Dynamics in domestic terrorist organizations

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Abstract

The number of incidents provoked by a domestic terrorist organization shows an oscillatory though irregular behaviour over time. There are periods of time where the organization carries out many incidents whereas during other periods, the activity diminishes or even is null. This paper attempts to explain the reasons of that behaviour considering a causal structure that picks up the interrelations between the actions of the organization and the government of the country where the organization focus mainly its activities. While the terrorist organization controls positive feedback loops, the governmental policies implemented to fight against it are led by negative feedback loops fraught with uncertainty. The dynamic emerging from the interrelations between the positive and the negative feedback loops would explain the evolution of the number of attacks carried by the organization. In order to check the strength of the causal structure a simulation exercise is proposed to characterize the number of incidents of a specific organization during a concrete temporal horizon. The aim is to check the degree of fit between the real data and those obtained by simulation, which includes specific features of the organization to study.

Key words: Domestic terrorism, System Dynamics, Simulation.

Introduction

There is no international consensus regarding the meaning of terrorism. The concept has proven elusive as shown by the United Nations whose attempt to define the term during the 1970s and 1980s was unsuccessful. Any definition is controversial and refuted by both governments and scholars. It seems difficult to join together because whereas some considers a person a terrorist, another one thinks that really that person is a freedom fighter. The issue is that the dilemma is transferred on data: what events must be considered terrorists actions? What characteristics distinguish terrorist attacks from attacks carried out, for example, by gangs?

There are several databases using different criteria to distinguish whether a specific incident is a terrorist event or not. Many papers handling data (Enders et al. (2000), (2005)) use the International Terrorism: Attributes of Terrorism Events (ITERATE) database as main resource of research. The ITERATE database was created using a broad definition of terrorism relying on the world's news print and electronic media for its data, particularly it relies on the Foreign Broadcast Information Service, which gathered the data. The database contains 67,165 transnational terrorist events around the world from 1970 to 1991.

Other database is the Global Terrorism Database (GTD) that includes information on terrorist events around the world since 1970 (LaFree et al. (2006)). The GTD is currently divided into two separate databases, referred to as GTD1 and GTD2. The first database contents data from 1970 to 1997 (not 1993) and considers as definition of terrorism *the threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious or social goal through fear, coercion or intimidation*. The GTD2 database, which contains data from 1998 to 2004, does not set a definition of terrorism. An event is included in the database if it verifies two necessary criteria and two out of three sufficient criteria (the specifications of the criteria used by the GTD2 are available in start.umd.edu/data/gtd/). The database now includes almost 80,000 cases of which 10,000 correspond to GTD2.

Although there are some more databases created by different organizations and victims of terrorist events, the GTD has certain advantages. Apart from its feasibility to obtain data, it presents systematic data on international as well as domestic terrorism incidents. The information contented in the GTD2, which is selected in this study in order to follow a common criterion, shows the international extent of the terrorism. However, some countries are stronger punished than others. From 1998 to 2004 twelve countries supported the higher number of terrorist attacks: India (784), Colombia (571), Russian Federation (435), Algeria (426), Philippines (380), Iraq (317), Spain (284), Pakistan (236), Northern Ireland (235), Indonesia (215), Afghanistan (199) and Israel (191). According to the United Nations, there are more than one hundred terrorist organizations mobilized worldwide of different idiosyncrasy: ethno-nationalist with 1,269 attacks, religious with 991 or secular left-wing with 844 are the most representative perpetrators from 1998 to 2004.

Selecting a concrete terrorist organization, the number of incidents within a country, in which are included armed intrusion, arson, assassination, bombing, hijacking, kidnapping, sabotage, maiming and others, shows an irregular though oscillatory behaviour over time. There are periods of time in which the organization provokes

many incidents whereas during the others, the organization is less active. Such behaviour can be observed in figures 1 and 2, which show the evolution over time of two historic and domestic terrorist organizations. The first figure shows the number of attacks carried out by the Fuerzas Armadas Revolucionarias de Colombia (FARC) in Colombia. Figure 2 shows the number of incidents of the Euskadi ta Askatasuna (ETA) in Spain. Both figures are constructed using data provided by GTD2.

The study of the patterns of behaviour over time shown by events attributed to terrorist organizations is investigated using different approaches. Some authors use statistical methods to find some regularity in the data series, while others try to explain why the time series oscillate. Inside the first group are Enders and Sandler (2000) who considering a time series of terrorist events worldwide and using econometrics methods found that the number of terrorist incidents contains a long-term primary cycle and a medium-term secondary cycle. Clauset et al. (2007) analyzing the autocorrelation function of the time series about terrorist attacks worldwide showed that the fluctuations of severe events exhibit a strong degree of periodicity on the order of thirteen years. Inside the second group are Fleichtinger et al. (2001), who focusing the paper on terrorism in tourism industry and using control theory, justified the existence of cycles taking into account that investments in tourism attract terrorism that, in turn, cause a decline of tourism and as a result a decrease of terrorism moving back the industry to the original situation. Das (2008), generating a predator-prey structure, argues that terror cycles arise from the interaction between the actions of a terrorist organization and a defending state. This study shows that if some parameters are selected in a specific way, bifurcations and endogenous cycles emerge.

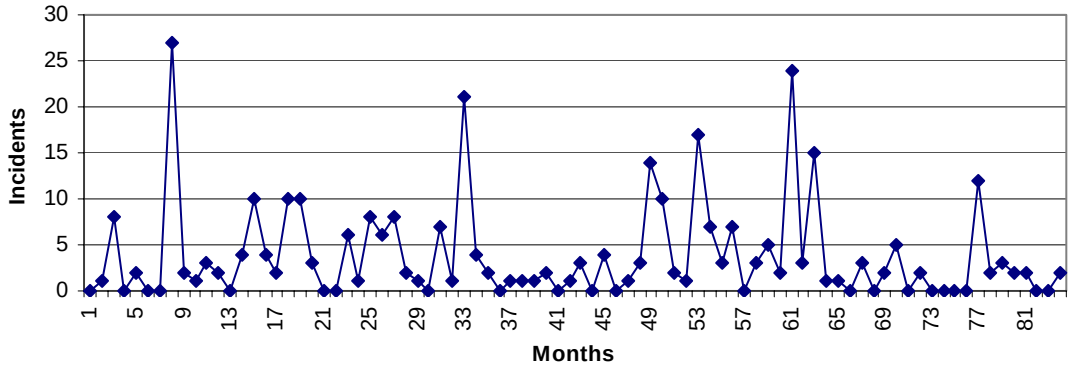

Figure 1: Incidents of the FARC

System Dynamics methodology could also explain the patterns of behaviour over time of incidents carried out by a domestic terrorist organization taking into account the interactions between the terrorist activities and the counterterrorist measures implemented by the government. Nevertheless, studies that pursue similar aims and are based on the interactions between a government and a terrorist organization are also constructed using other methodological approaches. For example, Fleichtinger et al. integrate the interactions in a problem of dynamic optimisation; Das bases his study on the solution of two problems of static optimisation and Rosendorff et al. (2005) mentioned different researches in which the interactions between both agents are used to seek equilibrium strategies according to game theory.

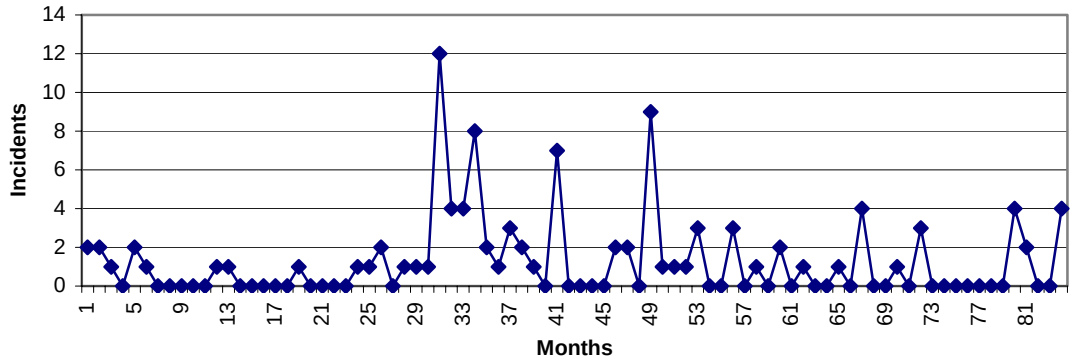

Figure 2: Incidents of the ETA

Then, why is System Dynamic selected in this study? The reason is simple because unlike other methodologies, System Dynamics method is able to consider more realistic aspects linked to the matter. It can take into account radical changes of strategies of the actors involved in the process by different reasons: change of leader in the terrorist organization, change of government in the country or even, shifts in the international environment. In addition, the methodology can capture all aspects by what other methodologies were selected. It can perceive the underlying uncertainty regarding both the activities of the organization and the responses of the government to them. In particular, the methodology could cover assumptions included in other studies. For example, it could consider a leader and a follower like game theory. Nevertheless, in spite of the fact that system dynamics methodology seems very suitable to study matters related to terrorism, concrete studies about that topic are unusual in literature. The paper of Akcam et al. (2005) is an exception. It shows the possibilities offered by the methodology considering a deep analysis about the causal relationships in ethnic terrorism.

The aim of this paper is to explain the evolution over time of the number of incidents of domestic terrorist organizations using System Dynamics methodology. Firstly, a causal structure is built to explain the interactions between a domestic terrorist organization and a defending state. That construction is articulated in several stages. First, those elements that influence the decisions made by the organization are studied and later, the responses of the government to that actions are analysed. That causal structure would explain certain general dynamic aspects shown by the series time of the number of incidents of a terrorist organization. In particular, it would justify the fluctuations though not their amplitude. Then, in order to improve the analysis, the causal structure is widened considering the irregular activities of a organization. Unlike other activities, they would be targeted to get more resources and, consequently might be not considered like terrorist. However, their inclusion within the causal structure would justify the differences in amplitude of the oscillations that the real data show. Nevertheless, though the causal structure proposed has a general scope, it is clear that each terrorist organization has its own peculiarities often affected by an unforeseeable variability. This fact makes difficult to check the capacity of the model for forecasting. Likewise, the own factors of each organization provoke that the explanatory effects of the structure cannot follow the same patterns for any organization. Because of that, adding specific features, the strength of the structure is tested considering the ETA organization that operates in Spain. Different statistical tools are considered to assess the degree of

fitting (Sterman (2000), pp. 875) between the real and simulated data of the number of incidents carried out by that organization in Spain. Finally, the paper concludes emphasising those results considered more important.

Model Structure

According to Faria (2003) and Das (2005) the dynamics of the number of incidents of a terrorist organization could be explained from the interactions between the decisions made by both the organization and the government of the country where the organization develops mainly its terrorist activities. The aims persecuted by the organization have to justify its violent actions whereas the government threats by the organization, will try to thwart or if it were possible, to eliminate its activities. The following sections specify the scenario in which both agents make decisions.

The success of a terrorist organization

At least, any terrorist organization that operates in a specific country has two important aims, being one consequence of the other. The first one would be related to some type of political, religious, ethnic, nationalistic or ideological concession that the organization expects to get. Reaching that aim is the reason of its existence whereas the second aim would arise as a result of the denial to its pretensions by the current government. The aspirations that are not accepted would be the justification of its terrorist activities, which would be aimed to scatter terror on the citizens living in the country. The creation of an atmosphere of fear would be the main weapon against the government. In this regard, the pressure over the government would be higher if the activities of the organization become news because, in this way, the organization can foster and expand the fear in addition to achieve international repercussion in order to find more support to its demands.

The success of a domestic terrorist organization and consequently, its persistence over time could be explained by means of four positive feedback loops that describe how the fear influences the resources in the hand of the organization.

The fear is a variable shared by the four feedback loops and in agreement with Das, it grows if either the number of attacks carried out by the organization or the damage caused by each attack increases. In this regard, each new attack would increase the fear, but the growth of the fear would depend on the characteristics of each attack. The growth would be higher, if the attack entails strong human and material damages. Undoubtedly, the generation of fear has a limit which would correspond to a panic situation caused from a current and successful terrorist event of high magnitude. However, the panic does not last because very soon people face the situation. Nevertheless, if the organization does not follow a strategy of massive or very destructive attacks, a new attack increases the fear, but it does not increase in the same degree that the same attack would provoke on citizens who do not coexist with such type of organization because when people coexist with a terrorist organization they learn to overcome the fear.

A distinctive feature of the terrorist organizations in contrast to other organizations that also try to sow terror is that its members do not pursue the enrichment. However, the organization needs economic resources for surviving over time. Moreover, every attack

requires both material and human resources, which depend on the economic resources to a large extent. Forgetting the possible aid of other governments and supporters, the most common way of obtaining economic resources should be from the extortions and the ransoms from kidnappings. It is clear that the success of these activities grow if the fear felt by the population increases.

In a wide sense the organization needs for surviving three types of resources: economic, material and human. The economic resources provide its members means of living and allow the organization to obtain both material and human resources. Both types of resources are necessary elements to carry out the terrorist attacks, which are usually duties of cells. Thought within an organization could have different types of cells depending on the tasks, a cell would be operative in case its members are poised for carrying out attacks and, additionally, they have at disposal the material resources necessaries.

Figure 3 shows how the organization manages the number of attacks and the damage of each attack depending on its resources.

The positive feedback loop R1 links the causal relationship between the material resources and the operative cells to the damage provoked by each attack. This loop takes into account that when the material resources in the hands of the organization increase the potential damage of each attack also grows. Similarly, the second positive feedback loop R3 arises to consider the causal relationships between the human resources, the operative cells and the damage of each attack.

Notice that, the increase of economic resources in the hands of the organization could strengthen its human resources because the organization could increase the proselytise activities, even, if the organization does not have enough human resources, at a specific period of time, it could contract people unconnected with the organization to carry out terrorist activities. Thus, if the organization has more human resources, it could make up more operative cells and then the number of attacks grows. This last causal relationship closes the positive feedback loop R4. The loop R2 considers that the growth of the material resources could also cause a growth of the number of operative cells and, once again, the number of attacks grows.

In spite of fact that the loops managed by the organization are positive they do not determine an unlimited growth of the number of attacks over time because of the assumptions about the behaviour of the fear. In fact, the fear could have a spectacular growth due to the violence shown by the organization but it cannot exceed the limit marked by a situation of panic. Then the causal structure suggests that, at most, the economic resources in the hands of the organization, which depend on the fear, could also tend to a stationary situation. Thus, both the number of members living from the organization and the capacity of the organization to buy new material resources would have a limit. In this instance, the resources of the organization would tend to a practically stable situation and consequently, the number of attacks would show the same evolution.

Nevertheless, the limited growth of the number of incidents justified by the causal relationships foregoing analysed (figure 3) can be exceeded, if other real activities are considered. In fact, the organization could obtain more material and economic resources

from other sources. For example, an organization could steal explosive material to make bombs (the ETA organization has often been accused of stealing explosive material in France according the Spanish newspaper El Mundo, 1999, 2006); an terrorist organization could get economic resources from legal or illegal business (the FARC became involved with the cocaine trade during the 1980s to finance itself). Likewise, the terrorist organizations can obtain economic resources from supporters (no all governments cooperate to curb terrorist finances (Rosendorff et al. pp.173)).

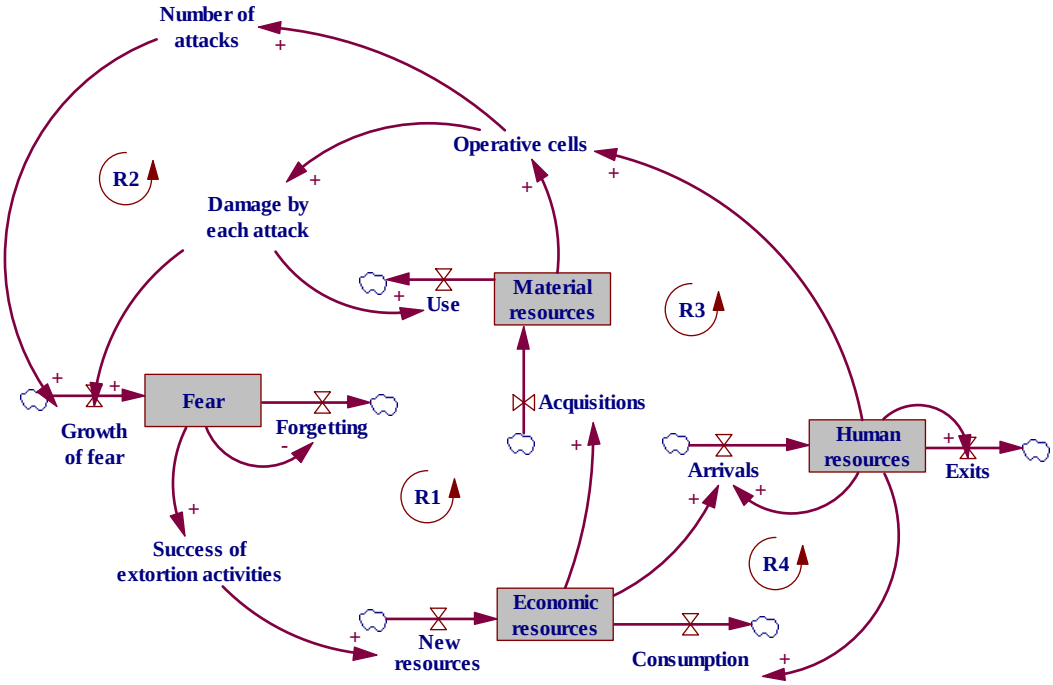

Figure 3: Feedback loops supporting the success of a terrorist organization

The integration of these activities within the causal structure will be analysed later in relation to the role of the leader in the terrorist organization. Notice that these activities might not be annotated by the databases as incidents of the organization because they could verify the conditions to be excluded.

Thwarting the success of the organization

Terrorist organizations have strong expectations about some radical transformation of some established system either within of a country or within of specific regions in the world. The first group would include organizations such as the ETA or the FARC where the attacks are led toward institutions, citizens, properties and policies of a specific country, whereas al-Qaeda would be included in the second one.

Focusing the matter within a specific country, the established system is represented by its current government. Consequently, the existence of the organization is a threat for the government so it will try to defend itself. The government has at its disposal all the resources of the state, then, at first glance, the confrontation between the organization and the government could seem enough uneven. Nevertheless, the fight against terrorism is not easy and requires the state to earmark too many public resources in order to achieve some success. In this way, the cost of the process could be inside the debate of the efficient utilization of the public resources. Due to that reason, usually the

fight against terrorism is a priority aim but not the only governmental aim. The government could implement different types of protocols to fight against the terror hinging on the social pressure; this is, it assesses the fear felt by population as consequence of the number or the aggressiveness of the attacks and as a result it puts in practical certain measures. A higher level of alarm means that the government uses more public resources and as a result, the government would have a higher likelihood both to capture resources and abort current and future activities of the organization. For example, the government might abort extortion activities or deterrence business or robberies.

Figure 4 illustrates six negative feedback loops that allow the government to decrease the resources in the hands of the organization, but the causal relationships must be only considered in terms of likelihood. The loop B1 reflects the negative influence that the alarm level has on the success of the extortion activities; B2 considers the possibility of detecting material resources causing its destruction. The loops B3, B4 and B5 take into account how the alarm level affects the possibility of detecting human resources; B3 supports the idea about what if members of the organization are captured, some information about the material resources in the hands of the organization could be obtained. Similarly, B4 assumes that the capture of members could propitiate the detection of economic resources. B5 points out that the captures diminish the human resources, which affect the number of operative cells. Finally, B6 considers how the human resources affect the number of attacks.

Observe that whereas the positive feedback loops managed by the terrorist group are linked by the fear, the negative feedback loops caused from the actions of the government are, in addition, related to the level of alarm, which is set by the government in reply to the aggressiveness of the terrorist organization. The interactions between both types of feedback loops will influence the available resources of the organization that, in turn, will affect both the number of attack and the damage of each attack. Nevertheless, the dynamics generated by the feedback loops depend on the efficacy of the governmental actions. The alternation in the efficient actions would justify the fluctuations of the number of incidents of any terrorist organization over time that the real data show.

According to Calduch (1993, pp.330) an essential element to explain the lack of events of a terrorist organization over time is the lack of resources. It is clear that without resources the organization cannot carry out attacks. Nevertheless, in spite of resources, the organization might not undertake new actions. The reasons are simple, the terrorist organization acts out of the law, therefore, it can have the resources but not in the suitable place or the timely moment. Even more, it could be assessed that there is too risk for the executors or also, the conditions can be considered adverse due to the security and deterrence measures adopted by government. Hence, the opportunity is also an important element to explain the lack of activity of a terrorist organization over time.

The favourable occasions can be included in the causal structure (figure 5) producing two new negative feedback loops. Both loops take into account the inverse behaviour over time of the alarm level established by the government and the opportunity of carried out new attacks. Whereas one of them considers the parallel increase between the opportunity and the number of attacks, the other one relates the opportunity and the aggressiveness of the attacks.

The role of the leader

If inside any organization a leader is important, within a terrorist organization, a leader is essential due to the own naturalize of the group. Most of their members belong to the organization due to their convictions that are encouraged by the leader, who will mark the guidelines of behaviour in order to achieve the success of the ideals defended by the organization.

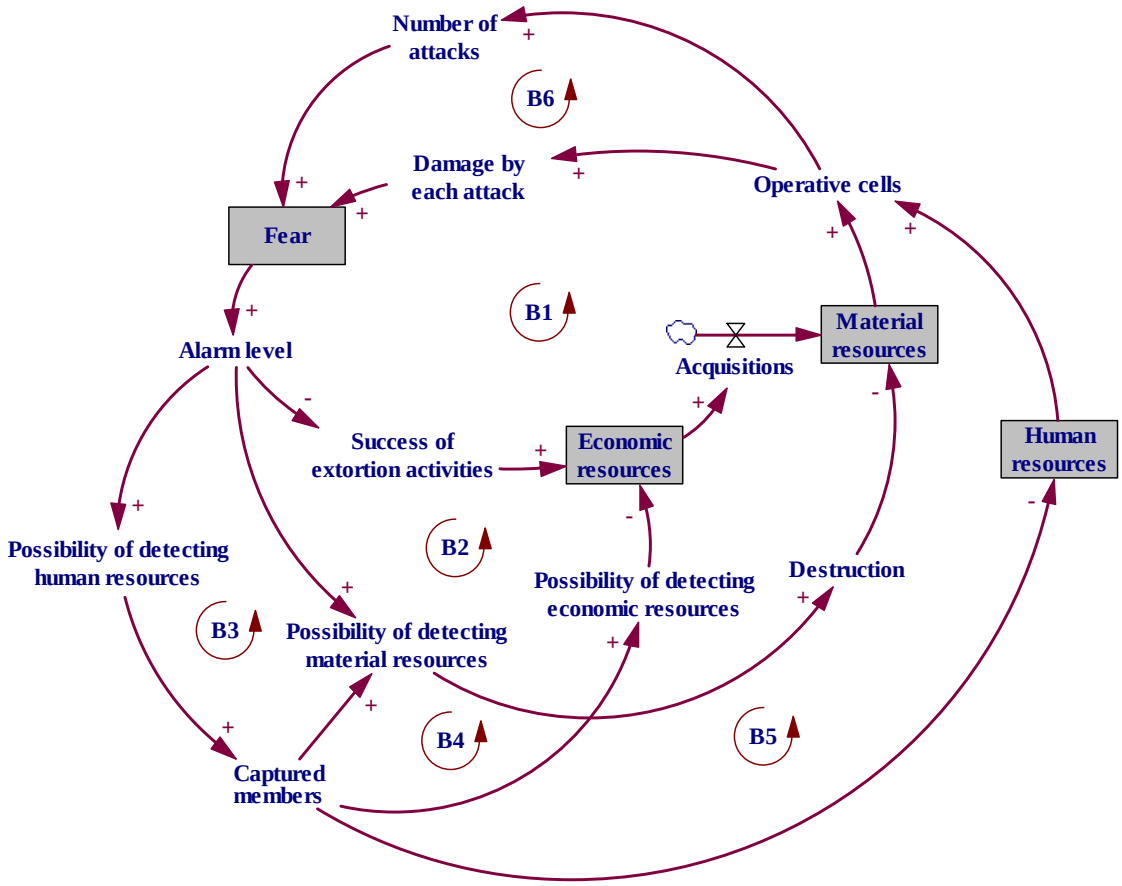

Figure 4: Feedback loops thwarting the success of a terrorist organization

Each current individual leader, or each group leader, will determine a strategic plan besides all tactical aspects tied to it. For example, the leader will make decisions about the function of each member within the organization, number of targets to reach, number of attacks, where and how they will be carry out, its opportunity, if the attacks will be led toward citizens, toward governmental staff or toward buildings or if, for example, the organization will warn of the placement of a bomb, etc. But, in addition, it is obvious that the daily fight will need certain doses of intuition for making decisions.

In particular, the strategic plan established by the leader could include the desired damage. In this instance, it is possible to consider the difference between the planed damage and the current capacity of violence of the organization. The discrepancy would drive to increase the irregular activities of the organization targeted to get more resources in order to achieve the aims planned. These new activities could not be to consider as terrorist activities since they could not imply terrorist attacks, though the opportunity will also influence their execution.

Figure 5 shows the interactions between feedback loops managed by the organization and the defending state. Likewise, the figure includes the unidirectional influence that the current leader has on two variables: the opportunity of carrying out both the regular and irregular activities and the desired damage to inflict by the operative cells on the population over time.

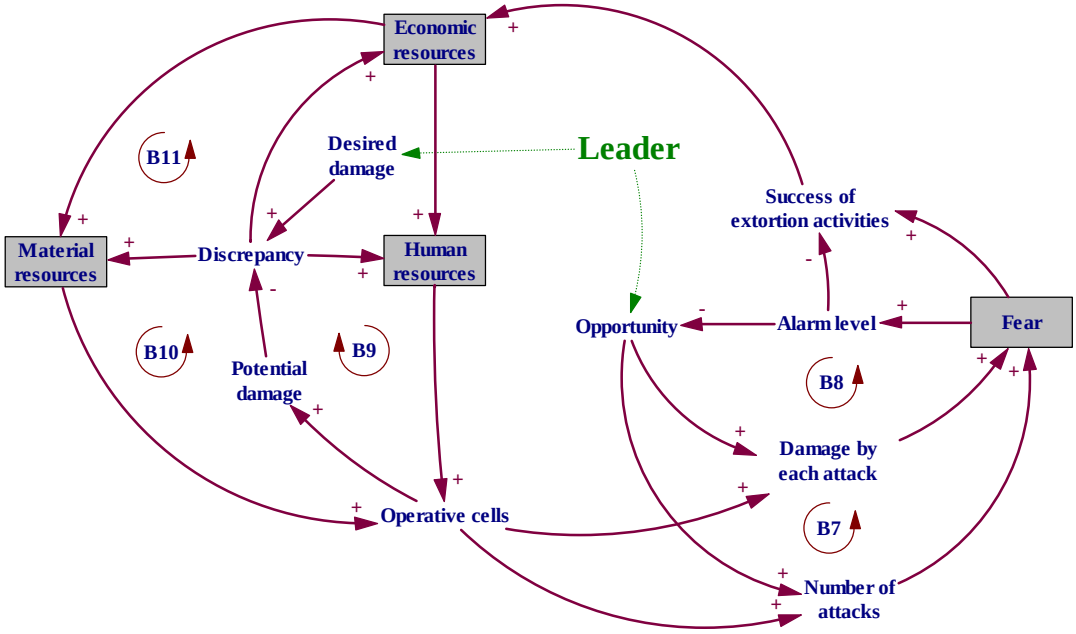

Figure 5: Implications of the leadership in the organization

Finding the behaviour of the stocks

The fear felt by people (scaled from zero to one and dimensionless) is considered a level variable that grows with the number of attacks and the damage caused by each attack but it diminishes with the forgetting:

$$Fear(t+\Delta t) = Fear(t) + \Delta t(Generation\ of\ \ fear(t) - Forgetting(t)).$$

As previous said, the growth of the fear is related to the size of each attacks, but new attacks do not generate the same growth. If

$$Total\ \ damage(t) = Number\ \ of\ \ attacks(t)\ \ Damage\ by\ each\ attack(t),$$

which is measured by monetary units, then the model assumes that the growth of the fear is defined following the expression:

$$Generation\ of\ \ fear(t) = \min\left\{1 - e^{-Total\ damage(t)}, 1 - Fear(t)\right\} / \ Generation\ \ adjustment\ \ time.$$

Hence, if $Total\ \ damage(t) = 0$, there is not growth regardless of the fear felt at t; $Generation\ of\ \ fear$ grows with $Total\ \ damage$, but it grows more when $Total\ \ damage$

is high. In addition, the growth of fear is limited and it can reach exceptionally the value one (panic). Moreover, the fear does not reach a value superior to one.

The forgetting curve, discovered by H. Ebbinghaus in 1885, illustrates the decline of memory retention in time. It can be suitable to modeller the exit flow associated to fear. The curve follows a negative exponential (see figure 6) where the slope of the decrease depends on two aspects: the time elapsed from the event and the impact caused by the attack as well. Then, the model assumes that fear is forgotten following the expression:

$$Forgetting(t) = e^{-Fear(t)}\ Fear(t) / Forgetting\ \ adjustment\ time\,.$$

Thus, if there is fear, a proportion of fear is forgotten during a simulation step. The proportion is high when the fear is small.

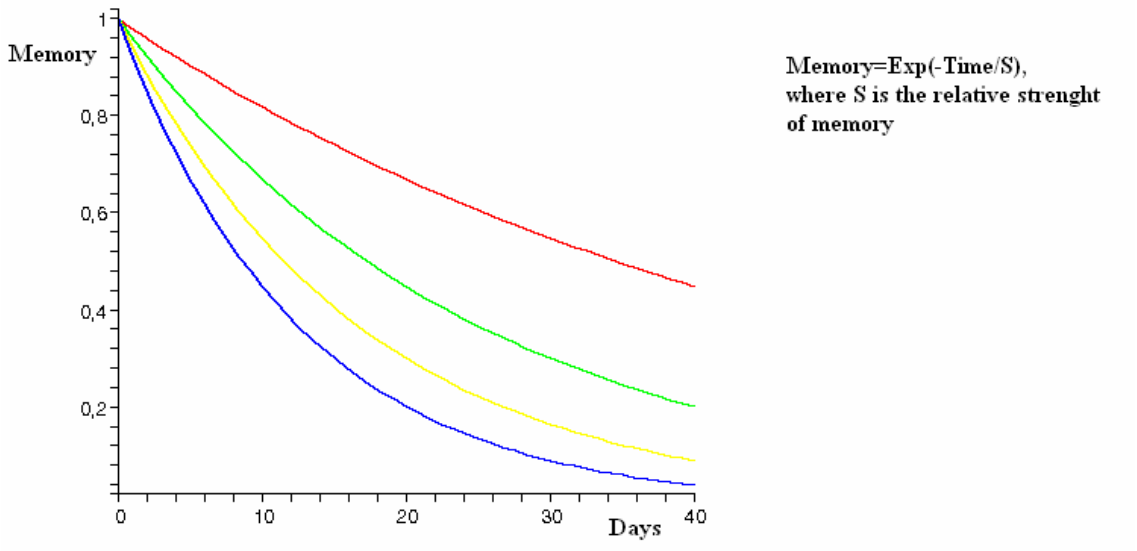

Figure 6: The forgetting curve

The net variation of the economic resources in the hands of the organization depends on the new resources obtained by different means including the extortion activities, ransoms, business, etc. It also contains the consumption that includes all the spending necessaries of its members: food, clothes, housing, lawyers, etc. and finally, the net variation covers the economic loss due to the governmental actions:

$$New\ resources(t) - Apprehending(t) - Consumption(t)\,.$$

The net variation of the material resources is due to acquisitions, use, destruction and depreciation. The new material could be either bought or stolen; its use considers the utilization in the terrorist attacks; the destruction takes into account the captures carried out by governmental actions and finally, the depreciation will be consequence of a lack of use or good maintenance and consequently it might result to be obsolete. The net variation of the material resources will be determined by the expression:

$$Acquisitions(t) - Use(t) - Depreciation(t) - Destruction(t)\,.$$

The variation of the human resources includes the arrivals of new members, the exits and the captures. The exits of the members of the organization could be due to natural reasons or the abandon weapons, whereas the captures, once again, are due to the governmental actions. However, it could also be thought that the terrorist attacks would cause mortal victims within the organization. But in spite of that possibility is right, a common feature of terrorist organizations (see Calduch, pp. 234) is to provoke as incidents as possible with the lesser risk for its members. For this reason, that possibility can be included within the natural deaths. Then the net variation would follow the expression:

$$Arrivals(t) - Exits(t) - Captures(t)$$

Terrorist cells

A common way of distributing the tasks within a terrorist organization is by means of cells constituted by several members with a complex system of contact among them and inside them. The aim with such type of structural organization is to prevent that the apprehensions could achieve the collapse of the organization. The cells have different tasks. Some of them are devoted to gather information relative to future attacks, others are dedicated to the management of the own organization, others recruit new members, others are devoted to training of new members and only a small percentage are in charge of the terrorist attacks. The organization will have, at each moment of time, a number of operative cells depending on the current number of members, the current material resources and the capacity of getting new material resources now and in the future.

Generation and analysis of results

The causal structure analysed shows two outstanding characteristics of the interactions between the actions of the organization and the government, which undoubtedly will condition the dynamics of the terrorist events: the resources are vital for the survival of the organization and the success of the actions undertaken by the government is only likely. Consequently the activities of the organization are also fraught with uncertainty. The leader can only plan its strategies in terms of likelihood, the targets are not sure to achieve, the number of operative cells could diminish suddenly, etc. Due to these characteristics the results obtained by simulation have the risk of being rejected because they are not representative unless the variables were specified accurately. But even though the matter focuses on a concrete organization and the corresponding government, the risk of rejecting continues, since, for obvious reasons, it is an impossible task to try to quantify certain aspects relative to both an active terrorist organization and concrete measures adopted by a government under different situations.

Likewise, it seems important to emphasise that the forecasting capacity of the causal structure proposed is very limited, even in the short term, if it tries to be adapted to a concrete organization. The reason is simple, since the irregular activities are as important for explaining the survival of an organization as the regular activities. But explaining the irregular activities of an organization in advance needs a deep knowledge about it, which is difficult or impossible to achieve. Notice that if it were possible the most counterterrorist actions would be successful, which is not showed by the evidence.

However, despite all problems it seems important to check the strength of the causal structure constructed. In order to alleviate the difficulties, a simulation exercise is proposed considering certain simplifications about certain variables. The exercise tries to simulate the number of attacks carried out by the ETA organization from 1998 to 2004 (figure 2).

In first place, some aspects shown by the real data are analysed before obtaining the simulated data. In the evolution of the number of attacks carried out by the ETA organization during the selected period, it is possible to distinguish three stages, which differ from the activity developed. During the first thirty months, the data show that the organization carries out a terrorism of low activity with regard to number of attacks: there is an average of 0.6 incidents per month and for 16 months the organization does not carry out attacks. However, during this period 13 fatalities and 14 injured were counted. The following 20 months showed a high activity: the monthly average is 2.9 incidents whereas only for six months there are not registered incidents. The figures of this period show 22 fatalities and 202 injured. Finally, the last stage, covering the last 34 months, presented a terrorism of intermediate activity: the monthly average is next to one while for 20 months the organization does not carry out attacks. In this period occurred 6 fatalities and 84 injured. Figure 7 permits to compare fatalities and injured per period.

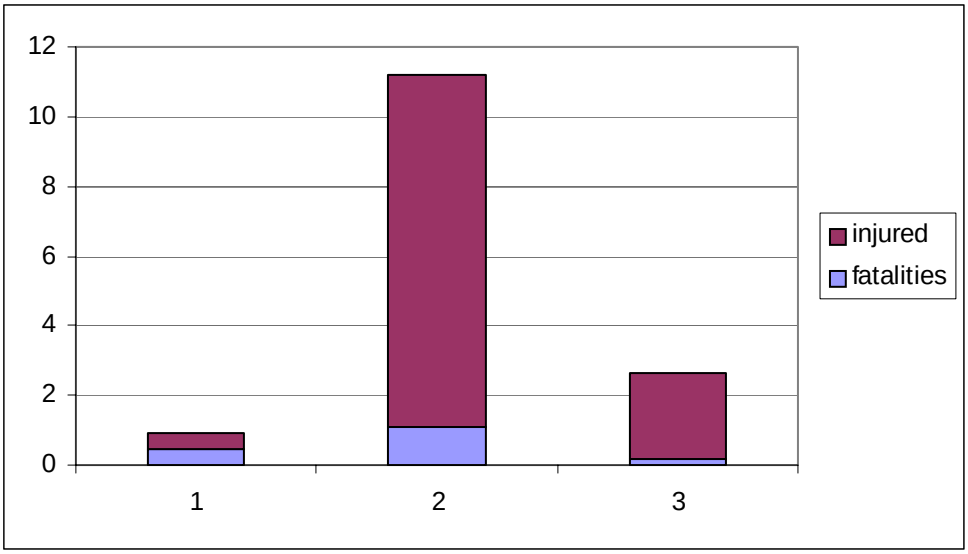

Figure 7: Injured and fatalities per month and period

In order to simulate such stages, the model considers that the terrorist process was immersed in the following aspects:

- The organization did not have difficulties in human resources during the whole period. Actually, the model assumes that the organization could make up as cells as desired. The economic resources are dedicated mainly to proportionate means of living to its members. Only a small fraction of the economic resources is dedicated to small acquisitions of material resources.

- Nevertheless, the organization had difficulties with the material resources provoking that the number of operative cells was limited according the expression:

MAX(CEIL(MIN(Percentage*Cells, Material resources/Point of reference))-1,0)

where Percentage determinates the maximum number of operative cells per month. It is determined as a function of the material resources: more resources entail higher Percentage. Point of reference is a constant collecting the precaution of maintaining always resources as well as the necessity of resources of each operative cell. In addition, it is assumed that each operative cell acts only once a month.

- The level of material resources is initialised in order to internalise the low activity shown by the organization during the first stage. The model considers that a low level of material resources leads to carry out irregular events. Then, since the level of material resources is initialised low, the organization has to get material resources toward the end of the first stage. The effect of such irregular activity is observed in the beginning of the second stage, which starts very active as the real data show. Nothing another irregular activity is pondered during the horizon of simulation.

- The results are obtained considering certain simplifications with regard to the causal structure. One of these simplifications assumes that the damage of each attack is constant. Likewise, all the uncertainty related to the captures of resources is not considered. The model focuses this uncertainty only on the opportunity of carrying out the attacks. The behaviour of this variable is assumed to follow a discrete probability distribution.

- The opportunity of the attacks follows a Poisson distribution truncated by the number of operative cells. In this way, the number of successful attacks of the organization is determined by the expression:

  MIN(Operative cells, Poisson (Average, seed))

  The average of the Poisson distribution could vary for each step of the simulation. It is determined considering two possibilities. First, an average of the success of the organization during the foregoing months is calculated. The distribution is led by that average in case it was positive. But, if the calculated average is null, the average of the Poisson distribution coincides with the number of operative cells, assuming that, in that situation, an attacks is imminent as the real data seem to manifest.

Figure 8 shows the evolution over time of the number of simulated incidents. The two time series, real (figure 1) and simulated (figure 8), differ slightly in average and standard deviation: 1.27 (real average) faces to 1.23 and 2.13 (real standard deviation) faces to 2.09.

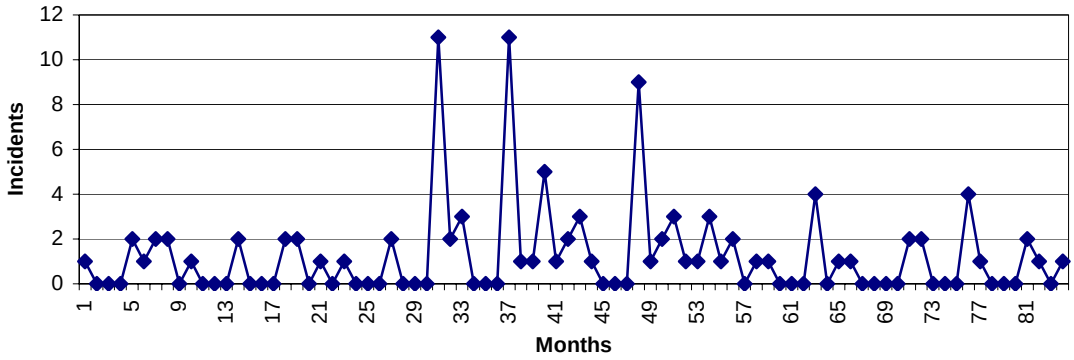

Figure 8: Simulated incidents of the ETA

Mean square error (MSE) is equal to 6.15 and its decomposition (Sterman, pp.875) determines the following result

$$U^m = 0, U^v = 0, U^c = 1,$$

which guarantees that the majority of error is unsystematic though a large U^c also indicates the presence of noise or cyclical modes in the time series not captured by the model. Point by point measures of error such as correlation coefficient (0.29), mean absolute percent error (MAPE=1.24) and MSE are not meaningful because the model tries to explain more the fluctuations than to replicate the same behaviour as observed in the real data.

Conclusions

According with Calduch (pp. 330) the terrorist violence has the characteristic of being unforeseeable as consequence of two aspects: the vulnerability of the modern societies and the impossibility of forecasting the moment, the place, the target and the modality that each terrorist action will present. He asserts that the terrorist strategy has to be totally random and it cannot follow established guidelines of behaviour. These characteristics make difficult to forecast the evolution over time of any variable associated to a terrorist organization, even in the short term. He concludes that it might be possible to estimate the number of members or operative cells at each moment of time as well as its economic resources or even its material resources. Nevertheless, the estimations can change daily as a result of the random behaviour associated to terrorist strategy.

In spite of the unquestionable difficulties to predict the behaviour over time of a terrorist organization, the interactions between a set of feedback loops would explain not when but the way of proceeding of the organization. But the formation of a causal structure explaining the operative way of an organization is not the only contribution of System Dynamics methodologies to the analysis of terrorism. In fact, taking into account that each terrorist organization has its own peculiarities, the methodology would permit capture those aspects. Then, it would be possible to construct a model for each organization. In this way it would be possible to contrast real data with simulated

data in order to assess the capacity of the model to reproduce the behaviour shown by the organization.

Considering another terrorist organization to check the potential of the model presented could be a future line of research. Though, it is possible to consider more alternatives to widen the study. For example, the matter could focus on other variables linked to terrorist events such as the number of fatalities, casualties, big damages, etc.

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