

Forecasting the Risk of Extreme Massacres in Syria

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An abundance of large data sets and improved estimation methods have enabled conflict researchers to estimate the risk of war or terrorist incidents quite precisely. However, as it is the case with the prediction of particularly violent earthquakes, forecasting extremely bloody events in ongoing conflicts has been difficult until now. This article reports how the power laws can be used to predict extreme massacres *ex post* and *ex ante*. The power law distribution that we use is based on the observation that the standard probability distributions like the normal distribution typically underestimate the risk of such escalations. Using fatality data until the end of February 2013, we calculate the probability of at least one single event with 250 or more dead civilians at 80% (59% - 94%) and between March and May 2013 of up to 48%. We discuss the ethical and practical implications of these findings and argue that the forecasts could provide a transparent risk assessment tool to decision makers.

One-sided violence - civil war - power law distribution - conflict prediction - early warning - Syria

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1. Introduction¹

The Syrian civil war has aroused a wide variety of fears. These concerns especially included from the very beginning of this conflict the speculation about the possible use of weapons of mass destruction and the occurrence of extreme massacres. When the fighting in Aleppo, the second largest city, intensified in the summer of 2012, British Foreign Secretary Hague² warned of a “potential massacre”: “This utterly unacceptable escalation of the conflict could lead to a devastating loss of civilian life and a humanitarian disaster.” UN Special Envoy Brahimi similarly alerted the world community in early 2013 that the civil war could claim more than 100,000 civilian casualties until the end of the year should no political solution be found.³

As we sadly know, these prophecies have become more than true in the meantime. The Ghouta chemical attack of August 21, 2013, left several hundred people dead. Four months later, the UN confirmed in an official report that weapons of mass destruction had been used in this incident as well as in four other incidents.⁴ According to the Syrian Observatory for Human Rights, more than 120,000 people had been killed in the war until December 2013.⁵

This article reports on the attempt to forecast in February 2013 whether the conflict would escalate further and whether the war-torn country would again fall victim to extreme massacres with several hundred people killed in the period from March to May, 2013.⁶ The central technical innovation of our article is the usage of power laws to predict massacres. A pioneer of peace and conflict studies, Lewis F. Richardson⁷, was the first researcher to establish that the number of fatalities in conflicts follow a power law distribution. This means that extremely violent conflicts like the two World Wars of the 20th century are indeed rare, but occur much more frequently than one would expect on the basis of the normal distribution or similarly distributions.

Events like the ones occurring during the Syrian civil war follow a power law if the probability of occurrence is inversely proportional to the intensity of the individual acts of violence. Hence, conflict dynamics exhibit similar statistical characteristics as other processes for which Nassim Taleb⁸ has introduced the metaphor of “black swans”. The financial industry has, in his opinion, systematically underestimated the risk of stock market crashes and similar events because traders have based their models on the wrong distributional assumptions and implausible causal mechanisms.

We investigate on this statistical basis for the civil war in Syria, which continued to rage at the time our analysis at the end of February 28, 2013, if the distribution in the intensity of violence follows a power law and if the information about the conflict can be used for the development of meaningful prediction for political practitioners. Our analysis shows that the violent acts within the Levantine conflict indeed follow a power law distribution. Based on the algorithms of Clauset and Woodard⁹, we estimate that there was a 11% to 48% risk that at least one massacre with more than 250 killed people would happen in one of the 14 Syrian governorates in the period from March to May, 2013.

Our article ends with a plea in favor of systematic conflict forecasts. Systematic predictions and the establishment of sound early warning schemes are necessary tools for crisis decision making if the key governments were not able to prevent the crisis from breaking out in the first place. To this end, we compare our approach with other methods used for the forecasting of violent conflicts. We also discuss how power laws can be used as prediction tools, introduce our data sources and conclude with a presentation of our *ex post* and *ex ante* predictions and some general remarks.

2. Predicting political violence: Structural vs. procedural approaches

The literature on conflict forecasts differentiates between at least four ideal type forecasts.¹⁰ First, media and government agencies often rely on the predictions, sometimes precise, sometimes oracular, of experts who are considered especially knowledgeable on particular countries, regions, or actors. The qualitative predictions these specialists provide have undeniable advantages such as the ability to derive predictions that take the context of the particular case into account. Moreover, such conjectures easily reach a wide audience as they are most often not accompanied by an elaborate technical discussion. Qualitative predictions of individual experts have, however, the disadvantage that they cannot be replicated and that the accuracy often remains unsatisfactory, as Kahneman¹¹ and Tetlock¹² amply show. Experts are especially biased in the analysis of on-going conflicts. Yet, as the audience often shares the ideology of the specialists, inaccurate forecasts do not necessarily lead to a loss of reputation. The variance of the forecasts grows with the ideological diversity of the consulted experts. It is therefore not surprising that an evaluation of the predictive accuracy of experts (newspaper commentators) and quasi-experts (financial market traders)

establishes that the second group predicts more precisely the fate of ceasefires of various Middle Eastern conflicts. This superiority is not the least a consequence of the financial losses that inaccurate forecasts provide.¹³

A second approach to conflict prediction resorts to game-theoretic models of varying complexity.¹⁴ This approach takes expert information on the strength, the strategies, and interests of the actors involved into account, but does not include the speculations of these conflict specialists on possible conflict results. While this approach has found various applications especially in the analysis of EU decision making¹⁵, mainly Bueno de Mesquita has employed it in security studies as for instance in an examination of the potential for conflict resolution in the Middle East.¹⁶ In our view it is, however, slightly problematic that this pioneer of political forecasting has not published the algorithms on which his predictions are based.

The third approach to conflict prediction is much more transparent. It attempts to forecast conflict in a country or region through the usage of structural attributes of their units of analysis. Such comparisons have for instance been used in the analysis of interstate war. For example, Ward et al.¹⁷ demonstrate that the Democratic Peace theory is able to predict the occurrence of peace in country dyads, but not the onset of war. Technically, this means that the liberal theory is able to explain the event which is of lesser interest, peace, but that it cannot be equally successfully be employed to predict the complementary event, which is conflict, at the same time. Forecasts of civil conflict, conversely, are significantly more accurate. Rost et al.¹⁸, for instance, predict in an extension of Fearon and Laitin¹⁹ also the onset of internal wars.²⁰

Structural forecast share the basic features of the assessments of seismologists that a particular region carries a higher risk to experience earthquakes than another one. As structural data are often only available on the yearly level of analysis, we can use this approach to forecast *ex ante* the risk of political violence for a year not covered by the data set. Such predictions can, however, not clarify why some escalations processes in similarly risky countries end in large-scale violence, while others do not. What we therefore need is a process-based forecast for a particular state or region to assess dynamics of the conflict and to deduce from this basis predictions about the future development of violence.

The subsequent analysis of the conflict dynamics in Syria falls into the fourth category of conflict predictions. Methodologically, this type of forecast has resorted in recent years to

temporarily and spatially disaggregated event data. The appearance of “big data” has revolutionized the possibilities to analyze conflict dynamics. Researchers use in this context advanced statistical techniques and exploit new information sources such as social media.²¹ Ruhe²², for example, attempts to forecast switches from more to less escalated conflict phases and *vice versa*. What is here, however, missing is a forecast of the death toll of particularly violent events.

In the following, we intend to close this gap with a micro-level analysis of the dynamics of so-called one-sided political violence in Syria.²³ As indicated, we will employ in our forecasts of civilian victimization in the Syrian civil war the insights of Richardson and his successors that power laws apply to the intensity of violence across conflicts.

3. Using power laws as a tool for procedural conflict forecasts

There are many natural and social phenomena that follow a power law. For example, phenomena that are suspected to follow such a distribution – sometimes even wrongly – include the magnitudes of earth quakes, the diameters of moon craters, the intensities of solar flares, the sizes of forest fires, or the number of people affected by electricity blackouts.²⁴ Based on this insight, scholars have attempted to follow the early work of Richardson²⁵ and to use the unique characteristics of power law distributions to analyze the severity of violence across conflicts.²⁶

Power law distributions possess two main features that are of particular interest for scholar when researching the intensities of armed conflict. They belong to the family of so-called heavy-tailed probability distributions. In contrast to conventional distributions like the normal distribution, power laws have more mass in their tail. Unlike the normal distribution under which extremely violent events are almost impossible to occur, power law distributions attach even to genocidal massacres substantial probabilities that they might occur.²⁷

Heavy tails are, however, not an exclusive feature of power law distributions. There is a variety of probability distributions that allocate higher probabilities to events of extreme magnitude than the Gaussian distribution does. The unique feature of power laws is their so-called scale invariance. Scale invariance means that the probability of occurrence of every

event, like a massacre, is inversely proportional to its magnitude or intensity. If violence in a given conflict follows a power law, its probability of occurrence is defined by

$$\Pr(X \geq x) = x^{-\alpha}, \text{ for } x \geq x_{\min}. \quad (1)$$

Equation 1 shows that the so-called scaling parameter α is sufficient to describe the shape of the power law distribution. The scaling parameter hereby links the magnitude of a real or hypothetical violent event x with its probability of occurrence $\Pr(X \geq x)$.²⁸ It is therefore the scaling parameter α that determines the heavy-tailedness of the distribution. The smaller the parameter, the more heavy-tailed is the power law and thus the higher is the risk that the distribution attaches to extremely violent events.²⁹ Both the heavy-tails as well as the scale variance of power laws exhibit important implications for the prediction of violence against civilians in conflicts like the one we observe in Syria.

By estimating the scaling parameter it is possible to predict the occurrence of hypothetical events like a very extreme massacre if the violence within an ongoing armed conflict follows a power law distribution. Leaving the details on how to exactly estimate power laws to the technically interested reader³⁰, it is important to know that there are three general steps in the identification of this kind of probability distribution.³¹ In the first step, the scaling parameter α of the power law distribution is estimated. Real empirical phenomena usually do not follow a power law distribution for all values of the quantity of interest x . It is therefore necessary to estimate a lower bound called x_{\min} for which x , in our case one-sided violence in Syria, is characterized by the power law. If both parameters are identified, the second step consists of assessing the plausibility of the estimated power law distribution given the empirical data at hand. This includes both a test of the goodness-of-fit between the fatality data and the estimated power as well as an evaluation if other fat-tailed statistical distributions (like the log-normal distribution and the stretched exponential distribution, also known as the Weibull distribution) provide a better model of death tolls in a given conflict.³² If the power law survives these tests, scholars can then use the estimated power law to predict the probabilities for different violent events using a non-parametric algorithm.³³ Predicting massacres with power law distributions inevitably requires the identification of such a distribution. If and only if the power law offers a plausible statistical

model of violent acts within an armed conflict, scholars can use the scaling parameter to predict such incidents.³⁴

How ubiquitous are power law distributions in conflict? Using data on violence against civilians³⁵ and the method developed by Aaron Clauset, Cosma Rohilla Shalizi, and Marc Newman³⁶, Adam Scharpf³⁷ shows that violence against civilians is often power law distributed. Drawing on these results, Table 1 provides an overview on the presence of power law distributions in data on violence against civilians. Out of the 49 analyzed civil conflict settings, nearly half of them follow a power law.³⁸ In Europe and Latin America all conflicts follow a power law distribution. This result is heavily influenced by the bloody disputes in Bosnia, Chechnya, and Colombia. While there are conflicts in Africa and Asia that can be described by a power law (for example, Rwanda, Uganda, Indonesia, Sri Lanka), there are almost as many conflicts that do not show such a pattern of violence (for example, DR Congo, Liberia, and India). Analyzing the death tolls of conflicts in the Middle East, almost a third these deadly quarrels show fluctuations in violence that support the power law distribution.

Table 1 about here

Among these conflicts, the war in Bosnia is particularly well-suited to exemplify the political value of procedural predictions. In the following, we demonstrate how the methods sketched above provide the means to historically predict an event of the size of the Srebrenica massacre with at least 6.000 killed civilians between 1990 and 1995. Our data source is the Konstanz One-Sided Event Dataset (KOSVED).³⁹ Because this event dataset codes several up-to-date news sources, the death toll it provides for the Srebrenica massacre deviates significantly from current estimates.⁴⁰ However, we argue that this does not pose a serious problem since in ongoing conflicts like Syria competing parties have to rely on up-to-date news sources. Moreover, until quite recently news reports have been the only sources available on daily level that provided researchers with the necessary data to predict the risk of future atrocities. Figure 1-A depicts the result for predicting one-sided violence for the war in Bosnia. It maps the power law in a plot with double logarithmized

axes. While the x-axis shows the number of killed civilians, the y-axis depicts the probability of experiencing at least one event of size x or larger.⁴¹ Among the displayed atrocities the Srebrenica massacre is readily identifiable. The estimated power law features a scaling parameter of $\alpha = 1.84 (\pm 0.08)$ which implies that the probability distribution is considerably heavy-tailed.⁴²

Figure 1-B depicts our prediction results for the historical probability of the Srebrenica massacre.⁴³ Given the finite sample, we need to account for uncertainty in the estimated power law parameters, which is done by estimating slightly diverging power law models.⁴⁴ We account for uncertainty in parameters by estimating 10.000 bootstrapped power laws. 90% confidence intervals of the *ex post* probabilities are constructed by sampling 1000 synthetic data sets from every bootstrap power law model. For the Bosnian war, we ascertain a historical probability of 49% (25% - 73%) for at least one violent event of 6.000 or more killed civilians between 1990 and 1995.⁴⁵ These probabilities suggest that the massacre in Srebrenica was not a statistical outlier but rather a typical outcome of the process underlying this conflict.

Figure 1 about here

Overall, our results pose the question if the international community had been able to prevent the loss of more than 6.000 human lives would it have had information on the risk of such an extreme act of violence to intervene swiftly and early on in the conflict. Critical readers might argue that it is always possible to criticize (in-)action of actors after one has obtained substantive information after an event had occurred and after one is aware of its far-reaching consequences. To account for such an objection and to provide political decision makers with readily usable information for their crisis management, we undertake a real-time forecast for the violence against civilians in Syria in the following section.

4. Reporting violent events in Syria

The following analysis will address the question if we need to fear of another escalation of violence. We hereby use data from oppositional networks which have continuously monitored the number of killed civilians since the beginning of the conflict. A unique characteristic of the Syrian conflict is the publishing of body counts in real time. Organizations actively make use of internet platforms, social networks and other virtual means of communication and documentation to distribute data. The *Syrian Shuhada*⁴⁶ and the *Center for Documentation of Violations in Syria* (VDC)⁴⁷ allow direct access to their data. Access to other databases as the *Syrian Revolution General Council* or the *Syrian Network for Human Rights*, the *Syrian Observatory for Human Rights* or the *March 15 Group* appears to be more difficult. Apart from these non-governmental organizations, the Syrian news agency *Sana* only releases sporadic reports which include victim-counts for single events⁴⁸ and hence cannot be used for a comprehensive documentation. The validity of these data is especially questionable if we take into account that the death counts of the Syrian regime tremendously deviate from information provided by other sources.

A report by the human rights organization *Human Rights Data Analysis Group* (HRDAG) published in January 2013 on behalf of the United Nations combines data of various Syrian sources; to this date the United Nations and other international actors have rather confined themselves to vague estimates. According to the report, the casualty figure of the bloody struggle amounted to 59.648 conflict-related killings until the end of 2012⁴⁹ – a figure which was “much higher than expected” and “truly shocking” according to the United Nations and media.⁵⁰

Calling validity and reliability of the victim-statistics into question by different actors is inherent in the debate of armed conflicts.⁵¹ In the case of Syria, Joachim Guilliard⁵² declares the published data of victims as an “intervention-propaganda of the West”. It cannot be denied that the abovementioned Syrian NGOs follow political goals and are openly critical to the regime.⁵³ Missing access for independent actors is particularly problematic in this respect, as Paul Sérgio Pinheiro, the Chairman of the Independent International Commission of Inquiry for Syria, points out.⁵⁴ In order to make use of the available data, criteria as public access, comparability and verifiability, connection to local communities as well as the publication of disaggregated data are thus crucial.⁵⁵ In our analysis we therefore solely focus on sources that provide easy and unrestricted access to their online databases. The website *Syrian Shuhada*⁵⁶ maintains a detailed database with information on the location, date and

cause of death, as well as on the names, age and sex of the victims. Reports by the US *Congressional Research Service*⁵⁷ are mainly based on data of the *Syrian Shuhada*⁵⁸ database which draws upon various sources including news sources, oppositional organizations and Facebook-groups to collect information (e.g. *The Martyrs of Syrian Revolution*).⁵⁹ It also lists VDC⁶⁰ as a source of information. The VDC for its part works together with oppositional activist networks, so called *Local Coordination Committees*, and records according to its own statement “martyrs and detainees of the Revolution in line with international standards to document human rights violations”.⁶¹ Various Arabic and international NGOs relate to data of the VDC in their official statements.⁶² The German news magazine *Der Spiegel* classifies the VDC-data as “so far very reliable”⁶³ and the *Foreign Policy Magazine* uses it for their analyses.⁶⁴ Because *Syrian Shuhada*⁶⁵ database integrate data of the VDC⁶⁶ in their casualty figures, we draw on the former data source for our analysis. *Syrian Shuhada*⁶⁷ allows us to distinguish between civil and military casualties. To project the sufferings of the Syrian civil population as unbiasedly as possible, we will focus in our analysis exclusively on one-sided violence, meaning violence against civilians.

Figure 2 about here

Figure 2 highlights the amount of violence under which Syria’s civilian population has been suffering since spring 2011. The conflict has significantly intensified, as the daily numbers of civilian victims show in Figure 2-A. While days with a three-digit body count have been the exception during the first conflict year, the daily number of killed civilians has clearly increased since the beginning of 2012. We can find the most violent days of the Syrian conflict in this time period, as Figure 2-A shows. The day with the highest number of victims until the end of February 2013 has been August 25, 2012 with 414 killed civilians, of which 272 casualties alone account for the massacre in Daraya, a suburb of Damascus.⁶⁸ Only imperceptibly fewer civilians lost their lives on February 4, 2012. The death toll mainly stems from the military offensive in Homs, where 360 civilians were killed.⁶⁹ This day marks the bloodiest day in a Syrian province since the beginning of the documentation of one-sided violence in Syria. Also significant is August 26, 2012. On this day approximately 374 people

died. The disaggregated data here let us to conclude that the number of victims are not, as it could be assumed, the sole result of a bomb attack in the heart of Damascus, but that another massacre took place in a suburb of Damascus.⁷⁰

Starting with the deadly gunfire at protesters in Dara'a and Damascus in March 2012, the conflict has been geographically centered in the provinces of Hama, Homs, Dar'a and Idlib. Since the middle of the year 2012 the major cities of Aleppo and Damascus have also become places of clashes and massacres of the civilian population. This reflects the military strategy of the Syrian government and its affiliated militias. It seems to be the aim of the Syrian regime to maintain its power in the large cities as Hama, Idlib, Dar'a and Latakia while combining this with the directed siege of "troubled" smaller towns by regime troops. The Syrian Army hereby seems to mainly focus on "kittling" cities through air strikes and tank shelling, while oppositional groupings primarily concentrate on strategic objectives as oil fields or airports.⁷¹

While in single cases the Syrian military seems to target civilians seems for tactical reasons, as recent reports about the massacres indicate, significant casualties amongst the civilian population are the result of intentional shelling and extensive bombardments of residential districts.⁷² According to Figure 2-B, which shows the cumulative death toll over the trajectory of the Syrian civil war, violence against civilians shows no sign of decline. Till today the international community was not able to halt the violence in Syria. It rather seems that the suffering of the civil population has even been aggravated in the immediate context of the two veto-decisions in the UN Security Council. This raises the question of how likely different acts of violence in Syria have been in the past and will be in the future.

5. Forecasting violent events in Syria

"Useful forecasts need to be produced in near-real-time"⁷³. Based on this principle, we undertake a risk forecast of extreme acts of violence in the Syrian civil war, making use of the *Syrian Shuhada* database.⁷⁴ Our unit of analysis is hereby the single governorate-day.⁷⁵ Drawing on the methods briefly introduced above, we start with predicting historical probabilities for at least one governorate-day with 250, 360, 500, 750, and 1.000 or more civilian deaths. In a second step we undertake an *ex ante* forecast of the violence against

civilians for nearly three months starting on the March 1, 2013. We hereby predict the risk of observing at least one governorate-day with at least 125, 250, and 500 civilian casualties.

Based on the intensity of violence for 4495 governorate-days recorded by the *Syrian Shuhada* database, we estimate a power law with $x_{\min} = 45 (\pm 8)$ and a scaling parameter of $\alpha = 3.72 (\pm 0.33)$. The x_{\min} value demonstrates that the power law is a plausible description for extreme massacres. It governs the tail of the distribution and quickly drops off which is the result of the relatively high value of the scaling parameter. The effect of the different sizes of the scaling parameters is especially apparent when we compare the power law distribution for the Syrian civil war depicted in Figure 3-A with the power law of the war in Bosnia in Figure 1-A. In the Syrian case the power law distribution is far less heavy-tailed. Thus, while we should expect extreme violent acts to occur in Syria, genocidal acts like the Srebrenica massacre seem to be highly unlikely.⁷⁶

To substantiate our suspicion, we predict the historical probabilities of massacres of different sizes till the end of February 2013. The results of the *ex post* prediction are shown in Table 2 and Figure 3-B depicts the accompanying prediction models. The results demonstrate that while it has been reasonable to expect an increase in the severity of violence, we could have ruled out the occurrence of especially extreme violence since the beginning of the Syrian conflict. According to our prediction, for bloodiest day in Syria conflict with 360 civilian casualties in the Homs governorate there is a chance of nearly 47% (25.4% - 68.7%). For at least one governorate-day with 250 or more killed civilians we estimate the risk as being as high as 79.8% (59.4% - 94.1%). In the light of these substantial probabilities, we conclude that massacres are not single, randomly, and unforeseeable events.⁷⁷ Even an imaginary day in one of the 14 governorates with at least 500 deaths – these are over 100 victims more than the bloodiest day has claimed till the end of February 2013 in the whole of Syria – exhibits a substantial probability of 24% (10.6% - 41.0%).

Figure 3 about here

The results demonstrate how violence has escalated in the Syrian civil war till the end of February 2013. However, and this is also shown by our results, an unlimited spiraling of

violence is nearly impossible. With increasing death tolls, the probabilities of observing extreme acts of violence against civilians are significantly reduced. We estimate the risk of at least one day in one governorate with 1.000 or more killed civilians – that is four times the death toll of the most violent day in one of the Syrian governorates – to be about 4.4% (1.2% – 9.5%). While there has been a constant risk of extremely violent acts since the beginning of the Syrian conflict, the occurrence of acts with intensities that significantly exceed previous death figures were not very likely.

Table 2 about here

Given our historical predictions, how likely is a further escalation of violence in Syria? To answer this question we *ex ante* predict the risk of observing one or more days with at least 125, 250, and 500 killed in one or more of the 14 Syrian governorates between March and May 2013.⁷⁸ Our prediction relies on two crucial assumptions. First, the power law needs to be a plausible tail model for extreme events of violence in Syria. Our statistical tests show that test is indeed the case. However, the tests also reveal that the log-normal distribution as well as the stretched exponential distribution cannot be refuted as plausible models of the data. The question of whether a phenomenon follows a power law distribution or any other statistical distribution is highly relevant for the prediction of very extreme events that lie far out in distribution's tail.⁷⁹ For events of medium size heavy-tailed distributions like the log-normal distribution or the stretched exponential distribution are perfectly able to mimic power law distributions. For events of extreme magnitude this is not possible.⁸⁰ We therefore use all three probability distributions to predict the *ex ante* risk of massacres. Second, in order to forecast the likelihood of extreme massacres we need to assume a general trend in violence throughout our forecasting window. To cover a broad spectrum of potential developments, we construct three different scenarios. The "status quo" scenario assumes that the number of violent events remains stable.⁸¹ While the "pessimistic" scenario is based on the assumption of a doubling of violence, the "optimistic" scenario describes a halving of the number of violent governorate-days.

Table 3 about here

Table 3 shows the results of our predictions. For at least one day with at least 250 civilian deaths in one of the 14 Syrian governorates we calculate a probability between 11% and 48%. Taking into consideration that there were only two events within our whole period of study that exceeded this intensity of violence this is a clear indication that we should be prepared to experience more extreme massacres in the next three months. This result is further strengthened by our forecast of observing at least one governorate-day with 125 or more civilian casualties. We estimate a chance between 60% and 98% for such an event.

Aside of these worrying results, our prediction also shows that a general cooling-down of the conflict leads to a substantial reduction in the risk of extreme massacres. If the number of days throughout Syria that feature civilian deaths are reduced by one half, the probability of a massacre with at least 250 deaths occurring falls below 16% and for massacre with at least 125 it decreases from 87% to nearly 60%. Moreover, given the data at hand our results suggest that an extreme massacre with at least 500 killed civilians within one or more days in one of the governorates is relatively unlikely to occur. The chance of such an event is not more than 10% even under the pessimistic scenario.

Overall our results support two broad conclusions: If the international community does not bring itself to a political or military solution of the Syrian conflict in the next couple of weeks and months, we have to be prepared to observe further atrocities and war crimes in the near future. But a genocidal escalation of violence like the one we observed in Bosnia is – and from a humanitarian point of view that is the positive implication of our analysis – highly unlikely.

Evaluation:⁸² How accurate are our forecasts? The overall aim of this article is to provide policy makers with an early warning system to assess the risk of extreme massacres. Accordingly, we focus on a massacre of 500 killed civilians to evaluate the accuracy of our model. Readers may keep in mind that in the data that we use to train our model the most severe event exhibits 360 killed civilians. We therefore consider the prediction of a fictional governorate-day of 500 civilian deaths to be a crucial test to our system. Given the extremely rare character of events of this size and the highly disaggregated nature of our data, we

argue that a risk of greater than 1% for an event of this magnitude should be a strong alarm for political decision makers to react to the violence ongoing. To assess the accuracy of our *ex ante* prediction we collect data from the *Syrian Shuhada*⁸³ database for our 90 day forecasting window which were not available at the time we undertook our forecast. The data shows that the overall level of violence in Syria has remained relatively stable. There are 861 governorate-days of deadly violence against civilians. The “status quo” scenario which consists of 823 governorate-days provides us thus with the appropriate setting to evaluate our forecasts.

Looking at the “status quo” scenario in Table 3, we estimate the risk of observing at least one extreme event with 500 or more killed civilians to be two times the probability of our benchmark for rare and extreme events under the log-normal distribution. Under the power law distribution it is even five times the likelihood. With this information at hand, policy makers should therefore have expected such a governorate-day of this magnitude to occur.

Checking the data for our forecasting window between March and May 2013, we observe that there is indeed one governorate-day of such magnitude. On the April 21, government forces re-captured the city of Jdaidet al-Fadl outside of Damascus in the governorate of Rif Dimashq after several days of heavy fighting. On the last day of fighting, the Syrian Army allegedly perpetrated a massacre by summarily executing civilians.⁸⁴ *Syrian Shuhada*⁸⁵ reports the deaths of 503 civilian for this day thereby marking the most violent day in one of the Syrian governorates since the start of the civil war. Based on our forecasted probabilities our early warning system has not only predicted the occurrence of this massacre but it could have put decisions makers in a position of anticipating this event and of undertaking adequate steps to prevent this tragic event from occurring.

6. Discussion and Conclusion

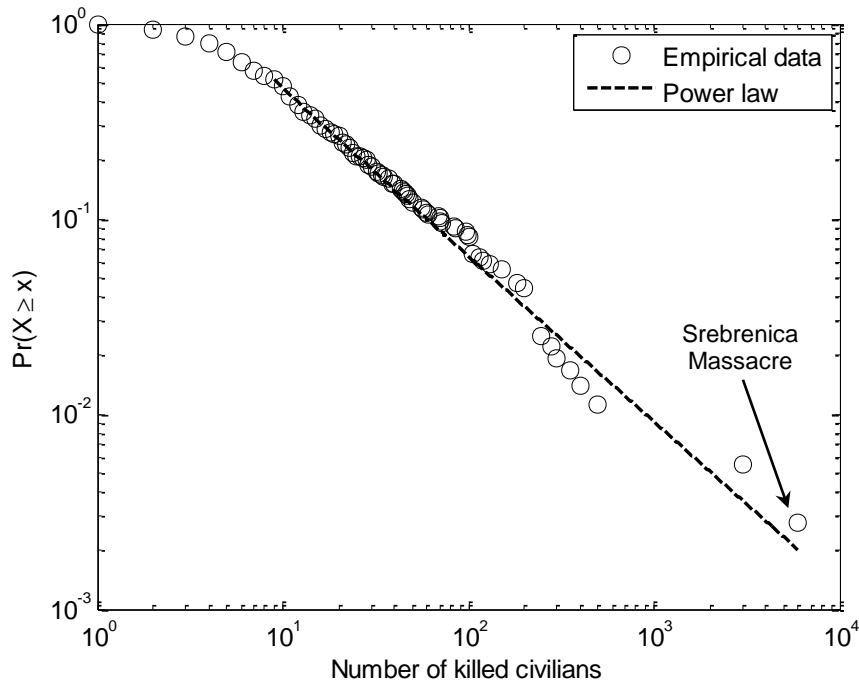
Our analysis reveals clearly that the lack of an early humanitarian intervention exacerbated the danger of a further escalation of the violence in the beginning of 2013. We are, based on this result and similar studies, convinced that decision makers should resort more systematically to dynamic conflict forecasts as these predictions not only enable them to assess the risk of extreme human rights violations and war crimes but also to strengthen those measures that improve the security of civilians.⁸⁶ Fortunately, there is an increased

interest of some Western decision makers in early warning. This tendency is simultaneously reflected in the growing importance of conflict forecasts in quantitative conflict analysis.⁸⁷ However, such predictions cannot - and should not - prejudice the choices of the responsible political leaders; they can also not replace other fundamental ingredients of the decision making process. But structural predictions that forecast the risk of conflict in the near future for countries and regions comparatively, should become as much a routine of the decision making process as the dynamic forecasts for which we have presented an application for Syria. Only this way can we ascertain that the extreme violence leveled against the population in a region can be systematically anticipated and prevented. We believe that the problem that our forecasts develop into "self-fulfilling prophecies" is rather small for Syria. Graham Greene and John Le Carré describe in their parodies *Our Man in Havana* and *The Tailor of Panama* this moral dilemma that any conflict forecast faces. The spying novel shows how agents contribute involuntarily through their invented events to the escalation of a conflict. Conflict forecasters can obviously not completely shield themselves against the danger to over- or underestimate the potential for conflict escalation through their usage of faked information or through the unavailability of reliable data. A biased informational basis will force them – voluntarily or involuntarily – to side with one of the warring parties. This risk of biased forecasts is, however, smaller in the Syrian case because of the surprisingly detailed victim statistics that various NGOs provide. We can nevertheless not completely exclude the possibility that the consulted sources overestimate - rather than underestimate the number of victims. Extensive reliability checks would obviously counter this risk, but this could only be done with a certain delay, preventing conflict forecasters from estimating the risk of escalation *ex ante* and reducing the value of systematic predictions for early warning. We believe that the radical alternative to completely repudiate the analysis and the prediction of actual political violence is morally more objectionable. The skepticism against forecasts is all too often based on the prejudice that (quantitative) conflict research does not possess any practical relevance. It is clear that forecasts can be far off the mark. But even if this is the case, we hope that we have contributed to an objectification of the debate about the responsibility of the West in the Syrian civil war and that we have illustrated the need to use scientifically based early warning mechanisms in crisis decision making.

Figures and Tables

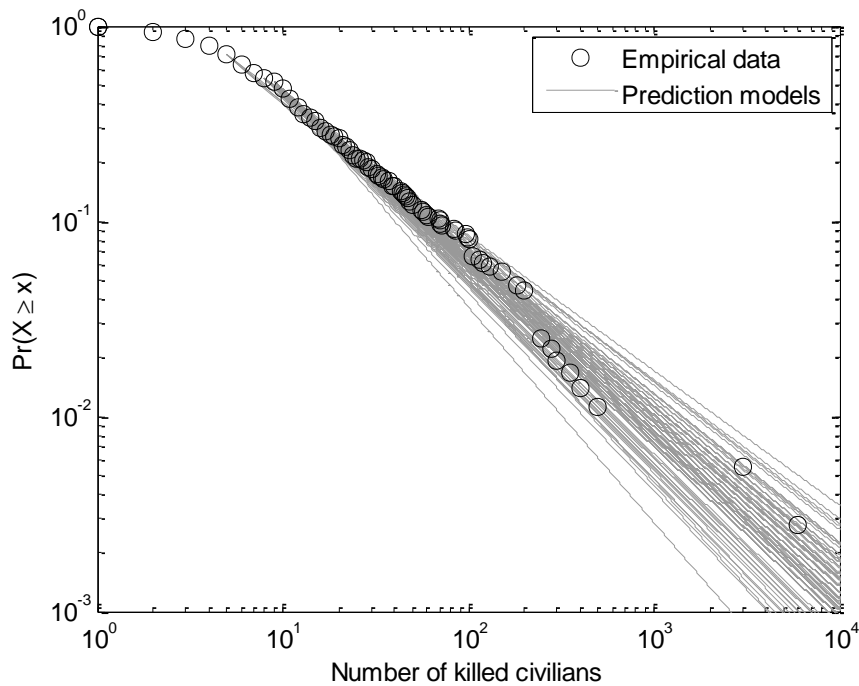
Figure 1: Predicting massive violence against civilians during the Bosnian war, 1990-1995, using power laws.

1-A: Identifying the probability distribution of violence severity



Note: Data taken from *Konstanz One-Sided Violence Event Dataset (KOSVED)*.

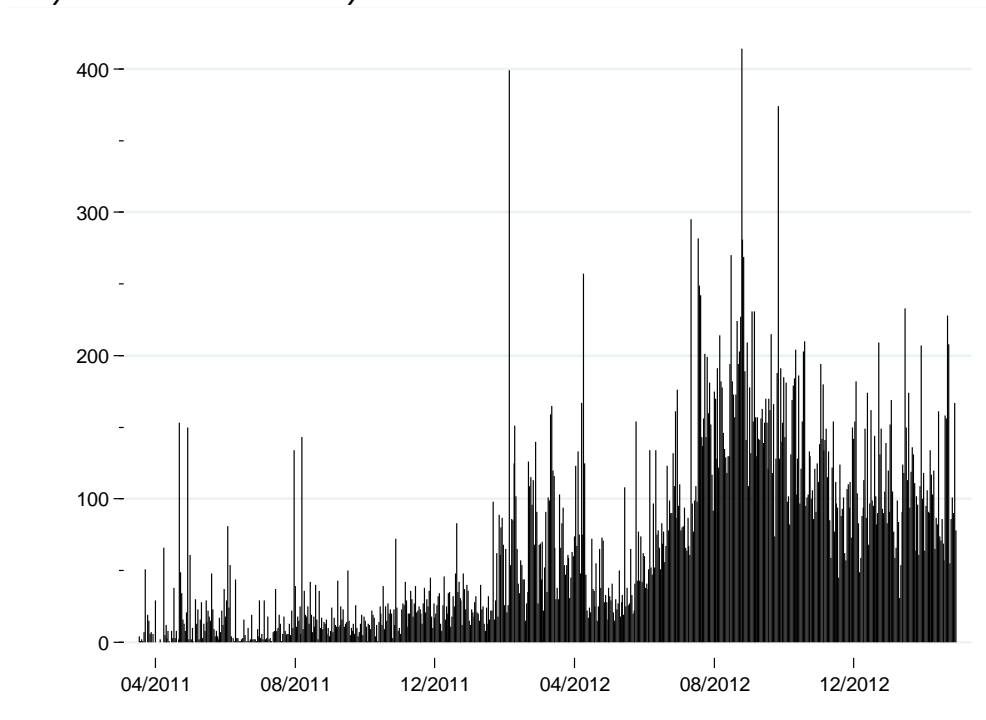
1-B: Ex post prediction of the Srebrenica Massacre



Note: Figure displays 100 of 10,000 bootstrap power law tail models with varying x_{\min} and scaling parameters. Data taken from the *Konstanz One-Sided Event Dataset (KOSVED)*.

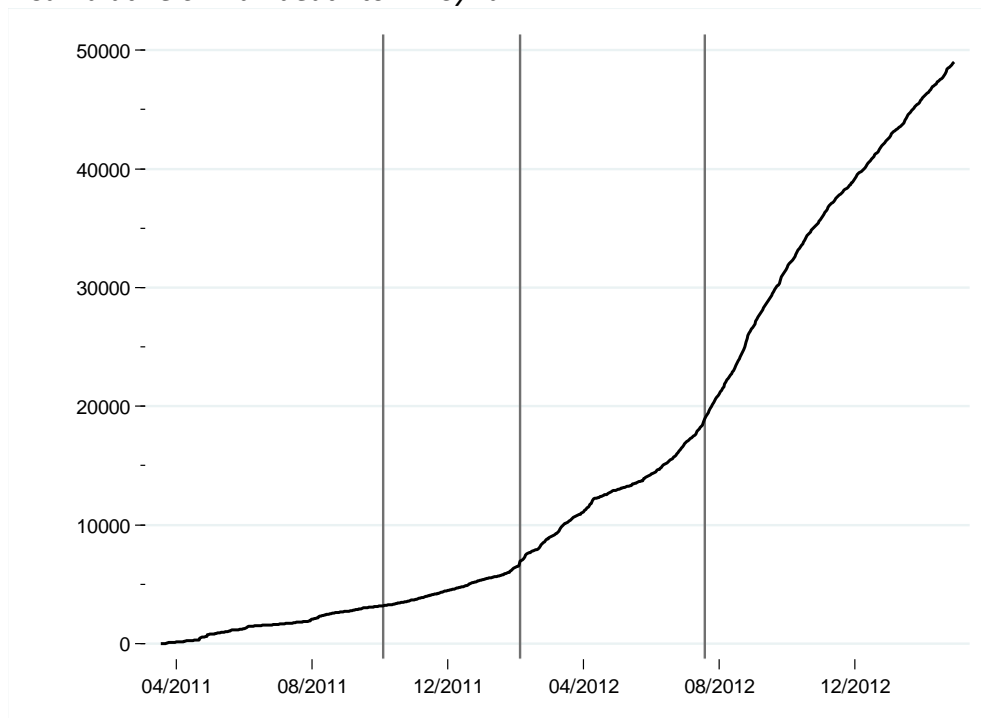
Figure 2: Trajectory of the Syrian conflict between March 2011 and February 2013.

2-A: Daily civilian death toll in Syria



Note: Data taken from the *Syrian Shuhada* database.

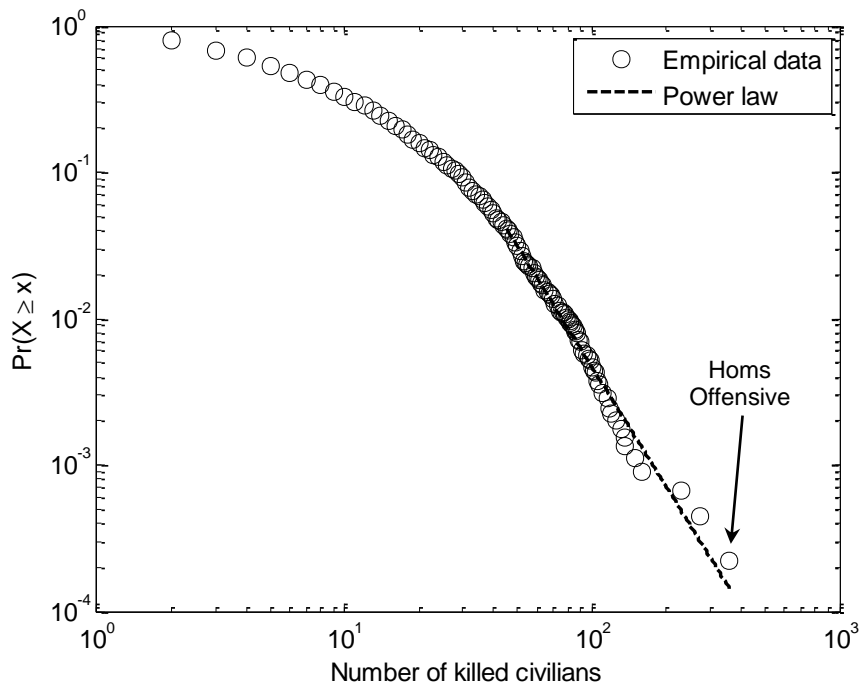
2-B: Cumulative civilian death toll in Syria



Note: Horizontal lines indicate vetoes in the UN Security Council. Data taken from the *Syrian Shuhada* database.

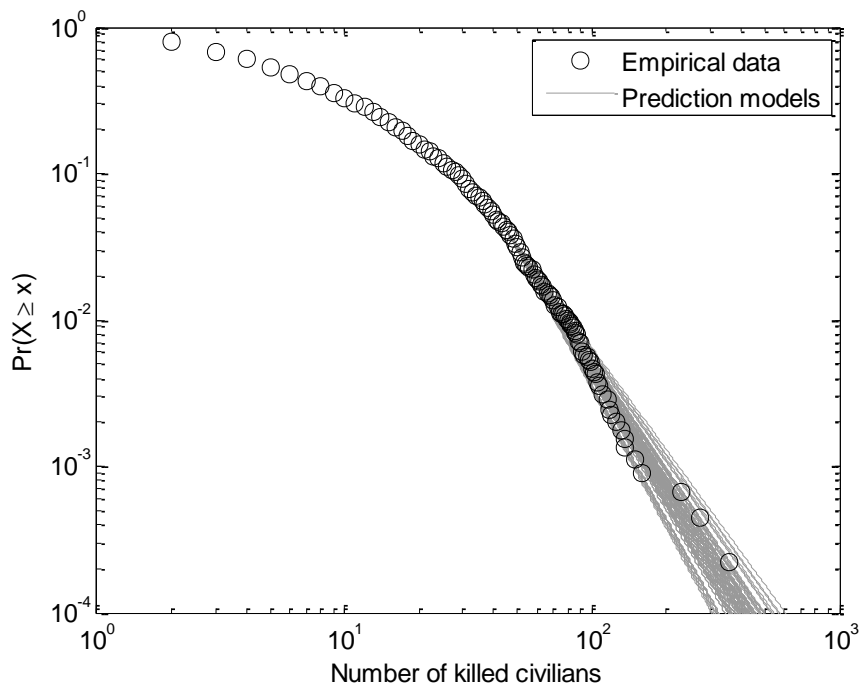
Figure 3: Predicting violence against civilians in Syria between March 2011 and February 2013 using power laws.

3-A: Identifying the probability distribution of violence severity



Note: Data taken from Syrian Shuhada database.

3-B: Ex post prediction of violence against civilians



Note: Figure displays 100 of 10,000 bootstrap power law tail models with fixed $x_{\min} = 45$ and varying scaling parameters for a massacre of at least 250 killed civilians. Data taken from Syrian Shuhada database.

Table 1: Power law distributed violence against civilians in civil wars.

Region	Power law	No power law	Total (%) N
Africa	45,5% (10)	54,5% (12)	100,0% (22)
Americas	100,0% (2)	0,0% (0)	100,0% (2)
Asia	50,0% (2)	50,0% (2)	100,0% (4)
Europe	100,0% (5)	0,0% (0)	100,0% (5)
Middle East	31,3% (5)	68,8% (11)	100,0% (16)
Total (%) N	49,0% (24)	51,0% (25)	100,0% (49)

Note: Numbers in parentheses denote absolute frequencies. Due to different data sources and operationalizations frequencies do not correspond to the number of analyzed conflicts.

Table 2: Historical risks of massacres in Syria between March 2011 and February 2013.

Number of civilian casualties	Probabilities of occurrence	90% confidence intervals
250	79.8%	59.4% - 94.1%
360	46.7%	25.4% - 68.7%
500	24.0%	10.6% - 41.0%
750	8.9%	2.9% - 17.7%
1.000	4.4%	1.2% - 9.5%

Note: *Ex post* predictions are based on 10.000 bootstrap power law tail models with $x_{\min} = 45$ and varying scaling parameters. Confidence intervals are calculated by sampling 1.000 synthetical data sets of each tail model. Data source is the *Syrian Shuhada* database.

Table 3: Ex ante risk prediction of massacres in Syria from the beginning of March till the end of May 2013.

Number of civilian casualties	Tail model	„Optimistic“ scenario with $N_{90\text{day}} = 412$	„Status quo“ scenario with $N_{90\text{day}} = 823$	„Pessimistic“ scenario with $N_{90\text{day}} = 1650$
125	Power law	65.1%	87.3%	98.1%
	Stretched exponential	61.6%	84.6%	97.3%
	Log-normal	60.1%	83.4%	96.7%
250	Power law	15.4%	28.2%	47.6%
	Stretched exponential	12.6%	23.3%	40.8%
	Log-normal	10.7%	20.0%	35.6%
500	Power law	2.6%	5.2%	10.0%
	Stretched exponential	1.9%	3.6%	7.1%
	Log-normal	1.3%	2.6%	5.0%

Note: Each ex ante prediction is based on 1.000.000 bootstrap tail models. Power law models feature $x_{\min} = 45$. For each scenario, $N_{90\text{day}}$ indicates the number of governorate-days with at least one killed civilian within the 90 day forecasting window starting on the 01st March 2013. Data source is the *Syrian Shuhada* database.

¹ The article was originally published in May 2013 in the *Zeitschrift für Friedens- und Konfliktforschung* (http://www.zefko.nomos.de/fileadmin/zefko/doc/Aufsatz_ZeFKo_13_01.pdf) and has been translated and slightly adapted by the authors for this publication. The data used in the original as well as this analysis can be found on the data replication page of the second author (<http://www.polver.uni-konstanz.de/gschneider/arbeitspapiere/replikationsdaten/>). Gerald Schneider has received financial support for this research through the *German Peace Science Foundation*. The original idea for this article has been presented at the workshop “The Quality of Measurement” at the Technical University Dresden in September 2012. This presentation and colloquia at the Universities of Mannheim and Konstanz as well as the Peace Research Foundation Frankfurt further strengthened the original article as well as this adaptation. We would like to thank Dominic Nyhuis for his support on the data extraction, the two reviewers for helpful comments,

Christoph Weller, Wolf-Dieter Eberwein, and Antoinette Groom for their help and their efficient management of the publication process.

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³¹ Code for implementing the methods used in this article are available under:

<http://tuvalu.santafe.edu/~aaronc/powerlaws/> and <http://tuvalu.santafe.edu/~aaronc/rareevents/> (accessed 3 February 2014)

³² Clauset, Shalizi, Newman, op. cit., p. 661-703

³³ Clauset and Woodard, op. cit., p. 1838-1865

³⁴ The method requires a stationary production process of events. For the *ex ante* forecast, we use a window of 90 days. The statistical procedure we use here is data driven as it does not take into account spatial patterns in the occurrence of events or the influence of variables that might change the conflict process. We use different scenarios to account for an overall change in the conflict process.

³⁵ Eck and Hultman, op. cit., p. 233-246; Schneider and Bussmann, op. cit., p. 635-644

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³⁷ Adam Scharpf, *Massacres and the Power Law: Explaining and Predicting One-Sided Violence*, Konstanz (2012), Master-Thesis

³⁸ Data sources differ considerably in terms of time coverage and operationalizations which makes it difficult to provide a precise count of analyzed intrastate armed conflicts. The study generally covers episodes of conflicts in 25 different countries. Conflict-specific results are given in Scharpf, op. cit.

³⁹ Schneider and Bussmann, op. cit., p. 635-644

⁴⁰ Helge Brunborg, Torkild Hovde Lyngstad, Hendrik Urdal, 'Accounting for Genocide: How Many Were Killed in Srebrenica?', *European Journal of Population*, Vol. 19, No. 3 (2003), p. 229-248; Potocari Memorial Center 2013: "Srebrenica – Potočari", available: http://www.potocarimc.ba/_ba/liste/nestali_z.php#z1 (accessed 3 February 2014)

⁴¹ Given the logarithmized axes and the complementary cumulative density function $\Pr(X \geq x)$, the power law is displayed as a straight line with a slope of $\alpha-1$.

⁴² We checked the goodness-of-fit between the estimated power law distribution and the data. The power law distribution is a plausible model of the data. Please note, however, that this is also true for other heavy-tailed distributions which can therefore not be rejected as plausible models.

⁴³ The Srebrenica massacre was excluded from the data before estimating its historical probability.

⁴⁴ Clauset and Woodard, op. cit., p. 1840-1841

⁴⁵ The estimation method allows us to hold the lower bound of the power law models x_{\min} constant. The resulting probability of the Srebrenica massacres remains with 47% (27% - 68%) virtually unchanged.

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⁵⁶ Syrian Shuhada, op. cit.

⁵⁷ Jeremy M. Sharp, Christopher M. Blanchard, "Armed Conflict in Syria: U.S. and International Response", *Congressional Research Service* (July 2012), available: <http://fpc.state.gov/documents/organization/195385.pdf> (accessed 3 February 2014)

⁵⁸ Syrian Shuhada, op. cit.

⁵⁹ The Facebook Group of *The Martyrs of Syrian Revolution* can be found under <https://www.facebook.com/Syr.Martyr>.

⁶⁰ VDC, op. cit.

⁶¹ *Ibid.*

⁶² These NGOs include *Human Rights Watch*, *Fédération Internationale des Droits de l'Homme* or the *Cairo Institute for Human Rights Studies*.

⁶³ Rania Salloum, "Hier foltern Assads Agenten", *Der Spiegel* (July 2012), available: <http://www.spiegel.de/politik/ausland/folter-in-syrien-human-rights-watch-veroeffentlichtneuen-bericht-a-842125.html> (accessed 3 February 2014)

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⁷⁴ Syrian Shuhada, op. cit.

⁷⁵ As the *Syrian Shuhada* database does not provide reliable spatial information, we aggregate the individual level data on the governorate-day level.

⁷⁶ One could therefore argue that the gas attack in Ghouta was either the result of change in the overall conflict dynamic or that the casualty figures are lower than the ones reported by some Syrian sources.

⁷⁷ See Stathis N. Kalyvas, 'Wanton and Senseless? The Logic of Massacres in Algeria', *Rationality and Society*, Vol. 11, No. 3 (1999), p. 243-285

⁷⁸ To simplify statistical computation, we predict the risk of governorate-days with different death tolls for a 90 days window.

⁷⁹ Clauzet, Shalizi, Newman, op. cit., footnote 10

⁸⁰ Taleb, op. cit., p. 396

⁸¹ The construction of scenarios is based on the overall number of governorate-days with at least one civilian casualty as well proportion of events with at least 45 deaths between 30th November 2012 and the 28th February 2013. Given this time span, our dataset contains 823 deathly governorate-days of which 34 feature 45 or more killed civilians.

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⁸⁶ See Jay Ulfelder, "Making a Case for (Imperfect) Statistical Modeling as the Basis for Genocide Early Warning", available: <http://www.usmmm.org/m/pdfs/20111021-ulfelder-early-warning.pdf> (accessed 3 February 2014)

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