Nicos Christodoulakis

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CONFLICT DYNAMICS AND COSTS

IN THE GREEK CIVIL WAR 1946-1949

NICOS CHRISTODOULAKIS

Athens University of Economics and Business, Patission 76, Athens Greece,
and Hellenic Observatory, London School of Economics.

Using a new set of data from Greek Army sources, US military archives and Communist Party documents, the paper provides a quantitative analysis of the armed confrontation that took place in Greece during 1946-1949. A dynamic Lotka-Volterra model is estimated, pointing to the existence of a conflict trap that explains the prolongation of the civil war and its dire consequences for the country. A regional analysis finds that the mobilization of guerrilla forces was crucially affected by morphology and the local persecutions of political rivals. Using neoclassical growth-accounting, the economic cost of the conflict is estimated to surpass an annual GDP, in line with similar findings in contemporary civil wars. The same framework is employed to assess the outcome in counterfactual situations discussed in the paper.

Keywords: Civil war, Greece, equilibrium and stability conditions, production function.
***JEL** Classification:* C62, E23, N44, O52

1. INTRODUCTION

The Greek Civil War (GCW) took place during 1946-1949 between the Communist Party of Greece (KKE) and a coalition Government of centre and rightwing parties, and had dramatic and lasting consequences for the country in general and the economy in particular. In comparison with other national tragedies, the human carnage in the Civil War exceeded the toll of battle-deaths that occurred during the Italian and German invasions in 1940-1941. In the first place, the Greek National Army (GNA) appeared to be vastly superior in size and equipment and this meant that it was unwinnable by the

guerrilla army. However, this was not translated to a clear advantage in the mountainous battlefields where the experienced fighters of the Democratic Army of Greece (DAG) proved to be undefeatable.

As a result, a stalemate soon emerged whereby the effort of one side to win was matched by the opponent's endurance and this led to the perpetuation of hostilities. By the end of the second year of fighting each side struggled to expand forces, acquire more resources, and obtain more support from the superpowers of the time; the Government from the US, while the guerrillas from the Soviet Union and its Eastern European allies. But despite the upgrading and spreading of fighting, no side gained a clear advantage over the other and a new stalemate prevailed, albeit this time at a much higher level of human losses and destruction.

These developments point to the existence of a 'conflict trap' in which the adversaries got stuck for nearly two more years, before a major offensive by the Government led to the capitulation of guerrillas and the termination of hostilities. The cost to the economy was immense as -on top of battle losses and widespread destruction of production units- there had been a massive exodus of defeated guerrillas and their sympathizers in order to avoid further persecutions. In the meanwhile, the geopolitical position of the country was seriously affected: instead of sharing the peace dividend of the postwar era, Greece became a test case of Cold War antagonism that shaped domestic politics for years to come. Political segregation lasted for a quarter century, making Greece a hotbed of authoritarianism culminated in a brutal dictatorship in 1967, before a liberal democracy was finally restored in 1974.

Amid many questions that are still pending on why and how the civil war erupted, there is a central paradox regarding the intensity and perseverance of the conflict. Ex post, it seems obvious that an early termination of hostilities could be beneficial for both sides, especially if one takes into account that the country had just exited another catastrophic war and prospects were naturally being expected to improve and provide more opportunities for all. But instead of opting for a constitutional power sharing, the adversaries engaged in a prolonged conflict with enormous consequences in human, economic and political terms.

To investigate these issues, the present paper explores the following aspects of the Greek Civil War: first, it examines the dynamics of fighting and the existence and stability of a

conflict trap. A modified version of the Lotka-Voltera model is set up to reflect battle dynamics in a realistic way and allow for non-trivial conflict equilibria. The parameters of the model are estimated by econometric techniques and compared with actual developments in the battlefield. Moreover, the regional aspects of the conflict are examined to see whether they were influenced by geographical morphology and local persecutions.

Second, it assesses the cost incurred in the Greek economy due to the vast destruction of the labor force, capital stock and livestock during the Civil War. By applying neoclassical growth accounting, the GDP losses during and after the conflict are determined and then compared with similar estimates on other civil wars to obtain a measure of the severity and long lasting consequences of GCW. The accounting framework is used to evaluate how much of such a cost could have been avoided on the counterfactual hypothesis of an earlier termination of hostilities.

The above objectives require coherent and systematic data series. To overcome their inadequacy or unavailability, new data series on battle casualties and persecutions covering the period 1946-1949 were compiled at a monthly frequency. This became possible by systematically recording detailed –though scattered- evidence that was found in Greek military reviews, the US military archives and various reports recently published by the Communist Party of Greece.

The rest of the paper is organized as follows: Section 2 briefly reviews the literature on civil wars in general and the Greek Civil War in particular. Section 3 provides a statistical analysis of battle data and establishes that the conflict should be examined in two phases to account for the escalation of fighting after 1947. Section 4 describes a dynamic model of conflict and examines the conditions under which a perpetuation of hostilities may occur. Section 5 presents an econometric estimation of the model and discusses its properties along with actual political and military developments in Greece at that time. In Section 6, a Cobb-Douglas production function is used to assess the cost in the economy and to which extent this could have been avoided by an earlier termination of hostilities. Section 7 presents the main findings and conclusions. The paper is followed by two supplements: Appendix A includes sources, definitions and data series, while the key properties of conflict models are described in detail in Appendix B.

2. A REVIEW OF THE LITERATURE

Academic research on civil wars is thriving and ranges from meticulous collection and analysis of actual conflicts to theoretical models that explain their motivation and dynamics. Alongside, a methodology for assessing their economic and social consequences has been developed.

In modeling conflict situations, a large variety of approaches is available and a comprehensive review can be found in Lichbach (1992). There, more than two hundred scholarly contributions are grouped into two broad categories: one includes those following the rational choice optimizing framework, and the other those employing stochastic models of conflict. The first body of literature focuses on the root-causes of a conflict and -by using cross country or regional panel data- tests its intensity against various explanatory variables. According to Collier and Hoeffler (2001), an individual participates in an insurgence if expected gains outweigh the costs of engagement plus benefits foregone by abandoning current activities. In a similar line of thought, Fearon and Laitin (2003) argue that violence is escalated when repression is poorly enforced, thus reducing the cost of insurgency and increasing expected payoffs for participants. In contrast, Sambanis (2002) criticizes the opportunity-cost model by arguing that the escalation of repression leads to larger-scale hostilities rather than suppressing them.

The second framework studies the dynamics of fighting by employing variants of Lotka-Volterra models. Though originally devised to study species interactions, these models soon were found useful in studying human rivalry generated by a variety of factors: such as by class-struggle (e.g. Goodwin, 1967), the arms race (e.g. Richardson, 1960), political competition (e.g. Francisco, 1996), riots (e.g. Burbeck et al, 1978) or outright revolution (e.g. Tsebelis and Sprague, 1989). More recently, a new strand in the quantitave literature assumes that battle casualties follow power-law distributions and the duration of conflict can be indicated by their complementary cumulative distribution function (*ccdf*).[1] The most-commonly used is the Pareto distribution, and in this case the probability of casualties *(X)* exceeding a certain level *(x*) is given as:

$$ccdf(x) = prob(X \geq x) = (x/h)^{-\lambda} \quad (1)$$

[1] This is frequently called the 'survivor' function, but here the term is unsuitable for describing battle deaths.

where *(λ)* is the conflict index and *(h)* represents a lower bound of fatalities, i.e. *prob(X > h)=1*. The higher the index *(λ)*, the less likely a large number of casualties will occur so as to lead to the termination of conflict. Using a large cross section of fatality data, Clauset et al (2007) show that they follow a Pareto distribution with an index equal to λ=2.50, which is taken to express a global constant of conflict. Bohorquez et al (2009) go a step further and relate power-law distributions with other confrontational phenomena, from ecology to finance and to social dynamics. As noted by Lichbach (1992), such an atheoretical approach amounts to claiming that conflicts occur randomly, in sharp contrast with the schools of thought that interpret them as outcomes of rational calculation or a response to grievances. If anything, such contrasting views underline not just the vast possibilities open to researchers but also the huge gap that still divides alternative approaches to analyzing the dynamics of conflict and quantifying its effect.

A stalemate in a civil conflict is attributed to the failure of the adversaries to negotiate effectively, either because agreements lack an enforcement technology or there is uncertainty about true motives of the opponent due to incomplete and asymmetric information. Skarpedas (2008) argues that the ability to enforce negotiated contracts between competing groups is weakened by various factors ranging from geography and ethnicity to external intervention. This makes the option for war as a means of appropriating power to look more appealing even if the cost of engagement is multiplied. In Cunningham (2013), indirect negotiations may fail because outside mediators may have ulterior motives beyond just ending the fighting, while Acemoglou and Wolitzky (2014) argue that incomplete information about rival's intentions may lead one side to interpret noisy signals as opportunistic tactics by the other. Thus it may opt to respond in a similar manner and, finally, each side maximizes its own aggression leading to 'conflict spirals'.

In assessing the economic legacy of a civil conflict, neoclassical growth theory can be employed to determine how the destruction of factors of production affects growth. Collier and Hoeffler (2007) estimate that a civil war incurs a loss totaling between 90% and 105% of a year's GDP. The growth-inflicting list of a civil war may also include the disruption of markets, curtailment of trade and deterrence of foreign investment. Furthermore, additional costs are incurring from the deterioration of productive infrastructure caused either by physical destruction or under-financing as Government

resources increasingly go for military procurement; see, for example, Murdoch and Sandler (2004).

In contrast to the prolific literature on civil conflicts worldwide, research on the Greek Civil War is rather narrow and idiosyncratic. Despite a plethora of contributions on the political and ideological issues pertaining GCW as well as a vast anecdotal evidence on individual battle episodes, a systematic analysis of the dynamics and consequences of the conflict is lacking. One reason was certainly political: for nearly three decades the only publicly available view was that of the winners, until it was reversed by a wave of left-wing interpretations that prevailed after 1974. It was only during the last two decades that key historical episodes have been scrutinized and a more balanced approach was adopted; see, for example, the collections by Baerentzen *et al* (1987), Iatrides and Wrigley (1995), Koutsoukis and Sakkas (2001), Nikolakopoulos *et al* (2002), among others.

The key impediment, however, was the inadequacy of existing data series on socioeconomic and military developments, due both to the official secrecy surrounding the conduct of the warfare as well as the fateful decision of the Greek Government in 1989 to destroy historical archives related to the Civil War.[2] Some quantitative evidence on GCW can be found in Margaritis (2000) where military and economic aspects of the conflict are described - though not in a formal framework. Marantzidis (2010) provides extensive information on the logistics of the guerrilla army, while particular aspects of the Civil War are quantitatively approached in Nikolakopoulos et al (2002). A discussion of some economic aspects of the Civil War is presented in Babanassis (2001), while its long run implications on the structure of the economy are examined by Thomadakis (1995). A path-breaking exception was the field research conducted by Kalyvas (2006) that led to the reconstruction of conflict data series and enabled a formal analysis on the origins and mechanisms of violence in the GCW. This, however, covered only one prefecture of Greece, thus aggregate or regional-wide comparisons cannot be undertaken.

[2] The Herostratian decision was taken in 1989 by a short-lived Government of the conservative and the communist parties on the naïve expectation that national reconciliation is better achieved by eliminating historical records rather than by studying and trying to understand the course of history.

3. CONFLICT DATA AND PERIODICITY

The main developments in the Greek Civil War are shown in Fig. 1 that displays monthly time series of battle-deaths and total battle-casualties[3] of DAG and GNA during the period from January 1946 until December 1949. The first issue is to define the starting and the termination dates of the conflict. Though there is a widespread belief that confrontations started on the eve of the elections in March 1946, it is clear that during the first half of 1946 casualties remained too low to qualify for a Civil War. For the present purposes, it is assumed that the Civil War started in July 1946 when open confrontation tactics were simultaneously adopted by the two adversaries. In response to widespread persecutions by rightwing militias, the Communist Party started to organize 'self-defense' groups throughout Greece,[4] and this prompted the Government to set up emergency martial courts to prosecute acts against "public order and safety".[5] In response, the formation of the "Democratic Army of Greece" was formally announced in October 1946. The conflict was concluded by the final offensive in August 1949, though sporadic hostilities continued for a few more months. The end of the Civil War is here set in September 1949 when the official surrender of DAG was signed.

[Table 1, here]

Statistical analysis

Some key conflict statistics are summarized in Table 1. Reflecting the escalation of the conflict, both time series of battle deaths and casualties are found to be non-stationary by a unit root test. Losses rise sharply in the beginning of 1947 when DAG forces attack several towns[6] and GNA launches the first wave of military operations to clear their holdings in the mountains.[7]

[3] Battle deaths and casualties include all people, combatant and civilian, that are killed or injured in armed engagements.

[4] The decision was initially taken in June 1945, by the 12th Plenary of KKE; see Rizospastis (2011, p149).

[5] The Third Decree of the State was issued in July 1946 and initially established eleven martial courts in key cities. A few months later the number rose to 30, covering most of the country.

[6] For an account of town sieges by the guerrilla army see Marantzidis (2010, p 192).

[7] The main army operations were 'Falcon-Ierax' and 'Stork-Pelargos' (4/1947), 'Eagle-Aetos' (5/1947), 'Swan-Kyknos' (6/1947) and 'Crow-Korax' (5-8/1947). Casualties are given by GES (1976) and GES (1980) as described in Appendix A.

[Fig.1 here]

By the end of 1947, the conflict intensifies and acquires new operational and political dimensions. Letting a simple time-trend to remove non-stationarity and applying Chow tests, a structural break is detected at the beginning of 1948 and this leads to a periodicity of two phases:[8] the first phase lasts from July 1946 to December 1947 and the second from January 1948 to September 1949.

Comparing the battle statistics in the two phases, a crucial change concerning the extent and nature of the conflict is revealed: the monthly average of battle-deaths increases fourfold, while that of total casualties rises more than eightfold. In Phase II, the volatility expressed as the ratio of standard deviation to the mean drops to less than half the size in Phase I, suggesting that the earlier pattern of widespread skirmishes gave way to larger-scale confrontations.

Finally, data are tested against a Pareto distribution to see whether the analysis of power-law models as described in the previous section is relevant for the GCW. As shown in Table 1, the conflict index *(λ)* in the first Phase is found to be substantially lower than the 2.50 value which applies for long term confrontations. A possible interpretation is that larger-scale events were becomin*g* more likely, in line with the quick escalation of conflict during that period. In Phase II, the index is found to be 1.55 for battle-deaths and 1.60 for total casualties, close to the estimates of 1.70 found by Bohorquez et al (2009) for the US and the Spanish civil wars. The finding suggests that GCW was turning into a major repetitive conflict, as in fact proved to be the case in the second Phase.

Army restructuring and conflict escalation

The conflict escalation in the beginning of 1948 was preceded by extensive operationalization and enlargement of both armies as shown in Fig. 2. The state army was steadily increasing and by the end of 1947 had reached 120,000 men from 92,000 men in the beginning of the year. But despite this enlargement, the state army proved incapable of swiftly containing guerrilla forces. Numerical supremacy of GNA was compromised in

[8] The hypothesis of no breakpoint between January and March 1948 is rejected at a range of levels from 1% to 10% for total casualties and battle-deaths as shown in Table 1.

practice as many of its forces were allocated in non-combatant duties, while others were untrained and/or inadequately equipped for fighting on a mountainous terrain; see Marantzidis (2010, p 92) and Averof (2010, p 208). Gregoriadis (2011, p 166) deplores the increase as no more than a "nervous acceleration", and it was only after 1947 that such drawbacks were decisively corrected. In the US, the 'Truman Doctrine' against the expansion of Soviet influence had been proclaimed and, soon, a special mission was set up to provide the state army with modern arms and training.

[Fig.2 here]

In 1948, GNA went further up to 132,000 men, while military shipments from the US were multiplied; see Fig. 3. Combat drilling became more demanding and non-combatant duties were delegated to the National Guard Battalions. At the same time, the political cleansing of the army intensified: left-leaning soldiers were massively transferred to isolated islands, and hundreds of officers were court-martialed for alleged communist infiltration.[9] Finally, a high US command arrived in Athens in February 1948 to directly coordinate military operations. This marked a radically new course in the civil war, both operationally and regarding the geopolitical repercussions on the ensuing Cold War.

[Fig.3 here]

Following a parallel –though definitely source-constrained– process, DAG was trying to expand its force and improve logistics. Neighboring Balkan states were offering military training and backyard facilities to retreating DAG fighters. Substantial military equipment was shipped from Poland and other Eastern European countries to DAG in 1948-1949 in an effort to counter the improved capabilities of GNA; details are given in Marantzidis (2010, pp 48-49). At the same time, DAG was extensively restructured to cover the mainland as well as the islands so that the conflict soon spread all over the country.[10]

To check the size of DAG from rising any further, more than 350,000 villagers were displaced from their land and transferred to refugee camps around cities in Northern Greece during 1948 and 1949. The Government presented the operation as protecting

[9] The most notorious concentration camp was at Makronisos where 28,800 soldiers and officers were kept during 1947-1950. Though the Government hailed the camp as a 'moral transforming institution', several of the interns perished out of torture and starvation; for an account see Kaltsogia-Tournaviti (2001, p 72).
[10] Details of the new structure in DAG are given by Kyritsis (2006, p 28).

"bandit-stricken" villagers from plunder, though KKE claimed[11] that it was a *scorched earth* policy aiming "to undercut provisions, recruitments and the intelligence system of DAG"; for a detailed account see Laiou (1987, p 61). Averof (2010, p 237) argues that, at the beginning, villagers were voluntarily fleeing their homes to escape terror and it was only after 1948 that the operation was extended and centrally organized. Whatever the motivation, displacements severely undercut DAG recruitments and this may be one of the reasons that its forces could not increase any further after 1948; Fig. 4 displays a strong negative correlation between displacements and increases in the DAG forces.

[Fig.4 here]

As the two armies were getting larger, military and political strategies became more ambitious for both the Government and the communists alike. In December 1947 the latter formed a 'Provisional Government' and launched their first tactical warfare operation to proclaim Konitsa –a town near the northern borders- as the capital of 'liberated territories'. After two weeks of intense fighting the offensive was defeated, and subsequently the strategy of DAG concentrated on the war in the countryside.[12] Days after the battle was concluded, the Communist Party as well as all fellow organizations were outlawed and a massive purge of militants swept the country.[13] Emergency martial courts were established in several more cities and procedures became swifter and stiffer; as a result prosecutions doubled in 1948 and death penalties increased threefold, as manifested in Fig. 5.

[Fig.5 here]

These developments further fuelled hostilities and undermined the chances of a negotiated end to the conflict. For example, the evacuees in the rural areas developed a strong opposition against DAG and several of them volunteered to fight against guerrillas for being the reason they were taken away from their land. On the other hand, the wave of prosecutions created a potential pool for guerrilla recruits as several would-be suspects opted for joining DAG in the mountains rather than being court-martialed. In the beginning of 1948 it was clear that both the Government and the guerrillas were moving toward a prolonged and deadly confrontation as analyzed in Section 5.

[11] Rizospastis (2011, p 457).
[12] Rizospastis (2011, p 290). That was the first open disagreement about strategy, with the DAG leader supporting the partisan fighting and the Secretary General of KKE insisting on urban struggle.
[13] For a description see Rizospastis (2011, p 292).

4. MODELING THE CONFLICT TRAP

A commonly used framework to model interactions between two groups is the Lotka-Volterra model, in which the evolution of each party depends on the size of, or the actions by, the other. In biological applications, variables represent species populations, though in conflict or otherwise competing situations they may express the outcome of the adversarial actions; for example in studying epidemic models, Epstein (1997) used the infective and susceptible populations, while in modeling civil conflicts in Europe, Francisco (2009) used variables denoting the casualties of each side. Regarding military confrontations, Collier and Hoeffler (2007) suggest that by using battle casualties rather than army populations, a more reliable assessment of the conflict is obtained. Following this line, the dynamics of the Greek conflict are expressed by a set of difference equations describing battle casualties of the guerrilla army (R_t) and the state army (S_t) as below:

$$\Delta R_t = -\alpha R_{t-1} + \beta R_{t-1} S_t + \theta + \xi_t \quad (2a)$$

$$\Delta S_t = -\gamma S_{t-1} + \delta S_{t-1} R_t + \varphi + \zeta_t \quad (2b)$$

Subscripts denote time periods (t), Δ is first-differencing, (ξ,ζ) are white noise processes, and Greek-letter parameters reflect fighting characteristics. The first terms in the rhs of the above equations denote how the rise in casualties of each army is influenced by its own past losses: if parameters (α,γ) are positive, they denote "survival rates" as each army gradually learns how to contain fatalities by better training and defense-building; if negative they denote "own-attrition" rates due to fight fatigue or loss of critical units.

The second terms in the rhs express the "firing effectiveness" of the adversary as in the terminology introduced by Epstein (1997, Ch. 2). They are increasing in past own-casualties as these make the combatant to be more vulnerable, and in the intensification of the aggression which is assumed to be proportional to the casualties suffered by the aggressor. Scaling coefficients (β,δ) may differ for the two sides because of different firing capabilities; for example, the deployment of air-force by the state army is expected to lead to a firing effectiveness coefficient much higher than that of the guerrillas, i.e. $\beta>\delta$.

Finally, (θ,φ) represent exogenous adverse factors for the guerrilla and state armies respectively. For example, rough terrain for untrained troops, insufficient medical care or

deterioration of logistics may steadily raise the toll in the battle. If negative, they indicate steady improvements. As the logistics of the state army were more frequently replenished and clearly outperformed those of the guerrillas, it is expected that $\varphi < \theta$. As battles intensified after 1948, adversity factors are expected to rise for both armies during the second Phase of the Civil War.

Conflict equilibria

A conflict trap is defined as a situation where fighting is recurring without any side gaining an advantage decisive enough so as to capitulate its opponent. In terms of model (2), such a stalemate is represented by an asymptotically stable equilibrium *(R*, S*)* and is found by setting $\Delta R = \Delta S = 0$, rearranging and solving the system:

$$S^* = \frac{\alpha}{\beta} - \frac{\theta}{\beta R^*} \tag{3a}$$

$$S^* = \frac{\varphi}{\gamma - \delta R^*} \tag{3b}$$

[Fig. 6a, b, here]

A graphical display of (3a, 3b) in Fig. 6a shows that there might be up to two stalemate equilibria. From (3a, 3b) a second-order equation is obtained and the sign of the discriminant determines the existence of positive equilibria. The following Propositions are easily established:

Proposition 1: Two positive equilibria exist if and only if the combination of survival rates is either too low or too high, i.e. one of the following conditions is satisfied:

$$\sqrt{\alpha\gamma} < \left|\sqrt{\beta\varphi} - \sqrt{\delta\theta}\right| \tag{4a}$$

or

$$\sqrt{\alpha\gamma} > \sqrt{\beta\varphi} + \sqrt{\delta\theta} \tag{4b}$$

Proposition 2: No positive equilibrium exists if the survival rates are in the intermediate range:

$$\left|\sqrt{\beta\varphi}-\sqrt{\delta\theta}\right|<\sqrt{\alpha\gamma}<\sqrt{\beta\varphi}+\sqrt{\delta\theta} \tag{5}$$

Proposition 3: A unique positive equilibrium exists if and only if one of the conditions (4a, 4b) holds as equality.

Proofs are given in Appendix B. Permissible areas for the existence of stalemate equilibrium are shown in Fig.6b. The characteristics roots that drive the dynamics of the system are the eigenvalues of the Jacobian matrix evaluated at the steady-state *(R*, S*)* as follows:

$$J(R^*,S^*)=\begin{bmatrix}\frac{\partial R_t}{\partial R_{t-1}} & \frac{\partial R_t}{\partial S_{t-1}}\\ \frac{\partial S_t}{\partial R_{t-1}} & \frac{\partial S_t}{\partial S_{t-1}}\end{bmatrix}=\frac{1}{\Omega}\cdot\begin{bmatrix}1-\frac{\theta}{R^*} & \beta R^*(1-\frac{\varphi}{S^*})\\ \delta S^*(1-\frac{\theta}{R^*}) & 1-\frac{\varphi}{S^*}\end{bmatrix} \tag{6a}$$

with expression *(Ω)* defined as:

$$\Omega \triangleq 1-\beta\delta R^*S^* \tag{6b}$$

Convergence to stalemate equilibrium requires that eigenvalues have a module below unity,[14] while complex roots imply limit cycles. Since expressions are nonlinear, results are only obtained numerically.

The above framework differs from the classical Lotka-Volterra settings in three important aspects: first, instead of making the unrealistic assumption that an army's current casualties are determined by the opponent's past losses, the present model allows for contemporaneous interactions between the two combatants as happens in an actual battle.

Second, it allows for exogenous factors to influence both the path of events and the size and nature of the steady-state. The autonomous conflict is obtained as a special case by letting $\theta=\varphi=0$. Some models (e.g. Francisco, 2009) unrealistically assume that a prolonged conflict has only autonomous dynamics and remains immune from the external environment. This may suit to *in vitro* biological experiments, but hardly is a sensible

[14] The characteristic equation takes the form $z^2-bz+c=0$, where *(b)* is calculated as the trace and *(c)* as the determinant of the Jacobian. A necessary and sufficient condition for two stable roots is $|b|<1+c<2$, no matter if they are real or complex.

assumption for actual wars. Moreover, autonomous systems with lagged interactions preclude the existence of stable non-trivial steady-states as shown in Appendix B. Therefore, they are unsuitable to describe prolonged conflicts, unless a more complicated non-linear structure is assumed.[15]

The third point has crucial implications for the existence of non-trivial conflict equilibria. In both the classical discrete-time framework with lagged interactions or the continuous-time system with contemporaneous terms, a limit cycle is obtained only if parameters (α,γ) are of opposite sign. As noted by Zhang et al (2007) this happens in a situation with predator-prey patterns, and to assume that guerrillas (or the state army) are prepared to act as preys and still enter a civil war is rather awkward. In practice, it is more likely that a conflict is prolonged exactly because the two sides adopt similar rather than diverging fighting patterns.[16] This asks for both parameters being similarly signed and is more suitable for modeling organized civil strife.

5. ESTIMATION

As shown in Section 3, a structural shift regarding the pattern of casualties took place at the beginning of 1948. Therefore, GCW should be separately examined in two phases: the first one covering the period from the breakout of the conflict in July 1946 to December 1947, while the second from January 1948 to September 1949 when it was concluded with the defeat of DAG. Using battle-deaths[17] as the dependent variable, the model (2a, 2b) is separately estimated over the two phases and results are displayed in Table 2. The explanatory power is satisfactory, and all coefficients are found to be statistically significant and correctly signed.

[Table 2, here]

[15] For example, Din (2013) considers a non-linear autonomous discrete-time model in fractional form and shows that the non-trivial equilibrium is asymptotically stable only if several complicated conditions are imposed upon the parameters.

[16] Pointedly, Clausewitz (1976, p 480) was advising that a guerrilla war should not be conceived as an isolated process but 'in the framework of a war conducted by the regular army'.

[17] Estimation was also carried out for battle casualties and results are similar to those reported for deaths. This is somehow embedded in the data as the figures for DAG fighters wounded in 1948-1949 were approximately set in the Government records to be three times that of deaths; estimation details are available by the author.

The main findings per phase of conflict are the following:

(i). The exogenous adverse factors (θ, φ) rise substantially in Phase II for both sides as the conflict becomes more aggressive. The rise, however, is more pronounced for DAG reflecting a deterioration of logistics and more impediments in tactical maneuvering after the closure of northern borders in 1949.

(ii). Survival parameters (α,γ) are found to be nearly the same for both armies in Phase I, suggesting that vulnerability of state troops was close to that of the insurgents. This is explained by the fact that state losses included those of the Gendarmerie and other poorly-trained local militias that were fighting without a central coordination by GNA. The balance shifts in Phase II, in which survival rates hardly change for DAG but improve by nearly half for GNA (from -1.128 to -1.697) due to its increasing professionalization and the fact that all other forces were placed under its single operational command.

(iii). The firing effectiveness (β) of GNA remains superior to that of DAG (δ) in both phases of the war. However, both decline in Phase II as the armies get better organized and the conflict now involves larger-scale and deadlier battles rather than skirmishes. It is noticeable, however, that the *relative* capability of GNA versus DAG (i.e. the ratio β/δ) falls substantially in Phase II from around sevenfold to twofold as a result of parameter β falling from 7.17 to 1.267. A Wald test reveals that the hypothesis of the two figures being the same is rejected only at the 14% level but nevertheless it is interesting to further inquire this finding. A possible reason is that during Phase I the state army basically was engaged in defensive operations[18] and fought against guerrillas only when a clear advantage was confirmed; this entailed more guerrillas killed per GNA death and explains the large size of (β) in Phase I. When major operations were undertaken by GNA in 1948 and 1949, guerrillas managed to keep key strongholds and succeeded in causing severe losses in the state army, thus the lowering of (β). From Fig. 7, it is noticeable that the battle-death ratio of DAG to GNA remained close to the average for most of the time.

[Fig.7 here]

[18] This looked like a 'situation being pregnant with disaster', as figuratively is described by Clausewitz (1976, p 596). It arises when the army is 'taking things the easy way – using superior force to filch some provinces, preferring the security of the minor conquest to a major success'.

The conflict trap in the GCW

The findings of the econometric estimation imply that though GNA was virtually impossible to be won by the guerrillas, at the same time it was not capable of securing a quick victory over them either. DAG was severed by inadequate replenishment, poor training and widespread inoperability of equipment, and Marantzidis (2010, p 97) claims that under such adverse factors no army can last for long. However, DAG was still mastering low-scale and mountainous engagements, and this made the conflict to take several turns before terminating.[19]

To determine possible stalemates, two non-zero steady-states are calculated for each set of estimated parameters; see Table 2. As the characteristic roots' module exceeds unity, the higher equilibrium is found to be asymptotically unstable in both phases. In contrast, the lower equilibrium is asymptotically stable suggesting the presence of conflict traps in both phases. Tellingly, both traps are found to be close to the historical average of battle deaths occurring in each phase. This implies that the conflict could have had been perpetuated around these levels for much longer, if exogenous factors had not been drastically altered in the meanwhile.

A turning point occurred in the autumn 1948 when GNA first cleared mountain Grammos but then failed to hold the neighboring Vitsi in northern Greece. The high toll of army casualties and the massive defections to DAG took Greek military leadership by surprise and demoralized its ranks.[20] According to Woodhouse (1976, pp 144-145), the US mission was seriously considering to withdraw from Greece, and it was only after the visit of the State and Defense Secretaries to Athens in October 1948 that their engagement was reaffirmed. To regain control, the shaken Government appointed a hardliner veteran as Field Marshal and decided to plan new offensives against DAG strongholds.

[19] That outcomes are not necessarily determined by army numbers was indignantly expressed by a Government supporter who was skeptical about "the alleged mathematical assertions … on so many more armies than bandits … How then it happens that the former do not snatch the latter from the neck, to finish them off?"; daily Kathimerini 30/1/1049, reprinted in Rizospastis (2011, pp 397-398).

[20] Averof (2010, pp 323-324) claims too that high ranking officials in the US were considering to opt out, while the Government was seriously contemplating defeat.

In 1949, three specific developments weakened DAG: first the leadership that favored partisan warfare was replaced by a team more eager to engage in large-scale operations, despite poor training and inferior equipment. Second, the logistic support to DAG from abroad was sharply diminished after the Soviet Union advised KKE leadership in April 1949 to terminate hostilities.[21] Third, DAG became more vulnerable after Yugoslavia sealed its borders in July 1949 and ceased to provide a safe backyard for retreating guerrillas.

Even so, DAG was not easily succumbed. To resolve the impasse, an out-of-proportions escalation took place in the summer of 1949, exceeding all previous battles in every relevant aspect: human losses peaked for both sides as DAG losses –including those captured or surrendered– reached 71% of its total strength, while the GNA soldiers killed in the field increased threefold relative to the average in the previous two years. The air force was intensively involved in the operation and bombing reached unprecedented levels. It was this specific escalation combined with the logistical collapse of DAG that made its forces to be terminally defeated and the conflict trap to be resolved.[22]

Regional formations

As partisan warfare was adopted as the main form of the armed struggle, guerrillas were gathering in the mountains and set up regional headquarters. Data are available for the guerrilla forces in eleven HQs in January 1948, and for 21 HQs between March and August 1949. These data are used to analyze the spatial characteristics of the conflict in terms of morphology and local political grievances in the two phases of the war. Note, however, that the limited number of observations in 1948 makes results for the first period to be only indicative.

A measure of political grievance is obtained by the number of state persecutions *(PRSC)* against local militants. In the first phase of the conflict, such purges during 1945-1946 had been documented in a DAG Report submitted to the United Nations in 1948; see

[21] According to his own testimony, the new DAG leader was notified in 20/4/1949 that "Stalin put forward the case for retreating, for ending the armed struggle"; quoted in Rizospastis (2011, p 449).

[22] The sweeping victory in Grammos was seen by many as vindicating the supremacy of military professionals over self-trained communist leaders who ignore fundamental principles of tactical war; see, for example, Tsakalotos (1971, p 317). Though factually true, the assertion should also include the huge material superiority as another critical factor.

Grammenos and Rodakis (1987). In the period ranging from 1949:03 to 1949:08, prior political grievances are measured by the number of citizens being prosecuted in the previous period 1946-1948 in the emergency martial courts of nearby towns; see Michiotis (2007). Details of data definitions and regional classifications so as to correspond to the positions of DAG HQs are given in Appendix A and summarized in Table 5.

Morphology is measured by the altitude of mountains (*MOUNT*) where HQs were set up, and their distance from the northern border of Greece (*DISTNB*). Other morphology indices, such as forest density, land cultivation or country roads, were not found to be statistically significant and are not reported. The following equation for regional DAG concentrations is finally estimated:

$$DAG^j = c^j + \beta_1 PRSC^j + \beta_2 MOUNT^j + \beta_3 DISTNB^j \quad (7)$$

Variables are per headquarter j ($j=1,\ldots,11$ in the first stage and $j=1,\ldots,21$ in the second), and constants (c^j) denote region-specific fixed effects. The sign of estimated coefficients depends on the form of the armed struggle and the relationship between the guerrillas and neighboring states. Thus, (β_1) would be negative if repression was effective in curtailing DAG recruitment and positive if it was counterproductive as discussed in Section 2. Coefficient (β_2) is expected to be positive for a partisan warfare and negative if the struggle was mainly urban. Finally, (β_3) would be negative if guerrillas were seeking refuge in neighboring states, and positive if the latter were allied with the Government and insurgents were handed over. The cross-section estimates are shown in Table 3 and some interesting findings are revealed.

[Table 3, here]

A strong positive elasticity with respect to prosecutions is detected in both phases, confirming Sambanis (2002) that political repression is usually counterproductive. The coefficients suggest that nearly half as many of those being persecuted chose to join DAG and thus avoid further purges. Regarding morphology, results show that guerrilla concentrations were stronger in high mountains, in line with the partisan character of the conflict. It is noticeable that the distance from northern borders is not found significant in 1948, as the strategy of DAG at that time was still promoting the conflict all over the country. The pattern changed in 1949 as DAG troops retreated in the northern part of

Greece and sought refuge in the communist Balkan states, thus the border effect is now found to be negative and significant.

6. THE ECONOMIC COST OF THE GREEK CIVIL WAR

The direct economic cost of the Civil War is estimated in GDP terms by calculating the destruction of production factors and the resulting suppression of growth brought about by the conflict. Assuming a production function with constant returns to scale, output in constant prices *(Y)* is given by:

$$Y = A(kN)^{\eta} Z^{\varepsilon} L^{1-\varepsilon-\eta} \tag{8}$$

where *A, N, k, Z* and *L* denote technology, number of factories, capital stock per factory, rural livestock and total wage labor respectively. Parameters *(η,ε)* denote the elasticities of output with respect to the non-agricultural capital stock and livestock respectively. Let *dN, dZ* and *dL* denote the destruction of factories, livestock and employment respectively. Let *(x)* denote the proportional loss of output, i.e. the drop in growth rate from what it could have prevailed in the absence of the Civil War. Assuming for simplicity that technology *(A)* remained unaffected by the conflict (i.e. *dA=0*), and using subscript CW to denote the Civil War period, the drop is given by the well-known accounting equation:

$$\psi = \frac{dY_{CW}}{Y_{CW}} = \eta \frac{d(N_{CW}k)}{(N_{CW}k)} + \varepsilon \frac{dZ_{CW}}{Z_{CW}} + (1-\eta-\varepsilon)\frac{dL_{CW}}{L_{CW}} \tag{9}$$

The above formula requires that factor destructions are calculated as proportions to their initial stocks, as described below:

(i). Employment: Let (P_t) denote the active population in period t. During the Civil War, active population (P_{CW}) was reduced by the number of battle-deaths, severe battle-casualties, and by those sentenced to death or convicted to long-term internment. After the termination of fighting, it was further reduced by the guerrillas and their families who fled Greece to avoid further persecution. According to Table 4, the above losses amount to dP_{CW}*=-236,787* persons. To obtain the losses in employment, it is further assumed that the proportion of unemployed *(u)* among those perished or expatriated was the same as in total active population. The nearest Census of active population took place in 1951 and reflected the

aforementioned reductions; therefore the loss in employment due to the civil war is calculated by the adjusted formula:

$$\frac{dL_{CW}}{L_{CW}} = \frac{(1-u)\cdot dP_{CW}}{(1-u)\cdot P_{CW}} = \frac{dP_{CW}}{P_{CW}} = \frac{dP_{CW}}{P_{1951}+dP_{CW}} \tag{10}$$

Using data from Table 4, the aggregate loss of employment is found to be -7.80%.

[Table 4, here]

(ii). Livestock: From Table 4, we have that the loss was dZ_{CW}= -1,480,669 animals. The nearest data available for total livestock are from the agricultural Census in 1950, thus a similar adjustment applies as in (10) and the destruction of livestock is calculated to be -11.52% of total. This probably underestimates the loss due to the Civil War as the calculation leaves out the fall in agricultural production brought about by the forced displacement of villagers away from their cultivations as discussed in Section 3.

(iii). Capital stock: The only information available about industrial losses is the number of factories being destroyed during the Civil War. To obtain an estimate of the destruction of capital stock, some simplifying assumptions are made: first, all industrial firms are assumed to be similar and producing the same output *(q)*, and, second, capital stock *(k)* per production unit was the same before and after WW2. These imply that total industry output is $Q=qN$ and its growth rate is given by $dQ/Q=dN/N$. With subscript PW denoting the prewar period 1934-1938, the proportion of destroyed factories is written:

$$\frac{dN_{CW}}{N_{CW}} = \frac{dN_{CW}}{dN_{PW}} \cdot \frac{N_{PW}}{N_{CW}} \cdot \frac{dN_{PW}}{N_{PW}} = \frac{dN_{CW}}{dN_{PW}} \cdot \frac{Q_{PW}}{Q_{CW}} \cdot \frac{dQ_{PW}}{Q_{PW}} \tag{11}$$

Industrial output in 1949 had reached 90% of its prewar level,[23] thus $N_{CW}/N_{PW} = Q_{CW}/Q_{PW} = 0.90$. Table 4 displays the annual growth rate of industrial output and the number of new factories set up during 1934-1938, (i.e. dQ_{PW}/Q_{PW} and dN_{PW} respectively). Rizospastis (2011, p 564) reports that $dN_{CW} = -241$ factories, thus the reduction of industrial capital stock can be calculated from (11) to be equal to -15.76% of its initial level.[24]

[23] As reported by Stathakis (2002, p 66).

[24] Similar estimates are found for the destruction in infrastructure; for example, Babanassis (2001) reports that 15% of rail lines were destroyed because of the conflict.

Elasticities of livestock and capital stock are approximated by the relative shares of their income in total value added. The share of non-agricultural capital income is obtained as $\eta=0.360$ in 1954, the nearest period where disaggregated data are available, while a similar calculation for agricultural income gives $\varepsilon=0.315$; for details see Christodoulakis et al (1996, p212). Substituting into (9), total drop in output by the end of conflict is found to be -11.84% or ψ=-2.84% per year in average during the period 1946-1949.

Collier and Hoeffler (2007) assert that if conditions return to normal after the termination of hostilities, losses continue for another 21 years before GDP reaches the level that would have prevailed without the conflict. After peace is established, a growth rebound of around 1% per year takes place and then gradually peters out as the economy returns to normal. Though such assertions are hard to apply universally and the trajectory of a post-conflict economy is influenced by highly idiosyncratic events, the Collier-Hoeffler time frame is a useful benchmark to compare losses across various civil wars.

Applying this frame to the Greek Civil War, the cumulative output losses are evaluated at present value in the beginning of the Civil War by the following formula:

$$LOSS = \sum_{t=1946}^{1970} \frac{Y_0 - Y_t}{(1+r)^{t-1946}} \quad (12)$$

Output index is set at $Y_0 = 100$ and then evaluated in each period by $Y_t = Y_{t-1}(1 + g_t)$, while (r) denotes the discount rate. The growth rate is set at $g_t = \psi = -2.84\%$ for the civil war period $t=1946\text{-}1949$ and afterwards by the formula:

$$g_t = \psi + b * (1 - \delta)^{t-1950} \quad (13)$$

The rebound effect is denoted by $b=1\%$ and δ is the rate at which it peters out. Letting a period of 21 years for recovery, a rate of $\delta=16\%$ is calibrated to imply that by 1970 the Civil War consequences had petered out as schematically is illustrated in Fig. 8.

Discounted at 5% annually, total losses in (12) amount to 129% of an annual GDP.[25] The loss estimate exceeds the upper side of the confidence interval [90÷110%] found by

[25] Averof (2010, p 385) asserts that material destruction due to the civil war amounted to USD 250 million in 1948 prices. By further adding damages in dwellings, refugees' costs and labour time forgone, the loss is raised to USD one billion in 1948 prices. Greek GDP in 1948 was Drs 63,706 million or $ 1,319 million in 1948 prices; (the 1970 exchange rate was 30 Drs/$ and US CPI 1970/1948 was 1.61). Thus, the estimate represents 75.82% of

Collier and Hoeffler (2007) to express cumulative GDP losses due to a relatively costly civil war. This is because the average Greek drop was below -2.20%, the annual growth loss found by the authors to accrue in other conflict-stricken economies.

The cost of conflict escalation

In addition to the estimation of losses caused by the Civil War, the growth-accounting framework may also be used to assess the effect that counterfactual developments could have had on the conflict burden. As analyzed in Section 4, after the escalation of fighting in 1948 the conflict reached yet another stalemate and was terminated only after a major offensive against guerrillas took place in the summer of 1949. The scale of the operation was unprecedented and so were its consequences in terms of battle casualties, material resources and overall destruction. Moreover, the overwhelming defeat of the guerrillas was used by the Government as the long-awaited opportunity for setting up a regime of repression and exclusion for decades to come.

The particular cost associated with the final offensive can be assessed in two steps as follows: first, evaluate the losses that would have accrued in the hypothetical case that an end of hostilities was negotiated just before the final offensive was launched. Then, by comparing the losses in the counterfactual and the actual case, an estimate of the escalation cost is obtained.

Assuming that an end to hostilities was negotiated in June 1949, the following characteristics would have prevailed:

(a) Casualties would be lower by those perished in the battles of July and August 1949, and similarly for the number of seriously wounded.
(b) Expatriation would have been altogether avoided.
(c) Imprisoned political rivals would have been released and re-enter active population soon afterwards. Given that most of the executions were already carried out by June 1949, the assumption does not apply to those sentenced to death.
(d) The destruction of capital stock and livestock is assumed to be the same as in the actual case, since the final confrontation took place in the mountains and had little

annual GDP in 1948, roughly two thirds of the present estimate. The difference is probably due to the fact that Averof leaves out of calculation the losses in human capital due to forced expatriation and imprisonment.

direct effect on urban or rural establishments. This implies that the rate at which the post-conflict rebound peters out is also assumed to be the same.

As seen in the last column of Table 4, there would have been 117,139 fewer human losses, or 51% lower than what actually happened. With active population increased by their participation and economic activity recovering more quickly, the Civil War effect on GDP would peter out in the early 1960s, rather than seven years later as shown in Fig. 8. Following the same accounting framework as before, GDP losses are now evaluated at 90% of an annual GDP. Therefore, the cost produced by the final offensive in summer 1949 is estimated around 39% of GDP, more than a quarter of total losses. Other counterfactual exercises may similarly be quantified.

7. CONCLUSIONS

Using a new set of data on battle outcomes between the Greek National Army and the Democratic Army of Greece, the paper examined the dynamics of conflict in the Civil War that ravaged the country during 1946-1949. In the first phase that lasted until late 1947, no clear winner emerged and the conflict seemed to have been trapped in repetitive fighting. To overcome the stalemate, both the Government and the guerrillas escalated the conflict by increasing recruitment and heavily relying on foreign support from US and Eastern Europe respectively. But, despite the escalation of the conflict, a new stalemate soon emerged involving higher levels of casualties, more material destruction and further suffering for the country.

In attempting to explain the paradox, a modified Lotka-Volterra model is estimated over the two phases. The econometric findings suggest that despite the numerical and logistical improvements in the state army, its supremacy was still not enough to secure a quick victory over the guerrillas and the fighting could perpetuate around a new (and deadlier) conflict trap. It is also found that purges against political sympathizers of the insurgents turned several of them into guerrillas, thus further aggravating the conflict. Such an impasse could have been resolved either by a negotiated termination of hostilities or by a massive new escalation that would exhaust the resources of the opponent.

The first option required the introduction and empowerment of institutions that promote social equity and participation in public life. Though this is not always sufficient to uproot the causes of a civil strife, it has proved quite efficient in alleviating an internal conflict in postwar Western Europe. For example, in Belgium the risk of a civil conflict was high in the aftermath of WW2 but finally subsided after a major reconciliation between the rival sides was reached; for an account see Conway (2012). Similarly in Italy, the civil war was avoided after the Communist Party denounced the armed struggle and accepted the Constitution despite the pressure exercised by domestic and outside hardliners to engage in a power conflict.[26]

In Greece, however, a similar reconciliation was never truly sought after by either side. The conflict ended only after a major military operation was organized by the Government troops to remove the guerrilla strongholds in northern Greece. As a consequence, human and material losses multiplied and the cost inflicted upon the economy reached very high levels. Still, this was not the end of the dire consequences. A meticulous system of policing enforced the exclusion of political rivals from public life and several economic activities, thus emigration was their only option and resulted to further losses being accumulated long after civil war hostilities had ended. Part of the exclusion politics against guerrillas and their kin survived even after the restoration of parliamentary democracy in 1974. It was only in 1982 that all discriminations related to Civil War actions were dropped and expatriates were allowed to return to Greece without facing prosecution. To quantify the economic cost, the destruction and subsequent exclusion of factors of production were calculated in a growth accounting framework and total loss was found to substantially exceed an annual GDP.

The main conclusions of the paper are summarized as follows:

First, a conflict that initially involves low scale hostilities may soon be trapped in a stalemate. Unless a breakthrough takes place or adversaries negotiate an end of hostilities, fighting will become repetitive with no clear termination in sight.

Second, extending and spreading up hostilities may not necessarily speed up the resolution of conflict. Unless some structural characteristics of fighting alter in a drastic

[26] Applebaum (2012, p 49) describes that the Communist International in Moscow was training key Italian communists to seize power in postwar Italy. According to Rizas (2001), the leadership of the Italian Communist Party was severely reprimanded by Moscow for its failure to act according to Stalin's expectations.

way, the model predicts that the escalation will rather drive the adversaries to a higher level of fighting stalemate.

Third, exiting a conflict trap by a major escalation of force may entail a huge cost in human and material resources. The burden was found to be so high in Greece that a negotiated end of hostilities should have been an absolute priority for both adversaries.

A final remark is perhaps in place as social violence and political extremism re-emerge in today's Greece as a consequence of the deep economic crisis and some lessons of history may be worth recalling. The present study showed that if one starts with deeply divisive politics, even a low-scale confrontation is likely to escalate into a self-perpetuated conflict with immense costs for all the sides involved. Better take care so that the streams of social discontent never escape the Aeolus' windbag.

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Table 1. Key statistics of battle deaths and casualties

	Total battle deaths		**Total casualties**	
Unit root test 46:07-49:08	-1.466 (p=0.53)		-1.027 (p=0.733)	
Jarque_Bera	2.72 (p=0.255)		2.98 (p=0.225)	
Correlation (j=0)	0.828		0.801	
Lag (j= -1)	0.435		0.533	
Period	**Breaking points (**Statistics for detrended series)			
47:12	F=0.31 LLR= 0.278		0.0722; 0.0530	
48:01	0.126; 0.099		0.0072; 0.0041	
48:02	0.0775; 0.0574		0.0076; 0.0043	
48:03	0.0187; 0.0117		0.0019; 0.0009	
Statistics	***Phase I 47:07-47:12***	***Phase II 48:01-49:08***	***Phase I 47:07-47:12***	***Phase II 48:01-49:08***
Mean	454	1714	1165	9023
Std dev	340	629	848	3150
Volatility %	75%	37%	73%	35%
Pareto c.c.d.f. index *(λ)*	0.396	1.55	0.62	1.60

Note: (F) denotes the F-statistic and LLR the likelihood ratio
Sources: Data as defined in Appendix A and Table A1.

Table 2. Battle dynamics

Dependent variable → Independent variable ↓	**Phase I 46:07- 47:12**		**Phase II 48:01- 49:09**		Wald test across Phases
	Guerrillas' battle deaths	***State's battle deaths***	***Guerrillas' battle deaths***	***State's battle deaths***	
Guerrillas' adversity ***(θ)***	0.145* (1.79)		1.088*** (3.95)		*p=0.03*
State army's adversity ***(φ)***		0.0672*** (3.40)		0.237*** (4.02)	*p=0.01*
Guerrillas' survival rate (***-α)***	-1.068** (2.56)		-1.156*** (6.00)		*p=0.65*
State army firing effectiveness ***(β)***	7.17* (1.84)		1.267*** (3.34)		*p=0.00*
State army's survival rate ***(-γ)***		-1.128*** (4.44)		-1.697*** (7.20)	*p=0.03*
Guerrillas' firing effectiveness ***(δ)***		0.940** (2.54)		0.664*** (4.59)	*p=0.07*
nobs	18	18	21	21	
R^2 adj	0.257	0.518	0.646	0.715	
S.E.	0.245	0.037	0.433	0.127	
DW	1.677	1.713	1.615	1.563	
F-stat (prob)	3.94 (0.042)	10.15 (0.002)	19.3 (0.00)	26.1 (0.00)	
High equilibrium	0.628	0.125	1.651	0.395	
Eigenvalues (unstable)	-1.18 and 5.78		-0.52 and 2.13		
Low equilibrium	**0.227**	**0.074**	**1.451**	**0.324**	
Eigenvalues (stable)	0.08 and 0.42		-0.02 and 0.88		
Historical average	**0.309**	**0.084**	**1.364**	**0.370**	

Notes: Variables in '000s, t-statistics in brackets. One, two or three stars indicate significance at the 10%, 5% and 1% level respectively. For the F-statistics, probabilities are in brackets. The Wald test is under the null that coefficients remain unchanged between the two phases. Data series are as in Table A1.

Table 3. Regional guerrilla formations

Dependent variable → Independent variable ↓	***Guerrillas' spatial concentration***	
	1948:01	**1949:03-1949:07**
constant	-5839.79** (3.13)	-1288.33* (1.87)
Early persecutions 1945-1946	0.497** (2.90)	
Court-martial prosecutions 7/1946-12/1948		0.4289** (2.11)
Mountain Altitude (m)	3.090** (3.07)	1.128*** (2.88)
Distance from borders (km)	-	-2.409*** (3.41)
Method	OLS	OLS, Period effects
Nobs	11x1	21x5
R^2 adj	0.799	0.246
F-stat (prob)	20.97 (0.0006)	5.18 (0.00)

Note: Data as defined in Appendix A and Tables A2, A3.

Table 4: Human toll and GDP losses due to the Civil War

	Factors of production	Actual losses	Termination In June 1949
	Human capital		
1	Total battle deaths	43,452	38,328
2	Seriously wounded (b=2a)	86,904	76,656
3	Ex-patriated by KKE	55,881	0
4	Sentenced to death	4,832	4,664
5	Sentenced to more than 10 years	45,718	0
6	Total losses in human capital, (1) to (5)	236,787	119,648
7	Active population 1951	2,800,413	
8	As % of active population adjusted by the losses	**-7.80%**	**-3.94%**
	Industry		
9	Industry, growth rate 1934-1938, annual	7.3%	
10	New factories 1934-1938, annual average	124	
11	Factories destroyed during the GCW	241	
12	As % of industrial units	**-15.76%**	
	Livestock		
13	Destruction during 1946-1949 (animals)	1,480,669	
14	Livestock in 1950 (animals)		
15	As % of livestock adjusted by the losses	**-11.52%**	
	Growth accounting		
16	Non-agricultural capital remuneration, % GDP 1954	0.360	
17	Agricultural income, as % GDP 1954	0.315	
18	Estimated growth rate loss during GCW	**-2.84%**	**-2.43%**
19	**Total GDP loss discounted at 5%**	**128.55%**	**89.70%**

Notes and data sources:

1. The sum of data series SKLD+RKLD. Averof (2010, pp 384-385) claims that battle deaths were 36,839 guerrillaguerrillas and 14,356 from GNA. Thus present calculation may be conservative.
2. Seriously wounded are estimated as twice the number of deaths.
3. Papathanasiou (2002, p 147). Of those 17,352 were children, but here are accounted as active population as most of them reached working age within a few years.

(4, 5). Michiotis (2007, pp 235-239).

7. ESYE (1951, Table 1, pp 2-9).

(9,10). ESYE (1939, Table B1, pp 123-124).

(11, 13). As quoted in Rizospastis (2011, p 564).

(14). ESYE (1958, Table IX, p XXIV). Small animals not included.

(16,17). Christodoulakis et al (1996, p 212).

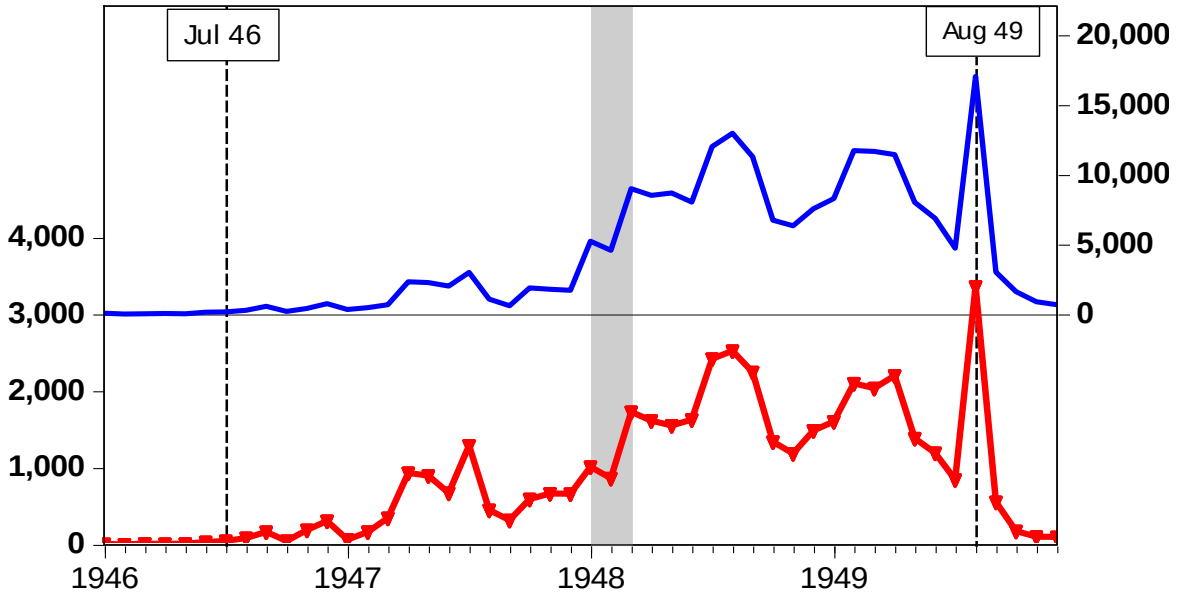

Fig. 1. Total casualties (upper graph, rhs) and battle deaths (marked graph, lhs), 1946:01-1949:12. The beginning of Civil War is marked in July 1946 and its end in August 1949. The shaded area in 1948 marks a structural break into two phases. *Source*: Data are described in Appendix A and listed in Table A1.

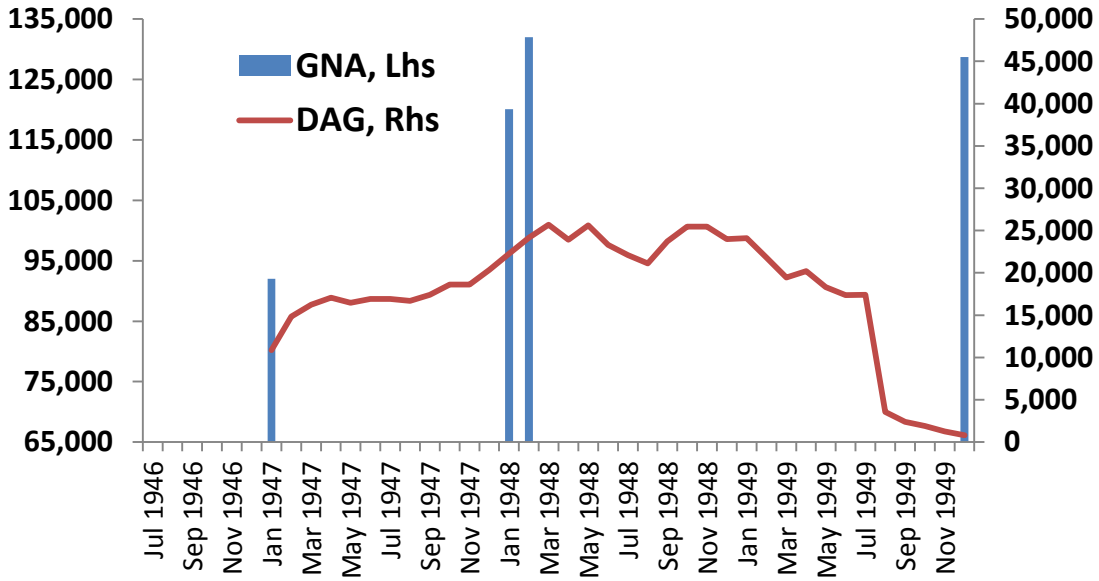

Fig. 2. The size of GNA (lhs) and DAG (rhs) armies, January 1947-December 1949 *Source*: Data described in Appendix A and Table A1.

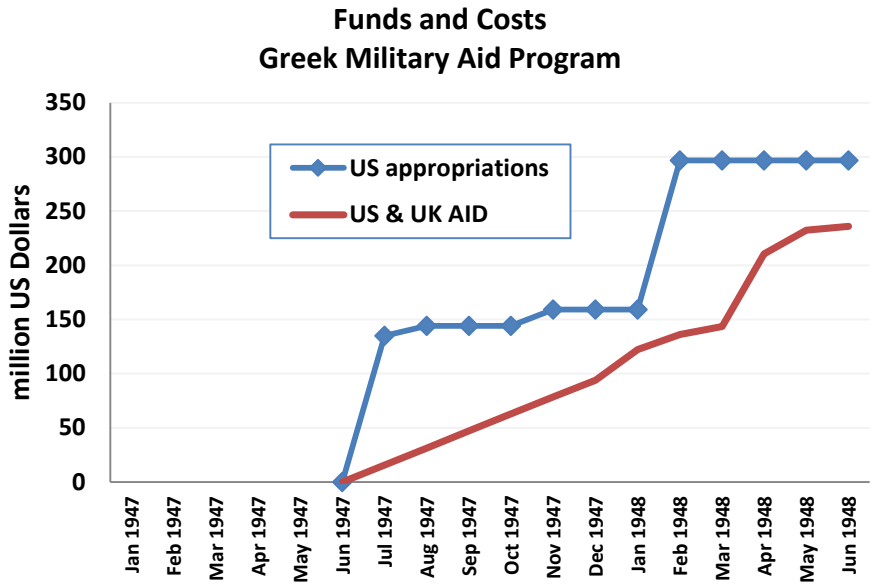

Fig. 3. The costs of military aid delivered to Greece on behalf of the GNA. *Source:* JUSMAGG 1949, Diagram Funds and Costs, Greek Military Aid Program, Ground and Air.

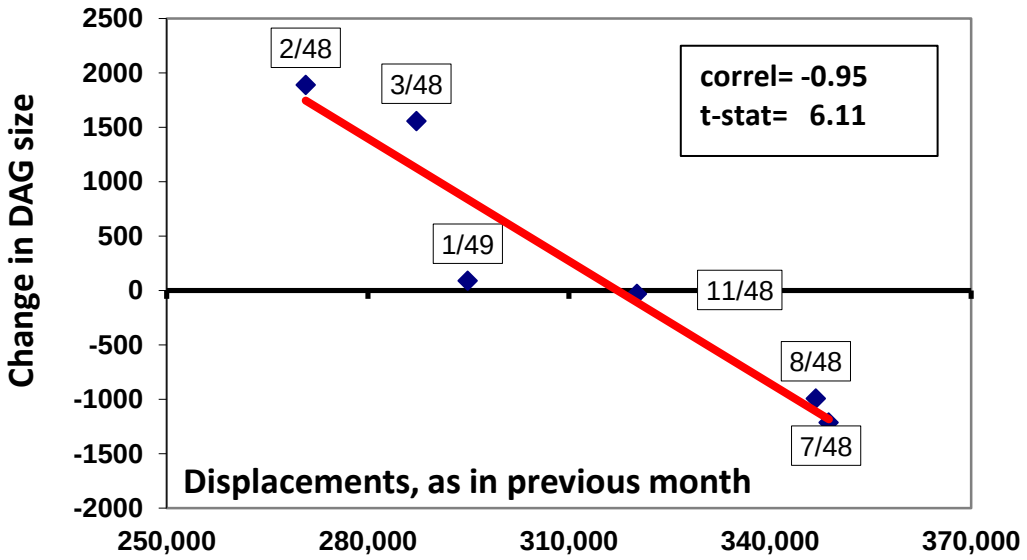

Fig. 4. Monthly changes in the DAG forces and aggregate displacements lagged one period. *Source:* Data described in Appendix A and Table A1.

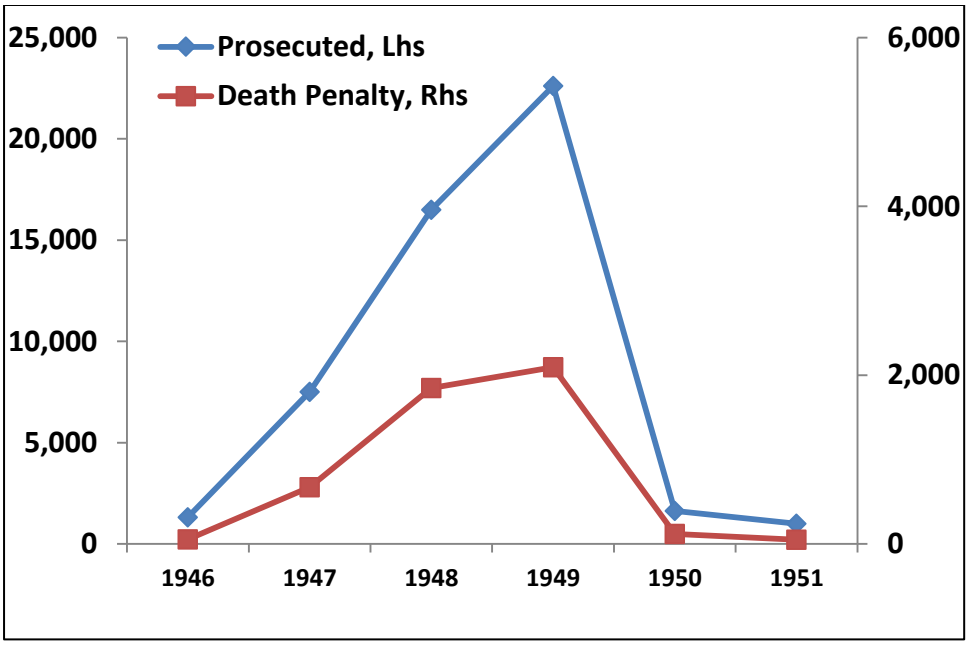

Fig. 5. Total prosecutions and death penalties in the emergency martial courts. *Source:* Michiotis 2007, Tables 1 and 2, pp 235-236.

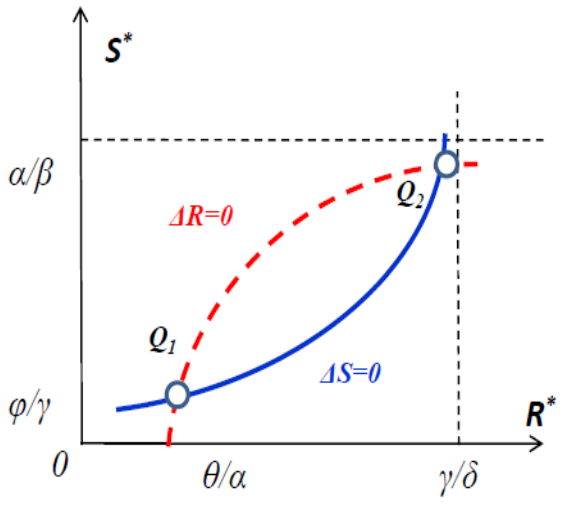

Fig. 6a. Positive conflict equilibria.

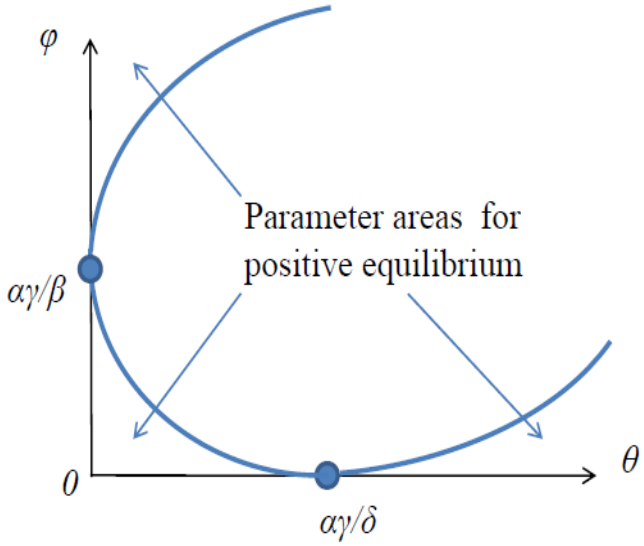

Fig. 6b. Values in the pointed areas give rise to positive conflict equilibria.

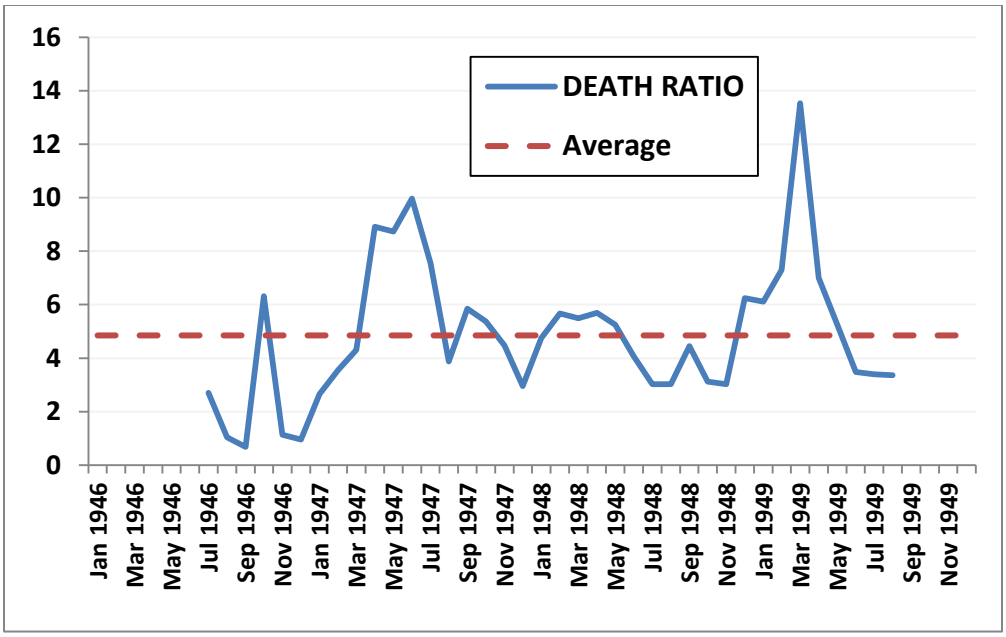

Fig. 7. Ratio of DAG to GNA battle-deaths, monthly data.
Source: Data defined in Appendix A and Table A1.

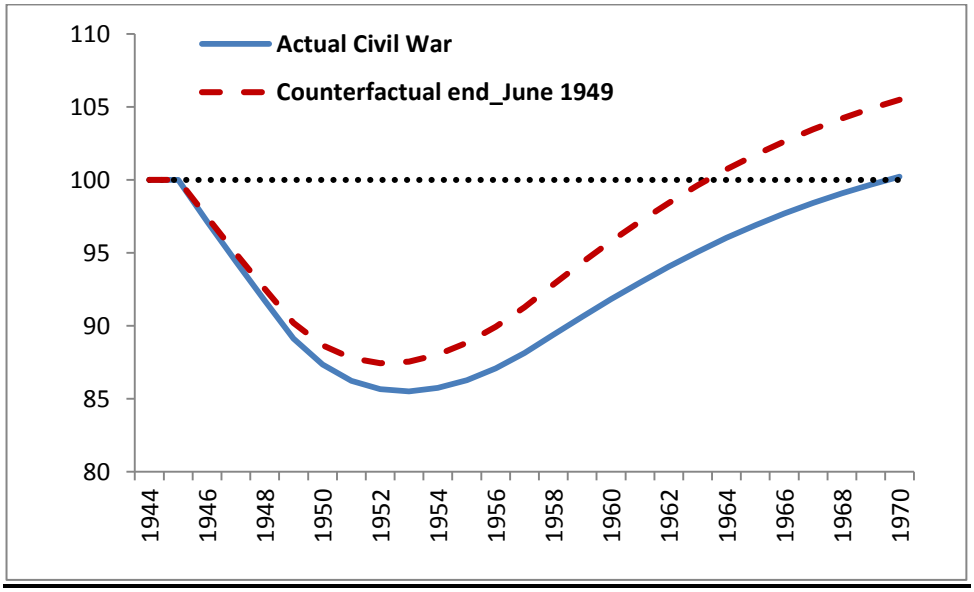

Fig. 8. A schematic representation of GDP recovery
(a) With Civil War casualties and persecutions as actually happened.
(b) Counterfactual termination of hostilities in June 1949.

Appendix A: Data and sources

Nomenclature

Nomenclature of the Greek Civil War was never agreeable and each side was offensively labeling its opponents. For the Government, the army was the Greek National Army (GNA) while its rivals were 'bandits', 'robber-bandits' or even 'Slav-gangs'. The communists had proclaimed the Democratic Army of Greece (DAG) and brandished the Government as 'imperialist lackeys' and its forces as 'monarchist-fascist troops', as well as 'robber-bandits' by reciprocation. The conflict itself was accordingly called 'contra-bandit struggle' or 'liberation struggle' by the Government and the communists respectively. It was mutually described as a 'civil war' only in the 1980s. The present paper adopts a terminology as close as possible to each side's preferences for its own troops. Thus GNA stands for Government troops, army soldiers and state forces, while guerrillas, fighters and rebel forces ('*andartes*') are interchanged in describing DAG.

Data sources

ESYE, 1939, *Annuaire Statistique de la Grèce 1939*. Athens.

ESYE, 1946, *Population de la Grèce 1940*. Athens.

ESYE, 1955, *Population de la Grèce 1951*. Athens.

ESYE, 1958, *Results of Agricultural Census of Year 1950*. Athens.

GES, 1970, *The Greek Army in the Anti-guerrilla Struggle 1946-49: The cleansing of Roumeli and the first battle of Grammos*. Athens, (in Greek).

GES, 1971, *The Greek Army in the Anti-guerrilla Struggle 1946-49: The first year of the anti-guerrilla struggle 1946*. Athens, (in Greek).

GES, 1976, *The Greek Army in the Anti-guerrilla Struggle 1946-49: Operations of the Third Army Corps 1947-1949*. Athens, (in Greek).

GES, 1980, *The Greek Army in the Anti-guerrilla Struggle 1946-49: The second year of the anti-guerrilla struggle 1947*. Athens, (in Greek).

JUSMAPG, *History, 1948-1950*, National Archives, US.

Michiotis N., 2007, *In the name of the King: Emergency martial courts in Greece 1946-1960*. Athens: Synchroni Epochi editions (in Greek).

Grammenos, B. and P. Rodakis, (1987) That's how Civil War started. Reproduction of *"The 1947 DAG Report to the UN"*. Athens: Glaros editions.

Battle data

State army (GNA) figures include the Army, Gendarmerie and armed nationalist groups. Guerrilla figures (DAG) include the fighters and civilians involved in skirmishes. Figures for 1946 are from GES (1971) as follows:

January-June 1946, monthly aggregates of all battles and skirmishes, classified by the author.

Figures for the period July-December 1946 are from Tables pp 54, 87, 93, 99, 110, 158 and 165. Data from GES (1980) are per military operation with the following adjustments: aggregate data for January and February 1947 are split equally per month; for Operation Korax (pp 173, 179) figures split into May and June; for Operation Lelaps (p 257) into August and September.

Figures for surrendered guerrillas in 1946 are from GES (1971, Table VII, p 235). For 1947, data are from GES (1980) for the areas under the A and B Army Corps, and GES (1976) for the areas under the C Army Corps. For 1947, data are from GES (1980), Diagrams 4 & 5, pp 386-387.

Data for the period 1948-1949 are from US military archives: JUSMAPG History, 1948, 1949.

Variables

Note: If not stated otherwise, sources are as described in the previous subsections.

DAG : Number of guerrilla fighters with the Democratic Army of Greece, monthly.

DHQ_area: Number of DAG fighters grouped per headquarter and mountain formation. *Source:* Data for January 1948, January to July 1949, September and December 1949 are from JUSMAPG, History, 1948-1949, maps.

DISPL : Total number of evacuees from villages in Northern Greece. *Source:* Laiou (1987, Table II, 2. Displaced persons in Northern Greece, per prefecture).

DISTNB: Distance of DAG HQs from northern borders in km; calculated by the author.

GNA: Number of personnel in the Greek National Army, monthly figures.

MOUNT: Altitude of mountains, compiled by the author. Source: http://en.wikipedia.org/wiki/List_of_mountains_in_Greece

PROSEC: Number of leftwing citizens prosecuted in the emergency martial courts during 1946-51. Initially martial courts were established in eleven cities, but as civil war was intensifying they were extended to thirty areas. Allocation is similar to that used for persecutions in 1945-46. *Source:* Michiotis (2007, Tables 1 & 2, pp 235-236).

PURGE: Number of persons persecuted and victimized during 1945-46 as described in DAG (1947). Data cover seven areas close to guerrilla HQs in Central and Northern Greece as explained in Grammenos and Rodakis (1987, pp 383-390). To correspond the data to more disaggregated guerrilla formations the seven regions are artificially split as shown in Table 5. *Source*: Rizospastis (2011, pp 138-140).

RCAP: Guerrillas captured, monthly.

RKLD: Battle deaths of DAG, monthly.

RSUR: Guerrillas surrendered to GNA, monthly.

RWND: Wounded guerrillas, monthly.

SKLD: Battle deaths of GNA, monthly.

SMIA: GNA soldiers missing in action, monthly.

SWND: Wounded of GNA, monthly.

TABLE A1. Conflict data 1946-1949, in persons

	GNA	SKLD	SWND	SMIA	DAG	RKLD	RWND	RCAP	RSUR	ABDUCT	DISPL
Jan 1946		5	4	0		3	4	36			
Feb 1946		0	0	0		0	0	0			
Mar 1946		11	5	0		0	0	1			
Apr 1946		4	8	0		4	12	15			
May 1946		8	16	0		1	0	0			
Jun 1946		22	12	17		10	5	62	6		
Jul 1946		24	35	40		65	32	146			
Aug 1946		50	58	52		52	0	45	31		
Sep 1946		126	81	82		85	43	36	134		
Oct 1946		22	42	34		139	70	61	43		
Nov 1946		108	83	70		123	62	26	27		
Dec 1946		120	81	141		115	57	52	118		
Jan 1947	92,000	49	58	101	10850	130	86	21	19	812	
Feb 1947		36	49	109	14850	128	84	37	15	1508	
Mar 1947		65	74	72	16250	280	143	31	7	794	28,651
Apr 1947		94	171	26	17050	838	185	756	246	1062	
May 1947		92	127	115	16450	804	381	477	249	852	
Jun 1947		61	170	21	16900	608	271	517	362	1403	140,880
Jul 1947		151	324	110	16900	1139	726	306	217	2085	
Aug 1947		92	206	155	16700	357	167	63	28	1933	159,191
Sep 1947		46	85	22	17400	269	76	72	30	2213	
Oct 1947		93	304	39	18600	499	131	484	327	3047	
Nov 1947		121	434	44	18600	541	320	210	115	2851	
Dec 1947		167	460	146	20350	494	203	88	143	1491	
Jan 1948	120,098	176	383	264	22250	835	2505	609	446	3650	270,727
Feb 1948	132,000	129	337	135	24140	731	2193	553	486	1500	287,239
Mar 1948		266	685	230	25700	1459	4377	968	999	2000	
Apr 1948		241	799	316	23900	1371	4113	1059	599	1600	
May 1948		248	609	162	25610	1301	3903	1527	931	810	
Jun 1948		321	983	345	23300	1304	3912	579	579	1062	348,772
Jul 1948		601	2433	172	22090	1817	5451	690	839	1404	346,831
Aug 1948		626	3258	158	21100	1896	5688	634	701	3010	
Sep 1948		412	1854	207	23720	1831	5493	635	833	2473	
Oct 1948		324	1241	167	25480	1012	3036	332	619	3600	320,168
Nov 1948		294	875	455	25450	891	2673	588	554	1924	
Dec 1948		205	618	192	24000	1279	3837	741	670	1848	294,906
Jan 1949		225	681	271	24090	1375	4125	657	931	1500	
Feb 1949		253	1222	792	21810	1846	5538	1264	791	1730	
Mar 1949		140	426	37	19450	1894	5682	2219	1263	319	
Apr 1949		275	1074	336	20200	1924	5772	1034	1020	415	
May 1949		221	817	146	18320	1161	3483	1133	1049	720	
Jun 1949		266	662	246	17365	927	2781	1199	781	100	
Jul 1949		192	599	42	17400	653	1959	696	573	143	
Aug 1949		771	3712	73	3580	2588	7764	1543	566	32	
Sep 1949					2410	551	1653	442	362	20	
Oct 1949					1910	173	519	450	464	11	
Nov 1949					1275	100	300	194	283	16	
Dec 1949	128,701				96	96	288	126	150	0	

Notes: For definitions of variables and data sources see Appendix A.

Table A2: DAG regional formations and allocation of persecutions

	Formation	Nearby mountain formations	Allocation of purges 1945-1946	Allocation of prosecutions 1946-1949	Purges 1945-1946	Prosecutions 1946-1948
1	Evia		23% of FFE	Thiva	644	671
2	Parnassos	Vardousia Panetolikon	50% of FFE	Athens, Lamia/2, Mesologi/2	1399	1671
3	Othrys	Magnesia	27% of FFE	Lamia/2, Volos	755	1137
4	Agrafa	Tzoumerka, Xinias,Souli	Arta,Trikala, Karditsa	Trikala	1109	1136
5	Pindos	Smolikas, Orliakas Zagoria, Mourgana	Ioannina/2	Ioannina/2	4065	587
6	Hasia	Antihasia, Koziakas, Kamvounia	50% Pieria & Larissa	Larissa/2	2000	1410
7	Olympos	Pieria, Ossa	50% Pieria & Larissa	Larissa/2	2000	1410
8	Vermion	Siniatsiko,Vourinos	50% of KGIP	Kozani/2	1417	1077
9	Grammos		Ioannina/2 Kastoria/2	Ioannina/2 Kastoria/2	5223	1636
10	Vitsi		Kastoria/2, Florina	Kastoria/2 Florina	3860	2625
11	Kaimktsalan	Paikon	50% of KGIP	Kozani/2, Veria	1416	1077
12	Belles	Korona, Krousia		Kilkis		405
13	Halkidiki	Kerdylia, Pangaion		Thessaloniki/2		1651
14	Serres	Orvilos		Serres, Thessaloniki/2		1651
15	Haidu	Boz-Dag		Drama		1704
16	Thrace	Vyrsini, Sapka		Xanthi, Alexandroupoli		1744
17	Lesvos			Mytilene/2		94
18	Samos	Icaria		Mytilene/2		94
19	Hania	Lefka Ori		Hania		448
20	Cephalonia	Enos		Mesologi/2		0
21	Peloponnese			Patras, Tripoli, Corinth,Calamata		3083
	TOTAL				**23,888**	**25,308**

Notes: FFE denotes the areas of Fthiotis, Fokis and Evia combined. Shares in local purges are set equal to the regional population shares in total population of Sterea (excluding Attica), according to the 1951 Census. KGIP denotes the areas defined by Kozani, Grevena, Imathia and Pella combined.

Table A3: DAG regional formations and morphology

	HQ	Mount. height average	Border distance	Guerrilla forces (in persons)							
		(m)	(km)	Jan48	Mar49	Apr49	May49	Jun49	July49	Sep49	Dec49
1	Evia	1,743	350	120	160	150	150	150	150	130	24
2	Parnas	2,292	300	1,600	210	650	720	280	100	50	42
3	Othris	1,726	250	400	110	200	50	250	110	40	64
4	Agrafa	2,069	200	1,600	2,750	1,460	1,100	400	260	200	0
5	Pindos	1,994	50	1,500	250	400	650	430	330	390	34
6	Hasia	1,626	150	550	800	1,030	550	70	40	120	20
7	Olympos	2,084	150	700	1,140	550	1,300	360	500	270	92
8	Vermion	2,014	100	550	300	350	350	500	340	230	55
9	Grammos	2,520	1	5,500	1,450	4,000	4,300	4,800	4,850	0	0
10	Vitsi	2,128	30	2,500	7,500	6,000	5,600	7,100	7,400	0	0
11	Kaimktsalan	2,087	50	1,500	860	830	900	780	350	80	20
12	Belles	1,445	1	600	750	730	1,530	1,430	1,430	0	80
13	Halkidiki	1,404	100	630	340	160	150	160	160	260	100
14	Serres	2,212	1	600	1,000	1,500	30	30	0	0	0
15	Haidu	1,823	1	600	390	270	70	460	450	50	80
16	Thrace	1,435	50	2,600	950	1,200	600	190	150	180	100
17	Lesvos	967	300		20	20	20	20	20	11	7
18	Samos	1,434	500		170	170	150	145	140	74	48
19	Hania	2,452	800		40	40	40	40	20	11	7
20	Cefalonia	1,628	400		20	20	20	20	20	10	7
21	Peloponnese	1,981	400	800	250	60	40	90	80	50	31
	TOTAL			**21,550**	**19,210**	**19,730**	**18,280**	**17,615**	**16,820**	**2,106**	**780**

Note: For definitions of variables and data sources see Appendix A.

Appendix B: On the dynamics of conflict models

Proof of Propositions 1, 2, 3

Combining (3a, 3b), the steady-state *R** is obtained as the positive root of the second-order equation:

$$\alpha\delta x^2 - (\alpha\gamma - \theta\delta - \varphi\beta)x + \theta\gamma = 0 \tag{14a}$$

Let *(D)* denote the discriminant:

$$D = (\alpha\gamma + \theta\delta - \varphi\beta)^2 - 4\alpha\gamma\delta\theta \tag{14b}$$

Two, one or none positive solutions exist depending on whether *D>0, D=0* or *D<0* respectively. The discriminant is expanded as:

$$D = (\alpha\gamma)^2 - 2(\alpha\gamma)(\varphi\beta + \theta\delta) + (\varphi\beta - \theta\delta)^2 \tag{14c}$$

This expression looks like a second-order function of *(αγ)* with roots (ρ_1, ρ_2) given by the expressions:

$$\rho_1 = \left[\sqrt{\varphi\beta} - \sqrt{\theta\delta}\,\right]^2 \tag{15a}$$

$$\rho_2 = \left[\sqrt{\varphi\beta} + \sqrt{\theta\delta}\,\right]^2 \tag{15b}$$

Discriminant *(D)* is positive if $\alpha\gamma < \rho_1$ or $\alpha\gamma > \rho_2$, negative if $\rho_1 < \alpha\gamma < \rho_2$, and zero if $\alpha\gamma = \rho_1$ or ρ_2. Substituting (ρ_1, ρ_2) from (15a, 15b), the three Propositions in Section 4 are readily obtained.

Autonomous models of conflict

An autonomous system with lagged interaction between the adversaries is written as:

$$\Delta R_t = R_{t-1} \cdot [-\alpha + \beta S_{t-1}] \tag{16a}$$

$$\Delta S_t = S_{t-1} \cdot [-\gamma + \delta R_{t-1}] \tag{16b}$$

Four steady-states (*R*, S*)* are obtained at *(0,0), (0,α/β), (γ/δ,0), (γ/δ, α/β)* and the following Jacobian matrices are formed respectively:

$$J_1 = \begin{bmatrix} 1-\alpha & 0 \\ 0 & 1-\gamma \end{bmatrix},\ J_2 = \begin{bmatrix} 1 & 0 \\ \frac{\alpha\delta}{\beta} & 1-\gamma \end{bmatrix},\ J_3 = \begin{bmatrix} 1-\alpha & \frac{\beta\gamma}{\delta} \\ 0 & 1 \end{bmatrix},\ J_4 = \begin{bmatrix} 1 & \frac{\beta\gamma}{\delta} \\ \frac{\alpha\delta}{\beta} & 1 \end{bmatrix} \quad (17)$$

The characteristic roots are respectively obtained as the following pairs $(1-\alpha, 1-\gamma), (1, 1-\gamma), (1-\alpha, 1)$ and $(1 \pm \sqrt{\alpha\gamma})$. In the first case of trivial equilibrium stability holds only if $\alpha>0$ and $\gamma>0$. The second and third cases are indeterminate, while the fourth case with possible non-trivial equilibria is *always* unstable. A non-trivial unstable limit cycle occurs only if $\alpha\gamma<0$, i.e. when one of the survival parameters turns negative. However, this implies that one of the armies becomes self-destructive and is ruled out.[27]

Similar problems arise in autonomous systems of continuous-time interaction. Omitting subscripts for simplicity, the model takes the form:

$$\dot{R} = R \cdot [-\alpha + \beta S] \quad (18a)$$

$$\dot{S} = S \cdot [-\gamma + \delta R] \quad (18b)$$

The non-zero equilibrium is the same as in (16a, 16b) and it is easy to check that the corresponding Jacobian has eigenvalues equal to $\pm\sqrt{\alpha\gamma}$. Thus if $\alpha\gamma>0$ the system is unstable, while for $\alpha\gamma<0$ it becomes indeterminate with a limit cycle. For the non-zero steady-state $(R^*=\gamma/\delta,\ S^*=\alpha/\beta)$ to be meaningful, the condition $\alpha\gamma<0$ requires that $\beta\delta<0$, again implying improbable opposite behaviors for the two fighting sides.

[27] Past casualties lead to more losses in the future if the army is either constantly depleted from critical support units or is panic stricken after a major defeat. However, none of them is compatible with a prolonged conflict. Losses can also be self-multiplied in suicidal insurgencies where a new wave of martyrs follows those previously perished but, again, this cannot last for very long.