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Articles

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Aims and scope

This journal raises and debates all issues related to the political economy of personal, communal, national, international, and global conflict, peace and security. The scope includes implications and ramifications of conventional and nonconventional conflict for all human and nonhuman life and for our common habitat. Special attention is paid to constructive proposals for conflict resolution and peacemaking. While open to noneconomic approaches, most contributions emphasize economic analysis of causes, consequences, and possible solutions to mitigate conflict.

The journal is aimed at specialist and nonspecialist readers, including policy analysts, policy and decisionmakers, national and international civil servants, members of the armed forces and of peacekeeping services, the business community, members of nongovernmental organizations and religious institutions, and others. Contributions are scholarly or practitioner-based, but written in a general-interest style.

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Abstracts

Ron Smith and **Ali Tasiran**. "The onset of peace." Using the Uppsala Conflict Data Program's Conflict Termination Dataset, 1946-2007, we investigate determinants of war duration—how long war lasts before the onset of peace. We provide an exposition of the nature of the data and of the transformations statistical issues involved in quantifying the dynamics of conflict, in particular the onset of peace. Various duration models are used to analyze the length of wars that ended with victory and peace or cease fires or show low activity. Multispell Cox proportional hazards models and single-spell log-logistic hazard models suggest that major wars are of shorter duration than minor wars, internal wars last longer than wars between states, and peace comes quicker in Europe than in other regions. We find only small differences in the determinants of terminated wars and wars with low activities or no activities. [Keywords: Peace; war; duration models; hazard models] [JEL codes: D74, H56]

Sam Perlo-Freeman and **Jennifer Brauner**. "Natural resources and military expenditure: The case of Algeria." With world military expenditure rising rapidly since 2000, one of the possible drivers that has drawn less attention has been the role of natural resource revenues, especially oil. Countries as diverse as Angola, Azerbaijan, Chad, Iraq, Kazakhstan, Nigeria, and Timor-Leste have seen huge rises in military expenditure on the back of rapidly increasing oil revenues. Natural resource extraction can generate conflict and create an imperative to protect resource infrastructure from internal or external threats. At the same time it provides a ready source of government revenue, and in particular foreign currency. The lack of transparency often associated with such revenues may facilitate off-budget spending or large, and possibly corrupt, arms purchases. Up to now, most econometric research has not considered the role of resource revenues as a determinant of military expenditure. We provide a preliminary analysis for the case of Algeria, estimating military expenditure as a function of oil revenues and other economic and security factors from 1975 to 2008. We find some evidence that oil revenues have had a statistically significant positive effect on Algerian military expenditure. [Keywords: Algeria; natural resources; oil; gas; military expenditure] [JEL codes: H56, O55, Q34]

Jurgen Brauer and **J. Paul Dunne**. "Terrorism, war, and global air traffic." It is thought that one of the affected industries of the 9/11 terror event was the global airline industry through the attack's effects on global air traffic demand for international, scheduled flights. Using data from the International Civil Aviation Organization, this article considers whether this was indeed the case. The study applies panel data analysis, focusing on the 20 largest airline companies. We find that when one takes account of potential confounding factors such as the general state of the economy, global air traffic was not greatly affected by the general level of terrorist attacks worldwide, and that it takes a truly exceptional event such as 9/11 to find a measurable impact on air traffic demand. Even then, the measured effect for the industry as a whole is small in magnitude. The reason for this finding appears to be that the demand for international scheduled air flights is rather heterogeneous across airlines. Aggregating across the whole of the global industry is not in all instances warranted. [Keywords: terror; war; air traffic] [JEL codes: D74, H56, L93]

William L. Anderson, **Scott A. Kjar**, and **James D. Yohe**. "War and the Austrian School: Modern Austrian economists take on aggressive wars." The Austrian school of economics increasingly has become identified with antiwar groups. This is not due to religious or political views. Rather, the antiwar viewpoints of the Austrians come from the fundamental tenets of economics as expressed by the school's founders and refined for 140 years. This article applies post-WWII Austrian thought to the subject of war. [Keywords: Austrian school; war] [JEL codes: B13, B31, D83, D90]

The onset of peace

Ron Smith and *Ali Tasiran*

During the twentieth century, following the work of the Quaker mathematical scientist Lewis F. Richardson, there developed a minor industry devoted to counting wars with the aim to identify statistical patterns in war data. Today's databases, such as the Correlates of War (COW) and the Uppsala Conflict Data Program (UCDP), have grown in detail and coverage and are widely analyzed. The statistical use of these large and complex datasets involves a variety of assumptions, not always appreciated by those unfamiliar with the techniques used. In this article, we examine the UCDP dataset on the duration of war and provide an exposition of the nature of the data, the transformations involved, and the statistical techniques used to quantify the dynamics of war. In particular, we are interested in determinants that may herald the onset of peace.

A recent review of 30 datasets on conflict shows significant differences between the two main sources, UCDP and COW, in the list of interstate wars, presumably the least difficult type of war to code.[1] Thus, the statistical focus on war and peace has not been uncontroversial and many have questioned whether it is possible to quantify such complex social phenomena. They argue that the coding rules used to turn inherently qualitative phenomena into quantitative measures will inevitably be arbitrary and that this makes them unsuitable for quantitative modeling. Others have argued that only the most sophisticated quantitative techniques will distinguish the signal from the noise in such data.[2]

A recent critique of quantitative studies identifies a variety of problems.[3] Indeed, it can be difficult to distinguish war from other types of violent conflict. One famous scholar, namely Lewis F. Richardson himself, avoided the distinction altogether and instead examined at what he called the Statistics of Deadly Quarrels, whether they might be counted as wars or not.[4] With one prominent recent exception, his lead has not generally been followed, and rules have been developed to distinguish war from other types of violence, for instance criminal violence. Whether this distinction is appropriate is a matter of judgment as violent death rates can be much higher in countries at peace, particularly in Latin America, than in countries at war.[5] One definitional characteristic used to distinguish war from other deadly quarrels is that a government must be directly involved in a conflict about a political or territorial issue. This still leaves difficulties such as distinguishing whether or not the conflict is between government and an organized criminal group or a politically motivated group, how to treat conflicts that take place in territories without a government, such as Somalia as from the 1990s, and how to treat multiple simultaneous conflicts: For example, should the various conflicts during World War II, or more recently in Sudan, be regarded as different conflicts or as part of the same conflict? Even when agreeing on war, coders may not agree on when it started and why, when it ended, how many died, and whether people died in battle or not. Disagreement along these and other dimensions results in differences across datasets.

Examining the Uppsala Conflict Data Program's dataset on the duration of war, we provide an exposition of the nature of the data, the data transformations involved, and the statistical techniques used to quantity the dynamics of war. We are interested in determinants that may herald the onset of peace.

Despite coding differences that may amount to measurement errors, quantitative data can capture important features of a complex qualitative social reality. It is useful to examine whether or not systematic patterns in the quantitative data on war may be found. Indeed, the large number of conflicts themselves may make it easier to identify systematic patterns, if any, because there is a probability (although no certainty) that measurement errors and conflict specific factors may cancel out. If this is the case, then so-called large-*n* analysis may allow one to identify *common* patterns—those underlying all wars—that may not be obvious when one conducts case studies of individual conflicts, as these are swamped by the effects of *specific* factors.

The UCDP dataset that we use records, since the end of World War II, a total of 235 armed conflicts, involving 123 countries in 149 locations. Many countries had multiple spells of conflict of varying durations. In 2007, our last data year, there were 35 ongoing armed conflicts in 22 locations. Historically speaking, this is a relatively low number but the continuous decline seen since the early 1990s now seems to have ceased.[6] Despite (or because of) the arrest in the decline of war, scholars continue to study the potential determinants of violent conflict, focusing for instance on the interdependence and duration of militarized conflict, the transnational dimensions of civil war, and the role of enduring internal rivalries in civil wars.[7]

Our aim is to examine the methods used to analyze war dynamics, variables such as the number of spells of war, their duration, and how they end, for example by victory or by cease-fire, and to learn whether they are influenced by the nature and/or source of the conflict (nature: e.g., an international dimension; source: e.g., an incompatibility over territory or government). Data on each of these variables are available in the UCDP dataset. The techniques we use are multispell transitions with a semiparametric Cox-type proportional hazard duration model and a fully parametric log-logistic duration model.

The next section characterizes Richardson's ideas, followed by a discussion of methodological issues. Then follow a presentation of the data, a discussion of the estimation strategy, and the reporting of the results of our semiparametric, Cox-type proportional hazard estimates and of the parametric log-logistic estimates which treat war spells according to spell order and outcomes. The final section concludes the article, followed by endnotes, references, and a technical appendix.

Richardson's ideas

Richardson is one of two persons usually cited as founders of the systematic study of the causes of war. (Quincy Wright is the other.) He favored quantitative study: "There are many anti-war societies, but they are concerned with propaganda, not research. There is a wide public interest in the subject provided it is expressed in bold rhetoric, but not if it is quantitative scientific study involving statistics and mathematics." A student of the great statistician Karl Pearson, Richardson accepted Pearson's contention that "popular beliefs ought to be tested by statistics." His quest led him to search for data on "deadly quarrels [in] the whole world since the beginning of A.D. 1820" about "belligerents."[8]

Richardson treated war as a species of "deadly quarrels." By this he meant any quarrel which caused death to humans. The term thus includes murder, banditry, mutiny, insurrection, and war small and large but excludes accidents and calamities such as earthquakes and tornadoes. Deaths by famine and disease are included if they were the immediate result of a quarrel, but not otherwise. In puzzling cases, the legal criterion of "malice aforethought" was taken as a guide.

Richardson defines "the magnitude of a quarrel [as] the logarithm to the base ten of the number of people who died because of that quarrel." He finds that the onset of the number of wars per year followed a Poisson distribution, as did the onset of peace. Stars in space, raisins in a cake, wrong-number calls per day received per telephone, deaths per cavalry regiment per year from horse kicks—all of these show empirical distributions that closely fit the theoretical Poisson distribution of rare events. The Poisson patterns found by Richardson are confirmed by Wilkinson (1980).

Richardson noted that a "the larger, the fewer" maxim describes his fatal quarrels data. Fitting several log-log linear functions of varying generality, complexity, and utility, he found that in all of them the number of quarrels of a given magnitude diminished as their magnitude rose. This approximate power law distribution between frequency and size of conflict, with size measured in number of deaths or casualties, has been replicated for many subsequent conflicts. One study, published in 2009, presents data for nine recent insurgencies where the relationship between event size, as measured by casualties, and event frequency follows power laws. Insurgencies have exponents close to 2.5, whereas for conventional wars the exponent is rather lower, at around 1.7. The Poisson distribution for war onset, the power law relationship between size and frequency, and the democratic peace hypothesis (that democracies tend not to fight each other) are examples of statistical regularities, or commonalities, that the analysis of large datasets can reveal.[9]

Survey of statistical issues in quantitative modeling

A large literature exists on measuring the duration of war, often written as d_{ij}, the length of war i in country j.[10] Without attributing particular methods or approaches to particular authors, our discussion here surveys the modeling issues.

War onset—the number of wars starting at any one point in time—is roughly constant at one to two percent of all countries in the international system per year. The number of wars in progress in any year is largely a function of their duration.

Unlike war termination, war onset is roughly constant at one to two percent of all countries in the international system per year. It follows that the number of wars in progress at any one point in time then largely reflects their duration. As war onset is difficult to predict, reducing the number of wars may be done more effectively by actions that speed the onset of peace. Believed to be caused by different things, it is common practice to separate the questions of what causes wars to start and of what causes them to continue once they have started. But one pair of authors note that this is a testable assumption, and they estimate a model that suggests that both onset and continuation reflect similar factors.[11] The dependent variable in their analysis is simply whether there was a war in a particular year (a binary "yes" or "no" variable). In contrast, we look at duration, measured in days, which is a continuous variable.

As mentioned, measuring wars is difficult enough, depending on conventions for coding them; measuring their duration is more difficult since there is often doubt about exactly when wars begin and end. In particular, many countries suffer multiple spells of war. There may be a period of intense conflict, a period of low activity, and then renewed, intense conflict. Whether this is coded as two short wars or one long war has a major impact on estimation. Coding war onset itself also matters, because wars before the start date of the data cannot be used to explain subsequent wars. Further, peace can come in various ways, from plain victory by one side, or from a formal peace agreement, which we abbreviate as "peace", or by cease-fire, or because the fighting just subsides.

The most common form of duration model are hazard models, the "hazard" being the rate of peace breaking out at a particular time, d, given that war continued up to then. (Technical details of such models are presented in Appendix A.) There is a baseline hazard, which shows how the rate (or "risk") of achieving peace moves over time. This risk is shifted by covariates such as external interventions and heterogeneity among the cases in the dataset. (This heterogeneity is usually unmeasured, or "unobserved" in statistical language, meaning that it is not explicitly coded in the dataset and results in being tucked away in the statistical model's degree of error.) The baseline hazard may be parametric—following a particular specified shape—or nonparametric, completely free to move over time.

There is an issue as to whether there should be a common model for all wars or separate models for different types of war: small wars versus large wars, or interstate wars versus intrastate wars. If one pools the data, one treats wars as homogeneous, except to the extent that the covariates include indicators for different types of war.

But if one partitions the data into wars of different types, one allows for heterogeneity in the form of the baseline hazard and the effect of the covariates, which may be plausible. For example, external intervention may have different effects on internal wars than on interstate wars. However, wars are comparatively rare events, so as one partitions the data, smaller samples result, making statistical estimation more difficult.

Various procedures are used to estimate the baseline hazard. Nonparametric procedures, which do not allow for covariates, involve graphing the empirical survival or hazard function, perhaps separately for different types of war. Semiparametric procedures, most commonly the Cox-type proportional hazards regression, allow for a completely flexible baseline hazard and measure the effect of the covariates. Again, one can allow the hazard function to differ for different types of wars. Parametric models specify a particular mathematical representation (functional form) for the baseline hazard, the simplest being the exponential function which depends on only one parameter—the exponent of the function—and has a constant probability or "hazard". Distributions with two parameters include the Weibull, log-normal, and log-logistic functions. The shape of the baseline hazard may be captured by binary variables, assuming a constant hazard over particular time intervals, or may be interacted with a parametric form, such as piecewise exponential. It is known that if the functional form accurately describes the duration dependence, parametric forms are more efficient: They use the available data more effectively.

The duration of war seems to depend of the way war ended: by victory, cease-fire, peace, or exhaustion. There is a circularity or information issue here—while war is in progress one does not know how it will end, and how it will end may depend on duration—so that disaggregating wars by how they ended raises statistical difficulties. Procedures to handle ending include competing-risks frameworks or modeling the type of termination directly with a multinomial choice model. The competing risks framework treats wars that do not end during the sample period as being censored.

Many countries have had multiple spells of war and characteristics of a prior-period war may influence the duration of a current-period war. This so-called state dependence arising from multiple wars is handled in various ways. A simple method is to include years of peace and number of prior wars as covariates, but one may also want to include other characteristics of prior wars, such as how they ended.

The covariates—the relevant variables that change the chance of war ending—are usually chosen on the basis of some theory of war. There are many theories of war emphasizing motives such as greed or grievance, the feasibility of conflict, or the credibility of commitments to conflict alternative. Thus, a large number of possible covariates have been used in the literature. One must also choose the functional form for the covariates. These choices include whether to use the change, level, or cumulative sum of the variable, using logarithms or other data transformations, or using flexible functional forms like splines. For interstate wars, one must choose how to model the way the covariates of the multiple countries involved interact, although it is common to use dyad data and simply consider pairs of countries. One must also consider endogeneity issues, since some of the covariates may be influenced by the duration of the conflict. This is sometimes dealt with by using covariates taken from before a conflict began, but in countries with multiple conflicts there is likely to be correlation with earlier conflicts.

Typically the covariates fall into the following categories. *Economic and social characteristics* of the country include per capita income, income inequality, a measure of size such as population, trade flows, education, ethnic or religious divisions, and demographic features such as fertility, life expectancy, infant mortality, and proportions of the population in particular groups such as young men. *Geographic characteristics* of the country include location, by continent, latitude, access to the sea, number and nature of the neighbors (as war can be contagious), and forests, mountains (perhaps making insurgency easier). *Nature of the state* variables include democracy/autocracy, measures of state capacity such as tax revenues, bureaucratic quality, corruption, the size and effectiveness of the military, the state's integration into the international system through membership in international organizations. *Source of conflict* is often coded over government or territory. *Economic or military intervention* by third parties is coded in various ways. The *intensity of war* is measured in deaths per year and by characteristics of prior wars. *Conflict financing* includes state dependence on natural resource earnings, lootable resources available, commodity price shocks, illegal drug production, and diaspora support. *Time* itself may matter, as there seems to be a trend for wars to become shorter, although this may reflect changes in other covariates. To allow for this, one can introduce binary variables to stand for decades in the covariates. For interstate wars one would need to include the covariates for all the parties.

That there exist such a large number of possible covariates and that many of these are correlated with each other makes determining the causes of war and its duration and termination difficult. To illustrate the statistical procedures, we use a fairly short list of covariates.

Data and estimation strategy

Our focus is on duration of war before the onset of peace. In this section we describe the data, the transformations involved, and the specific statistical techniques used to quantify conflict dynamics. We have information on the following characteristics:

- The date a conflict started and ended and thus its duration, measured in days.
- The number of conflict spells and their order from first to last.
- The cause of conflict (territory or government).
- The nature of conflict (extrasystemic, interstate, internal, or internationalized internal).
- The region of conflict (Europe, Middle East, Asia, Africa, or the Americas).
- The intensity of conflict, measured as battle-related deaths between 25 and 999

per year (minor) or 1,000 or more (major).

- The outcome of conflict (victory, peace agreement, cease-fire, no or low activity, or other).

There will be unobserved heterogeneity, that is, unmeasured factors which shorten or lengthen the duration of conflict.

Armed conflict is defined by UCDP as a contested incompatibility that concerns government or territory or both, where the use of arms forces between two parties results in at least 25 battle-related deaths in a year. Of the two parties, at least one has to be the government of a state. Conflicts are also classified by type as extrasystemic (an anticolonial or anti-imperialist war between one entity that is a member of an established set of states and one that is not), interstate (between two or more states), internal (between the government of a state and internal opposition), and internationalized internal (between the government of a state and one or more internal opposition groups, but with intervention from other states in the form of troops).

The dataset contains 123 countries over a 62-year period, 1946-2007, with a total of 235 armed conflicts recorded in 149 locations. This gives a total of 431 conflict spells (of which 35 were continuing at the end of 2007). Of these, 344 were minor wars and 87 were major wars. A conflict can change the level of severity from one year to the next. Table 1 presents data on the number of wars (major or minor) and the average length of war. Minor wars occur in almost twice as many locations and almost four time more frequently than do major wars, although the latter tend to be of shorter duration. The longest minor war was 48 years; the longest major war was 43 years. In Table 2, conflicts are ordered by the number of spells (repeat instances of the "same" war). The table also gives the mean spell duration (in days). Altogether, there are seven repeated conflict spells for a total of 431 spells. The first four spells are of approximately 4 years' length each, the fifth and sixth last about 2.5 years, and the seven-spell war—between India and Pakistan—adds up to almost 8 years of time. Table 3 gives the joint distribution of war size and source of conflict. The majority of the wars between 1946 and 2007 are internal, minor wars (260 of 431 wars). Purely internal plus internationalized internal wars are 346 in number. This is followed by interstate (63) and extra-systemic (22) wars. Extra-systemic wars are now far less common than used to be the case.

War termination is classified as (1) victory, (2) peace, (3) cease-fire, (4) no or low activity, and (5) other outcomes. Victory occurs when one side is either defeated or eliminated, or otherwise capitulates, surrenders, or makes a public announcement to that effect. Peace is an agreement—or the first in a series of agreements—concerned with the resolution of the incompatibility and signed, and/or publicly accepted, by all of the main actors in a conflict. Cease-fire is an agreement between all of the main actors in a conflict that terminates military operations. No or low activity conflicts are wars that idle or show very low activity. Other outcomes include cases where the conflict ceases without an observable victory or any type of agreement signed. Fighting may in fact continue but at a level lower than needed to be included by UCDP as an active armed conflict. Alternatively, a party may withdraw from war for tactical reasons or due to leadership changes, or it may have decided on a nonviolent strategy or may have lost support from an ally. Table 4 provides data on the joint distribution of war size and type of termination.

Table 5 provides descriptive statistics, in two groups, for all 1,912 terminated spell years. The first group of variables is related to conflict length such as mean duration, spell number, censoring information, and lags of prior conflict duration. The second pertains to conflict outcomes, incompatibility reasons, conflict regions, conflict intensities, and types of conflicts. The distribution of durations is highly skewed by a few long conflicts. The median length is 457 days (about a year and a quarter); the mean length is 1,415 days (almost 4 years). There are up to seven conflicts in a country, and the average number of conflicts is 1.85, although some countries have no conflicts. Nineteen percent of conflicts are censored, meaning that the conflict was still ongoing at the end of the data period in 2007. Twenty-seven percent of all

Table 1: Wars by size, location, spells, and average duration in days

Conflicts	*Locations*	*Spells*	*Average days*
Minor	97	344	1,347
Major	52	87	1,686
Total	149	431	

Table 2: Ordered spells, numbers of spells, and lengths of terminated wars

Ordered spells	*Number of spells*	*Mean duration (in days)*
1	235	1,434
2	99	1,480
3	54	1,326
4	21	1,559
5	15	937
6	6	863
7	1	2,887
Total	431	

Table 3. Distribution of wars by size and source of conflict

War type	*Minor*	*Major*	*Total*
Extrasystemic	18	4	22
Interstate	40	23	63
Internal	260	49	309
Internationalized internal	26	11	37
Total	344	87	431

Table 4: Distribution of wars by types of termination and size

	Minor	*Major*	*Total*
Continuing	30	5	35
Peace	41	15	56
Cease-fire	22	12	34
Victory	91	31	120
No war or low activity	129	15	144
Other	17	6	23
Total	344	87	431

Table 5: Descriptive statistics of variables

Variables	*Mean*	*Standard deviation*	*Median*
Spell duration	1,415	2,468	457
Spell numbers	1.85	1.20	1.00
Censored (proportion)	0.19	0.29	
Lag of first duration	530	1,653	
Lag of second duration	499	1,334	
Outcome (base)	0.34	0.47	
Outcome (peace)	0.20	0.40	
Outcome (victory)	0.27	0.44	
Incompatibility (territory)	0.01	0.10	
Incompatibility (government)	0.99	0.10	
Region (Europe)	0.09	0.29	
Region (Middle East)	0.14	0.35	
Region (Asia)	0.33	0.47	
Region (Africa)	0.33	0.47	
Region (Americas)	0.10	0.31	
Intensity (minor)	0.67	0.47	
Intensity (major)	0.33	0.47	
Type (extrasystemic)	0.05	0.22	
Type (interstate)	0.15	0.35	
Type (internal)	0.71	0.45	
Type (internationalized internal)	0.09	0.29	

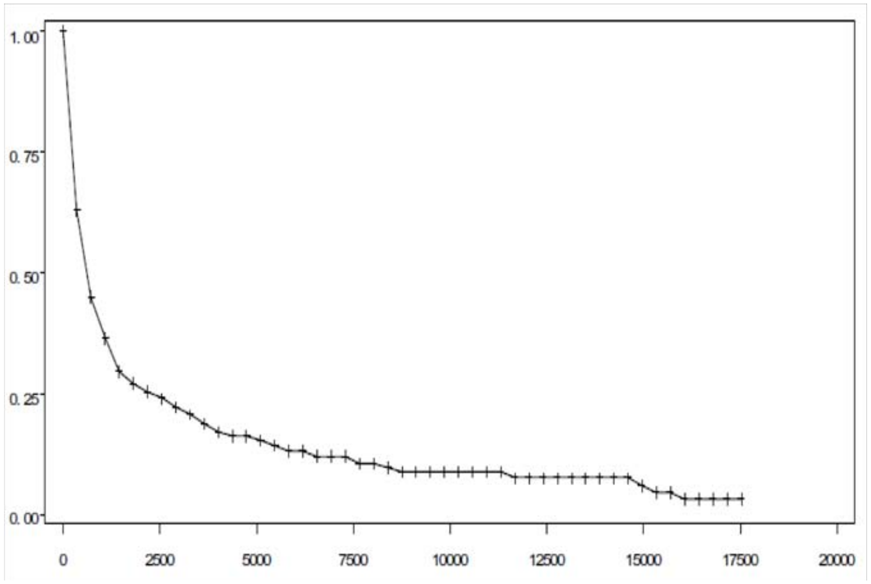

Figure 1: Survival function: Probability of conflict continuing, as a function of conflict duration (in days).

conflicts end with victory and twenty percent of conflicts end with a peace agreement. The proportion of territorial incompatibility is only 1 percent; the other 99 percent is for government incompatibility. The majority of spell years take place in Asia and Africa (33 percent each). The share of conflicts in the Middle East is 14 percent and is about 10 percent for the Americas and 9 percent for Europe. Minor wars have a larger share than major wars, 67 percent, and 80 percent of wars are internal: 71 percent purely internal and 9 percent internationalized internal.

Nonparametric estimation of survival and hazard functions

Conditional on a war having started in country *i* in year *t*, we examine its duration, d_{it}, measured in days. Figure 1 gives the survival function for terminated war spells. The graph shows the proportion of wars that are still continuing as a function of the duration, in days, of the conflict. Almost 40 percent of all wars terminate within one year and almost 60 percent terminate within two years.[12]

Figure 2 shows the hazard rate (the "hazard" of peace) for all war terminations as a function of war duration, measured in days. This measures the "risk" of peace breaking out on a specific day, given that war continued until the prior day. During the first years of conflict, the rates are fairly high but they decline quickly. The sharp movements of the curve at the end of the war termination period are observed because

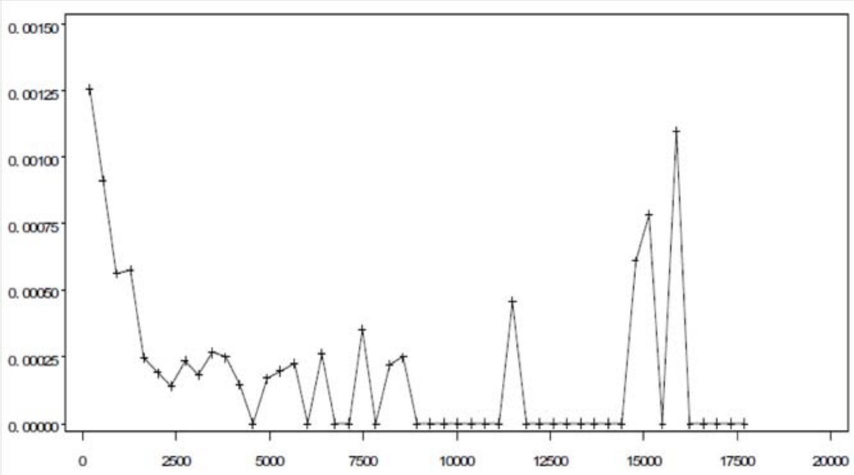

Figure 2: Hazard rates of peace as a function of war duration (in days).

few countries with continuing wars are left in the dataset and thus the "hazard" of peace in nonwar years must be zero.

Figure 3 shows the survival function for wars ending in a peace agreement, given the number of days the respective wars has been going on. The chances of a conflict ending with a peace agreement are above 75 percent during the first ten years or so, but then decline. Figure 4 gives the survival function for war spells ended by a cease-fire agreement. When directly comparing Figures 3 and 4 for any given day, say day 7,500, the chances of conflict ending by cease-fire are generally higher than conflict ending by peace agreement.

Estimates of semiparametric and parametric duration models

The survival and hazard functions discussed thus far are unconditional—they do not allow for specific conflict characteristics—and nonparametric. In this section, we report estimates of a semiparametric Cox-type model where the baseline hazard is unrestricted and of parametric duration models where the baseline hazard is assumed to be a particular function of time, such as exponential, Weibull, Gompertz, log-normal, or log-logistic. We prefer log-logistic because this permits nonmonotonic hazard rates and both positive and negative time dependency. Unobserved heterogeneity causes a negative time dependency if it is not taken into account in the estimation (even as in our specific models this coefficient happened to be statistically insignificant in all cases).

We estimated a Cox-type proportional hazard model for different spells, having

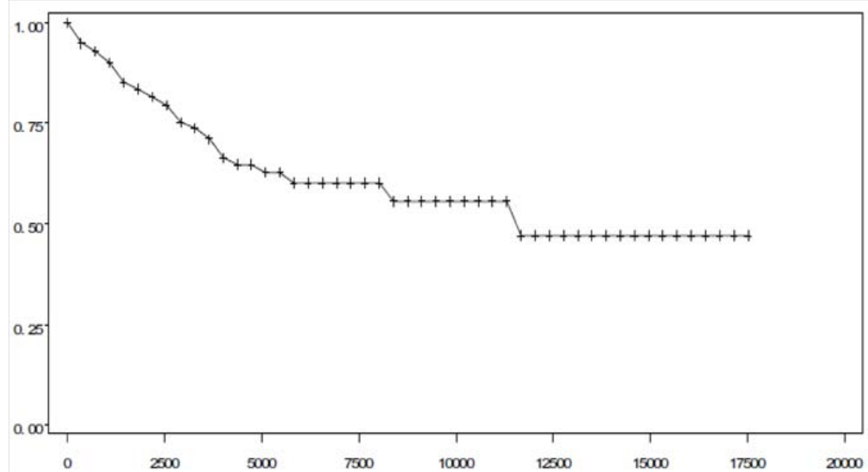

Figure 3: Survival function of conflicts ending with peace agreement.

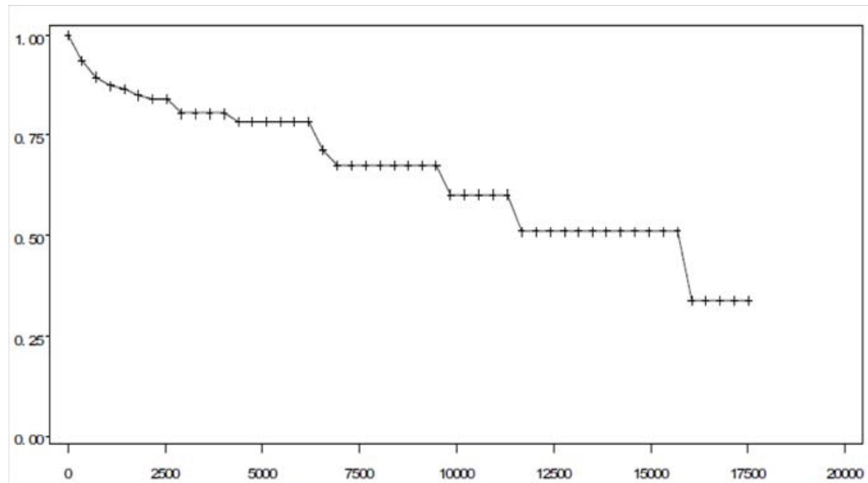

Figure 4: Survival function of conflicts ending with cease-fire.

different parameters for the first, second, and third or more spells and separate log-logistic models for different endings (peace, cease-fire, peace and cease-fire, victory for side A, victory for side B, no or low activity, and other), for cause of conflict (territory or government), for wars in the five regions, for minor and major wars, and for short and long wars (less/more than 1 year). We are interested in the outbreak of peace. The basic observation is a conflict year.

Because of its size, Table A1 is placed in Appendix B. It reports the parameter estimates for the semiparametric Cox-type proportional hazard model and for the parametric log-logistic model of conflict termination. Unobserved heterogeneity, or frailty, is not statistically significant. Therefore, the models which are reported in Table A1 are without unobserved heterogeneity parameter estimates.

The parameter of having an incompatibility because of governmental issues is only significantly estimated in the Cox-type proportional hazard model. The termination risk of conflict increases when it includes a governmental issue during the first spell but decreases during the second and third or more spells. The chances of conflict termination are higher during the first conflict spell when third parties are involved. If war has not ended during the first spell then the termination chances are becoming lower for repeated conflict spells.

Regardless of the conflict outcome, conflicts have longer spells in regions other than Europe. From shortest to the longest, conflict spells are distributed among the regions as follows: Europe, Africa, the Americas, the Middle East, and Asia.

The intensity of war is important: Major wars are more likely to end with peace or cease-fire agreements than do minor wars, and termination chances are higher for long wars. But interstate conflict lowers termination chances for low-activity wars or if these wars are in Africa or they are of a governmental incompatibility character. This means that major wars, for any reason, end faster than minor ones. This also means that we observe shorter spells if war costs more lives. Put differently, termination risks are lowered if conflicts are showing low or no activity. Conflicts between states terminate more quickly than internal wars.

Conclusions

Based on UCDP data for 1946 to 2007, we find that conflicts are shorter in Europe, followed in increasing length by Africa, the Americas, the Middle East, and Asia. Major conflicts terminate more quickly than do minor ones, except where they terminate because of low activity (which is to be expected). Conflicts between states terminate more quickly than internal wars. Holding conflict size constant, civil wars have longer spells than wars between states. The unobserved heterogeneity parameter is not statistically significant. The models estimated with the Cox-type proportional hazard model or the log-logistic model assumptions without controlling for unobserved heterogeneity fit the UCDP dataset well.

Notes

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1. Anderton and Carter (2011).

2. Many: See, e.g., Barrringer (1972), Hough (1964), Pruitt and Synder (1969), and Sambanis (2004). Others: See, e.g., Collier (1999), Richardson (1960), Russe (1972), Seaty (1968), Small and Singer (1982), and Wright (1942; 1965).

3. Cramer (2006).

4. Richardson (1948; 1960).

5. Exception: See GBAV (2008; 2011). Also see Brauer and Dunne (2011).

6. Harbom and Wallensteen (2007); also see the *Human Security Report 2009/10* <http://www.hsrgroup.org/> [accessed 25 October 2011].

7. Interdependence and duration: e.g., Krustev (2006); transnational dimensions: e.g., Gleditsch (2007); enduring internal rivalries: e.g., DeRouen and Bercovitch (2008).

8. The quotes come from Richardson (1960).

9. Recent study: Bohorquez, *et al*. (2009).

10. Large literature: See, e.g., Hegre (2004), which is an introduction to a special issue of the *Journal of Peace Research* on the duration and termination of war.

11. Bleaney and Dimico (2011).

12. The number of 17,500 days (almost 50 years) on the horizontal axis of Figure 2 is the total length of the longest first spell between Israel and Palestine. It is one of the 235 spells observed as first conflicts in Table 2.

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Appendix A: A duration model

A common model for duration specifies a hazard function of the form

(1) $h(d|x,v) = h_0(d)exp(\beta' x)v$,

where the hazard is the risk of peace occurring at time *d*, given that war had continued to time *d*. This is defined as

(2) $h(d) = f(d) / S(d)$,

where $f(d)$ is the probability density function, and

(3) $S(d) = 1 - F(d) = 1 - P(D < d)$

is the survival function, that is, one minus the cumulative distribution function. The integrated hazard function $\Lambda(d) = - \log S(d)$ is also useful. The baseline hazard is $h_0(d)$. This shows how the hazard behaves over time, such as how it increases or decreases. The baseline hazard is shifted by x, a vector of covariates, such as external intervention, and v, unobserved heterogeneity. We can then examine things like the expected time before the onset of peace $E(d_{it}|x_{i,t-1}*)$ where $x_{i,t-1}*$ contains the information in x_{it-1} plus the source of the current conflict $x_{i,t}$. Some wars, which have survived *d* periods, may not have ended during the data period and these are described as censored observations. We know that a war lasted at least *d* periods, but not when it ended.

Parametric versions of the model can be written as

(4) $h(d|x,v,\theta) = h_0(d,\alpha)exp(\beta' x)v(\gamma)$,

where $\theta = (\alpha, \beta, \gamma)$ is the full set of parameters, from baseline hazard, covariates, and unobserved heterogeneity. Parametric models are usually estimated by maximum likelihood, where the log likelihood takes the form of

(5) $\log L(\theta) = \Sigma_U \log f(d,\theta) + \Sigma_C \log S(d,\theta) = \Sigma_U \log h(d,\theta) + \Sigma_A \log S(d,\theta)$.

The sums are taken over uncensored observations (U), censored observations (C), and all observations (A). The censored observations thus only appear in the survival function.

An alternative was proposed by Cox (1972) and subsequently discussed by many other authors. For the single transition case, and based on a continuous time variable, *t*, the model, generally called a Cox-type proportional hazard model is

(6) $h(d|X,v) = h_0(d)\exp(\beta' X(t))v(\gamma)$.

The transition rate, $h(d|X,v)$, depends on an unspecified baseline rate, $h_0(d)$, and on a vector of covariates, $X(t)$, with coefficients β'. The covariates may vary over time, t.

As an example of a parametric model, the log-logistic model assumes that the baseline hazard follows a log-logistic distribution. The density, survivor, and rate functions for this distribution are:

(7) $f(t) = [b\, a^b\, t^{b-1}] / [1 + (at)^b]^2$, with a, b > 0

(8) $S(t) = 1 / [1 + (at)^b]$

(9) $h(t) = [b\, a^b\, t^{b-1}] / [1 + (at)^b]$.

The rate reaches its maximum h_{max}, given by $h_{max} = a(b-1)^{1-1/b}$, time t_{max}, given by $t_{max} = (1/a)\, (b-1)^{1/b}$. Starting values for estimating the standard log-logistic model are not critical, and in most situations it is sufficient to set the shape parameter $b=1$ and to use for the parameter a the constant rate of an accordingly defined exponential null model.

Appendix B

Table A1: Estimated parameters in Cox-type proportional hazard and log-logistic models of conflict termination

Variables	*Cox-type proportional hazard model*			*Log-logistic models*								
	Spell 1	*Spell 2*	*Spell 3 or more*	*All spells*	*Peace or cease-fire*	*Victory*	*No or low activity*	*Govern-ment*	*Long*	*Major*	*Internal*	
Constant A	0	0	0	-8.50 [0]	-9.55 [0]	-17.73 [0]	-12.67 [0]	-3.36	-7.39 [0]	-8.140 [0]	-8.579 [0]	**(See Table note)**
				(1.69)	(1.92)	(2.55)	(1.23)	(3.67)	(1.00)	(0.61)	(2.96)	
In_Government	8.14	-0.42	-0.47	-0.50	-1.28	0	0	0	-1.41	0	-0.52	
	(47.87)	(0.75)	(0.74)	(1.51)	(1.63)				(0.88)		(2.89)	
R_Middle East	-0.55	-1.60 [0]	-0.62 [9]	-2.71 [0]	-3.150 [0]	-3.13 [7]	-1.37 [5]	-3.07 [3]	-1.60 [0]	-0.37	-3.31 [0]	
	(0.38)	(0.39)	(0.37)	(0.59)	(0.82)	(1.72)	(0.69)	(1.41)	(0.42)	(0.76)	(0.70)	
R_Asia	-1.70 [0]	-2.38 [0]	-0.90 [1]	-4.34 [0]	-4.91 [0]	-7.69 [0]	-2.08 [0]	-6.83 [0]	-2.20 [0]	-3.09 [0]	-4.53 [0]	
	(0.37)	(0.34)	(0.33)	(0.54)	(0.74)	(1.71)	(0.63)	(1.36)	(0.37)	(0.67)	(0.62)	
R_Africa	-0.49	-1.18 [0]	-0.41	-2.12 [0]	-2.68 [0]	-2.15	-0.98	-9.46 [0]	-1.45 [0]	-3.11 [0]	-2.29 [0]	
	(0.34)	(0.31)	(0.34)	(0.53)	(0.67)	(1.53)	(0.64)	(0.51)	(0.37)	(0.69)	(0.61)	
R_Americas	0.38	-1.52 [0]	-1.99 [0]	-2.21 [0]	-3.22 [0]	1.11	-4.03 [0]	-5.42 [0]	-2.92 [0]	-2.27 [1]	-2.78 [0]	
	(0.36)	(0.43)	(0.59)	(0.63)	(0.88)	(1.63)	(1.07)	(1.36)	(0.55)	(0.88)	(0.73)	
Int_Major	0.31	0.11	-1.22 [0]	-0.03	1.15 [0]	0.09	-1.01 [1]	-1.12 [3]	0.65 [1]	0	-0.25	
	(0.22)	(0.23)	(0.28)	(0.30)	(0.42)	(0.88)	(0.37)	(0.52)	(0.20)		(0.36)	
T_Interstate	1.79 [0]	2.79 [0]	3.10 [0]	5.39 [0]	5.56 [0]	8.65 [0]	5.55 [0]	6.85 [9]	1.75 [0]	0	0	
	(0.53)	(0.49)	(0.64)	(0.72)	(1.02)	(2.40)	(1.16)	(3.99)	(0.50)			
T_Internal	0.25	-0.17	1.18 [5]	-0.09	-0.53	1.14	1.72	-3.16	-0.83 [2]	0	0	
	(0.047)	(0.44)	(0.59)	(0.59)	(0.86)	(2.03)	(1.05)	(3.46)	(0.35)			
Constant B (shape parameter)	0	0	0	-0.86 [0]	-0.65 [0]	-1.44 [0]	-0.55 [0]	-1.03 [0]	-0.21 [0]	-0.56 [0]	-0.95 [0]	
				(0.05)	(0.09)	(0.09)	(0.07)	(0.07)	(0.06)	(0.08)	(0.05)	
Neg Log-Lik (without variables)		2726		4362	1326	1494	1470	1915	2426	1411	3511	
Neg Log-Lik (with variable)		2584		3897	1186	1164	1643	1656	2357	1346	3187	
Spells												
0 to 0		1539		1516	1805	1790	1768	637	1502	428	1372	
0 to 1	122	107	79	396	107	122	144	175	207	129	313	
Sum		1912		1912	1912	1912	1912	812	1709	557	1685	

Note: The bracketed expressions show p-values of 0.1 or less of the estimated parameters. Instead of reporting the conventional significance levels at 5, 2.5, 1-percent levels, we prefer to report the calculated significance values of the estimated coefficients as p-values. Thus, for example, [5] means a p-value of 0.05. Coefficients without bracketed expressions have p-values greater than 0.1.

Natural resources and military expenditure: The case of Algeria

Sam Perlo-Freeman and *Jennifer Brauner*

Global military expenditure has risen rapidly over the decade of the 2000s, reaching USD1,631 billion in 2010, an increase of 53 percent in real terms compared to 2000.[1] Led by the United States, and followed by most countries and regions worldwide, one of the factors driving this trend lies in the ongoing efforts of the major global and regional powers to further develop their military power and influence. But another driver may lie in the large number of economically developing states whose natural resource revenue—derived from fossil fuel sales in particular—may provide the necessary income to help finance increases in military expenditure.

In one region, the Middle East, the link between oil and military expenditure has for a long time appeared so obvious as to be unremarkable. The region has by far the highest average ratio of military expenditure to gross domestic product. This is partly due to the high level of regional tension (in turn, partly due to conflict over fossil fuel resources), but also due to the sheer size of the oil and gas revenue that permits deals such as the Al-Yamamah series of arms contracts between the United Kingdom and Saudi Arabia.[2]

During the 2000s, a combination of high oil prices and new oil exploitation has generated high levels of revenue for many states of the developing world. In many cases, this has led to commensurate but extraordinarily high increases in military expenditure as well (see Table 1 for some examples). Other countries, such as Brazil, have seen less marked but still significant increases in military expenditure, but the link with oil is still apparent. Indeed, in Brazil's case, one justification that has been advanced for its purchase of submarines from France has been the need to protect newly-discovered offshore oil fields.[3] Also in South America, Chile's relatively high level of military expenditure has been supported by the guaranteed 10 percent share of copper export revenue that constitutionally goes toward arms purchases, a revenue stream that has increased sharply in recent years with the increase in copper prices.

The next section discusses some of these trends and looks at the reasons why natural resource revenue might have an effect on military expenditure over and above the general level of a country's economic resources as measured by GDP, the economic variable most often used in analyzing the determinants of military expenditure. Then follows a case study of Algeria, a country that has seen considerable variation both in military expenditure as well as in oil revenue. This is done in two sections, the first of which presents background information on Algeria's military, political, and economic development; and the second presents preliminary econometric results. The final section summarizes and concludes.

Global military expenditure has risen rapidly over the decade of the 2000s, reaching USD1.6 trillion in 2010, an increase of 53 percent in inflation-adjusted terms as compared to the year 2000. One driver of this increase may lie in the large number of developing countries whose natural resource export earnings may have provided the income to finance military expenditure. This article explores this possible link with a case study of Algeria.

Natural resources, conflict, governance, and military expenditure[4]

In recent years, the actual and potential role of natural resources in conflict and development has been extensively analyzed from the perspective of the so-called resource curse—the cycle of bad governance, political grievance, and armed conflict that can occur in states highly dependent on natural resource revenue.[5] Natural resources can fuel conflict through numerous channels. Importantly, they can act as a ready source of *actual* funds for rebel movements. Even the *potential* for resource looting can motivate rebellion in the first place.[6] Rather than seeking peace, profits to be made from resource exploitation can prolong conflict and can change what may have begun as a genuine national or social movement ("grievance" based) into a quasi-criminal organization whose primary objective is profit ("greed" based). Governments, too, can come to see maintaining their hold on resource exploitation as their primary raison d'être and use resource-based revenue to fund ongoing war. The military itself may become involved in mineral exploitation, as in the DR Congo, and generate a pattern of associated human rights abuses that stimulate and exacerbate

Table 1: Oil- and gas-producing states with large military expenditure increases

Country	*Mil. exp. increase, 2000-2009*
Algeria	105%
Azerbaijan	471%
Chad	663%
Ecuador	241%
Kazakhstan	360%
Nigeria	101%
Timor-Leste [a]	255%
Viet Nam [b]	55%

Source: SIPRI military expenditure database.

Note: All increases are in real terms.
[a] Increase 2003-2009
[b] Increase 2005-2009

violent conflict. Oil exploitation can cause adverse environmental effects, generating grievances as in the Niger Delta, where the failure of oil wealth to generate local economic benefits added another motive for rebellion.[7]

Natural resources can also carry negative consequences for governance. When handled in an opaque manner, bypassing normal budgetary procedures, people assigned to process natural resource revenue are susceptible to corruption. For example, bribes may be paid in return for exploitation concessions, a potential source of enormous personal enrichment for decisionmakers. Such concerns lie behind the Extractive Industries Transparency Initiative, which seeks to encourage companies to disclose what they pay to governments for resource concessions and for governments to openly account for resource revenue received. The voluntary nature of this initiative, however, perhaps limits its impact.

The potential implications of these and other issues for military expenditure are not hard to see but have rarely been the subject of detailed analysis.[8] First, and quite aside from the governance and conflict issues, natural resources provide a direct source of revenue that does not require taxing of the general population. For developing countries especially, most of whom may have limited tax bases and tax collection abilities, such revenue plays a disproportionately large role in overall government revenue. This may affect public spending in general, and in particular may make it easier for governments to engage in what might otherwise be unpopular major arms purchases—were they to be funded through taxation.

Second, the potential of natural resources to fuel conflict is itself likely to be a spur to military expenditure, both through the general cost of waging conflict and because resources are often a specific target of rebel groups, for example the widespread attacks on oil infrastructure in the Niger Delta that have led to major reductions in Nigeria's oil output.[9] Even where conflict does not actually occur, the desire to protect, for instance, oilfields from actual or potential internal or external threats may provide a motive for military expenditure.[10]

Third, low levels of transparency and correspondingly high levels of corruption potential may facilitate higher military expenditure, especially when such revenue can be a source of off-budget military expenditure.[11] In Chile, for instance, this goes through the copper law in a much more transparent manner than is usually the case, but still allows the military a guaranteed funding stream regardless of security needs. In particular, natural resource revenue is used to directly, and often nontransparently, fund major arms purchases. Such revenue provides a direct source of foreign currency, even as arms procurement contracts offer lucrative potential for bribes. Transparency International, a nongovernmental monitoring and advocacy group, considers the arms market to be one of the most corrupt legal industries in the world.[12] While off-budget purchases may not always find their way into published military expenditure figures, the acquired weapons will generate additional operations and maintenance costs.

A more subtle effect of resource revenue on military expenditure may be through its impact on the nature of the state. A state that is highly dependent on resource revenue may lead to a regime whose hold on power, and thus on the flow of resource revenue, depends more on keeping control of the revenue-generating infrastructure than on promoting the general economic development of the populace.[13] Thus, the military may acquire greater significance as the guarantor of regime survival. In contrast, governments dependent on general taxation have more need to maintain the consent of the governed.

These multiple potential channels of influence result in a strong a priori case for the proposition that natural resource revenue, and in particular high dependence on such revenue, may promote higher military expenditure. The examples of the Middle East and of the states presented in Table 1—of rapid military expenditure growth in recent years in certain oil-producing countries—provide at least anecdotal support for this hypothesis. But as yet, there has been little by way of systematic empirical testing. Most studies of the determinants of military expenditure limit themselves to GDP as a measure of resource availability. In this article, we begin to rectify this shortcoming in the literature.

Algeria: Background

At current prices, Algeria is thought to sport Africa's highest military expenditure, USD5.2 billion in 2008, as compared to USD3.5 billion for second-placed South Africa. This increased dramatically from 1992 onward, reflecting the outbreak of Algeria's civil war, but then continued to rise even after the war waned in 2000 (see Figure 1). In fact, Algeria recently launched major efforts to modernize its military, entering into a USD7.5 billion arms deal with Russia in 2006, as well as smaller deals with China, the United States, and various European suppliers.[14] These efforts may be motivated by at least three factors. First, albeit diminished since the 1990s, Algeria is responding to the continued threat posed by Islamic insurgents. But the types of equipment procured are not best-suited for counterinsurgency operations.[15] Second, Algeria seeks to boost its international influence and regional leadership ahead of its neighbors, Morocco in particular. Third, Algeria's efforts may be interpreted as a government attempt to appease the military. Even as the country takes cautious steps toward democracy, engages in modest economic privatization, and sees a diminishing role of the armed forces, the military remains a significant player behind the scenes.[16]

Described as "the real power in Algeria," the military descended directly from the revolutionary army. Deriving its legitimacy from the central role it played in liberating the country from France in an ugly, decade-long struggle, it perceives itself as "the true guarantor of the principles and aspirations of the Algerian revolution and statehood," with a continuing, major part to be played in politics. The military is closely linked with Algeria's ruling party, the National Liberation Front (FNL).[17] One observer explains that "the [FLN] movement was in a sense

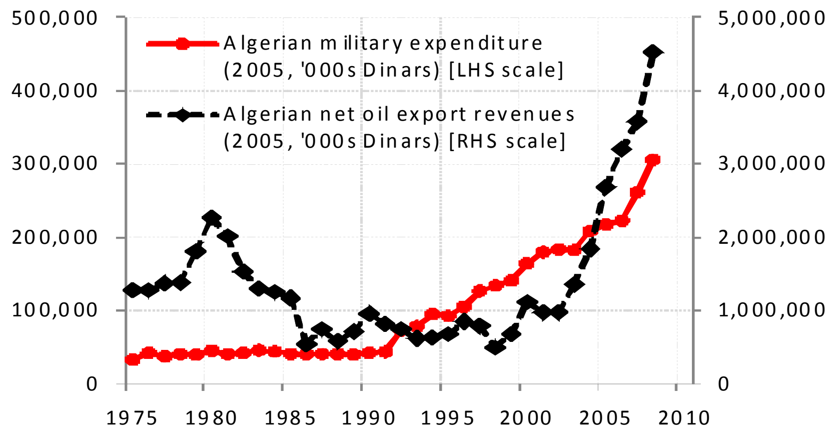

Figure 1: Algerian military expenditure and net oil export revenue, 1975-2008. *Sources*: See text.

reintegrated or absorbed into the army in the form of populist ideology ... the army thereby came to embody the historical heritage of the FLN."[18] The military holds key positions in government. In particular, it has had a disproportionately large say in determining Algeria's leadership, with several of the country's presidents drawn directly from its own ranks. In 1992, the military stepped in when the Islamic Salvation Front's success in Algeria's first multiparty national elections threatened the position of the FLN. The military pressured then-President Bendjedid into resigning, cancelled the elections, and appointed a five-member High Council of State to act as a collective presidency. Violence ensued and a state of emergency was declared under which the military was granted certain direct powers, for example, when dealing with insurgency and terrorism.[19] Since the civil war ended, the military has withdrawn from center stage, but it continues to exert its influence. For example, although Algeria's presidents are no longer recruited directly from the ranks of the military, a support base within the military High Command continues to be an informal requirement for the position. The current president, Abdelaziz Bouteflika, owes his position to the support of the military.

Algeria's military expenditure is funded in part by revenue from oil and gas exports. The country is the fourth largest crude oil producer in Africa, and the sixth largest natural gas producer in the world. Accounting for roughly 30 percent of GDP, 60 percent of budget revenue, and 95 percent of export earnings, hydrocarbon exports form the backbone of the Algerian economy and have been central to the government's strategy for the development of the country.[20] The industry was completely nationalized in 1971 and has since been organized by a state-owned company, Sonatrach, which is particularly close to government. Top positions in the company are frequently filled by former energy ministers, and vice versa, and it is noteworthy that while many sectors of the once nationalized economy are gradually being privatized, the energy sector remains under firm government control.[21] Tellingly, part of the 2006 arms deal with Russia included production-sharing agreements for Russian energy companies in Algerian oil and gas interests in return for price concessions for the arms procured.[22] Analysts reason that the government's continued control over the hydrocarbon sector is motivated by the links between oil and gas rents and the ability to fund military expenditure.

In the following section, we explore the statistical link, if any, between Algeria's natural resource revenue and military expenditure. We analyze time series of data spanning 34 years, from 1975 to 2008.

Algeria: Military expenditure and oil revenue

Method and data

We explore the relationship between Algerian military expenditure and oil export revenue (Figure 1) using a general to specific approach. We begin by estimating a general equation and then remove variables based on their joint significance and on the Akaike Information and Schwartz Bayesian criteria (AIC and SBC). Our most general equation is:

$$(\text{log\_milex})_t = ß_0 + (ß_1)(\text{log\_milex}_{t-1}) + (ß_2)(\text{log\_milex}_{t-2}) + (ß_3)(\text{log\_oil}_t) + (ß_4)(\text{log\_oil}_{t-1}) + (ß_5)(\text{log\_oil}_{t-2}) + (ß_6)(\text{log\_gdp}_t) + (ß_7)(\text{log\_gdp}_{t-1}) + (ß_8)(\text{log\_gdp}_{t-2}) + (ß_9)(\text{log\_morocco}_t) + (ß_{10})(\text{log\_morocco}_{t-1}) + (ß_{11})(\text{log\_morocco}_{t-2}) + (ß_{12})(\text{conflictdummy}) + e_t ,$$

where

- log_milex is the logarithm of Algerian military expenditure (in millions of constant [2005] dinars);
- log_oil is the logarithm of net oil export revenue (in millions of constant [2005] dinars);
- log_gdp is the logarithm of GDP (in millions of constant [2005] dinars);
- log_morocco is the logarithm of Moroccan military expenditure (in constant [2005] U.S. dollars);
- conflictdummy is a dummy variable controlling for wars and minor conflicts; and the subscripts
- t, t-1, and t-2 refer to time and time lagged by one or two years, respectively.

We include GDP as a measure of the government's capacity to fund military expenditure through general taxation and expect GDP to have a positive effect on military expenditure. A better measure to use may be total tax revenue but this is potentially endogenous as raising tax revenue may be influenced by how much the government wants to spend. We also consider Moroccan military expenditure. Considerable tension exists between the two because Algeria rejects Morocco's administration of Western Sahara and supports the Polisario Front's aspiration for independence there. Tension continue, even after a cease-fire was agreed in 1991. In turn, Morocco is wary of Algeria's dominant military capabilities, and analysts suggest that Algeria's recent arms procurement spree could intensify this rivalry.[23]

Finally, we include a dummy variable for the period during which Algeria has been in conflict, taking a value of 1 for the period from 1992 onward (since when there have been over 100 battle-related deaths each year, according to the Uppsala Conflict Database), and zero before that.[24]

Our annual data cover the period 1975 to 2008 which, while shorter than ideal, is at least clearly greater than 30 observations, often taken as a minimum requirement to carry out statistical work. Our data is compiled from various sources. With the exception of Moroccan military expenditure which is in constant (2005) U.S. dollars, all data is transformed into millions of constant (2005) dinars where relevant. Data on military expenditure both for Algeria and Morocco are taken from SIPRI's military expenditure database <www.sipri.org>. Data on Algerian net oil export revenue is provided by the United States Energy Information Administration <www.eia.doe.gov>. Regrettably, we could not find reliable data on gas export revenue. But these appear much smaller than oil revenue, so the omission is not likely to much affect our results. According to OPEC, in 2010, for example, Algeria's oil export revenue was USD53.2 billion out of a total oil and gas export revenue of USD55.7 billion, making gas less than 5 percent of the total.[25] Data on Algerian GDP is taken from the World Bank's *World Development Indicators* <www.worldbank.org>.

Estimation results

Table 2 summarizes the results for our general to specific regressions. The fourth regression (Model 4) returns the highest adjusted R-squared, measuring the closeness of the fit between estimated and actual data, adjusted for the number of variables included in the model. It also gives the best values of two other model diagnostic statistics used, the AIC and SBC. We also report the adjusted R-squared of the same models but using the first difference of log_milex as the dependent variable in the regression equation (d.log_milex in Table 2). This gives a more accurate idea of the goodness of fit of our model. According to this statistic our model is able to explain about 70 percent of the variation in the change of the logarithm in military expenditure. Statistically, the logarithm of net oil export revenue is highly significant in explaining Algerian military expenditure: A 10

Table 2: Algeria: General to specific regressions

Dependent variable: log_milex(t)

	Model 1	*Model 2*	*Model 3*	*Model 4*
log_milex(t-1)	0.298**	0.3112**	0.357***	0.3208***
	(0.1358)	(0.1242)	(0.1265)	(0.1171)
log_milex(t-2)	0.3487**	0.352***	0.3779***	0.3423***
	(0.1385)	(0.1268)	(0.1133)	(0.1203)
log_oil(t)	0.0773	0.07413	0.0887***	0.1042***
	(0.0635)	(0.0503)	(0.027)	(0.027)
log_oil(t-1)	0.0439	0.0478		
	(0.0756)	(0.0541)		
log_oil(t-2)	0.0013			
	(0.06)			
log_gdp(t)	-0.4388	-0.4433		-0.4141
	(0.7735)	(0.6725)		(0.6357)
log_gdp(t-1)	0.9166	0.668		0.6235
	(1.0562)	(0.5879)		(0.5551)
log_gdp(t-2)	-0.2158			
	(0.6548)			
log_morocco(t)	-0.0706	-0.0706		
	(0.1186)	(0.1007)		
log_morocco(t-1)	-0.0103	-0.02		
	(0.1127)	(0.0988)		
log_morocco(t-2)	-0.0371			
	(0.116)			
conflictdummy	0.4932***	0.477***	0.4536***	0.4603***
	(0.0755)	(0.0642)	(0.0627)	(0.0577)
constant	-0.9234	-0.7343	1.5907***	-0.9191
	(1.7613)	(1.5958)	(0.3959)	(1.5059)
Observations	32	32	32	32
R-squared	0.9941	0.9940	0.9918	0.9937
Adj. R-squared	0.9903	0.9915	0.9905	0.9922
Adj. R-squared with d.log_milex	0.6329	0.6788	0.6413	0.7035
AIC	-69.3	-74.8	-74.8	-79.3
SBC	-50.2	-60.2	-67.4	-69.0

***, **, * Significance at the 1%, 5%, and 10% levels, respectively.

percent increase in oil export revenue is associated with a 1.04 percent increase in military expenditure in the short-term (Model 4) and with a 2.8 percent increase in the long-term.[26]

In contrast, GDP is statistically insignificant in explaining Algerian military expenditure. This provides support for the proposition that there is something different about natural resource revenue that allows it to affect military expenditure directly. As discussed, unlike taxes levied on the population, natural resource revenue does not force the government to be accountable to its citizens. The conflict dummy results in a statistically highly significant positive coefficient on Algerian military expenditure. Based on the size of the coefficient, the armed conflict that began in 1991 is estimated to have led to a 58 percent short-term and 292 percent long-term increase in military expenditure.[27] Finally, Moroccan military expenditure is statistically insignificant in explaining Algerian military expenditure. This is perhaps unsurprising, as Algeria has a far higher level of military expenditure than does Morocco. Morocco may feel threatened by Algeria's military capabilities, but the opposite is less likely to be the case. Moreover, observers believe that the threat of a reignited conflict between Morocco and Algerian-backed Polisario forces is remote.[28]

Our results do not suffer from serial correlation or heteroskedasticity.[29] A further potential problem is endogeneity between military expenditure and GDP (that the two may influence each other, making it impossible to tell the direction of causation and distorting the results), but GDP being statistically insignificant in explaining military expenditure suggests that this is not a problem here. We noted earlier that there was a sharp upward trend in military expenditure in 1992. This reflected the outbreak of the civil war, but continued even after the war waned in early 2000. It is possible that the relation between the dependent variable and the regressors changed after 1992. We therefore tested for a structural break, that is, whether the coefficients of the independent variables changed as from 1992. This test found no evidence of a structural break.[30]

Overall, the results provide initial evidence that oil revenue has influenced Algerian military expenditure. The results should be treated tentatively, in particular as they varied somewhat according to specification. For example, the inclusion of a time-trend dummy after 1992 renders all other variables, including lagged military expenditure, apart from the conflict dummy, statistically insignificant (although this would provide more of a description of Algerian military expenditure than an explanation). Despite this caveat, the qualitative story remains quite telling: Algerian military expenditure increased rapidly as a result of the civil war; then, despite its waning, continued to rise at essentially the same rate, just at the time when oil revenue was taking off. This revenue made possible new spending to be directed, not anymore to fighting the armed conflict, but toward a major equipment modernization program that is propelling Algeria to a position of being a dominant regional power. It is hard to see how such a program would have been financed without the oil revenue.

Summary and conclusion

Military expenditure worldwide has risen dramatically over the 2000s. Some of the most dramatic rises in military expenditure in recent years have been seen in countries with high levels of natural resource revenue, boosted both by increasing prices and by new development of oil and gas production in a number of countries outside the traditional major producing region of the Middle East. There are many reasons to suppose that natural resource revenue may have a particular role in fueling military expenditure, over and above the general level of GDP. They provide a direct source of government revenue not requiring taxation, and in particular a source of foreign currency for arms purchases. They can be a factor in provoking or prolonging conflict and can also create a demand for military power to protect extraction infrastructure. They can lead to nontransparent and corrupt practices, which may favor off-budget military expenditure and large arms deals with lucrative bribe potential.

Algeria provides one case where this resource revenue–military expenditure hypothesis may be tested empirically. While the principal determinants of Algeria's military expenditure are political—the conflict with Islamist groups since 1992 (leading to very rapid military expenditure growth) and the powerful role of the military in Algerian politics—another potentially significant factor lies with the country's oil and natural gas revenue, which also has grown rapidly in recent years.

We estimated the determinants of military expenditure, using lagged military expenditure, GDP, oil revenue, Moroccan military expenditure, and a conflict dummy as independent variables. The results show that, apart from conflict, oil revenue was the only statistically significant variable, exerting a strongly positive effect on military expenditure. The fact that it was oil revenue, rather than GDP, which was significant, suggests that this direct source of government revenue provides a much easier and politically attractive means of funding the military than does general taxation. While tentative, the results provide support for the main hypothesis, which we consider to be worthy of more systematic exploration through other case studies and through panel and cross-section studies.

Notes

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1. Perlo-Freeman, *et al*. (2011).

2. See, e.g., Leigh and Evans (2007).

3. See, e.g., Perlo-Freeman, Perdomo, Sköns, and Stålenheim (2009).

4. The authors acknowledge the contribution of Prof. J. Paul Dunne in developing ideas for this section.

5. For discussion of different aspects of the issues, see, e.g., Kaldor, *et al*. (2007). Also see Bannon and Collier (2003), Collier and Hoeffler (2004), Hodler (2006), Le Billon (2005), and Ross (2001; 2004).

6. Collier and Hoeffler (2004).

7. See, e.g., Oyefus (2007) for a discussion of the role of oil in Nigerian conflicts.

8. Only occasionally is a dummy variable for oil-producing states included in regression analyses on the determinants of military expenditure. See, e.g., Deger (1986); Deger and Smith (1983).

9. See, e.g., "Attacks Cripple Shell's Niger Delta Operations." *The Wall Street Journal*. 19 July 2009.

10. For example, Brazil justified their recent purchase of submarines partly by the need to protect newly-discovered oilfields (see endnote 3.) Likewise, many of Nigeria's recent arms purchases have been related to protecting oil production in the Niger Delta from insurgents (see Perlo-Freeman, Ismail, and Solmirano, 2010).

11. See, e.g., Hendrickson and Ball (2002).

12. Courtney (2002).

13. See, e.g., Karl (1997).

14. Gelfand (2009, p. 23).

15. Gelfand (2009, p. 24).

16. Sorenson (2007, p. 105).

17. First quote: Cook (2007, p. 27). Second quote: Stone (1997, p. 129). From 1962 to 1989, Algeria was a single-party state, ruled by the FLN. Following the 1988 riots, a new constitution was adopted that allowed for the formation of other political parties. Nevertheless, the FLN has remained firmly in power, even through the "Arab spring" turmoil of 2011.

18. Addi (1998).

19. Stone (1997, p. 134).

20. Figures from Central Intelligence Agency (2010).

21. Entelis (1999, pp. 4; 11).

22. Vatanka and Weitz (2007, p. 39).

23. Vatanka and Weitz (2007, p. 39).

24. See www.pcr.uu.se/research/UCDP/index.htm. We initially used a more graduated conflict variable, but the simpler one/zero dummy proved more effective at explaining variations in Algerian military expenditure.

25. See http://www.eia.gov/cabs/OPEC_Revenues/Factsheet.html and "Algeria oil and gas revenues up 25 percent in 2010, minister," AFP. 3 Jan 2011, http://www.energy-daily.com/reports/Algeria_oil_and_gas_revenues_up_25_percent_in_2010_minister_999.html.

26. Equivalently, 0.104 and 0.28 are the short- and long-term elasticities of military expenditure (milex) with respect to oil revenue. The long-term figure is higher because of the influence of the previous two years' milex on the current year's milex. Thus, the initial increase due to oil revenue feeds through into further increases in later years. The long-term coefficient is calculated as the short-term coefficient divided by (one minus the sum of the coefficients of lagged milex), i.e., 1.04/(1-0.3028-0.3423)=0.28.

27. This is based on the conflict dummy coefficient in Table 2, and computed as exp(0.46)=1.58, or a 58 percent increase for the short-term effect. See endnote 26 for the long-term effect computation.

28. For example, Vatanka and Weitz (2007, p. 39).

29. Serial correlation: Durbin's d-statistic (7,32)=2.22; Breusch-Godfrey test: $\chi 2(1)=1.01$, $p=0.3149$. Heteroskedasticity: Breusch-Pagan test: $\chi 2(1)=0.22$, $p=0.636$.

30. The test was performed by introducing slope dummies for the relevant variable, interacting the conflict dummy (=1 from 1992 onward) with the other variables in Model 4. This is equivalent to the standard Chow test, which could not be used directly as the conflict variable is already an intercept dummy. The result was $F(5,20)=1.37$, $p=0.2783$.

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Terrorism, war, and global air traffic

Jurgen Brauer and *J. Paul Dunne*

On its website, the International Air Transport Association (IATA), a business group, publishes summary data on airline traffic and other variables. Figure 1 is taken from IATA. The bold line reflects seasonally adjusted data for international scheduled passenger traffic and shows sharp declines in revenue-passenger kilometers flown (RPK) in the second half of 2001 as well as in the first half of 2003. At first sight, this could reflect, respectively, the 11 September 2001 ("9/11") terror event and the combat phase of the Iraq war (20 March to 1 May 2003). But the latter event was completely overlaid by a pandemic threat caused by the appearance in Asia and consequent rapid global spread of Severe Acute Respiratory Syndrome (SARS), lasting from November 2002 through July 2003. Consequently, the apparent drop in RPKs flown might be due to either, or both, events. Freight traffic also appears to have been affected, although not in the same degree. In both cases, it is possible that the apparent effects on the airline industry do not stem so much from violence (terror and war) as from third factors such as pandemics, natural catastrophes, or financial crises. The possible effects of the world financial crisis of 2008/9, for example, would seem clearly visible in Figure 1.

Nonetheless, in the months after 9/11, the global airline industry lamented the billions of dollars of losses on account of the event. Air traffic appeared to have dropped sharply, beyond what might be explained by seasonality alone. While airline companies were struggling financially before the attack, it seems that their prospects worsened significantly following it, and some major airlines declared bankruptcy, e.g., Sabena in 2001 and Air Canada in 2003.

The purpose of this article is to revisit the effects, if any, of large-scale violent events, such as terror and war, on global air traffic for the top-20 airlines in the world (by 2007 revenue), while accounting for potential confounding factors.[1]

Brief review of extant literature

Within the academic literature, Ito and Lee (2005a; 2005b) measure the effect of the impact of 9/11 on domestic U.S. and international airline traffic, respectively. In both cases, they use aggregate data obtained from the U.S. Air Transport Association, the Association of European Airlines, and government organizations such as those in Canada and Australia. Using revenue-passenger kilometers (RPKs)—except for Australia, where the authors use the number of passengers flown—they find a statistically significant adverse impact of 9/11 on air traffic but argue that this effect was quite subtle and complex. For example, travelers' responses depended on risk perceptions, and these varied across countries. Marked changes were already taking

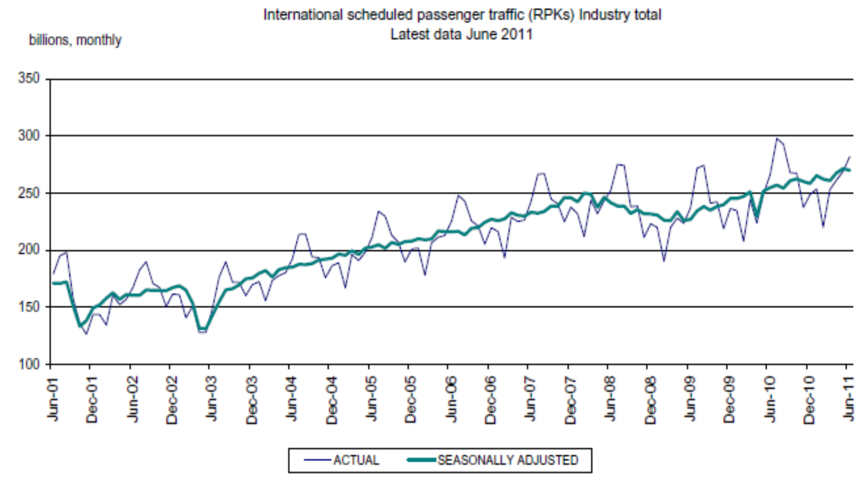

Figure 1: Revenue passenger kilometers (RPK) for international scheduled passenger traffic, June 2001 to June 2011, industry total.
Source: IATA (2011). See http://www.iata.org/whatwedo/economics/Pages/traffic_analysis.aspx [accessed 10 September 2011].

place in the industry, for instance, industry-wide restructuring and a number of high profile bankruptcies, so that it proved difficult statistically to distinguish the 9/11-effect from these other developments. Liu and Zeng (2007) used annual aggregate industry data obtained from the Air Transport Association of America and Airsafe.com to estimate traffic models for U.S. airlines. The use of annual data does rather limit their model's ability of picking up shock effects. The authors find that increases in fatality rates do tend to reduce the demand for air travel but that the 9/11-related increase in fatalities does *not* explain all of the subsequently observed fall in air traffic. Rupp, *et al*. (2005) examine airline schedule recoveries after U.S. airport closures and find the resulting flight outcomes difficult to explain.[2]

Overall, the impact of 9/11 on the industry does appear unprecedented, but there is in fact no clarity over how it has affected airline traffic. The event created some fear of flying, to be sure, but also led to the introduction of more rigorous security measures at airports, which by themselves may have reduced traffic. Passengers could have moved to "safer" airlines, so that non-U.S. international air traffic may have benefitted. Because of such potentially offsetting responses to 9/11, its effect on global air traffic, if any, is an empirical rather than theoretical question. The extant studies tend to find that 9/11 does not fully explain the subsequent decline in air traffic at the time. Moreover, measured effects appear to have been relatively short-term in duration.

Our study is novel in several ways. It employs a new, unique air traffic dataset; it examines airlines beyond the United States; it includes measures beyond revenue-passenger kilometers (RPK); it employs data with monthly rather than annual frequency; and it controls for (1) terror and war, (2) pandemics, (3) financial shocks, and (4) natural catastrophes on the global airline industry, specifically on international scheduled air traffic.[3] In what follows we discuss our data, present the results of our models with respect to the top-20 global airlines, and discuss size effects—the estimated magnitude of the effect of the relevant factors on airline performance. The final section concludes and is followed by endnotes and references.

Data

International scheduled airline traffic

We acquired data from the International Civil Aviation Organization (ICAO), an organization of the United Nations system.[4] The data cover monthly traffic-related statistics for all ICAO member airlines in the world, with records for some airlines going back several decades. In the event, we used monthly data from January 1980 to December 2007. The indicators for airline traffic used are aircraft kilometers flown (ak), number of passengers carried (pc), passenger load factor in percent (plf), and weight load factor in percent (wlf). The load factors are *actual* passenger and weight traffic measured as a percentage of available *capacity* to carry passengers and weight.

Although we include the weight carried variable (cargo traveling with passenger aircraft), on the whole we focus on understanding the monthly passenger volume of international scheduled airline traffic.[5] We focus on passenger volume because this may help to isolate factors that may influence passenger airline traffic, the airlines' major revenue earner. Because airlines can countermand fluctuations in passenger volume with pricing, studying airline revenue is not a modeler's first-choice approach to studying the industry. In addition, the choice of focusing on the volume variable is also dictated by the data in that airline financials are available on an annual basis only whereas the nature of the problem we study often involves single-day episodes that cannot be expected to affect airline traffic across the whole of a year, and, depending on the specific event, may not even affect them over the whole of a month.

Terror events data

For our purposes, the well-known ITERATE database (Enders and Sandler, 2012) suffered from one crucial shortcoming in that it focuses on transnational terror alone. At first sight, this may seem entirely sufficient for a study of international scheduled passenger air traffic. But domestic terror attacks in Egypt (Cairo), India (New Dehli), Norway (Oslo), Spain (Basque country), or the United States (Oklahoma City, Oklahoma), may affect international scheduled passenger air traffic from and to these locations and thus it seemed important to obtain data on domestic terror as well. The University of Maryland's Global Terrorism Database (GTD) contains a day-by-day record of over 87,000 coded domestic and transnational terror events worldwide, but with the detailed data for 1993 missing. An aggregate figure for 1993, however, was available, and we estimated the monthly data for 1993 using a statistical procedure.

Data issues with ICAO and GTD

Severe data quality problems were encountered with both the ICAO and GTD data.[6] The Global Terrorism Database (GTD) for example codes over 87,000 terror events—recording some 200,000 killed and 245,000 injured victims of terror attacks—but it does not distinguish between domestic and transnational events. Given the variables in GTD and the coding criteria employed, there is no immediately obvious way to effect such separation ourselves.[7] Also, there is no simple way to extract data according to characteristics that might have been of interest for the purpose of our study. For example, the Madrid train bombing of 11 March 2004 might have affected all international airlines—not just, say, Iberia—flying scheduled service to and from that city. Coded as six separate events in GTD, the perpetrators are identified as the Abu Hafs al-Masri Brigades. Yet it is unclear whether this was a "domestic" or "transnational" terror event. In fact, it is not even clear that the group ever existed.

Proceeding on the assumption that both the overall number of terror events and the magnitude of the mayhem caused affect general airline traffic more than does any specific event, location, and magnitude, we worked with four different measures of terror: (1) the total number of terror incidents, (2) victims wounded, (3) victims killed, and (4) the number of total casualties (wounded or killed).

Control variables

Security-related factors other than incidents of terror may shock the global airline industry, and for this reason dummy variables were constructed for the 1991 Persian Gulf war, the 9/11 terror event, and the 2003 Iraq war. That is, we code one especially prominent terror event as well as two prominent wars. To control for economic factors of airline passenger traffic, our preference would have been to employ some measure of output such as monthly GDP data. But countries do not report GDP monthly. Instead, monthly unemployment rates—commonly used as a measure of economic health in such situations—were collected from the Organization for Economic Cooperation and Development (OECD). Available as from January 1980 for the countries that provide the bulk of international air traffic, these data were added to the dataset. The U.S. unemployment rate was used as an indicator of the global business cycle and of changes in global air traffic. (When unemployment is high in the U.S., this usually means that both the United States and the world economy are in recession.)

Financial shocks—such as Wall Street's Black Monday in October 1987, the

Asian financial crisis that began in July 1997 in Thailand, or the bursting of the “dot com” bubble in the U.S. as from March 2000—may also have adversely affected passenger airline demand. Thus, we used unemployment rates as a measure of the global business cycle (earned-income effect) and employed information based on the S&P500 index to capture financial shocks (wealth effect). Specifically, if monthly changes in the S&P500 index exceeded +/-10%, we coded the corresponding month as a shock, not unlike our coding of the 9/11 terror event and the two wars.

The Severe Acute Respiratory Syndrome (SARS) pandemic is a different matter. Even though the death toll was small, news media attention given to the outbreak and the behavioral response that followed may well have affected global air traffic. The Centers for Disease Control and Prevention (CDC) in Atlanta, GA, USA, and the World Health Organization (WHO) in Geneva, Switzerland, list a number of severe pandemic outbreaks: For example, a Hong Kong flu in 1968/69 is estimated to have killed one million people worldwide. The effect on air travel, if any, will come through news media amplification such as was the case for the SARS pandemic threat. While the list of *epidemics* is long and while these might have regional effects, *pandemics* today are few a number and are, with rare lapses such as SARS, mostly threats that are quickly handled via CDC/WHO. We therefore coded only the SARS outbreak in our dataset. (The H1N1 outbreak in 2009 lies outside our time frame of 1980-2007.)

Analysis of the top-20 passenger airline companies

Estimating a model for the panel of the top-20 airlines using the logarithm of air kilometers flown (ak) as the dependent variable and total terror events as the indicator of terrorist threat (the “incidence” variable) gives the results summarized in Table 1. Values that are statistically significant are indicated with an asterisk and are set in bold typeface.

The results suggest that the growth of airline kilometers flown is a function of past levels of traffic (*lak1*), adverse changes in the S&P500 index (*drop10*), a one-time negative shock of the 9/11 attack (*d911*), an upward-pointing trend (*ym*)—which captures factors such as population and average income growth—and a handful of seasonality variables (*s1*, *s2*, *s3*, *s5*, *s7*, *s9*, and *s11*) relative to December. Neither the number of terror incidents, nor the unemployment proxy or the wars or the pandemic variable showed anything close to statistical significance. Moreover, the S&P500 variable is of the “wrong” sign, indicating that air traffic would increase following a ten-percentage point or more drop in the index.

A similar set of estimations was undertaken on the alternative measures of air traffic and terror. Results are reported in Table 2 where the variables marked by an asterisk and bold typeface are statistically significant. (For convenience, we ignore the coefficient signs and also the 11 seasonal variables as they are not germane to the issues at hand here.) The first block of rows (“*by incidents*”) relates the four traffic measures (aircraft kilometers; passengers carried; passenger load factor; and weight load factor) to terror measured by the total number of terror incidents, so that the first column is a shortened version of Table 1. In blocks 2, 3, and 4, the exercise is repeated except that the measure of terror is changed, respectively, from the number of total terror *incidents* to the number of people *killed* in terror attacks, the number *wounded* in such attacks, and the total number of *casualties* on account of terror attacks (wounded and killed).

While the variables in the first block do not seem to much explain airline traffic as measured by the logarithm of the *absolute* indicators of kilometers flown (ak) or

Table 1: Top-20 global airlines, monthly for 1980-2007

Dependent variable: Change in log of kilometers flown (*dlak*)

Independent variables	*Var.*	*Coeff.*	*t-value*
***Lagged log of kilometers flown**	***lak1**	**-0.204**	**-27.5**
Change in log incidents	dlinc	-0.001	-0.1
Log of incidents lagged	linc1	-0.002	-0.2
Change in log of U.S. unemployment	dluus	-0.188	-1.2
U.S. unemployment lagged	luus1	-0.015	-0.4
SARS	sars	-0.001	0.0
***S&P500 10% decline**	**drop10**	**0.086**	**2.7**
S&P500 10% increase	inc10	-0.008	-0.2
***Dummy for 9/11**	***d911**	**-0.062**	**-3.8**
Iraq war dummy	diraq	-0.01	-0.2
Gulf war dummy	dgulf	0.014	0.5
***Trend**	***ym**	**0.001**	**13.2**
Months (seasonality)	***s1**	**0.41**	**2.3**
	***s2**	**-0.81**	**-4.5**
	***s3**	**0.093**	**5.1**
	s4	-0.003	-0.2
	***s5**	**0.049**	**2.7**
	s6	0.014	0.8
	***s7**	**0.041**	**2.3**
	s8	0.021	1.2
	***s9**	**-0.049**	**-2.7**
	s10	0.031	1.7
	***s11**	**-0.046**	**-2.5**
***Constant**	***cons**	**3.112**	**22.7**

Table 2: Top-20 global airlines; results for different specifications

Aircraft kilometers (dlak)	*Passengers carried (dlpc)*	*Passenger load factor (dlplf)*	*Weight load factor (dlwlf)*
Block 1: by incidents			
__*lak1__	__*lpc1__	__*lplf1__	__*lwlf1__
dlinc	dlinc	dlinc	dlinc
linc1	linc1	linc1	linc1
dluus	dluus	dluus	__*dluus__
luus1	luus1	__*luus1__	__*luus1__
sars	sars	sars	sars
__*drop10__	__*drop10__	drop10	drop10
inc10	inc10	__*inc10__	__*inc10__
__*d911__	__*d911__	__*d911__	__*d911__
diraq	__*diraq__	__*diraq__	__*diraq__
dgulf	dgulf	__*dgulf__	__*dgulf__
__*ym__	__*ym__	__*ym__	ym
Block 2: by killed			
__*lak1__	__*lpc1__	__*lplf1__	__*lwlf1__
dlkill	dlkill	dlkill	dlkill
lkill1	__*lkill1__	__*lkill1__	lkill1
dluus	dluus	dluus	__*dluus__
luus1	luus1	__*luus1__	__*luus1__
sars	sars	sars	sars
__*drop10__	__*drop10__	drop10	__*drop10__
inc10	inc10	__*inc10__	__*inc10__
__*d911__	d911	__*d911__	__*d911__
diraq	__*diraq__	__*diraq__	__*diraq__
dgulf	dgulf	__*dgulf__	__*dgulf__
__*ym__	__*ym__	__*ym__	ym

Table 2: (continued)

Aircraft kilometers (dlak)	*Passengers carried (dlpc)*	*Passenger load factor (dlplf)*	*Weight load factor (dlwlf)*
Block 3: by wounded			
__*lak1__	__*lpc1__	__*lplf1__	__*lwlf1__
dlwound	dlwound	dlwound	dlwound
lwound1	lwound1	lwound1	lwound1
dluus	dluus	dluus	__*dluus__
luus1	luus1	__*luus1__	__*luus1__
sars	sars	sars	sars
__*drop10__	__*drop10__	drop10	__*drop10__
inc10	inc10	__*inc10__	__*inc10__
__*d911__	__*d911__	__*d911__	__*d911__
diraq	__*diraq__	__*diraq__	__*diraq__
dgulf	dgulf	__*dgulf__	__*dgulf__
__*ym__	__*ym__	__*ym__	ym
Block 4: by total casualties			
__*lak1__	__*lpc1__	__*lplf1__	__*lwlf1__
dlcasualties	dlcasualties	dlcasualties	dlcasualties
lcasualties1	lcasualties1	__*lcasualties1__	lcasualties1
dluus	dluus	dluus	__*dluus__
luus1	luus1	__*luus1__	__*luus1__
sars	sars	sars	sars
__*drop10__	__*drop10__	drop10	__*drop10__
inc10	inc10	__*inc10__	__*inc10__
__*d911__	__*d911__	__*d911__	__*d911__
diraq	__*diraq__	__*diraq__	__*diraq__
dgulf	dgulf	__*dgulf__	__*dgulf__
__*ym__	__*ym__	__*ym__	ym

passengers carried (pc), they do seem somewhat more helpful in explaining the *relative* air traffic measures, that is, passenger and weight load factors (plf and wlf, respectively). For example, in column 3, the growth in passenger load factor across the 20 airlines for our monthly data from 1980 to 2007 would appear to depend on system inertia (the lagged value of plf), the lagged value of U.S. unemployment, an increase in the S&P500 index, 9/11, the two wars, and the overall trend variable. At least at first sight, this appears to be a reasonable result.

Interestingly, the statistical results are nearly perfectly consistent across the four blocks of rows: Regardless of which measure of terror is employed, in each case the models pick out the same explanatory variables as statistically significant, or not. Moreover, the results are also nearly perfectly consistent between the two absolute measures of air traffic and the two relative measures.

When we examined the results for individual airlines, rather than for the panel of all of the top-20 jointly, we found a considerable amount of heterogeneity among the carriers. To deal with this, the base model was estimated using the random coefficient method. This involved estimating separate equations for each of the 20 airlines and then computing the mean for each of the relevant coefficients. The distribution of the means provides the standard errors within which the true, but unknown, coefficients are expected to lie.

The results, shown in Table 3, are remarkably similar to the fixed-effect results (Table 1) with the coefficient on the lagged dependent variable (lak1) close to -0.2, and significant for 17 of the 20 airlines. (The bolded lines in Table 3 do not indicate statistical significance; instead, they highlight those variables that are statistically significant for 10 or more of the 20 airlines, that is, for half or more of our sample.) Except for *drop10*, which had the "wrong" sign in Table 1, the same variables are significant, namely *lak1*, *d911*, and the trend, *ym*. Moreover, the three statistically significant coefficients in Table 3 are identical in sign and very similar in magnitude to those of Table 1. From a statistical point of view, all this is somewhat reassuring.

Also in Table 3, the GTD data for the number of terror events per se (*incidents*) add virtually no explanatory power to the number of airline kilometers flown for each of the top-20 global airlines, 1980 to 2007. The only consistently significant security effect is the 9/11 event, yet even this is statistically significant for just 10 of the top-20 airlines (and 7 of the 20 are North American). Instead, airline traffic as measured by air kilometers seems to be determined as an autoregressive process (that is, inertia) around a trend with seasonal dummies, with the odd shock specific to individual airlines and the more general impact of 9/11. This suggests that 9/11 was an aberration or, alternatively, that it takes an event as massive as 9/11 to shock global airline traffic, as measured by aircraft kilometers flown.

Re-estimating the other variants of the model gives the results displayed in Table 4 (where _x_ stands for the other terror measures, *killed*, *wounded*, *all casualties*). Consistent with the kilometers flown indicator, only the 9/11 event appears relevant among the shock variables. Everything else appears determined by inertia, trend, and seasonality. Although perhaps a surprising result, this is welcomed for its message of statistical consistency.

When the exercise of Tables 3 and 4 is repeated for passenger load factor (plf) rather than air kilometers (ak), the following variables are statistically significant for 10 or more of the 20 airlines: Inertia (that is, lagged *plf*), lagged U.S. unemployment, a 10% increase in the S&P500 index, and the trend and seasonality variables. The four terror and two war measures are statistically significant only for between 6 to 8 airlines, never more than that. Economics trumps security. Once more, this result points to considerable heterogeneity in the sample of the top-20 airlines. It appears that it may be inappropriate to lump rather diverse airlines into a single sample.

Table 3: Random coefficient model results, top-20 global airlines

Change in log of kilometers flown	*Var.*	*#sig*	*Mean*	*St.Dev.*
Lagged log of kilometers flown	**lak1**	**17**	**-0.184**	**0.199**
Change in log incidents	dlinc	2	0.000	0.013
Log of incidents lagged	linc1	4	-0.003	0.022
Change in log of U.S. unemployment	dluus	7	-0.074	0.267
U.S. unemployment lagged	luus1	2	-0.005	0.091
Dummy for SARS	dsars	1	-0.001	0.088
Dummy for S&P500 10% decline	drop10	1	0.074	0.117
Dummy for S&P500 10% increase	inc10	4	-0.003	0.101
Dummy for 9/11	**d911**	**10**	**-0.056**	**0.101**
Dummy for Iraq war	diraq	1	-0.023	0.067
Dummy for Persian Gulf war	dgulf	1	-0.001	0.039
Trend	**ym**	**15**	**0.001**	**0.002**

Note: Results of seasonal (monthly) variables not shown.

Table 4: Random coefficient model results, top-20 global airlines, for other airline traffic measures

	Killed			*Wounded*			*All casualties*		
	#sig	*Mean*	*Std*	*#sig*	*Mean*	*Std*	*#sig*	*Mean*	*Std*
lak1	**17**	**-0.178**	**0.197**	**17**	**-0.180**	**0.200**	**17**	**-0.180**	**0.199**
dl_x_	3	-0.003	0.020	1	-0.004	0.021	3	-0.004	0.024
l_x_1	2	-0.007	0.020	4	-0.001	0.021	4	-0.005	0.017
dluus	7	-0.094	0.241	6	-0.066	0.226	6	-0.079	0.228
luus1	3	-0.001	0.066	4	-0.010	0.085	3	-0.003	0.070
sars	1	-0.004	0.073	1	-0.001	0.088	1	-0.004	0.079
drop10	1	0.074	0.433	1	0.074	0.426	1	0.074	0.431
inc10	4	-0.003	0.119	5	-0.002	0.120	5	-0.003	0.120
d911	**10**	**-0.056**	**0.104**	**11**	**-0.057**	**0.110**	**11**	**-0.057**	**0.108**
diraq	1	-0.025	0.066	1	-0.026	0.068	1	-0.026	0.068
dgulf	1	-0.001	0.041	2	-0.001	0.042	2	-0.002	0.041
ym	**15**	**0.001**	**0.002**	**16**	**0.001**	**0.002**	**16**	**0.001**	**0.002**

Note: The "_x_" in dl_x_ and l_x_1 stands for *killed*, *wounded*, and *all casualties* in the respective equations. Results of seasonal (monthly) variables not shown.

Size effects

To illustrate size effects, Table 5 records the coefficient estimates for the passenger load factor (*plf*) model for the top-20 global airlines, with the terror variable using the number of people killed in terror events. (For convenience, the 11 monthly estimates have been omitted from the table.) In this specification, various violence indicators and economic proxies are statistically significant, suggesting that they do influence the passenger load factor—the share of passenger kilometers flown as a percentage of seat kilometers available. The dependent variable is the *change* in the logarithm of the passenger load factor (*dlpdf*).

The first significant factor is the prior-month logarithm of the level of plf (*lplf1*): The higher the prior-month plf, the more pronounced the percentage decline in *plf* to the next month, and vice versa. In other words, the more unusual any one month's aberration, the more the next month's *plf* is likely to get "pulled back" to trend. This effect is in addition to the overall rising trend (*ym*) itself and to seasonality effects (not shown in the table) and simply means that inertial forces are by far the overriding factors accounting for month-to-month passenger load factor changes in the ordinary course of the airlines' business. None of this comes as a surprise: The statistical estimation merely provides a quantification of these effects (as well as a check on these intuitions).

The factors that are intrinsic to the airline business (inertia, trend, and seasonality) are amplified by external variables. U.S. unemployment is statistically significant but only in its prior-month variant, *luus1*. A worsening unemployment number in any one month adversely affects changes in the growth rate in the passenger load factor in the follow-on month. This, also, is as expected. In contrast, the +/– 10-percentage point changes in the S&P500 index (*inc10* and *drop10*) do not appear to work well, statistically. The *drop10* variable has a negative coefficient, as might be expected, but is not statistically significantly different from zero. The *inc10* is statistically significantly, and strongly so, but has the "wrong" sign, suggesting that a drastic increase in the index reduces the *plf* growth rate that month. Although one can rationalize this result, it seems counterintuitive. The coefficient value, however, is small in size (–0.061) and in any case affects a mere four months of data (1982:09; 1991:02; 1998:11; and 2009:04). The SARS variable is statistically insignificant. As discussed, despite its pandemic classification, in effect it was an epidemic, primarily affecting the Pacific/Asian airlines in our sample and not showing an effect in the whole sample of the top-20 global airlines.

More important for our purposes, the growth in the passenger load factor in any given month is influenced in a statistically significant way by the number of people killed in prior-month terror events (*lkill1*). As expected, the coefficient is negative, which means that an increase in the number of terror-related killings reduces the follow-on month growth rate in the passenger load factor, and vice versa (fewer terror killings are associated with higher load factors).

In a similar manner, the two wars (*diraq* and *dgulf*) exert statistically significant adverse effects on passenger load factors for each month in which the wars were in the combat stage. Finally, the coefficient for the 9/11-event is strongly statistically significant but comes out with a *positive* sign. This may appear puzzling—why would 9/11 have led to an *in*crease in the plf growth rate?—but recall that the plf is the *ratio* of passengers carried to available seat capacity. Unquestionably, air kilometers traveled and passengers carried (pc) declined in response to 9/11 [the relevant coefficients from those models are –0.062 (t = –3.9), and –0.025 (t = –2.1)] but, as all travelers know, airlines responded by withdrawing aircraft from service, or using smaller aircraft, and packing their remaining aircraft with more passengers. In a word, efficiencies increased, as shown with rising passenger load factors. Upon individual inspection of the *plf* charts for each of the top-20 airlines, it becomes clear, however, that increasing *plf* efficiencies are part of a long-term trend, particularly for the U.S.-based airlines, so that this 9/11-related effect is not apparent in an unambiguous manner. Only the statistical modeling and estimation reveals that such an effect exists. However, at 0.018, the size of the 9/11-coefficient is not large. It is, in fact, smaller than are the coefficients of the two wars.

Table 5: Top-20 global airlines, monthly, 1980-2007

dlplf	*Coeff.*	*t-value*
***lplf1**	**-0.265**	**-32.0**
dlkill	0.001	0.6
***lkill1**	**-0.004**	**-3.0**
dluus	-0.042	-1.4
***luus1**	**-0.041**	**-6.1**
sars	-0.001	-0.2
drop10	-0.010	-1.6
***inc10**	**-0.061**	**-7.7**
***d911**	**0.018**	**6.1**
***diraq**	**-0.053**	**-5.9**
***dgulf**	**-0.020**	**-4.1**
***ym**	**0.000**	**3.4**
***cons**	**1.215**	**30.2**

Note: Seasonals omitted.

Additional to short-term effects on month-to-month growth rates, the mathematics of the model permits one to derive long-term relationships in the data that determines the log-levels of *plf*. This can be computed by setting the log-level values equal to their lagged values, which makes the change variables equal to zero and drops out the lag-variables. With coefficients rounded to the third decimal place and omitting the seasonal factors, the long-term relationship then can be written as

$$(1)\quad 0 = -0.265\, lplf - 0.004\, lkill - 0.041\, luus - 0.001\, sars - 0.010\, drop10 - 0.061\, inc10 + 0.018\, d911 - 0.053\, diraq - 0.020\, dgulf + 0.000\, ym + 1.215.$$

Solving for *lplf* gives

$$(2)\quad lplf = 4.579 - 0.016\, lkill - 0.154\, luus - 0.006\, sars - 0.038\, drop10 - 0.230\, inc10 + 0.070\, d911 - 0.199\, diraq - 0.076\, dgulf + 0.000\, ym.$$

The interpretation is that the immediate, short-term effect of a 1% increase in the *growth* of the number of people killed in global terror events increased *growth* of the passenger load factor of our top-20 global airlines by 0.001% (the *dlkill* coefficient in Table 5), while in the long-term every 1% increase in the *number* of people killed decreased the passenger load factor *ratio* by 0.016% (the *lkill* coefficient in equation 2).

Because the coefficients for *lkill* and *luus* in equation (2) both refer to percentage changes, they may be compared to each other. Thus, the effect of a 10% increase in the U.S. unemployment rate (for instance, from 5.0 to 5.5 percent) exerts an effect about 10 times as strong (0.154/0.016 = 9.625) than would a 10% increase in the number of people killed in terror events (for example, from 50 to 55). More important than killings per se are the event shocks: The Persian Gulf war reduced the passenger load factor for the top-20 global airlines by about 0.08% per month of war. Similarly, the shock of the Iraq war was about -0.2% on *plf*. These coefficients are small in size.

Summary and conclusion

This research aimed to undertake a quantitative study of the effect, if any, of large-scale violence in the form of terror and war on global air traffic, while taking account of confounding shock factors such as economic and financial crises, pandemics, or natural catastrophes. We excluded from consideration natural catastrophe-related effects on international scheduled air traffic. (They are always localized effects and cannot be expected to affect global air traffic.) The empirical work involved acquiring ICAO data on airline traffic and GTD data on terror events. This saw considerable practical problems and concern over the quality and consistency of the data. The ICAO data came to more than 370,000 observations; the terror data to more than 87,000 cases. We added economic, financial, and other data as well.

Constructing panels of data produced seemingly reasonable results. The empirical tests suggest that the pandemic variable (SARS) is never relevant at a global level. Statistically, SARS acts more like an epidemic through its effects on airlines in Asia. The economic and financial variables exert complex effects: For the top-20 airlines, absolute international scheduled air traffic measures (ak; pc) are not affected by unemployment but are affected by a fall in the S&P500 index, whereas relative air traffic measures (plf; wlf) are affected by unemployment and the S&P500 index. In regard to measures of violence (terror and war), the one-off 9/11-event is fairly consistently relevant for about half of the top-20 airlines, and the Iraq war somewhat more than the Gulf war. We observed considerable statistical mingling of the effects of specific shocks on specific airlines that, once amalgamated into the larger sample, appears to signal results that may not in fact be justified: Building up a joint sample from diverse individual airlines may yield misleading results, an outcome which may cast some doubt on the findings in the aggregate studies that tend to dominate the literature.

Notes

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1. This article is a much shortened version of a commissioned study in which we also consider a larger sample of 443 airlines (Brauer and Dunne, 2011). The full study is available upon request from Thea Harvey <theaharvey@epsusa.org>.

2. There are other studies on 9/11 and the airline industry: Guzhva (2008), e.g., finds that the long-term effects were considerably smaller than the short-term ones and that the airlines were not equally affected. He also finds that the pricing of airline stocks was much less accurate for smaller airlines than for larger ones. A number of other papers consider the stock market effects, for example Gillen and Lall (2003).

3. In our final models, we excluded variables for natural catastrophes (earthquakes, hurricanes, volcanic eruptions, etc.). The reason is that natural catastrophes always are localized events, not much affecting *global* air traffic. When modeling for specific airlines in specific regions, however, it may well be appropriate to take account of natural catastrophes.

4. A data request made to IATA in late 2008 was not fulfilled.

5. Note that in this article, we do not study (1) domestic air traffic, (2) nonscheduled, e.g., chartered, air traffic, or (3) airfreight carriers' traffic, such as FedEx, UPS, or the cargo subsidiaries of the major passenger airlines.

6. For details, see Brauer and Dunne (2011).

7. An attempt by Enders, Sandler, and Gaibulloev (2011) to sort through the GDT dataset of, at the time, 82,536 events led, first, to the exclusion of about 18,000 events as not meeting the definition of terror and, second, to the classification of a further 7,000 events as "unknown," leaving 46,413 domestic and 12,862 transnational events in their rendition of the GTD dataset.

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War and the Austrian School: Modern Austrian economists take on aggressive wars

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Early Austrian economists, exemplified by Menger, Böhm-Bawerk, and Wieser, were known for their emphasis on marginal analysis, money, capital structure, time horizons, and alternative cost. A subsequent generation, led by Mises and Hayek, enriched that analysis in myriad ways, including an increased focus on the structure of production, the distorting effects of monetary policy, and an understanding of the role played by societal and governmental institutions. These key scholars and their ideas play an important role in understanding the Austrian school's views on both the economics of war and the economic consequences of war.[1]

What's more, the Austrians see effects emanating from the structure of production not only on an economy but on civilization itself, as well as on specific cultures. As noted by Menger, Böhm-Bawerk, Hoppe, and others, economic development is a civilizing force. As entrepreneurs expand the matrix of capital and increase infrastructure, they extend the range over which trade occurs. Further, by necessity, economic development extends the time horizons of entrepreneurs who look ever farther into the future to project consumer demand, production methods, costs, and revenues. This leads to a better understanding of the societies and cultures involved in trade, thereby reducing overall tensions. Thus, the expansion of trade drives both a higher standard of living at home and an increased awareness of the abroad. Hence, trade is a civilizing force.

During war, the emphasis on short-term destruction rather than long-term production has exactly the opposite set of effects. Instead of entrepreneurs concerning themselves with how best to meet the future needs of domestic and foreign markets and, hence, how best to structure the matrix of capital to maximum productive capacity in the long term, the focus is on how to force the existing matrix of capital to fit a short-term goal of maximum destruction. Instead of consumers and entrepreneurs looking after their own long-term goals, they look after the short-term ends of political and military leaders. Likewise, rather than being concerned about what other cultures believe and want, entire societies become concerned with destroying those other cultures and their beliefs. In other words, in the Austrian view, war is destructive to civilization itself, as well as to local cultures.

Since World War II, a third generation of Austrian economists has continued to develop and expand these Austrian ideas, often in ways even more explicitly antiwar than did the previous generations. This is not to say that Austrians are necessarily pacifists. No less an antiwar activist than Murray N. Rothbard believed in "just war" theory. However, the literature since World War II makes clear that Austrians do not hesitate to criticize governments for engaging in warfare. This article discusses examples of relevant contributions made by this third generation of Austrians.

This article is the third in a trilogy on the Austrian school of economics and its views of questions of war and peace. Although not necessarily pacifist, modern Austrians view war as destructive to civilization itself as well as to local cultures. Thus, modern Austrians do not hesitate to criticize governments for engaging in warfare.

Henry Hazlitt on opportunity cost

At the heart of Austrian opposition to war is the simple economic concept of opportunity cost. Perhaps no Austrian has demonstrated the power of opportunity cost more than Henry Hazlitt, whose *Economics in One Lesson* is often cited by Austrians as a very good practical guide to economic thinking in general. According to Hazlitt, "The art of economics consists in looking not merely at the immediate but at the longer effects of any act or policy; it consists in tracing the consequences of that policy not merely for one group but for all people."[2]

Throughout the entire book, Hazlitt stresses the idea that each time one outcome occurs, some other outcome is foregone. For example, in the well-known broken window fallacy, if a hoodlum breaks a store window, thereby causing a shopkeeper to buy a new window, the shopkeeper is now unable to purchase a new suit. The new business generated for the glazer is exactly met by the lost business to the tailor. Absent the hoodlum's act, society would have had both a window and a new suit; following the act of destruction, society will have a new window, but not the suit. Thus, the cost of the act is not only the broken window, but the suit that will never come into existence. This lesson is the foundation for Hazlitt's explication of the economic effects of war.

Hazlitt devotes an ironic chapter to "The Blessings of Destruction," the idea that there are "almost endless benefits in enormous acts of destruction." It is easy to see a destroyed building—whether by act of war or act of nature, such as a hurricane or tornado—and then to imagine the jobs necessary to rebuild it. Construction work is highly visible, and even the most casual bystander can see the jobs created to rebuild things that have been destroyed. Anyone can see a destroyed building, and then see the new building that replaced it.

The energy needed to replace a single destroyed building is vastly multiplied by war: Entire cities are laid to waste, industrial sectors destroyed, and roads and bridges demolished. Those who commit the broken window fallacy—seeing only the new window without seeing the lost suit—commit the same fallacy on a grand scale here. There are thousands, or even millions, of workers mobilized to rebuild that which has been lost. Skilled and unskilled workers, managers, people engaged in transportation, people who make concrete and steel, those who fell timber, and more, all are visibly active in the rebuilding process.

Yet all of those people and resources, absent the destruction, could have been turned toward other ends. During the time a destroyed refrigerator factory is being rebuilt, for example, the economy could instead have been producing actual refrigerators. Instead of rebuilding schools that have been destroyed in war, peacetime resources could have been directed toward educating children. As Hazlitt stresses, "Wherever business was increased in one direction, it was (except insofar as productive energies were stimulated by a sense of want and urgency) correspondingly reduced in another."[3]

Even the argument that the newly rebuilt factories and schools are somehow better or more efficient than those destroyed is not sufficient justification for the destruction. After all, if a new factory is better than the existing one, the factory owner can blow it up himself; if a new school is better than the existing one, the school board can tear it down and rebuild. If new efficiencies truly outweighed the costs of destruction, shop owners, factory owners, homeowners, and school boards would engage in the destruction themselves. War is not needed to accomplish such necessary destruction.

Hazlitt's analysis does not stop with the physical destruction. He points out, in the chapters "Public Works Mean Taxes" and "Taxes Discourage Production," that any costs government bears in rebuilding ultimately are born by taxpayers who already are bearing the costs of their own rebuilding. A homeowner whose home was destroyed now pays both for his own rebuilding and for the rebuilding of roads, bridges, police buildings, and other infrastructure projects. As taxes are raised to pay for such public works projects, entrepreneurship is weakened. The reason for this is that resources that might have been available to start new businesses or to expand existing ones are taxed away to support a government-directed rebuilding effort. But the higher the tax rate, the greater the disincentive for a prospective entrepreneur to create new projects that generate permanent jobs and long-term wealth. Thus, the rebuilding boom that occurs after war does not generate permanent prosperity. Rather, it generates the temporary appearance of prosperity at the cost of long-term wealth-building activities. We thus come to see the "blessings" of destruction in at least three ways: (1) as actual destruction during the war; (2) as resource shifts away from consumer and societal needs toward war goods production during war; and (3) as entrepreneurial disincentives and resource shifts away from long-tem wealth production after war.

Robert Higgs on crises and their effects on the size of government

Like Mises and Hayek, Robert Higgs (1987) examines government intervention, adding a focus on the growth of government during and after crises. In particular, he identifies wars and economic downturns as the primary periods during which the influence, scope, and power of government have substantially increased. Of particular importance to Higgs is his observation that when governments expand during a crisis, they rarely shrink to their prior size following its resolution. Instead, Higgs says, there is a "ratchet effect" of government intervention. It goes as follows:

- A crisis occurs (often created by the government itself, such as a war);
- government intervenes into economic and social affairs;
- the crisis ends; and
- some but not all of the government controls are lifted.

Higgs points out that during World War I, the United States government assumed powers clearly outside the realm of constitutional law. True, many wartime regulatory agencies like the Food Administration and the Railroad Administration were scrapped by the end of 1920, yet railroad and shipping regulations remained, and laws like the Espionage Act and the Trading with the Enemy Act were left intact. He also points out that "Wartime prohibition of alcoholic beverages, a purported conservation measure, transmogrified into the ill-fated 18th Amendment."[4]

Government economic intervention during war also convinces people that such mobilization would work in peacetime. Higgs writes:

> Most importantly, the dominant contemporary interpretation of the war mobilization, including the belief that federal economic controls had been instrumental in achieving the victory, persisted, especially among the elites who had played leading roles in the wartime economic management.[5]

Further, Higgs argues that much of the New Deal apparatus came from the economic controls imposed in World War I, citing the War Finance Corporation's re-emergence as the Reconstruction Finance Corporation, the War Industries Board reappearing as the National Recovery Administration, the Food Administration as the Agricultural Adjustment Administration, and many more.[6]

Higgs's position—of the "success" of war being seen as a direct result of economic controls—is echoed by Anderson (1949) and Mises (1949), both of whom say that U.S. American economic controls in World War II retarded the output of weapons and war materiel. In fact, Higgs challenges the belief that World War II "brought the country out of the Great Depression."[7] Dealing with what he says is the "general consensus" among historians that the war was an economic success, he writes that relatively high GDP figures just reflected high military expenditure while ordinary consumers were far worse off than before. Without new cars and new spare parts, and with gasoline rationing, travel to work became difficult, forcing people to move to population centers. This, in turn, led to overcrowded housing, which was exacerbated by rent controls, creating disincentives for landlords to repair existing housing or build new housing. Many goods became unavailable, and black markets flourished, creating new costs involved in searching for goods in illegal markets, arranging trades using ration coupons, or standing in lines. He writes: "The government exhorted the public to 'use it up, wear it out, make it do, or do without.' In thousands of ways, consumers lost their freedom of choice."[8]

As for the war's effect upon unemployment, which fell from double-digits to less

Robert Higgs emphasizes that during World War II, the United States saw very little private sector investment and production and that the war did not produce an economic miracle as some have claimed. Austrian school economists argue that economic prosperity returned not because of the war but in spite of it.

than two percent, Higgs writes that placing 12 million men into the armed forces (in which most were "employed" in jobs they rather would not have had) accounts for almost all of the change in the unemployment rate. Furthermore, these "jobs," he writes, were not equal tradeoffs. Military jobs were physically risky, death was likely, and the pay did not compensate sufficiently.

> Physical casualties included 405,399 dead and 670,846 wounded. To treat military jobs as commensurable with civilian jobs, as economists do in computing the tradeoffs between them, betrays a monumental obtuseness to their realities.[9]

In his paper on the "prosperity" of World War II, Higgs emphasizes that there was very little private investment and production during that time, as most of the economic production was directed toward war goods. The war did not produce the "economic miracle" that some have claimed. To further challenge the "war prosperity" thesis, only after the war, when government spending fell drastically, did real economic prosperity return. Writes Higgs:

> By early 1945, almost everyone expected the war to end soon. The prospect of a peacetime economy electrified investors. Stock prices surged in 1945 and again in 1946. In just two years the Standard & Poor's index increased by 37 percent and the value of all shares on registered exchanges by 92 percent, despite a decline of current-dollar after-tax corporate profits from their peak in 1944. Did people expect the end of "wartime prosperity" to be economically deleterious? Obviously not.[10]

True, during the war there were jobs to be had on the home front, and while life was hard, people did have employment. But it was in producing war goods or in coordinating the war effort, neither of which can be consumed by ordinary people. (People cannot "consume" artillery shells or bombs dropped from 30,000 feet.) Although there can be some transference of the technologies of producing war goods to producing civilian goods, nonetheless a large portion of wartime capital is abandoned after the war is over, and World War II was no exception.

Austrian school economists emphasize that prosperity returned not because of World War II but in spite of it. Certainly, war goods capital could be sustained only for the duration of the war itself. Because the capital formation was meaningful solely because of its relation to war production, the only way for business owners to be able to direct production to civilian goods was either to abandon those producers' goods altogether or find a way to redirect them to other uses. Nonetheless, as Higgs so aptly points out, the perception—especially in the popular media—that World War II ended the Great Depression is still popular today.[11] It is not a long step to imagine that "the equivalent of war spending" will bring economic prosperity, and it also is not a long step to believing that another war is just what an economy might need.

Israel Kirzner on the role of the entrepreneur

Kirzner (1973) argues that entrepreneurship springs from the basic idea of arbitrage: Entrepreneurs seek to buy low and sell high. Arbitrage not only includes finding a particular good at different prices in different markets, but includes finding factors of production at a price less than the discounted present value of the future price of the finished good. Following Menger (1994), the Austrian school sees a finished good and its factors of production (including entrepreneurship and time) as equivalent. Thus, an entrepreneur who buys factors, engages in production, and then sells the finished product at a profit has engaged in arbitrage, understood broadly: He bought (factors) low and sold (goods) high.

In the absence of a large government presence in the market, entrepreneurs are continually alert to shifting consumer sentiment. Goods that provide consumer satisfaction or fulfill Menger's "needs" in one era can become obsolete, either as the need becomes entirely fulfilled or as other products are introduced that can better fulfill those needs. Being alert to expected consumer desires as well as to resources available in the market, entrepreneurs stand ready to engage in productive arbitrage, removing resources from one allocation and placing them into another, higher-valued, allocation.

But during war, government's presence looms large in markets. Even setting aside issues of price controls, rationing, nationalization of key industries, and other common economic issues in war, the clear fact is that government's demand for war goods skyrockets. Entrepreneurs alert to changes in markets can see that profits have shifted out of consumer goods and into war goods. The Kirznerian arbitrage opportunity comes in, taking resources that otherwise would have been allocated to schools, houses, and consumer vehicles and shifting them toward munitions factories, barracks, and military vehicles. An increase in the number of men in uniform also drives other changes, such as a shift from packing soup in small cans for home consumption into packing soup into barrels for mess hall consumption. In the former case, subtle changes in taste might have huge impacts on profits; in the latter, sheer volume is the primary issue. Quality is expendable.

In peacetime, entrepreneurs likely seek sustainable projects that generate ongoing profits. In wartime, entrepreneurs likely see quick-profit projects that have no ability to generate profits once war is over. Thus, wars can distort entrepreneurial endeavors, because the Kirznerian entrepreneur, alert to changes in the economy, reacts predictably to changed incentives brought about by war. The entrepreneur shifts the economy's matrix of capital away from consumer goods and toward war goods. The societal cost, as always, lies not merely in the tax paid for war goods, but also in the foregone utility from consumer goods that are not created for the duration of the war.

Roger Garrison on capital and the structure of production

One area in which Austrian economists differ from the economic mainstream is in their views on capital and capital formation. Following Mises, Hayek, and Rothbard, Garrison (2001) emphasizes the intertemporal nature of capital formation,[12] All of them note that capital structure (the matrix of capital) is embedded into an economy in a way that either can be sustained if capital investments follow real savings and spending patterns or, alternatively, is malinvested if capital formation cannot be sustained over time.

In this context, the concept of a societal time preference rate (TPR) lies at the heart of the Austrian understanding of capital. A society with a high TPR prefers its consumer goods sooner, while a society with a low TPR is willing to wait until later. A high-TPR society thus reduces its savings, drives up interest rates, and makes long-term capital-intensive production more expensive. In contrast, a low-TPR society reduces consumption, increases savings, and drives down interest rates, making long-term capital-intensive production less expensive. If a society changes its TPR, it therefore also drives changes in its long-term capital structure. The Austrian school refers to this as adding "orders of goods" to the process. A first-order good is a consumer good. Second-order goods directly make first-order goods. Third-order goods make second-order goods, and so forth. A lower TPR drives longer production processes and many higher orders of goods.

Garrison picks up the idea that capital is not merely a homogeneous blob that can be moved into and out of production processes at whim. A machine that makes candy bars is very different from a machine that makes shoes, even though both candy bars and shoes are consumer goods (lower-order goods). Likewise, a machine that mines coal is different from a machine that drills oil, even though both are extractive capital (higher-order goods). The candy machine and the oil drill are extremely different. An entrepreneur involved in capital formation, then, is involved in making a specific type of capital to perform a specific type of task at a specific time and in a specific place in a specific production process in anticipation of a specific future need.

Entrepreneurs who anticipate a future candy craze will develop and acquire different capital than will entrepreneurs who anticipate a future war. Entrepreneurs who anticipate a long, steady period of economic growth will develop goods further from consumers; those who anticipate uneven economic performance will focus on goods much closer to consumers. Entrepreneurial expectations of what will sell high in the near or far future thus drive the matrix of capital.

It takes time to develop a matrix of capital designed to provide maximum production of any good. Progressively higher orders of goods must be developed and produced, thereby lengthening the structure of production and increasing total output in the long term. However, as Mises noted, "War can only be waged with present goods."[13] Once war starts, it is too late to begin the long-term changes necessary to engage in efficient production of war goods. Instead, the current structure of production must be modified to make do in order to turn out war goods immediately. This inefficient use leads to the consumption of an economy's capital, since machines are used in ways that are not quite what they were designed to do, and production schedules are rushed, thereby pushing equipment beyond the tolerances for which they were constructed. This ongoing consumption of capital will have its starkest appearance not during the war, but likely after the war, as it finally breaks down and decays beyond all repair.[14]

Joe Salerno on the effects of wartime monetary policy

Salerno (1999) notes that the economics of war involve both a "horizontal" and a "vertical" shift in resources and ties this explicitly to entrepreneurial error caused by monetary policy. Governments have three basic funding sources for war, and for all other government activities: taxation, borrowing, and money creation.[15] Under normal, nonwar times, governments fund their activities with combinations of these three sources. Capital acquisition and investment by entrepreneurs occur within a given framework of government funding, e.g., if capital gains are taxed higher than is income, entrepreneurs have less incentive to engage in long-term projects, but if capital gains are taxed lower, or not at all, then entrepreneurs have more incentive to save current income to invest in projects that are sustainable in the long term.

With war, government's need for financing rises dramatically. Historically, governments have increased taxes—a fiscal "policy" measure—although at least as far back as 1215, when renegade nobles forced King John of England to sign the Magna Carta, this has proven politically unpopular.[16] Subsequently, governments tried monetary "policy," such as borrowing money by issuing war bonds. Bonds, whether for war or other purposes, are issued when a government runs a budget deficit and simply needs to borrow money. Myriad costs are associated with government bonds. As the Austrians see it, when government enters the market for loanable funds, it drives interest rates higher than they would otherwise be. Interest rates, in turn, cause changes in the matrix of capital. Government budget deficits thus lead to alterations in the market allocation of capital but in ways that are not always clear. If "crowding out" occurs, then there will be fewer firms creating fewer products and hiring fewer employees.

Since the advent of central banking and the corresponding monopoly to issue bank notes, the quickest and surest way for a government to generate funds needed for fighting wars has been via the printing press. Rather than merely causing changes in prices or in quantities of production and consumption, Austrians see a change in the money supply as causing a shift in investment patterns. If a monetary expansion drives interest rates below their free-market levels, entrepreneurs whose projects were previously not sufficiently profitable to allow them to be undertaken will now find that lower-priced money makes their projects feasible. Unfortunately, cheaper money does not mean that scarce resources themselves are any less scarce; instead, more projects now vie for the same resources, suggesting that any short-term increase in economic activity will be met by a long-term decline when these competing projects find that there are not enough resources to complete all of the projects, and many will have to be liquidated.

This analysis complements Salerno's argument about changes in the vertical structure of an economy. War goods themselves cause one set of changes to an economy's matrix of capital, while inflationary policies used to pay for them cause another set of changes to an economy's matrix of capital. Because both sets of changes are not viable in the long term, the economy is likely to be in worse shape following war than before or during war.

Further exacerbating the issue is the fact that a monetary inflation does not cause an equal price inflation at every level of every industry at the same time. Instead, some industries and individuals see the new money first, before prices have fully adjusted. Such individuals and industries have a net wealth gain because they can command more resources and goods before prices adjust. During wartime, the first recipients of the new money will be the war goods industries. Other industries and firms fall into the middle of the process and might see some prices rise before receiving the new money, therefore being in a slightly worse position. Still other people will be the last to receive the new money: They face the increased prices long before they receive increased wages. These people are made substantially worse off by the inflation, in effect suffering a wealth transfer away from them and toward the government and its preferred industries that received the new money first. Thus, inflation serves not only to distort production, it also serves as a hidden tax in that it transfers wealth from late recipients to early recipients and to the government itself.

Murray Rothbard on "just war" theory

Since before the days of Adam Smith, economists of many schools and political persuasions have crossed academic boundaries in search of truth. John Locke might be best known for his work on political philosophy, but his ideas were closely related to his views on economics. John Stuart Mill wrote on such topics as philosophy, logic, race relations, and sexual equality, seeing them all as woven into his economics. William Stanley Jevons wrote on logic, the scientific methods, social reform, and other topics, in addition to his renowned work in theoretical and applied economics. Gunnar Myrdal studied race relations and economics and was a Member of Parliament in Sweden. Gary Becker tied economic analysis to drug addiction, crime, family structures, and more. Myriad other examples could be drawn showing the interdisciplinary work of many leading economists.

Murray N. Rothbard, dean of the Austrian school of economics during the last quarter of the twentieth century, worked in this interdisciplinary tradition. With multivolume works on U.S. history, the history of economic thought, and political economy, and with books on ethics, political theory, and economic theory, Rothbard found it impossible to discuss any issue solely within the confines of one academic field, such as economics. Rather, to discuss a topic such as war, Rothbard drew on many fields, including economics, history, ethics, and political philosophy.

Calling himself an Austro-libertarian, Rothbard (1998; 2002) opposed nearly all wars on two grounds. First, as an issue of political economy, war increases the amount and effects of government coercion. On the latter, Rothbard accepts the view put forward by Randolph Bourne that "war is the health of the state."[17] Second, as a moral or ethical issue, in most instances, war is unjust. The issue of a just war is important in understanding Rothbard, who writes that "a just war exists when a people tries to ward off a threat of coercive domination by another people, or to overthrow an already existing domination." In essence, Rothbard would view any attempt by nonstate or state actors to repel the use of force as just. Revolutions and defensive wars are just, offensive wars are unjust. Yet, according to Rothbard, as "even a just war cannot be entered into lightly; an unjust one must therefore be anathema."[18]

Just war theory is hardly new, and Rothbard draws heavily on such 16th-century Spanish scholastics as Franscisco de Vitoria, who founded the philosophical School of Salamanca, and Francisco Suarez, a natural law theorist and early writer on international law. Likewise, Rothbard follows Dutch natural law theorist Hugo Grotius, who argued three ways in which a war might be considered just: (1) to engage in self-defense (but not to aggress), (2) to garner restitution (but not to loot), and (3) to punish. Further, Grotius argued that all parties to a war, whether just or not, are bound by a civilized code of conduct that existed into the 19th century. (Clearly, recent events such as the United States engaging in "enhanced interrogation methods" at Guantanamo fall outside of Grotius's code.)

Rothbard notes that the classical international lawyers, writing during the rise of the nation-state, recognized that it was folly to try to ban war, the position "that has been dominant since 1914, by the dominant partisans of the League of Nations and the United Nations."[19] Rather than take such a utopian and naive view, the classical theorists sought instead to contain and limit the state. According to Rothbard, classical international lawyers were successful in getting nations to adopt two key points. First,

> ... above all, don't target civilians. If you must fight, let the rulers and their loyal or hired retainers slug it out, but keep civilians on both sides out of it as much as possible. The growth of democracy, the identification of citizens with the state, conscription, and the idea of a "nation in arms," all whittled away this excellent tenet of international law.[20]

Rothbard would take this concept of not targeting civilians on either side one step further. "War, then, even a just, defensive war, is only proper when the exercise of violence is rigorously limited to the individual criminals [the aggressor]."[21] The implications of this tenet of Rothbard's thought would counter the justifications of the Bush administration which claimed that the war in Afghanistan was defensive in nature, and therefore just. One civilian death would counter the just war tag of any act whether considered offensive or defensive.

This leads Rothbard to view the use of nuclear weapons, and other similar devices as unjust, even in a defensive war.

> It has often been maintained, especially by conservatives, that the development of horrendous modern weapons of mass murder (nuclear weapons, rockets, germ warfare, etc.) is only a difference of degree rather than kind from the simpler weapons of an earlier era. Of course, one answer to this is that when the degree is the number of human lives, the difference is a very big one. But a particular libertarian reply is that while the bow and arrow, even the rifle, can be pinpointed, if the will be there, against actual criminals, modern nuclear weapons cannot. Here is a crucial difference in kind. Of course, the bow and arrow could be used for aggressive purposes, but it could also be pinpointed to use only against aggressors. Nuclear weapons, even "conventional" aerial bombs, cannot be. These weapons are ipso facto engines of indiscriminate mass destruction. (The only exception would be the extremely rare case where a mass of people who were all criminals inhabited a vast geographical area.) We must, therefore, conclude that the use of nuclear or similar weapons, or the threat thereof, is a crime against humanity for which there can be no justification.[22]

The second tenant of classical international law theory was that the rights of neutral states should be recognized. This is opposed to the modern notion that

> ... "neutrality" has been treated as somehow deeply immoral. Nowadays, if countries A and B get into a fight, it becomes every nation's moral obligation to figure out, quickly, which county is the "bad guy," and then if, say, A is condemned as the bad guy, to rush in and pummel A in defense of the alleged good guy B.[23]

We see this played out in the "war on terrorism." The U.S. government pressured other states to enter the war on its side. The U.S. judged Iraq and Afghanistan guilty, and then demanded that all other nations do the same. States that so joined, such as Saudi Arabia, were considered American allies, regardless of any ties that might have existed between its government and those very terrorists who are being sought. In contrast, states that refused to join—those that sought to maintain neutrality—such as France or Germany, were accused of being pro-terrorist and anti-American.

Conclusion

The modern Austrian school's position is neither prowar nor antiwar per se. As Rothbard notes in his just war analysis, in some instances, it is appropriate to fight defensively. However, the Austrian are opposed to aggressive wars.

The Austrian school builds from its fundamental tenets to derive its general antiwar (or non-prowar) stance. From its views on scarcity, utility, the origins and derivation of money, the nature of capital, and the role of the entrepreneur, the Austrian view is a well-integrated economic position that has clear and obvious application to the question of war.

This position grows out of the unique Austrian application of opportunity cost and its implications on the structure of production. Thus, the Austrians are concerned not only about the short-term effects during war but also about the long-term effects generated by the alteration in the matrix of capital, effects that are worsened as a war is lengthened. By shifting the attention of entrepreneurs away from consumer desires and toward government desires, war drives changes in both horizontal and vertical economic domains that are damaging to consumers. The increased role of intrusive government has effects on the relations between and among money, interest, capital, and consumer goods that are short-term and long-term in their implications.

John Denson's *The Costs of War* (1999) is subtitled "America's Pyrrhic Victories." It makes the point that any short-term benefits from war are more than offset by long-term costs. Denson notes that in 280 B.C. and 279 B.C., Pyrrhus defeated the Romans and sent them into retreat. However, the costs of Pyrrhus's wins were greater than the benefits, and in the long term, Pyrrhus was destroyed. To the Austrians, this is always the problem with aggressive war: Regardless of which side wins, the people on both sides lose, and in the long term, even the victor will be destroyed by the inexorable economics of war.

Notes

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1. This article is the last in a trilogy on contributions by the Austrian school of economists on questions of war and peace. See Kjar and Anderson (2010) and Westley, Anderson, and Kjar (2011).

2. Hazlitt (1996, p. 5).

3. Hazlitt (1996, p. 15).

4. Higgs (1999, p. 27).

5. Higgs (1999, p. 27).

6. Higgs (1987, pp. 154-156).

7. Higgs (1992; 1997a; 1997b).

8. Higgs (1992, pp. 52-53).

9. Higgs (1992, p. 43).

10. Higgs (1992, p. 58).

11. McCardle (2009), Smiley (2008), Library of Congress (n/d.).

12. Mises (1949), Hayek (2008), Rothbard (1962).

13. Mises (1983, p. 163). George W. Bush's Secretary of Defense, Donald Rumsfeld, made a similar statement: "You go to war with the army you have." See Kaplan (2004).

14. Schumpeter (1991).

15. Rothbard (1992).

16. Thorne (1965).

17. Bourne (1964).

18. Rothbard (1999, p. 119).

19. Rothbard (1999, p. 120).

20. Rothbard (1999, p. 120).

21.Rothbard (1998, p. 190).

22. Rothbard (1998, pp. 190-191).

23. Rothbard (1998, p. 120).

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