Theory in study of terrorism include: evaluation of strategy how nations allocate funds to combat terrorism and how they deal with situations after the attack, assessment of risks associated with terrorism, determines whether state policy of not negotiating with terrorists discourage these activities".

This article includes analysis of terrorism in specific economic context and it is also introduction to Game Theory applications in research of this phenomenon.

2 Game Theory
Game Theory is scientific discipline that deals with decision making in conflict situations. Conflict situation can arise in many cases. "The concept of the game in modern Game Theory has very general meaning, which includes not only the type of salon games such as chess or poker, but basically any situation of conflict between individuals, companies, armies, states, political parties, biological species."

To perform the analysis of critical situations, Game Theory uses not only mathematical apparatus, but also psychology, sociology or economics. The goal is strategy that is based on analysis of a set of decision situations. "Anyone who tries the strategic behavior should be clear in several cases. The first one is the goal to which it wants to get".

Another characteristic feature of Game Theory is uncertain decision making. Valenčík [4] defines Game Theory as a "theory of decision models under uncertainty, where entity ("player") only has information about a number of possible situations, but not to all." The goal is optimal choice of strategy, it is necessary to respect the strategy and expected procedure of another player or players. It is therefore a specific situation where the players interact, changing strategies, create countermeasures. Player or participant may be an individual, couple or group. Decisions of players are implemented on the basis of strategies. Game Theory is applied in many areas. An example can be its using in economics, sociology, political science, cybernetics and biology. Game Theory can describe a number of specific phenomena: interpersonal relations, competition, war and political conflicts.

From a historical perspective Game Theory can be identified in the works of ancient philosophers. The first modern development of Game Theory is associated with names of John von Neumann and Oskar Morgenstern, and their work from 1928. The study focuses on theoretical foundations of Game Theory and also was performed the proof of basic
2.1 Definition of Terrorism in Economic Context

When can be violent criminal activity considered as terrorism? Generally accepted definition refers to terrorism as: "Premeditated use or threat of extreme violence to achieve political or other goals through intimidation and fear aimed at public."[6]

Definition consists of two basic parts. The first type is selected targets. If it was not political (religious) goal, then the violent attacks can not be regarded as terrorist, but rather as a violent crime. Another key part is using extreme violence that leads to escalating brutality of terrorists attacks. Reason can be to get more publicity, promotion, prestige, or recruit new members and supporters.

Besides the classical view of terrorism it is being studied in recent years more in economic context. Joint Economic Committee of U.S. Congress described the costs of terrorism as "loss of human capital, uncertainty in the behavior of consumers and investors, restrictions in specific sectors or areas, increased security costs (tax on terrorism), and anti-terrorism expenses that displaces productivity."[7] This definition can also be divided into two parts. Terrorist attacks destroy not only lives but also property and infrastructure. It follows that, apart from the loss of life, such economies suffer loss of productivity that is associated with this. Losses to property and infrastructure include not only its primary destruction, but also the costs of remediation and repair. In atmosphere of fear and uncertainty caused by terrorist activity or threat, there is also a decline in consumption and investment. Abadie and Gardeazabal in their work [8] indicates that even if terrorist activities are only a small part of economic risk of the country, their impact on the decrease of foreign direct investment is considerable. It causes indirect impact on economic systems. An example of a direct negative impact is air travel or tourism. Companies that are directly touched by impact of terrorism lose not only customers but also must increase the cost of safety. Indirect impacts affect the whole society in terms of travel delay lines, higher insurance or increasing transport costs.

Terrorism thus affects the economy of the state. Abadie and Gardeazabal [8] reported in work called Terrorism and the World Economy four main areas that are affected by terrorism: a) Capital of country (It is directly affected (reduced) terrorist attacks.) b) Threat of terrorism increases uncertainty. c) Terrorism is the cause of higher spending on security. Resources are allocated from the productive sector and used for security.
d) Terrorism adversely affects some sectors of economy such as tourism.

Although there are many different ways and views on how to define terrorism and its appearance corresponds to different approaches there can be identified several points at which agrees with most definitions: a) Terrorism is form of aggression against targets, no - aggressors (civilians, politicians, governments, companies, infrastructure).

b) Targets of the attacks are not primarily military objects and the goal is not victory in war.

c) Terrorist act is not itself the goal of terrorists, it is getting attention, change in opinion or attitude. It is therefore necessary to identify what is target of violence and what is the real aim of terrorists.

d) Creating an atmosphere of fear and uncertainty is only a means to achieve goals.
e) Increased spending on security is associated with terrorism. Some authors deal with how to reduce level of terrorism through economic instruments. Frey [9] identifies three ways of using indifference analysis. The first is to increase the cost of terrorism, the second is reduction of benefits of terrorism and the third is to increase the benefits from non-terrorists activities. Author assumes that terrorists can achieve their goals using terrorist (T) non-terrorists activity (L), while non-terrorists activities are legal ways to achieve goals. Budget line represents the sources of terrorists, points on indifference curve represents a combination of legal and illegal activities that can be used to achieve political or other goals. Goals can be achieved by various combinations of legal and illegal practices. The aim of all three anti-terrorism strategies is the highest rate of substitution of illegal activities legal.

Image 1: Decision Calculus of Terrorists

Source: URL <http://www.bsfrey.ch/articles/390_03.pdf>

Prerequisite for the first strategy is that if state or other potentially endangered entity will increase the cost of terrorist activity, the terrorists will substitute legal activities. Examples of such cost increasing could be improving security measures which shift the budget line to left. According to indifference analysis terrorist activities will be reduced replaced by legal activities.

Image 2: Increasing Costs of Terrorism

Source: URL <http://www.bsfrey.ch/articles/390_03.pdf>

The second strategy is based on reducing the advantages of terrorist illegal activity. Terrorist acts are only a means of gaining the attention of terrorists to achieve goals. If attacked subject is able to reduce damage caused by terrorism, shift in the indifference curve line upwards which will again lead to substitution for illegal activities legal. An example might be higher degree of decentralization of threatened structures, which thus is less affected by attacks.

Image 3: Reducing Benefits of Terrorism

Source: URL <http://www.bsfrey.ch/articles/390_03.pdf>

The third way that Frey says is to increase the benefits from legitimate activities. Attacked subject (in this case usually state) should be in accordance with this strategy to offer terrorist groups participate in political decision making. This will increase the benefits that will bring terrorists legal actions.

Image 4: Reducing Costs of Other Activities

Source: URL <http://www.bsfrey.ch/articles/390_03.pdf>
3 Game Theory and Terrorism

Research on application of methods of Game Theory on terrorism began in 80. of the last century, when Sandler introduced the model of negotiations between the state and terrorists. The model shows that behavior and capabilities of terrorists depend on how they will respond to state apparatus and vice versa. After 9/11 issue of terrorism began to be studied intensively with using Game Theory. Successfully planned and carried out attacks showed the rationality of terrorists decision-making. Rationality of actors and the choice of strategies are one of the basic assumptions of Game Theory. An example might be installing metal detectors at airports in 1973 and the associated immediate substitution of kidnapping people (mainly diplomats, politicians, senior government officials) instead of the hijacking a planes. When increased costs of security prevent kidnappings, terrorists replaced it by suicide attacks. Game is appropriate tool to research terrorism because it captures the interaction between attacked subject and terrorist organization, when the steps are interdependent and therefore can not be analyzed separately. Each subject (in the terminology of TH player) is in such a way as to maximize its benefits.

Game Theory seems to be useful tool for research on terrorism for several reasons: a) Game Theory captured terrorists and governments act as interdependent b) Government and the terrorists are rational actors who respond to opponents steps c) Government and terrorists behave so as to gain a strategic advantage d) Government and terrorists are trying rationally maximize their benefits (an example of hijacking was mentioned above) e) Government and terrorists make decisions on incomplete information [10]

Game theory can also be used in design of future anti-terrorism policies. Sandler and Arce [10] model situation when and whether the government should accede to demands of terrorists. Generally known pillar of the U.S. government's counterterrorism policy is "no concessions to terrorists." Authors add conditions that result from the application of Game Theory. The first reflects the government's position to be at this point is always tough. The second conditions are terrorist’s incomplete information about government counterterrorism policy.

Another example is use of Game Theory is implementation of security measures among countries. Sandler and Arce use Game Theory [10] to describe what they call "races in intimidation" among countries. There are two potentially vulnerable countries by one terrorist group. If one country increases security costs, costs associated with the terrorist attacks are increasing. But it also represents a negative externality of the other country, because the costs of terror attack in the other country is relatively declining. Consequently, the second country increases its security costs, because it wants to reduce probability of being attacked as an alternative target. If the other country will increase security measures (and associated costs) above the first country, the negative externality is poured on the first one. Such a scenario suggests that countries overestimate the costs necessary to ensure their safety.

3.1 Game Example

Classic and probably the most discussed example of the use of Game Theory is the prisoner's dilemma. It is given to situations where the crime was committed and there are arrested two suspects, A and B. The evidence is incomplete and therefore it is very difficult to prove the crime to both potential suspects. Both suspects are interrogated separately (A do not know how to decide B and vice versa), both suspects are offered these options: a) If one suspect confesses and the other did not, then the one who confessed will be get one year. The other one who did not confess will be arrested for 10 years. b) If both confess they will be arrested for seven years. c) If both not confess, they will be arrested for three years.

Table 1 shows the results of the prisoner's dilemma with the costs assigned to the players.

<table>
<thead>
<tr>
<th></th>
<th>confess</th>
<th>not confess</th>
</tr>
</thead>
<tbody>
<tr>
<td>confess</td>
<td>7,7</td>
<td>1,10</td>
</tr>
<tr>
<td>not confess</td>
<td>10,1</td>
<td>3,3</td>
</tr>
</tbody>
</table>

Source: Author

Decisions will be examined first in terms of prisoner A. Prisoner A does not know how will respond prisoner B and trying to maintain so that the result for him was the most advantageous. The possibilities in the matrix show that if prisoner B confesses, prisoner A is advantageous to also confess. In this case gets a penalty of seven years. If he would not confess the amount of penalty will be ten years. If prisoner B does not confess, prisoner A is again advantageous to confess, because then his judgment will be for one year compared to three years which are condemned if he would not confess.
Prisoner B will choose the same decision. The result is that both will confess and their judgment will be seven years in prison for each. If you would not confess, both will be arrested for three years. Confess is both the dominant strategy. Dominant strategy is closely related to Nash equilibrium, which occurs: "If every player follows the best strategy for themselves, that is the dominant strategy, while if he deviated from it and the second player (if more players other players), the will keep the dominant strategy, then he would get worse "[5]

Prisoner's Dilemma is a situation when individual players in the game (states, firms, individuals) follow their dominant strategy, which points to the fact that these players can ultimately be worse off. Prisoner's dilemma can be used in states deciding whether they comply with agreement on arms or companies that comply with (eg. cartel) agreements. Sandler [10] applies to Prisoner's dilemma situation where governments choose between active and reactive counterterrorism policies. Active policy is about open and active fight against terrorism, which consists mainly in, search and destruction of terrorist, destruction of resources and infrastructure of terrorists, active monitoring of terrorist activities and preventive action against terrorists and their sponsors. If active anti-terrorism policy implemented by one state is successful and if such actions destroy terrorist cell, there is tendency of other states rely on active actions of this country. In such cases it is so-called free-rider effect when the risks and costs associated with the active fight against terrorism carries one state, while others receive only the benefits of it. Active policy is then characterized in particular by solving the effects terrorist acts. Free-rider effect is illustrated by prisoner's dilemma in the following matrix.

Tab 2. Application of Prisoner's Dilemma

<table>
<thead>
<tr>
<th></th>
<th>active</th>
<th>reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>active</td>
<td>2,2</td>
<td>-2,4</td>
</tr>
<tr>
<td>reactive</td>
<td>4,2</td>
<td>0,0</td>
</tr>
</tbody>
</table>

Source: Author

There are two players - the U.S. and the European Union (EU). Both countries face common threat of potential terrorist attacks, and both must agree on whether or not to jointly apply active counter-terrorism policy. It is assumed that active policy for individual countries gains benefits of 4 and costs of 6 for country that applied active policy. If the U.S. is applying active policy and the EU will be the state that will only get benefits associated with it (free-rider effect), then the EU will have the advantages of the 4. U.S. gets -2 (4-6). Cost of 6 shall be deducted from the benefits of 4. Otherwise, if the U.S. is a free-rider, the benefits are reversed. If both countries use active policy, then everyone gets the benefit of 2 (6 - 2x4). The result is prisoner's dilemma game, in which no country wants to apply active counter-terrorism policy.

### 3.1 Game Theory Application

Authors, who deal with Game Theory and its application in creating counterterrorism strategies considering national or global range. New area is the use of this theoretical framework for regional and private sector. The subject if research is important chemical company located 5 km from the town of Pardubice in eastern Bohemia region. Company is the largest producer of chemicals in the Czech Republic, which is focused primarily on production of pharmaceuticals, dyes, acids, pigments, solvents and others. Accident caused by terrorist attack would have direct impact on the city of Pardubice and its surroundings. Research carried out in cooperation with the firm and takes primarily data from company security documents. Using Game Theory, focusing on the Czech business sector brings number of advantages opposite national or international concept. Main advantage is option to create an exact description of game players and potential conflict situations. Creating of security strategy must be preceded by detailed research of participants (players). Namely, in this case it is terrorist and company. In reality, it can be assumed participation of other players, such as police, government authorities, international organizations and others. For the purpose the research there are only two above mentioned players – company and terrorist (terrorist group). Research and subsequent analysis of the Czech security reality are the first prerequisite to identify possible threats. It was necessary to focus attention on threat of domestic extremism and terrorism - the first player. This follows from the Czech security situation, which defines literature as a relatively quiet in terms of international terrorism. There were defined main currents of extremist activities, their characteristics, methods and forms. The analysis shows that extremism (terrorism) in the Czech Republic is represented mainly by extreme-right and extreme-left wing political parties. Both have a tendency to
radicalization. The second player is company. Direct cooperation with management and staff, the possibility of empirical research in the area of company and studying strategy documents provide enough data for the subsequent description and analysis. The output of application the theoretical framework of Game Theory is a security and defence strategy to prevent terrorist attacks. Although during the testing of hypotheses and development of a strategy there are used concrete date, results of security strategy and recommendations can be generalized and then applied.

4 Conclusion

Need to examine extremism and terrorism has dramatically increased especially after the attacks of 11th September. The relationship between terrorists and governments, terrorists and target other subjects in the world in recent decades is increasingly viewed by Game Theory. Game Theory becomes not only a mean to study this issue, but also an effective tool in the hands of politicians to help create effective counterterrorism strategy. Opportunity to present difficult measured data using numerical values with the subsequent modelling opens up new areas for research on extremism and terrorism. The aim of this article was to bring the issue of extremism and terrorism in economic context and introduce Game Theory as an instrument of next research.

References:


