

Growth and Violence: Argument for a Per Capita Measure of Civil War *

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June 10, 2014

Abstract

This article proposes a new measure of civil war. The measure defines violence intensity in casualties per capita instead of number of casualties. We discuss the assumptions behind this *per capita model* and the existing *standard model*. We show that the two measures behave differently in standard growth regressions at the country level and argue that this is because the standard model is a mis-specification in this context. Casualties appear to affect growth more in smaller populations. Using spatially disaggregated data we show that the validity of the per capita model is driven by spacial decay of the effects of violence. This makes the model valid at the local level but invalid at the country level. In this way the two measures can help distinguish between competing theories in the conflict literature.

Keywords: civil war, conflict, growth

JEL-Codes: D74, O11, O47

*I thank Tim Besley, Olivier van den Eynde, David Laitin, Torsten Persson, David Schoenholzer and Jacob Shapiro for their useful comments and encouragement. I acknowledge financial support from the Ramon y Cajal programme and Spanish Ministry of Economy and Competitiveness, through the Severo Ochoa Programme for Centres of Excellence in R&D (SEV-2011-0075). All errors are mine.

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1 Introduction

The empirical study of civil war has recently experienced a boom. An important tool for this research has been data on conflict victims both on the national level and, more recently, at the sub-national level. Typically, empirical work uses the absolute number of victims or conflict events to distinguish between different intensities of violence.¹ The UCDP/PRIO Armed Conflict Dataset, for example, uses two thresholds of 25 and 1000 battle related deaths to define dummy variables which have been used extensively in the cross-country literature. Even when other data is used, the 1000 death threshold is an important element of the way civil wars are defined.

Countries differ significantly in their population size. The thresholds of 1000 and 25 casualties are therefore applied to units of observation that are extremely heterogenous. Figure 1 illustrates one consequence of this definition. The figure shows the relationship between population size and the prevalence of civil war, as defined by the 1000 casualties threshold.² The higher is population, the higher is the likelihood of experiencing a civil war. This raises the concern that the combination of heterogenous units and an absolute threshold is the "wrong" model to study the effects and causes of civil war. At the extreme this is trivially true - without population violence is impossible.

This article discusses the theoretical assumptions behind two ways of coding civil wars: a violence measure that uses absolute numbers (the standard model) and a measure in per capita terms (the per capita model). We show that the two measures imply very different assumptions regarding the relationship between violence and the respective independent or dependant variables. For example, the effect of violence needs to grow proportionally with population to justify the use of the standard model in studies of the effect of violence. In other words, there must be a public bad aspect to violence. As a rule of thumb, the per capita model seems more adequate if violence is put into a relationship with economic factors like the unemployment rate or GDP per capita, i.e. if decentralized individual decisions are to be explained. Political factors like state fragility, political crisis or ethnic conflict will typically have strong public aspects that can justify a state-centered view and, hence, use of the standard model.

¹See, for example, Besley and Persson (2011), Brueckner and Ciccone (2010), Collier et al (2009), Esteban et al (2012), Faeron and Laitin (2003), Miguel et al (2004).

²Figure 1 shows twenty country groups in which each group contains 5 percent of the sample. Countries are grouped according to their population size and the graph reports the log of the mean within the group. The pattern for the lower threshold of 25 casualties is the same.

To illustrate the potential impact of this modelling choice we first study the effect of civil war on GDP per capita growth at the country level.³ We show that defining civil wars with the number of battle-related deaths in this context could be an error. The economies of populous countries appear to be significantly less affected by casualties than the economies of less populous countries. Indeed, when we analyze the economic impact of civil wars on growth, the per capita measure produces estimates that are up to 40 percent larger than in the standard model.

This should not be seen as an argument that the per capita model is the "right" model in all cases. Instead, we argue that theory should provide the fundament for empirical work. There is a conceptual weak spot that is generated by the use of the standard model as a default. The danger is that new insights from micro studies will be hard to interpret and extrapolate. In order to illustrate this we bring the analysis to a more disaggregated level. While data limitations are important here our analysis for the African continent suggests that, locally, the standard model appears to do a much better job in predicting the damage caused by violence. Violence seems to be a public bad locally, i.e. at 50 km distance.

If the cell-level analysis is consistent with the cross-country evidence it must be true that the correlation between violence and low growth dissipates across distance. We show that, indeed, violence in the close vicinity of about 150km is still correlated with growth but that this effect fades out between 150 and 250km distance. This suggests that violence in the corner of a large, populous country like India does not affect the whole population. In other words, violence is not a public bad at the country level and the standard model is not adequate to study the effect of violence at the country level.

We proceed as follows. Section 2 discusses some of the related literature to show that the issue of scale is largely sidestepped. The following section provides the theoretical underpinnings of the standard and the per capita model. In Section 4 we illustrate the importance of the model choice with the analysis of the impact of violence on per capita GDP growth. Section 5 discusses the findings and their relevance for existing work.

³We address concerns of unobserved heterogeneity by including country and year fixed effects. Reverse causality remains a concern. However, the issue to be illustrated here remains regardless of the direction of causality.

2 Related Literature

The measurement and definition of civil war has always been a contentious issue.⁴ However, there is a large implicit consensus regarding the use of absolute numbers as a measure for intensity in the empirical literature. The theory behind using absolute numbers is rarely made explicit.

We start our discussion with the cross-country literature. Murdoch and Sandler (2002) develop a full growth model but then use death counts without a discussion of scale. Cerra and Saxena (2008) analyze the growth effect of civil wars in the cross country data. They follow the definition in the conflict literature and use the standard model without a discussion of scale. Our results show that their results, and those provided by Mueller (2012), could be an underestimate. The resulting estimate is also much higher than the 2.2 percent found in Collier (1999) which has been used extensively in policy work like, for example, in The Copenhagen Consensus project and by the World Bank.

Besley and Persson (2010) explain the rise of state capacity, measured by the share of taxes in GDP per capita, through internal and external wars. They use the standard model without a discussion of its validity. Collier, Hoeffler and Rohner (2009), use per capita data to explain civil war defined with the 1000 threshold, but ignore the question of scale. Hegre and Sambanis (2006) explicitly state that the likelihood of civil war rises with higher population because of scale but use this argument only to argue for population as a control variable.

Esteban, Mayoral and Ray (2012) derive a per capita conflict effort in their theory. Their paper is one of the rare examples that derives the regression equation directly from a micro-founded theory. However, they still use the 25 and the 1000 threshold, and do not discuss why this captures per capita conflict effort. We illustrate in the appendix that one of their most important results which holds at the 25 threshold does not scale up; results are not robust to using the 1000 threshold. However, results are strikingly consistent when the per capita model is used. This is to be expected from their theory if the 25 threshold is regarded as valid proxy for the per capita model.

There is a relatively new literature that tries to bring exogenous variation in weather and commodity prices to understand the economic triggers of civil war. Bruckner and Ciccone (2010) use the standard model to show that negative economic shocks caused by commodity price shocks

⁴See Sambanis (2004) for an excellent review. Sambanis also briefly discusses a relative threshold but for different reasons.

lead to the onset of civil war. They instrument for GDP per capita growth but do not explain why a decline of GDP per capita in a small country should lead to the same number of casualties as in a large country. Miguel et al (2004) study the impact of per capita growth on civil war onset using the 25 deaths threshold. Their paper also does not discuss scale. Hsiang et al (2011) study the same phenomenon on a global scale and with the 25 deaths threshold. Here the logics is very clearly a decentralized one working through averages in geographic cells - the size of countries is still not taken into account.

Bazzi and Blattman (2011) provide a review of the price shock literature. They discuss most existing theories that link violence and income shocks and provide a tour-de force through possible empirical specifications. However, they never discuss scale. Using the continuous measure of battle-related deaths, for example, they find that rising prices, both agricultural and mineral, lead to fewer battle deaths. But why should a shock to per capita income lead to less conflict per capita in more populous countries?

Most importantly, perhaps, the absence of a discussion of scale makes the incorporation of new evidence difficult. Micro-studies like, for example, Dube and Vargas (2012) find an effect of price shocks on the absolute number of killings (events). Berman, Felner and Shapiro (2011) is one of the few papers that uses a per capita model as the dependant variable. The argument in their paper is that public service spending per capita and population shares should affect violence per capita and not the count.⁵ These differences in models make it difficult to compare the findings in Dube and Vargas (2012) and Berman et al (2011). In addition, it is not clear whether the findings in these studies are consistent with the use of the standard model at the country level in Miguel et al (2004) or Bruckner and Ciccone (2010).

In their study of house prices Besley and Mueller (2012) discuss what they call the public bad aspect of violence and therefore use the standard model. Mueller, Rohner and Schoenhoelzer (2013) model the cause of violence in the interaction between the individuals of different groups across space. In their model population size plays an important role as large population leads to more interactions. They use this model to analyze the spatial distribution of violence in Northern Ireland and confirm the role of scale. Their results also highlight the role of distance - sectarian violence between Catholics and Protestants falls with distance. A result that will be echoed here.

⁵The authors are not explicit about this but the argument follows from the formal derivation in this paper.

3 The Per-Capital Model of Violence

Consider two ways of using violence data available in a panel dataset. The first is to use the absolute value of victims of violence. The data could be used to construct a dummy or used as a count. Our argument is valid in both cases but for expositional purposes we focus on the case in which the count is used. Define the variable W_{ct} as the number of deaths in geographic area c at time t ,

$$W_{ct} \equiv D_{ct}. \quad (1)$$

We will call this the *standard model* of the intensity of civil war. It is used in most empirical studies of violence, mostly in shape of a dummy that attributes civil wars to country/year observations that cross a threshold in the count of deaths.

As an alternative, we suggest the number of deaths weighted by population in area c at time t ,

$$\hat{W}_{ct} \equiv D_{ct}/P_{ct}, \quad (2)$$

where P_{ct} is population. We will call this the *per capita model*.

We first discuss the difference between these two models when violence is used as an explanatory variable. The literature has typically used the standard model. Per capita (economic) outcomes, y_{ct} , are put in a relationship to the absolute number of deaths

$$y_{ct} = \alpha \times W_{ct}.$$

In the per capita model this equation is

$$y_{ct} = \hat{\alpha} \times \hat{W}_{ct},$$

and in both of these models, the parameters α and $\hat{\alpha}$ are assumed to be constant across c and t .

The marginal effect of a death on per capita outcomes is therefore

$$\frac{\partial y_{ct}}{\partial D_{ct}} = \alpha \quad (3)$$

in the standard model, and

$$\frac{\partial y_{ct}}{\partial D_{ct}} = \hat{\alpha}/P_{ct} \quad (4)$$

in the per capita model.

From equation (3) we can see that in the standard model the marginal effect of a death on production per capita is assumed to be constant across time and units. Most relevant here is the

assumption that the effect of an additional casualty is independent from the population in c . In other words, violence is treated as a public bad so that the impact of violence is independent of the size of the population. In the per capita model displayed in equation (4) the effect of one death is assumed to fall with population. The impact of violence on the individual level is proportional to the risk of becoming a victim to violence.

Both models have their merits. If violence patterns are hard to predict, for example, there is a strong public bad aspect to violence. Also, violence could proxy for political processes which affect all individuals regardless of population size. Violence could proxy for a government crisis, for example, and therefore affect the economy regardless of its size. The per capita model in equation (4), in contrast, is particularly relevant if violence patterns are localized compared to the size of the whole geographic unit, i.e. if fighting is restricted to only a part of a country. The difference between the standard and the per capita model is particularly relevant if the underlying geographic units differ in population.

Similar arguments apply to civil war as a dependant variable. In the standard model the individual likelihood to engage in violence needs to be inversely related to population. In other words, the standard model is realistic if per capita conflict effort is decreasing in population. It could be, for example, that conflict is centralized and can therefore be modelled by one aggregate contest function. The free-rider problem within groups will then reduce per capita effort in larger populations. The standard model should also be used if the correct unit of observation is the government or the state rather than the country. A putsch could, for example, lead to violence levels that are independent of the size of the country. In the per capita model this decision is independent of population. If conflict is decentralized and triggered by local characteristics then the per capita model needs to be used.

It is important to note that the difference between the models is not restricted to the country level. Units c could as well be grid cells or sub-national political regions like districts or states. These units can feature similar differences in population to the country level and, hence, imply similar problems.

4 Economic Growth and Violence

In this section we turn towards contrasting the two measures in the previous section empirically. Before we present the empirical specification we briefly discuss the effect of violence on growth theoretically. We then study the relationship between growth and civil war in the cross-country data. Cross-country data of civil wars is important as it forms the backbone to most of the micro

studies and has been used extensively in studies not concerned with the effect of violence directly. In addition, the cross-country work has served as an important pillar for policy work.

In section 4.3 we explore the difference between the per capita and standard model by looking at different intensities of violence. In section 4.4 we then contrast the two measures with disaggregated data at the 1-degree (100 km^2) cell level.

4.1 A Simple Theory of Violence and Growth

A good way to reflect on the effect of violence on growth is the productivity parameter A in AK model. Assume that per capita output in country c in year t , y_{ct} , is given by

$$y_{ct} = A_{ct} \times k_{ct}$$

where k_{ct} is the per capita stock of capital. Assume that the per capita capital stock changes according to

$$\begin{aligned} k_{ct} &= sy_{ct-1} - \delta k_{ct-1} \\ &= (sA_{ct-1} - \delta) k_{ct-1} \end{aligned}$$

and per capita output growth can therefore be approximated by

$$\begin{aligned} g_{ct} &= \ln y_{ct} - \ln y_{ct-1} \\ &= \ln A_{ct} - \ln A_{ct-1} + \ln (sA_{ct-1} - \delta) \end{aligned} \tag{5}$$

so that a persistent reduction in A_{ct} has two effects. First, growth drops immediately because the existing capital stock has become less productive (reduction of A_{ct}). Second, a reduction in output hinders the accumulation of capital in the following periods (reduction of A_{ct-1}). We expect a persistent reduction to lower growth most in the first year of civil war.⁶

The difference between the standard and the per capita model is in how the number of deaths, D_{ct} , affects productivity A_{ct} . In the standard model a casualty is assumed to lower A_{ct} independently of population. This could be the case, for example, if violence is a proxy for political turmoil in the central government which leads to a reduction of public services in all of the country.

⁶This idea is supported by the data. Since the dynamic effects are not at the centre of this study, however, we do not analyze heterogeneity across civil war length.

The per capita model takes a more decentralized view. It assumes that a casualty in a country with a large population reduces A_{ct} less than in a country with a small population. Violence has little impact on economic activity if it affects only a tiny proportion of the population. The individual victimization risk is what drives changes in A_{ct} in the per capita model.

4.2 Cross-Country Evidence

We now bring the two models to the data. All studies of the effects of civil war face the problem of both omitted variable bias and reverse causality. We include country (later cell) and year fixed effects to reduce concerns of omitted variable bias. Reverse causality would, in principle, remain a problem. However, the size of the effects that we find both at the country and cell level and at varying degrees of intensity of violence are hard to explain without a causal link running from violence to reduced growth.⁷ In any case, we are mostly interested in illustrating the difference between the standard and per capita model. Differences in the results between these two models are therefore interesting regardless of the direction of causality.

In the standard model we focus on the threshold of 1000 battle-related deaths and use the count of casualties as a robustness check.⁸ To ensure comparability between the two models we construct the per capita measure as close as possible to the standard measure of 1000 battle-related deaths. To do this we first divide the PRIO count of battle-related deaths by the population of the country. We try both average population and current population in this step in order to be able to check robustness in this regard. We then construct a dummy that uses an intensity threshold such that the number of civil war years is equal to the number of civil war years in the standard model. In this way we make sure that differences in the results are not due to one event being more or less common than the other.

We match the resulting dummies with GDP per capita data from the Penn World Tables. This gives us data from 1950 to 2011 and from 187 countries. For a detailed discussion of the sources and data see the appendix. Table 1 provides summary statistics. By construction, the means of the per capita measure match that of the standard measure. In other words, we exchanged

⁷Miguel et al (2004), for example, find that a reduction in growth by 5 percentage points increases the likelihood of low intensity conflict by (merely) 12 percent.

⁸Many studies use the low threshold of 25 battle-related deaths either as the main specification or as a robustness check. As smaller events remain largely unreported this threshold captures the extensive margin of political violence which will yield similar results in the standard and per capita model.

some country/years above the 1000 casualty threshold with others below the threshold. This moves about 100 country/year observations below (and 100 above) the threshold. This is about 20 percent of all observations of civil war.

Using the model and the constructed civil war dummies we run standard growth regressions of the form

$$g_{ct} = \alpha W_{ct} + \mu_c + \eta_t + \epsilon_{ct} \quad (6)$$

where g_{ct} is per capita GDP growth, W_{ct} is the respective measure of civil war, μ_c are country fixed effects and η_t are year fixed effects.

The parameter of interest is α . We expect this to be negative if violence hinders economic activity. Changes in the estimated α from the standard to the per capita model will be due to the selection of country/years which qualify as "treatment". In the standard model α captures the impact of a war with more than 1000 battle-related deaths on growth. In the per-capita model α captures the effect of a civil war with an intensity of more than 0.065 battle related deaths per capita.⁹

The results from estimating equation (6) are in Table 2. In column (1) we use the civil war dummy from the standard model. If we interpret the coefficient in Table 2 as causal, a civil war year as defined by the 1000 deaths threshold reduces growth by about 2.8 percentage points.¹⁰

In the previous section we argued that the validity of the standard model depends on whether the reaction of per capita growth to one death is constant across countries with different population. In column (2) we divide the civil war dummy by population in order to check whether civil war affects growth differently depending on the size of the population. We use average population to avoid that time variation in population drives results. The coefficient on the resulting variable reveals considerable heterogeneity of the effects of civil war depending on population. Growth in more populous countries reacts less to a conflict that exceeds 1000 battle-related casualties. In fact, heterogeneity is so large that the standard measure is insignificant now. This is direct evidence against the standard model. In column (3) we then run the same test with the count of battle-related deaths instead of the dummy. Again, the measure of casualties per capita enters significantly and with a negative sign which indicates that the economies of more populous countries are significantly less affected by casualties.

⁹This is the threshold for average population. If we use current population we need use the threshold 0.058 to equalize the total number of civil wars.

¹⁰Here we define growth as the actual growth rate in percent not the ln difference in GDPpc.

Columns (1) to (3) suggest that the standard model is the wrong model when analyzing growth. Growth seems to be affected less by casualties in populous countries. This motivates the use of the per capita model. In column (4) we run the same specification as in column (1) only now we replace the absolute measure by our per capita measure. A civil war year now reduces growth by 3.5 percentage points. This is a striking difference given that we only redrew the line of what qualifies as a civil war but did not change the total number of civil war observations. Column (5) uses the population at time t and not the average to calculate violence intensities. The fact that there is almost no change in the coefficient indicates that it is the general scale of countries and not smaller variations of population that determine the difference to the standard model.

In Table 2 we find that the switch to the per capita model increased the size of the estimated coefficient α in equation (6) by more than 20 percent. In Table (3) we run some robustness checks regarding this increase. In columns (1) and (2) we use only data after 1989. Estimates in the standard and in the per capita model increase. The point estimate in the per capita model is more than 40 percent higher. In columns (3) and (4) we restrict the sample to countries below the mean income. The per capita estimate is about 30 percent higher now.

Columns (5) and (6) of Table 3 restrict the sample to countries with an average population of less than 10 million. As expected, the impact of civil war in the standard model increases compared to the main estimate in column (1) of Table (2). Both models now suggest a similar growth impact of about -4.5 percent. This highlights the fact that the heterogeneity in population in the sample is what really drove the larger growth effect in the per capita model. When heterogeneity is restricted, the two models yield similar results.

4.3 Intensity of Violence and Growth

The per capita and standard model make different assumptions regarding what counts as more intense violence. If the per capita model is correct in the context of economic growth then counts of casualties should be an imperfect measure of intensity. One simple way to check this empirically is to run the regression

$$g_{ct} = \sum_{i=1}^{10} \alpha_i W_{i,ct} + \mu_c + \eta_t + \epsilon_{ct}$$

where $W_{i,ct}$ are now a set of dummies that capture deciles of violence intensity in the two models. In the standard model we group all country/years according the number of battle-related deaths such that $W_{1,ct}$ captures the 10 percent of violent country/years with the lowest number of battle-related deaths. In the per capita model we group all country/years according to the number of

battle-related deaths per population.

In Figure 2 we show the estimated α_i coefficients in the standard model, i.e. with growing intensity deciles. At an intensity of 6 the negative growth impact of violence becomes significant. However, this is reversed at an intensity of $i = 9$. We have $\hat{\alpha}_9 > \hat{\alpha}_8$ and cannot reject the hypothesis that $\hat{\alpha}_9 = 0$. Figure 2 also shows an example to illustrate the role of population in this reversal. The decile $i = 9$ contains the year 1991 in India (average population of over 840 Million) and the year 1979 in Nicaragua (average population of 3.8 million).

Figure 3 displays the estimated α_i in the per capita model. Now the Indian civil war episode in 1991 is coded as an event of intensity $i = 4$ while the civil war in Nicaragua falls in the most intense violence category. The impact on the ordering of the estimated α_i is shown in figure 3. There is now a much clearer negative trend after an intensity of 4 with coefficients becoming significant at $i = 6$ and no reversal at $i = 9$.

4.4 Growth and Violence at the Cell Level

The standard model appears to be the wrong model when trying to explain per capita growth at the country level.¹¹ Economic activity on the country level reacts to violence risk and not the number of casualties. Put differently, violence is not a public bad on the country level. This does, of course, not mean that violence cannot be a public bad in smaller geographic units or that the standard model is not valid in other applications. In order to test whether the per capita model also applies at lower levels of disaggregation we use data on geographic cells. The G-Econ project provides GDP data for the years 1990, 1995, 2000 and 2005 by 1 degree cells. This means we can construct growth numbers for 100km by 100km cells.

We match this data with data on violent events from the Armed Conflict Location and Event Data Project (ACLED) for the African continent. Since this data only starts in 1997 we can match it to only two five-year growth episodes: 1995-2000 and 2000-2005. This gives us 5382 observations in 2691 cells. The average African country contains about 130 of these cells.

We code a cell as experiencing a civil war in the standard model if fatalities in the 5 year period exceed 1000 fatalities. As before, we code the civil war dummy in the per capita model so that it takes the same mean.¹² Figures on fatalities in ACLED are based on event reports and

¹¹A similar pattern holds when analyzing the investment ratio or foreign direct investment. Preliminary results available on request.

¹²Figure A3 shows the resulting distribution of civil wars. Blue squares represent datapoints in the in the G-Econ

are not the main focus of the dataset. As a robustness check we therefore also code a civil war dummy in terms of events, i.e. if the number of ACLED events exceeds 100 in a 5-year period.

In table Table 4 we present results from estimating the specification in equation (6) on the cell level. The calculation of cell fixed effects in this context means that we control quite precisely for geographic and political characteristics and only identify the effect of conflict from the changes in conflict across the two periods. We now find larger coefficients in the standard model than in the per capita model. This is true both when we use fatalities to define civil war in columns (1) and (2) and when we define civil wars through events. This suggests that, within cells, violence can indeed be regarded a public bad so that the standard model is adequate.¹³

How can this be reconciled with the findings at the country level? Our discussion in section 3 and equation (5) put forward the idea that the standard model on the country level would be adequate if the effect of violence on individuals was independent of the affected population. We called this the public bad character of violence. One way to show that this assumption is violated is to show that the correlation between violence and growth declines with distance.¹⁴ We expect little decay if the link between growth and violence is at the country level.

Table 5 suggests, instead, that the effect of violence is decreasing rapidly across space. Column (1) repeats the within-cell result from Table 4. Column (2) adds the number of civil wars in the eight cells surrounding each cell. Column (3) adds civil wars at two cells distance. Columns (4) to (6) repeat the same exercise for our event measure. A clear picture emerges. The impact of civil wars on growth is small at 250km distance and significantly smaller than the impact of civil wars at 150km distance. We could find no evidence for any effect of civil wars beyond this distance. Violence, as measured by the ACLED dataset, does not seem to have an economic impact beyond a radius of 250km.

Decay across space means that the standard model should not be used at the country level. Large countries will have a big share of their population unaffected by the violence. The more population lives outside of the 250km radius, the lower we expect the impact of a civil war to be. In other words, it is exactly the combination of decay and differences in country size that makes

dataset. Red squares represent the observation of more than 1000 fatalities in the ACLED data.

¹³We also confirmed this using interaction effects with population as in Table 2.

¹⁴Since the average country comprises 130 cells, most adjacent cells will be in the same country.

the impact of violence heterogenous in population on the country level.¹⁵

Remember that the validity of the standard model on the cell level does not translate to the country level. The reverse could be true as well. If different models are valid at different levels of aggregation it is impossible to generalize from evidence provided on one level to another. If the new findings are to be integrated then a consistent theoretical structure is needed.

5 Discussion

There is a broad consensus in the economics literature regarding the use of counts of casualties or violence events as the measure of conflict intensity. We have argued that with regional units that are heterogenous in population the use of absolute counts imposes a particular model which should be made explicit and, perhaps, questioned. We suggest an alternative model that we call the per capita model. In this model casualties are weighted by population to give a measure of violence risk.

We have contrasted the two models by running standard cross-country growth regressions in both of them. The per capita model appears to capture intensity of conflict better in this context. We have shown that intensity in the standard model leads to growth effects that are non-monotonic in intensity. This can be explained by the fact that very populous countries, which are less affected by casualties, are mixed with less populous countries in this model. In the per capita model higher intensity is a better predictor of larger economic damage. This implies that the standard model could have led to an underestimate of the economic impact of violence on economic activity in existing studies.

As a second step we have moved to more disaggregated data. For this we combined GDP data on 100 km^2 cells with event data for Africa. At this level of disaggregation the per capita model fails completely while the standard model fares considerably better. We argue that this is not inconsistent with the cross-country findings. If the negative effects of violence decay with distance then larger countries will have a share of their population unaffected even if, locally, violence is a public bad. The data provides strong evidence for this. The correlation between violence and growth fades at a distance of 150 – 250 km. The impact of violence on the economy does not appear to operate through factors at the country level but through more local factors

¹⁵Indeed, we show in the appendix Table A3 that if the ACLED violence data is aggregated to the country level, the standard model again loses its validity.

directly related to the exposure to violence.

The distinction between the standard and per capita model could also be relevant in the analysis of the causes of civil war. A central theoretical idea in this area is that conflict increases if the opportunity costs of conflict at the individual level decrease. If income from agriculture falls in a drought, for example, then violence increases because opportunities of non-violent activities decrease. This mechanism works at the individual level. Shocks to per capita income should therefore lead to patterns more in line with the per capita model. If 10 million individuals lose their livelihoods in a drought then this should, a priori, lead to more violence than if 10,000 individuals lose their livelihoods.

The theory presented here offers a new perspective on existing empirical findings. Miguel et al (2004), for example, use the standard model when they conduct their analysis of weather shocks on conflict. If the standard model is correctly used in their study then this tests for a mechanism that is valid at the state level, not at a more disaggregate level. Income shocks then trigger violence because they lead to a government crisis - not because they lower the opportunity cost to violence. This interpretation would be in line with Bazzi and Blattmann (2011) who suggest that the mechanism that links commodity price shocks and civil wars might be operating through the fragility of the state. If this is true then economic shocks lead to violence because they weaken the state and it is correct to use the standard model.

While these conjectures are speculative they illustrate the main point of this article. The empirical literature on the causes and consequences of civil war needs to put its foot down regarding the mechanisms behind its empirical specifications. As a rule of thumb, state-centred theories should use the standard model while economic/opportunity cost channels should use the per capita model. The current surge in disaggregated data makes these issues even more pressing. In most cases it will be theoretically inconsistent to use the standard model at different levels of aggregation as the literature currently does. If the standard model is valid at the micro level, then a larger population will produce more violence which makes the standard model invalid at the country level. A theory-driven approach is needed to link country and micro findings.

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A Scalability in Esteban, Mayoral and Ray (2012)

Esteban, Mayoral and Ray (2012) derive conflict as a function of three indexes (P, F and G) constructed from data on ethnic groups. In their main specifications, per capita violence effort is proxied by the PRIO 25 battle-deaths dummy. Events with less killings are hard to detect so that both the per capita and standard model would yield the same coding at this threshold.

Section V, in their paper studies the role of public and private rents for conflict.¹⁶ According to their theory, per capita conflict should increase when a high degree of publicness in the nature

¹⁶For details regarding the variables and data see Esteban, Mayoral and Ray (2012).

of the conflict coincides with high ethnic polarization. The results here are particularly interesting as the interaction between ethnic composition and economic incentives provides richer time variation.

Table A1, column (1) reproduces the specification from Table 9 column (1) which uses the 25 death threshold. The coefficients show that conflict is triggered by publicness for highly polarized countries and by privateness for highly factionalized countries. Column (2) uses the data in Esteban, Mayoral and Ray (2012) to run a robustness check with the standard model and the 1000 threshold. Results are not robust. Only the Gini index (G/N) predicts conflict. In other words, the specification from column (1) does not scale up to more intense conflicts.

Column (3) runs the same analysis with the per capita model - results are now almost identical to column (1). In other words, the low 25 threshold might indeed be a proxy for per capita violence effort. Column (4) omits the population control. Results are robust to this.

B Data Sources

In our study of growth on the country level we try to build a panel of as many countries as possible that reaches as far back as possible. We use data on battle-related deaths by Lacina and Gleditsch (2005) between 1946 and 1989. This data is complemented by the compatible UCDP Battle-Related Deaths Dataset v.5-2013. In both of these datasets we used the "best" estimate where possible and the average between low and high when no "best" estimate was available. In order to be as consistent as possible with the casualties data we generate the civil war dummies from the data of battle-related deaths.

We merge the conflict data with the Penn World Tables data version 7.1 from Heston et al (2012). We use real per capita GDP data ($rgdpl$) and calculate growth as the percentage point increase of per capita GDP compared to the previous year.

On the cell level we use data from the G-Econ research project. This project is devoted to developing a geophysically based data set on economic activity for the world. We use the current data set (GEcon 4.0) which provides "gross cell product" for all regions for 1990, 1995, 2000, and 2005 and includes 27,500 terrestrial observations. The basic metric is the regional equivalent of gross domestic product. Gross cell product (GCP) is measured at a 1-degree longitude by 1-degree latitude resolution at a global scale. For a detailed description see Nordhaus et al (2006). We construct GDP per capita values by dividing through current population.

We match this data to data from the ACLED (Armed Conflict Location and Event Data Project) which provides disaggregated conflict event data for the whole African continent. For a

detailed description see Clionadh et al (2010). We use two metrics, the number of ACLED events (battles, attacks on civilians and riots) and the total fatalities reported in all events. We match events to the 1 degree cells using the latitude and longitude information. As the G-Econ data provides the southwest corner we match events that are in the interval $([x...x + 1], [y...y + 1])$ to the G-Econ cell (x, y) . As a robustness check for our cross-country results we also match the ACLED data by country name to the PWT information.

Table 1: Summary Statistics - Cross Country Analysis

Variable	Mean	Std. Dev.	Min	Max
battle-related deaths (in thousand)	0.38	3.47	0	150
population (in thousand)	29038	107534	12	1330141
growth	2.23	7.04	-65	115
standard model				
1000 casualties dummy	0.052	0.222	0	1
25 casualties dummy	0.127	0.333	0	1
per capita model				
civil war (average pop)	0.052	0.222	0	1
civil war (current pop)	0.052	0.221	0	1

Table 2: Civil War and Growth in the Cross-Country Model

	(1)	(2)	(3)	(4)	(5)
VARIABLES	growth	growth	growth	growth	growth
civil war (standard model)	-2.818*** (0.634)	-1.124 (0.784)			
civil war (standard model) / population		-18,072*** (6,511)			
civil war (per capita model)				-3.459*** (0.699)	-3.531*** (0.715)
battle-related deaths			0.100* (0.0600)		
battle-related deaths / population			-3.003*** (0.431)		
country fixed effects	yes	yes	yes	yes	yes
year fixed effects	yes	yes	yes	yes	yes
Observations	8,642	8,642	8,642	8,642	8,642
R-squared	0.050	0.052	0.061	0.053	0.053
Number of countries	187	187	187	187	187

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. "Growth" is real GDP per capita growth in percent. "Civil war (standard model)" is a dummy that takes a value of 1 if the number of battledeaths exceeds 1000. "Civil war (per capita model)" is a dummy that takes a value of 1 if the number of battle-related deaths per population exceeds a threshold. The threshold is chosen such that there are exactly as many civil wars in the sample as in the standard model. Columns (2)-(4) use average population, column (5) uses population in the same year.

Table 3: Robustness Checks

VARIABLES	(1) growth	(2) growth	(3) growth	(4) growth	(5) growth	(6) growth
civil war (standard model)	-3.165*** (1.063)		-2.756*** (0.627)		-4.777*** (1.053)	
civil war (per capita model)		-4.503*** (1.386)		-3.512*** (0.740)		-4.495*** (1.073)
country fixed effects	yes	yes	yes	yes	ye	yes
year fixed effects	yes	yes	yes	yes	yes	yes
Observations	3,866	3,866	5,763	5,763	5,874	5,874
R-squared	0.063	0.069	0.048	0.052	0.051	0.051
Number of countryid	187	187	124	124	134	134

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. "Civil war (standard model)" is a dummy that takes a value of 1 if the number of battledeaths exceeds 1000. "Civil war (per capita model)" is a dummy that takes a value of 1 if the number of battle-related deaths per population exceeds a threshold. The threshold is chosen such that there are as many civil wars in the sample as in the standard model. Columns (1) and (2) use only data after 1989. Columns (3) and (4) use only data from countries with a GDP per capita below the mean. Columns (5) and (6) use only countries with an average population of less than 10 million.

Table 4: Civil War and Growth in Africa, Cell Level

	(1)	(2)	(3)	(4)
VARIABLES	growth	growth	growth	growth
civil war (standard model)	-6.497** (2.765)		-30.65*** (11.85)	
civil war (per capita model)		0.621 (4.358)		-7.794** (3.966)
cell fixed effects	yes	yes	yes	yes
year fixed effect	yes	yes	yes	yes
Observations	5,382	5,382	5,382	5,382
R-squared	0.148	0.147	0.159	0.148
Number of cells	2,691	2,691	2,691	2,691

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Data is on cells that have a size of approximately 100km x 100km. "Growth" is real GDP per capita growth in percent. "Civil war (standard model)" is a dummy that takes a value of 1 if the number of fatalities exceed 1000 in column (1). It is a dummy that takes a value of 1 if the number of events exceeds 100 in columns (4). "Civil war (per capita model)" is a dummy that takes a value of 1 if the number of fatalities or events exceeds a relative threshold of violence per population. The threshold is chosen such that there are exactly as many civil wars in the sample as in the standard model.

Table 5: Decay of Violence Impact Across Space

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	growth	growth	growth	growth	growth	growth
civil war (standard model)	-6.497** (2.765)	-3.639 (2.740)	-4.122 (2.784)	-30.65*** (11.85)	-15.60 (11.64)	-21.87* (11.58)
number of civil wars in 50-150km radius		-2.635*** (0.927)	-2.823*** (0.937)		-15.74*** (3.299)	-16.66*** (3.276)
number of civil wars in 150-250km radius			-0.306*** (0.0773)			-3.546*** (0.457)
cell fixed effects	yes	yes	yes	yes	yes	yes
year fixed effect	yes	yes	yes	yes	yes	yes
Observations	5,382	5,382	5,382	5,382	5,382	5,382
R-squared	0.148	0.150	0.152	0.159	0.188	0.222
Number of cells	2,691	2,691	2,691	2,691	2,691	2,691

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Data is on cells that have a size of approximately 100km x 100km. "Growth" is real GDP per capita growth in percent in a 5 year period. "Civil war (standard model)" is a dummy that takes a value of 1 if the number of fatalities exceed 1000 in columns (1) to (3). Civil war is a dummy that takes a value of 1 if the number of ACLED events exceeds 100 in columns (4) to (6).

Figure 1: Population and Prevalence of Civil War

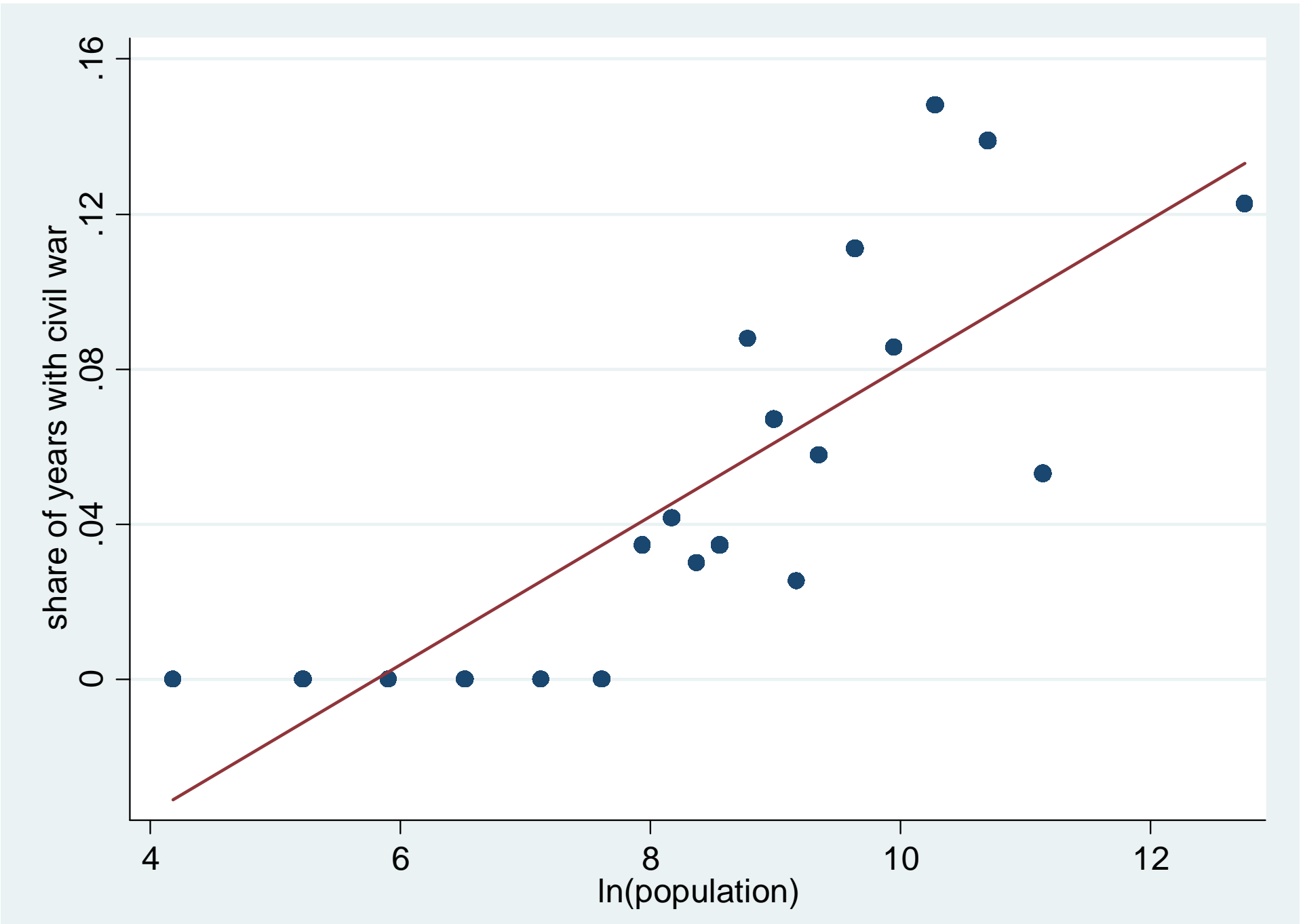
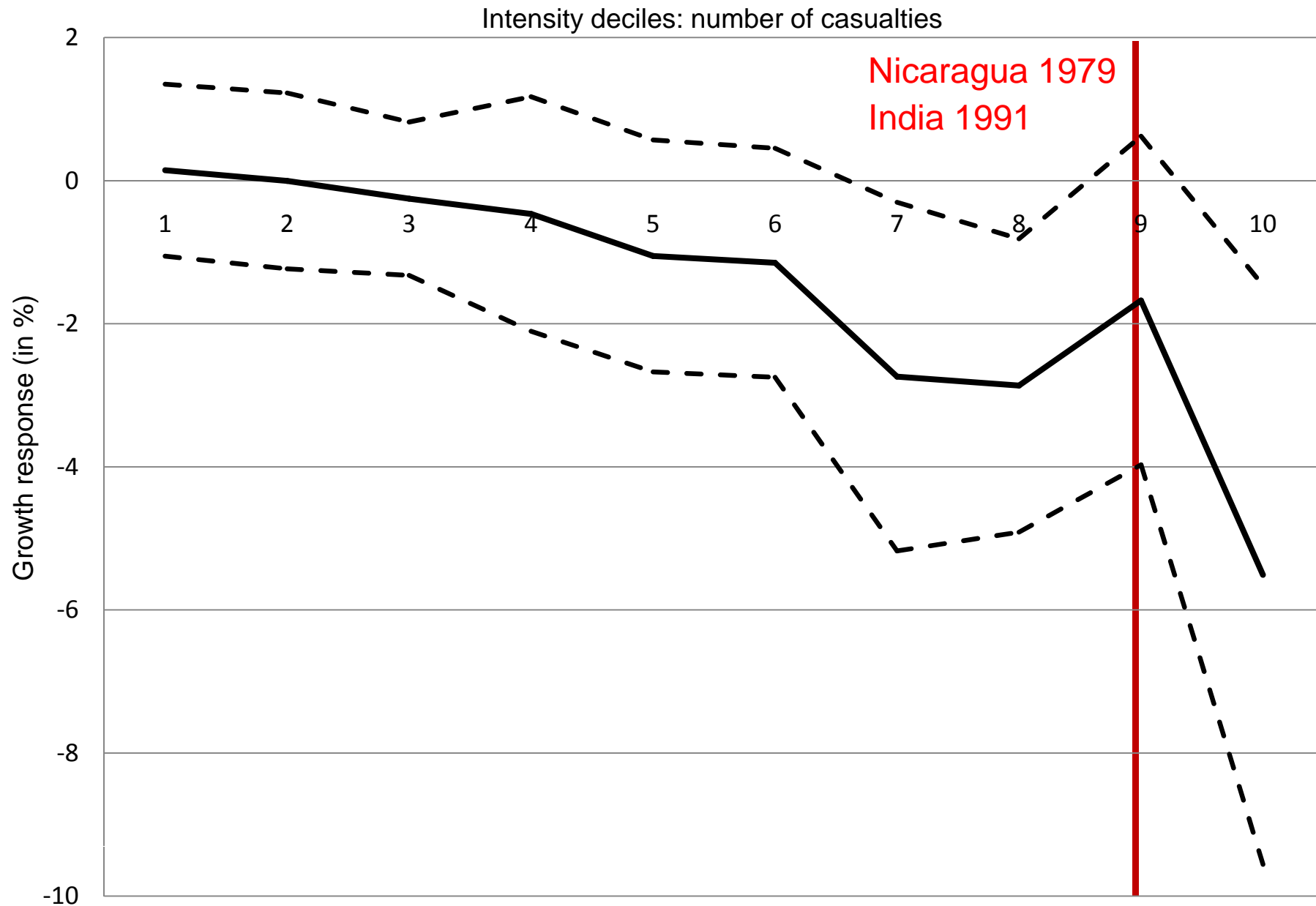
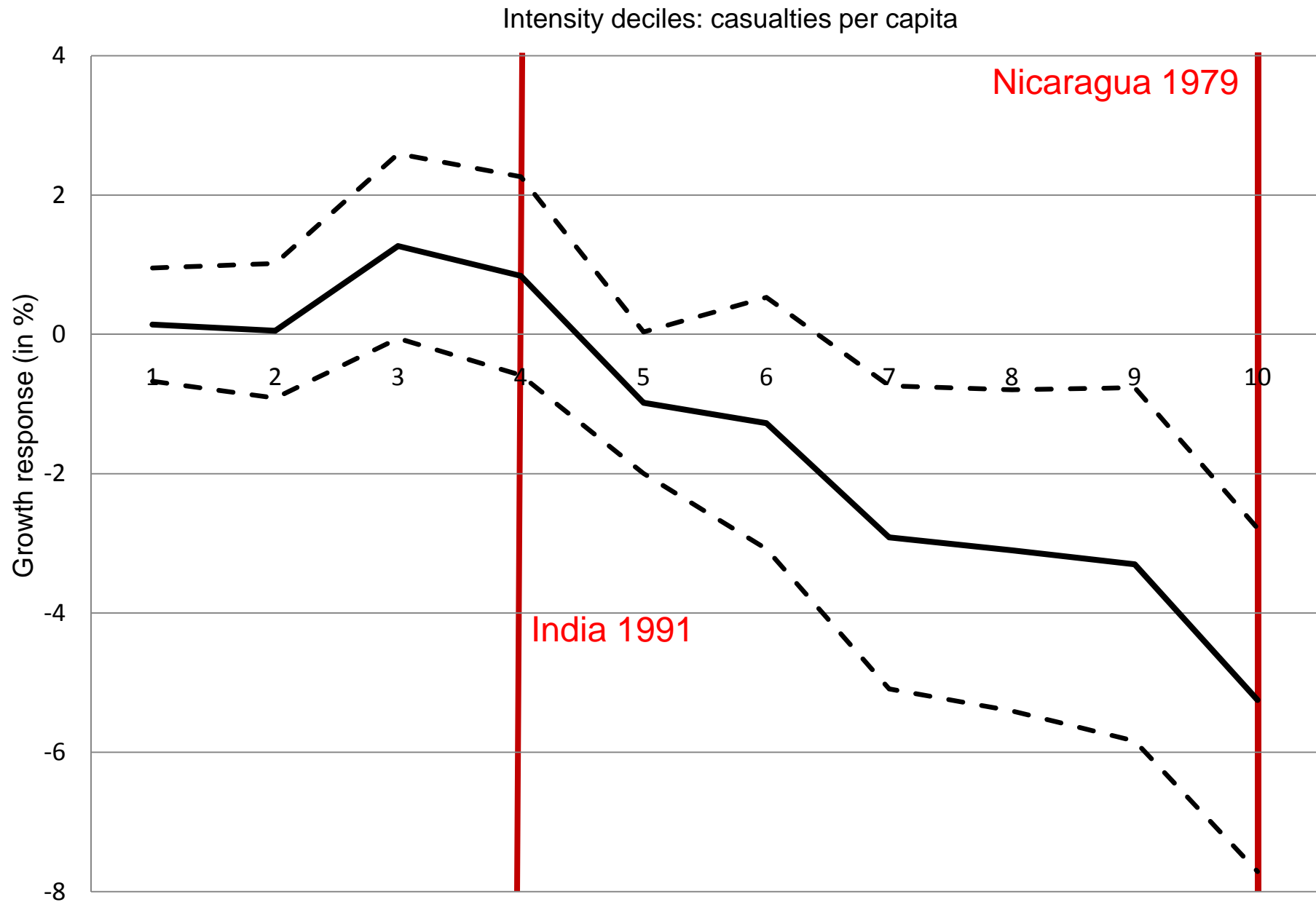


Figure 2: War Intensity and Growth in the Standard Model



The figure shows coefficients of a regression of GDP per capita growth on 10 intensity decile dummies, country and year fixed effects. Dotted lines indicate 95 percent robust confidence intervals.

Figure 3: War Intensity and Growth in the Per Capita Model



The figure shows coefficients of a regression of GDP per capita growth on 10 intensity decile dummies, country and year fixed effects. Dotted lines indicate 95 percent robust confidence intervals.

Table A1: Scale in Esteban, Mayoral and Ray (2012)

VARIABLES	(1) low intensity conflict	(2) civil war (standard model)	(3) civil war (per capita model)	(4) civil war (per capita model)
P	-3.313 (4.143)	5.594 (3.751)	0.716 (4.509)	-0.844 (-4.335)
F	0.727 (0.578)	0.755 (0.755)	0.531 (0.836)	0.336 (-0.807)
G/N	-5.073 (5.379)	-18.74** (8.337)	-5.340 (5.856)	-2.431 (-3.587)
P * public price	17.38*** (5.226)	6.940 (5.335)	13.71** (5.864)	13.06** (-5.823)
F * private price	2.529*** (0.861)	1.299* (0.696)	2.212*** (0.818)	2.143*** (-0.825)
(G/N) * public price	-0.720 (6.553)	6.571 (9.531)	0.0678 (7.569)	2.06 (-6.216)
controls	yes	yes	yes	yes*
Observations	1,104	1,104	1,104	1,104

Robust standard errors clustered at the country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Column (1) recreates column (1) in Table 9 of Esteban, Mayoral and Ray (2012). Column (4) omits population as control variable.

Table A2: Summary Statistics - Cell/Cross-Country Analysis for Africa

cell-level, 5-year periods data

Variable	Mean	Std. Dev.	Min	Max
growth (in percent)	13	21	-33	284
civil war (standard model), defined by fatalities>1000	0.0093	0.0959	0	1
civil war (per capita model), defined through fatalities	0.0093	0.0959	0	1
civil war (standard model), defined by events with events>100	0.0091	0.0950	0	1
civil war (per capita model), defined through events	0.0091	0.0950	0	1
population (in thousands)	293683	764547	47	22000000

cross-country, yearly data

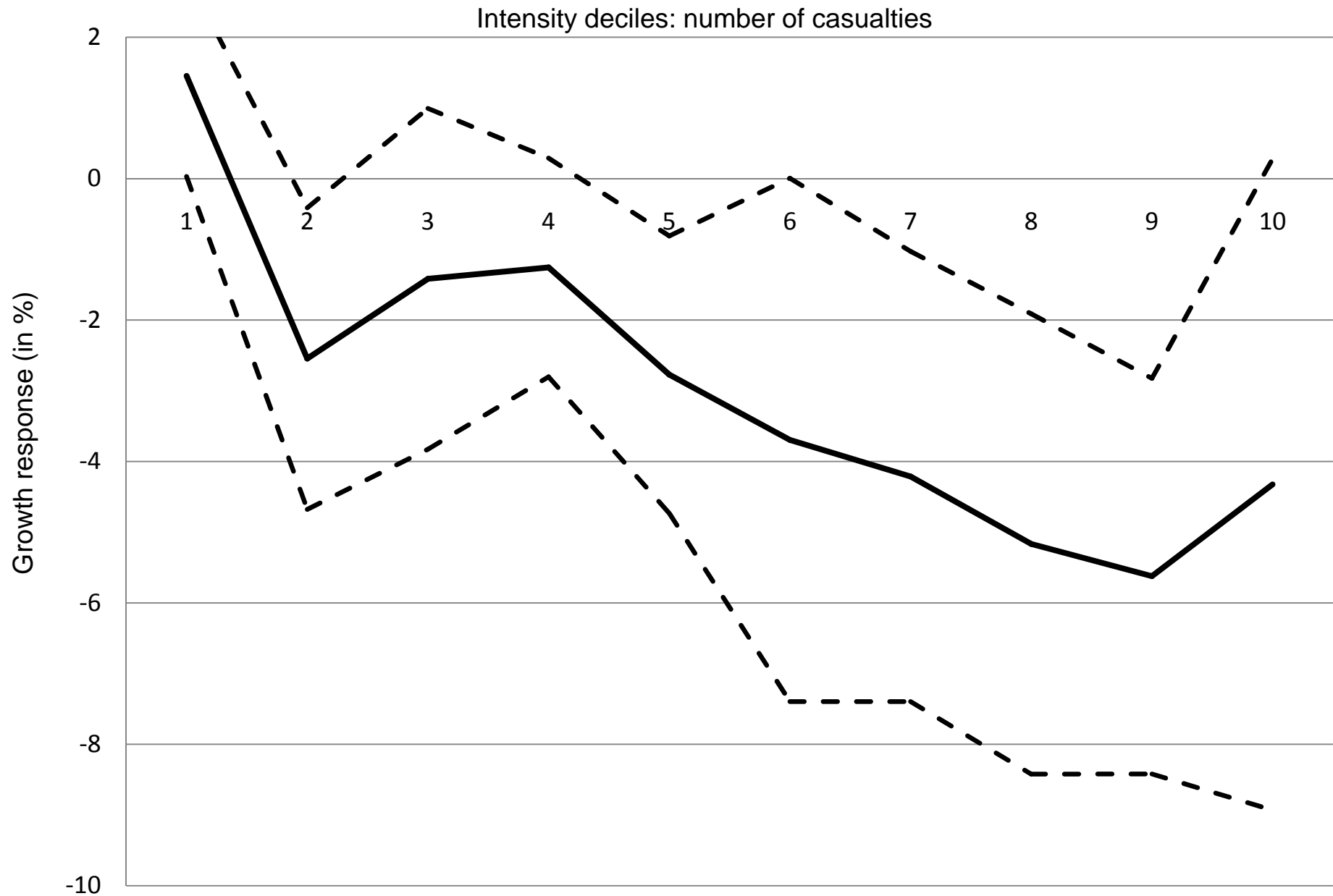
Variable	Mean	Std. Dev.	Min	Max
growth	1.97	6.15	-30.94	47.18
civil war (standard model), defined by fatalities>1000	0.10	0.30	0	1
civil war (per capita model), defined through fatalities	0.10	0.30	0	1
civil war (standard model), defined by events with events>100	0.21	0.41	0	1
civil war (per capita model), defined through fatalities	0.21	0.41	0	1
population (in thousands)	18551	24575	464	152217

Table A3: Growth on the Country Level, ACLED data

VARIABLES	(1) growth	(2) growth	(3) growth	(4) growth
civil war (standard model)	-1.594 (1.279)		-2.296* (1.360)	
civil war (per capita model)		-1.960* (1.001)		-0.905 (1.071)
Country Fixed Effects	yes	yes	yes	yes
Year Fixed Effects	yes	yes	yes	yes
Observations	617	617	617	617
R-squared	0.033	0.036	0.040	0.031
Number of countryid	48	48	48	48

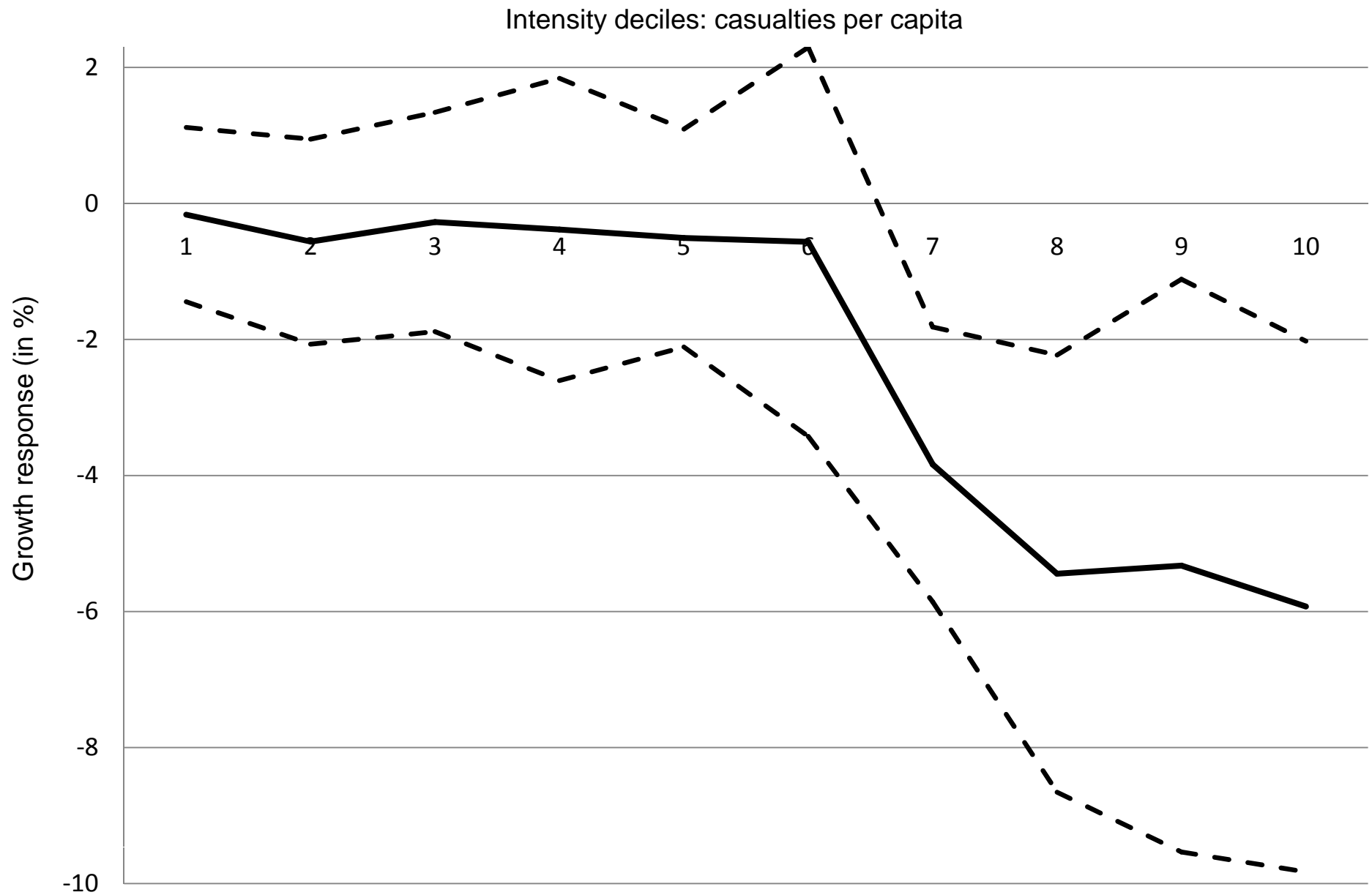
Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The Table shows a match between the ACLED data aggregated to the country level with the growth data from the Penn World Tables. Variables are defined as in Tables 2 and 4.

Figure A1: War Intensity and Growth in the Standard Model (post Cold War)



The figure shows coefficients of a regression of GDP per capita growth on 10 intensity decile dummies, country and year fixed effects. Dotted lines indicate 95 percent robust confidence intervals.

Figure A2: War Intensity and Growth in the Per Capita Model (Post Cold War)



The figure shows coefficients of a regression of GDP per capita growth on 10 intensity decile dummies, country and year fixed effects. Dotted lines indicate 95 percent robust confidence intervals.

Figure A3: Conflict at the G-Econ Cell Level

