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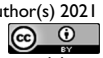

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Economic legacy effects of armed conflict: Insights from the civil war in Aceh, Indonesia

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Abstract
The province of Aceh in Indonesia provides a promising case for studying the economic legacy effects of conflict given subnational district-level data on violence and gross domestic product. We demonstrate specific negative economic legacy effects of armed conflict despite a general peace dividend: whilst all districts in Aceh grow faster after conflict ends in 2005 than during the conflict, the districts that suffered relatively more from violence during the war grow relatively more slowly during peacetime than districts that experienced relatively little violence. These negative legacy effects are relatively short-lived, however, and are no longer statistically significant from 2009 onwards.
JEL classification: O40, O47, Q54

Keywords
Aceh, armed conflict, economic growth, Indonesia, natural disaster, peace dividend

Introduction

Many studies examine the nexus between economic growth and armed civil conflict. Some investigate whether development failures, economic shocks and economic depressions increase the likelihood of conflicts (e.g. Bazzi and Blattman, 2014; Collier and Hoeffler, 2004; Gomes 2015; Miguel et al., 2004; Sharma 2006). Others analyse the economic damage caused by civil war (see e.g. Arunatilake et al. 2001; Collier 1999; Costalli et al., 2017). Unsurprisingly, by and large, the literature agrees that bad economic performance makes civil wars more likely and also that civil war reduces growth (Collier and Hoeffler, 2007), although recent interventions stress the heterogeneous impact of civil war with large

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differences across countries (Bove et al., 2017; Minhas and Radford, 2017). However, what happens once war is over?

We know much less about the economic legacy effects of civil wars. Empirical studies at the national or cross-national level have great difficulty accounting for the endogeneity of civil war and civil war endings and, more importantly, by definition cannot account for heterogeneous economic legacy effects across subnational units. Only few studies analyse differences in post-civil war performance at the subnational level. Miguel and Roland (2011) find that Vietnamese districts and provinces that were more heavily bombed by the USA during 1965–1975 than others experienced no statistically significant differences in terms of poverty rates, consumption levels and population density in 1999–2002. Of course, Vietnam was a fully internationalized civil war, US bombing is just one aspect of the violence experienced during this conflict and 25 years is probably too long a time period to find negative economic legacy effects, which limits the direct comparability of this study to two other studies that are closer to our own analysis. Collier and Duponchel (2013) assess the performance of firms in Sierra Leone and find that firms operating in what were previously conflict zones lag behind firms operating in other areas 5 years after the end of Sierra Leone's conflict in 2002. Finally, Serneels and Verpoorten (2015) examine consumption levels of households aggregated to sectors in Rwanda. Their estimates suggest that rural households and communities that experienced more violence during the genocide in 1994 and the ensuing civil war have lower consumption levels 6 years after the end of violence than households and communities that experienced less violence.

Aceh provides a good case study since, in addition to high-quality geocoded data covering conflict intensity in the form of recorded deaths as well as injuries, kidnappings and rapes attributed to the separatist armed conflict, our study also benefits from the existence of a database on subnational gross domestic product (GDP). This allows us to directly analyse economic growth performance at the subnational level. We can therefore examine whether subnational units which experience more violence grow faster or slower after the end of the civil war than those units which experience less violence.

Employing differences-in-differences as our causal inference technique, we demonstrate that during the years of conflict there are no statistically significant growth differences across districts within Aceh as a function of how much violence they experienced during the civil war. The most likely reason for this is negative economic spill-over effects from more violent to less violent units, well documented in the literature albeit in different contexts (e.g. Murdoch and Sandler, 2004), essentially depressing economic activity everywhere during conflict. This general growth-depressing effect makes sense given the small size of Aceh, which is less than three-quarters of the size of Scotland or approximately the size of the US state of West Virginia. Essentially, Aceh is too small for some parts of the peninsula to have escaped the detrimental effects of the violence on the economy during the conflict.

This absence of statistically significant growth differences during the conflict allows us to make the identifying parallel historic paths assumption that districts which experienced less violence during the conflict can function as credible counter-factual units for those districts that experienced relatively more violence such that the economic legacy effects after the end of conflict can be estimated via differences-in-differences. We find that those districts within Aceh that experienced more violence during the civil war grow *relatively* more slowly *after* the end of the conflict than districts that experienced relatively less war-time violence. This relative growth disadvantage exists despite the fact that all districts benefit from a peace dividend in that all districts grew faster after the end of the civil war than they did during the

civil war. We thus find the co-existence of a general positive peace dividend (all districts grow faster after the end of civil war than they did during the civil war) together with specific negative legacy effects (districts that experienced more violence during the conflict grow relatively more slowly after the end of the civil war than districts that experienced less violence during the conflict). However, the negative legacy effects are relatively short-lived in that, at the latest, from 2009 onwards, i.e. 4 years after the end of conflict, districts that experienced more violence no longer grow statistically significantly more slowly than districts that were less exposed to violence during the armed conflict.

In the next section we review the existing literature on the economic legacy effects of armed conflict. Then we explain how the separatist conflict in Aceh came to an end and why some observers would regard the end of conflict as plausibly exogenous, although this is contested. The research design and the empirical strategy of employing differences-in-differences regression for causal identification, which does not depend on the end of conflict representing an exogenous quasi-natural experiment setting, are described next, and then the results are presented. The sixth section explores the robustness of these findings and discusses potential threats to the inferential validity of the results. The final section concludes.

Economic legacy effects of civil war

Standard macro-economic theory suggests that economic recovery will kick in once peace has been reached. The neoclassical growth model predicts a return to the steady-state level of the capital stock with the end of the fighting (Blattman and Miguel, 2010). Large rates of return to investment are expected after the end of conflict as the physical capital stock returns to its equilibrium level, boosting economic growth. The prediction from the neoclassical growth model is thus convergence to the steady state, which implies higher catch-up growth rates than the counterfactual after violence stops (Justino, 2011a), until the pre-war equilibrium is reached again. Endogenous growth models, which place more emphasis on human capital, typically predict more lasting damage to economic performance and a longer delay to the return to steady state as human capital loss is more difficult to replenish than physical capital (Barro and Sala-i-Martin, 2003). More pessimistically still, poverty trap models, as advanced by Sachs (2005) for example, suggest that prolonged and intense violent conflict can trap countries in a poor economic state until long after conflict has ceased.

The empirical macroeconomic literature looking at country-level aggregate economic output data after the end of civil wars provides mixed evidence. Kang and Meernik (2005) examine post-civil war growth performance in a global sample over the period 1960–2002 and find that countries with intense civil wars experience double digit negative economic growth rates in every year in the 6 year period after the end of conflict. In our view, these estimates are much too high to carry credibility. Chen et al. (2008) find that the average post-conflict per capita growth rate accelerates by about 2.4 percentage points after the conflict, compared with before the conflict, mostly owing to increased investment rates. The authors use an event-study methodology in a cross-section of countries and conclude that post-conflict economies eventually converge to the counterfactual of countries not affected by conflict. A similar acceleration in post-conflict growth rates, one of 2 percentage points, albeit comparing post-conflict with conflict growth rates within countries, was also found by Elbadawi et al. (2008), but only for the first 2 years after the conflict ended. Growth rates decelerated markedly after these 2 years, thus are probably not indicative of convergence. An influential study by Cerra and Saxena (2008) finds that output rebounded relatively

quickly in the years after the civil wars started. However, Mueller (2012) recoded the dataset of Cerra and Saxena (2008), after discovering a coding error, and re-estimated the original empirical model. He came to the opposite conclusion, which is that the average civil war start depresses the economy and there is no recovery to the counterfactual trend. As noted by Mueller (2012), the methodology employed by Cerra and Saxena (2008) also fails to distinguish between civil wars that end shortly after they began and civil wars of longer duration such that the estimates based on this methodology mix up economic performance during and after civil wars. Lastly, Collier and Hoeffler (2002) find that it takes on average 14 years for post-conflict countries to get back to their counterfactual GDP trajectory.

Existing empirical macroeconomic evidence at the national or cross-national level is therefore somewhat inconsistent. Moreover, as Blattman and Miguel (2010: 39) point out, selection bias and problems with data measurement hamper reliable estimates. Yet the main problem with national or cross-national level studies is that they do not allow one to analyse heterogeneous economic legacy effects that differ across subnational units as a function of the extent to which they were exposed to conflict violence, which requires a subnational analysis. For example, it may well be that even though the national economy grows significantly faster in peace times than in war times this may be due to the better economic performance of areas that were affected relatively little by the brunt of the violence. It could still be that areas which suffered heavily from the war experience negative legacy effects, growing relatively more slowly during peace times than regions that were relatively little affected even though their growth performance during peace time may well be higher than their own growth performance during the conflict. Our subnational data on economic growth and violence in Aceh allows us to test for heterogeneous economic legacy effects as a function of conflict intensity directly and credibly.

Micro-economic studies provide many reasons why the peace time economic performance of areas that were heavily affected by violence during the prior conflict may be negatively impacted relative to areas that were much less affected by violence. There is mounting evidence suggesting lasting negative economic legacy effects from the impact of violent conflict on human health and human capital that linger on even when war is over. Devakumar et al. (2014) provide a theoretical framework linking health outcomes to conflict distinguishing between several different channels through which conflicts negatively affect health outcomes. Exposure to violent attacks leads not only to physical health damage, but also to mental and emotional traumas (see e.g. Bratti et al., 2016; Murthy and Lakshiminarayana, 2006; Yehuda and Bierer, 2008) that linger for many years with the affected individuals, and possibly even with the next generation that had not yet been born during the times of the conflict (see Devakumar et al., 2014). Psychological traumas severely affect living conditions and economic activity and may substantially impair economic life in the long run. In a systematic literature review on the impact of violent conflict in the Middle East on the mental health of children and adolescents, Dimitry (2012) finds that conflict-related traumatic experiences correlate with the prevalence of mental health issues and behavioural problems of individuals.

Conflict effects on health in early childhood are particularly dangerous as they are hard to make up over the course of the rest of the life (Verwimp et al., 2010) and early childhood development is a good predictor for later levels of human development reached in the form of, for example, income, education and health (see Almond, 2006; Maccini and Yang, 2009). Akbulut-Yuksel (2017) finds that individual exposure during both prenatal (i.e. *in utero*) and early postnatal periods to intense destruction during World War II in Germany correlate with higher body mass index, a higher incidence of adult obesity and higher incidence of chronic

health problems later on. Mansour and Rees (2012) report a modest increase in the probability of giving birth to a baby with lower birth weight if the mother was exposed to greater conflict intensity in the al-Aqsa Intifada. Akresh et al. (2012a) find that children and adolescents exposed to the Nigerian Civil War are stunted in their growth. Interestingly, whilst much of the literature emphasises the importance of violence on early childhood, these authors actually find the stature-reducing effect to be stronger for adolescent exposure than for early childhood exposure. Akresh et al. (2017) expand this analysis and similarly find that the long-term negative consequences on women exposed to war in terms of likelihood of being stunted, being overweight and lower educational attainment increase if their exposure happens during adolescence rather than early childhood. The children of these women are also more likely to die in early childhood, are more likely to be stunted if surviving and possibly achieve less education.

Educational enrolment and attainment are typically lower in regions heavily affected by conflict even after the conflict stops (Justino et al., 2013). For example, malnutrition during preschool times had adverse effects on human capital formation (grades completed) in Zimbabwe (Alderman et al., 2006). Chamarbagwala and Morán (2011) find that rural Mayans in departments where more acts of violence were committed achieved significantly fewer years of schooling than their counterparts in more peaceful departments. Akresh et al (2012b) find that Ethiopian–Eritrean children exposed to violence during the civil war are substantially shorter than those that were not (by about 0.42 standard deviations). Justino et al. (2013) followed Eastern Timorese cohorts of students that started primary school during the final years of the civil war and during a particularly intense wave of violence in 1999, relating their achievements over the short and the long term to pupils who were not affected by the violence. They find not only short-term effects of lower school completion for the pupils exposed to the peak of the violence, but also subsequently lower school completion rates. The short-term legacy effects of violence were significant for both sexes, whereas the long-term consequences only applied to boys. Bertoni et al. (2018) find that the violent conflict with the Boko Haram terror group in north-east Nigeria reduces school enrolment and years of education completed, with no differences found in terms of gender, religion or type of residential location.

Related to human capital, Collier and Duponchel (2012) suggest 'forgetting by not doing' (a kind of reverse of 'learning by doing') as the principal causal mechanism behind their finding that firms operating in what were previously conflict zones lag behind firms operating in other areas 5 years after the end of Sierra Leone's conflict in 2002. Another potential mechanism via which prior conflict can negatively impact on growth performance during peace times is the negative impact of conflict on social capital. Kijewski and Freitag (2018) find that individuals who had war-related experiences during the Kosovo war were less likely to form social trust during peace time and the same is true for higher contextual war exposure independently of whether the individuals themselves have war-related experiences.

Not all empirical evidence points in the direction of negative legacy effects of violent conflict, however. Valente (2014) finds that a larger number of abductions by Maoist groups in the civil conflict in Nepal, which are often targeted at schoolchildren, negatively impact female educational attainment, in line with most of the findings reported above. However, somewhat counterintuitively, she also finds elevated female educational attainment in places that experienced greater conflict casualties and attributes this to the progressive ideology of the insurgents with respect to gender equality and its policing of teacher absenteeism. Also for Nepal, Gilligan et al. (2014) find that communities experiencing greater violence exhibit, albeit in a laboratory-in-the-field setting, greater levels of social capital in the form of

altruistic giving, contributions to collective goods, investments in trust-based transactions and willingness to reciprocate trust-based investments.

Existing studies thus provide conflicting evidence on the economic legacy effects of armed conflict. Much, though not all, of the macro-economic literature suggests a positive peace dividend whilst many, although again not all, micro-economic studies suggest negative economic legacy effects. We therefore test two competing hypotheses against each other:

H1: Districts in Aceh that experienced relatively more violence during the conflict grow relatively *faster* during peace times than districts that experienced relatively less violence during the conflict.
H2: Districts in Aceh that experienced relatively more violence during the conflict grow relatively *slower* during peace times than districts that experienced relatively less violence during the conflict.

The separatist conflict in Aceh and its end in the wake of the 2004 tsunami

Aceh has historically been different from the rest of Indonesia in terms of culture and religion. A more conservative form of Islam is and has been prevalent in this region at the westernmost tip of the Sumatra Island (see Map 1). The tensions between Acehnese independence ambitions and Jakarta's centralist agenda as well as several political, cultural and religious undercurrents, and crucially also disagreements with the central government on how to share the rents from resources extracted in Aceh, led to the formation of the Free Aceh Movement, or GAM (short for Gerakan Aceh Merdeka), and the declaration of independence in 1976.

Map 1. Peacetime growth (2006–2012) vs. wartime conflict casualties per capita (1999–2004) in Acehnese districts.

Note: GDP per capita growth rate refers to the average annual log growth rate during peacetime. Killed persons refer to the number of casualties during wartime. There are 23 districts in Aceh. The equation for the fitted linear regression line is $y = 7.39 - 0.63x$, with a coefficient significant at the 5% level ($p = 0.023$) and an R^2 of 0.22. The two overlapping and therefore illegible district labels are 'Lhokseumawe' and 'Pidie Jaya'.

Energy wealth, in particular riches related to oil and gas, may increase the risk of civil war (De Soysa and Neumayer, 2007), particularly in combination with ethnic fractionalization (Wegenast and Basedau, 2014). Besides oil and gas, Ross (2005) identified five additional reasons why the civil war continued for nearly 30 years: (1) Indonesia's democratic institutions, put in place after the demise of Suharto, the country's long-term autocratic leader, were too fledgling and weak to channel Acehnese dissent through non-violent means; (2) GAM benefited from the entrepreneurship of its leader, Hasan di Tiro; (3) large parts of the Acehnese population felt aggrieved by the central government's refusal to grant independence; (4) the East Timor referendum, which resulted in independence of this former part of Indonesia, had a symbolic and exemplary effect; and (5) there was a lack of a credible and viable offer of the central government for an autonomous Aceh solution short of independence. Other reasons included opposition to inward migration from other islands, most notably Java and other parts of Sumatra, which many Acehnese perceived as a threat to the cultural and religious way of life in Aceh.

An estimated 30,000 people were killed and close to 350,000 people were injured during the almost 30 years of the conflict (MSR, 2009). Yet, depending on one's interpretation of events, the 2004 Boxing Day Indian Ocean tsunami either brought a swift end to the civil conflict between the GAM rebels and the Indonesian Army (TNI – short for Tentara Nasional Indonesia; see e.g. Aspinall, 2005) or at the very least further facilitated a peace process that was already well under way and would have probably also have occurred in the absence of the tsunami (see e.g. Waizenegger, 2007). In the former perspective, the end of conflict could be regarded as plausibly exogenous and representing a quasi-natural experiment setting, whereas in the latter perspective this would be a stretch too far. As we will explain in the next section, our inferential technique of differences-in-differences does not depend on the cessation of conflict representing a quasi-natural experiment.

The floods made way for a massive humanitarian response and the start of cooperation between the central government and the rebels as they sought a unified response to the disaster. Jakarta first responded by lifting military emergency law, which paved the way for reconstruction to take place. The moderate, pragmatic and cooperative course of action of the Indonesian president Yudhoyono towards GAM in the aftermath of the tsunami led him to take the GAM concerns seriously, enabling a peace deal (Enia, 2008). Reacting towards a moderate stance of the president, the rebel group signalled an unequivocal readiness to negotiate a peace agreement (Enia, 2008). The skilled peace negotiators, led by former Finnish President Martti Ahtisaari, and the significant attention brought by the international community also facilitated peace, as did the presence of humanitarian relief operations in the region.

The peace deal, or Memorandum of Understanding as it was called, included disarmament of the rebels and withdrawal of government troops from Acehnese territory (with the exception of 25,000 soldiers that remained) and the formation of a regional political party (Donnan and Bergstrom, 2005) in exchange for autonomy or self-governance (an important compromising step shy of independence), which DeRouen et al. (2009) suggest is conducive to lasting peace. Moreover, it was agreed that the Acehnese population should receive 70% of the resource revenues exploited in the region, which were however dwindling owing to resource stocks running out, as well as a much enhanced proportion of the General Allocation Fund (Dana Alokasi Umum), a block grant from the central government to Indonesian regions. On 15 August 2005 a peace accord was signed in Helsinki. For a detailed account of the peace process, see Kingsbury (2006).

The lingering detrimental impacts of the civil war on the health and well-being of Acehnese people were significant beyond what the 30,000 fatalities and close to 350,000 injuries during the course of conflict would suggest. Surveying the 14 districts most affected by the violence in Aceh revealed staggeringly high numbers of physical and psychological effects indicating severe traumas (IOM, 2007). In a household survey with a total sample size of 1972 interviewed households, 74% of the respondents report having had a combat experience, 35% report having fled from a burning building, 46% report having been forced to flee danger, 28% report having been beaten to the body, 26% report having been beaten on the head, 13% report having been strangled, 17% report having been attacked by a knife or gun, 43% report having a family member or friend killed, 5% of women report that their husbands were killed, 45% report having a family member or friend kidnapped or disappear and 31% report having been extorted or robbed. Psychological symptoms amongst the Acehnese population were extraordinarily high amongst the sample surveyed in 2006 (IOM, 2006): 65% showed depression symptoms and 34% showed symptoms of post-traumatic stress disorder (PTSD). Out of these symptomatic psychological attests, 18% were diagnosed with severe depression and 10% had severe PTSD.

Not only was the health of individuals negatively affected by acts of war, and after the war by lingering injuries, but so was access to health in post-war times. In several high conflict districts, particularly in Bireuen and Aceh Utara, only about one-third of the interviewed households signalled a readiness to receive healthcare delivered by public health clinics (as they are operated by the central government, which the majority of the Acehnese in the affected areas did not trust). Physical capital destruction was also significant in Aceh. Upon returning to their houses, many temporarily displaced households found their livestock, rice fields, gardens, plantations and tools burnt or pillaged (IOM, 2006). In fact, 'we had to start from zero' was a phrase violence-affected households frequently replied when asked in the household interviews. Overall 43% responded that their property had been destroyed or confiscated (IOM, 2007). Reintegration of ex-combatants, known to be a very significant problem from other country settings (see, e.g. Subedi, 2014), posed a severe challenge, including insufficient reintegration allowances (so called *Jadup*) that were supposed to help the former rebels integrate into the labour market, with the focus on starting business (Schulze, 2007). There were several allegations of unequal distributions and corruption of these funds.

Research design and empirical strategy

We assembled a unique district-level dataset by merging local level GDP measures with local-level violence measures. The violence data stem from the National Violence Monitoring System (NVMS), which is an innovative data tool that allows keeping track of acts of violence in Indonesia from 1999 onwards.[1] The World Bank in conjunction with the Indonesian Ministry of People's Welfare piloted it in 2011 with the aim to publicly document past acts of violence as well as keeping track of current ones in a mission to better manage and prevent violence. The online data portal contains data on where, when and why violence took place and with what intensity. It contains in total about 180,000 incidents of violence for the entire country and uses national and local newspaper accounts, which record incidents since 1999. A detailed elaboration on the construction of the dataset as well as its advantages relative to other prevailing violence datasets in Indonesia can be found in Barron et al. (2014). In particular, there are two often-used competing sources of data on

violence, namely the Armed Conflict Location and Event Dataset (ACLED) and the Uppsala Conflict Data Program (UCDP) source. We cannot use ACLED since it records data for Indonesia only from 2016 onwards. The reason why we prefer the NVMS dataset over the Uppsala UCDP is that UCDP mainly relies on international news reporting, while NVMS in contrast also covers more than 100 newspapers operating not only at the national, but also at provincial and district levels, making it harder to miss incidents, which is important given that our research design is at the subnational level. UCDP has no data on non-fatal violence but we can compare our data on fatalities per capita with UCDP. We find correlation coefficients of 0.74, 0.72 and 0.68 with, respectively, the low, best and high estimates data reported in UCDP.[2]

The NVMS dataset contains information on violence from the separatist conflict and from other sources. Separatist conflict refers to 'violence triggered by efforts to secede from the unitary state of the Republic of Indonesia'. We use two measures of conflict intensity attributed to the separatist conflict, namely fatal violence, which is the sum total over the period 1999–2004 of people killed (fatalities), and non-fatal violence, which is the sum total of people suffering injuries, kidnappings and rapes. We express both measures of violence in per capita terms (of 1000 people) to make them comparable across districts. This is consistent with the argument of Mueller (2016) that in order to compare violence levels across areas that vary considerably in population size one should employ violence per capita measures.

The evolution of deaths from violence and conflict in Aceh shows that before the tsunami struck in late 2004 and the peace deal came about in 2005, most deaths were due to the separatist conflict (see Figure 1). Most of the casualties were civilians (Human Rights Watch, 2003; ICG, 2001). The separatist conflict may have spilled over to other forms of violence, as deaths from non-separatist-related violence also appeared to have been surging during times of war. The numbers of separatist casualties came down after the Indian Ocean tsunami struck Acehnese shores on 26 December 2004 and essentially stopped after the peace deal was signed in August 2005. In the early 2000s, a rough average of about 2000 persons a year lost their lives in the separatist conflict, going down to 208 casualties in 2005, then to only 1 casualty in 2006, and finally 0 casualties in 2007.[3]

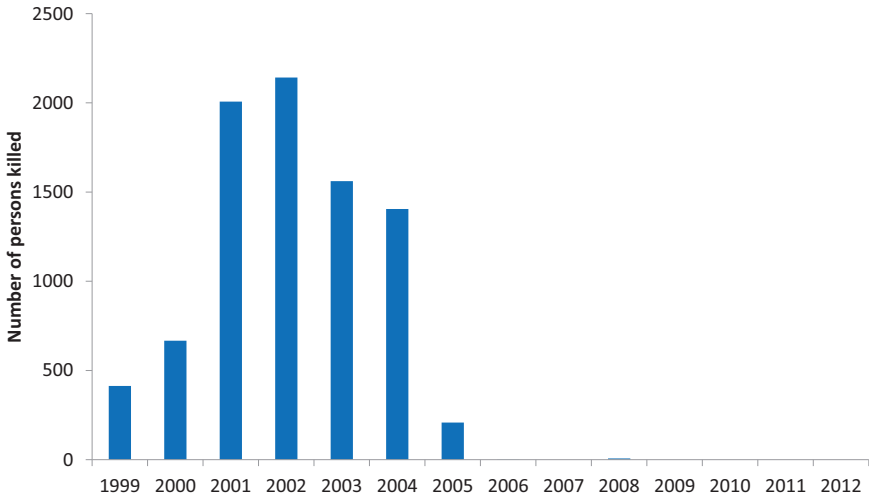


Figure 1. Aceh, Indonesia, surrounding countries and the origin of the Tsunami earthquake.

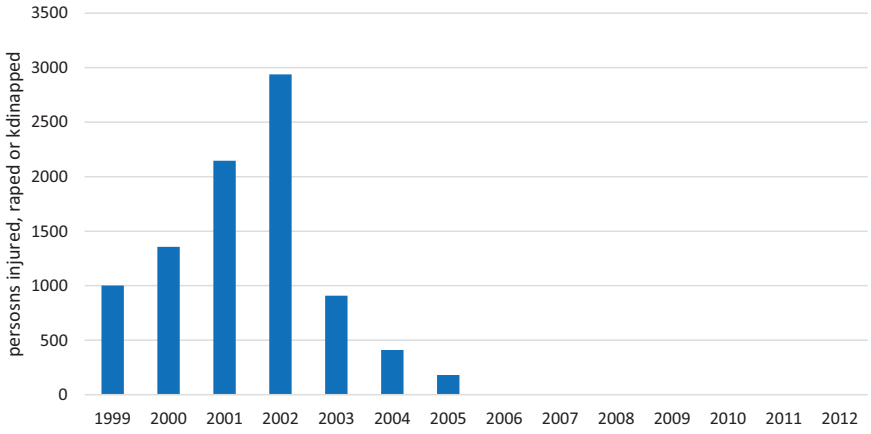


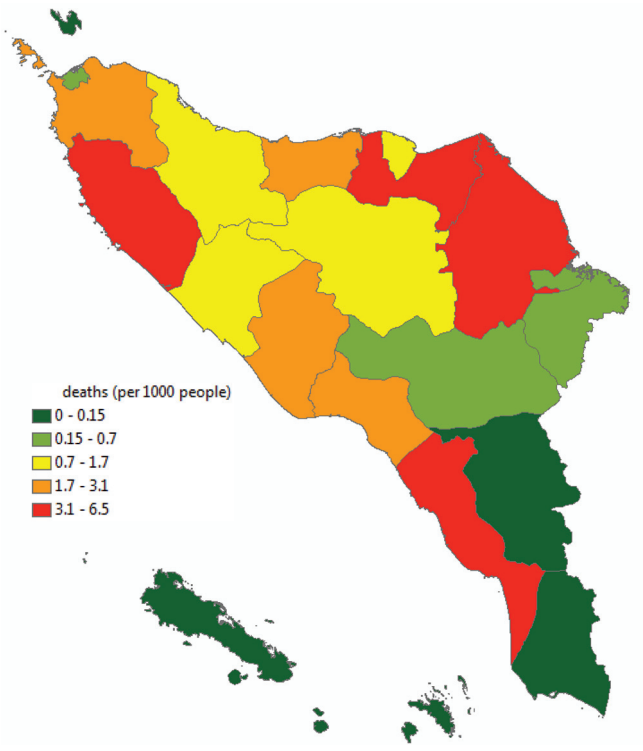
Figure 2. Fatal violence from separatist conflict in Aceh over time.
Note: The graph depicts the sum of all deaths occurring in all districts of Aceh.

Similar to deaths, non-fatal violence from separatist war also came to a complete halt after the peace agreement (see Figure 2). Injuries include bruises, loss of consciousness, broken bones and any issues requiring hospital treatment. Rapes include men, women and children raped or molested. Kidnappings denote the number of people abducted or taken hostage.

Violence is not homogeneously distributed across Aceh: there were certain hotspots of violence, hubs of relative peace and grades in-between (see Map 2 for fatal violence and Map 3 for non-fatal violence). The geographical distributions of both measures are rather similar and they are correlated at $r = 0.89$ with each other. No clear pattern of spatial clustering of violence is apparent from the maps with all sides of the island being affected, in the South towards the Indian Ocean and in the North towards the Strait of Malacca, both West and East coasts of the province. Rural districts tended to experience more violence than the more urban districts of Banda Aceh, Langsa, Lhokseumawe, Sabang and Subulussalam since it was easier for the rebels to organize and hide in more rural districts. For this and other reasons, one of our robustness tests will exclude the more urban districts from the estimations.

We sourced district-level GDP data from the Indonesia Database for Policy and Economic Research (INDO-DAPOER), which is maintained by the World Bank.[4] DAPOER is based on data collected by the annual National Socio-Economic Survey (SUSENAS). SUSENAS is fielded every year, covers a sample of about 250,000 households and is representative at the district level. For two reasons, the oil and gas sector are excluded from the GDP data in our main analysis. Firstly, the economic activity from oil and gas production is much more volatile than economic output from other sectors. Secondly, according to the World Bank (2009), there are concerns about data quality which lead to large discrepancies in data coming from the Ministry of Energy and Mineral Resources and other governmental agencies (see World Bank, 2009). However, we include the oil and gas sector in the GDP data in a robustness test.

GDP data for the district of Subulussalam over the period 2003–2006 are evidently unreliable in INDO-DAPOER, probably on account of administrative changes, and are therefore set to missing. Our findings on the negative economic legacy effects of armed conflict

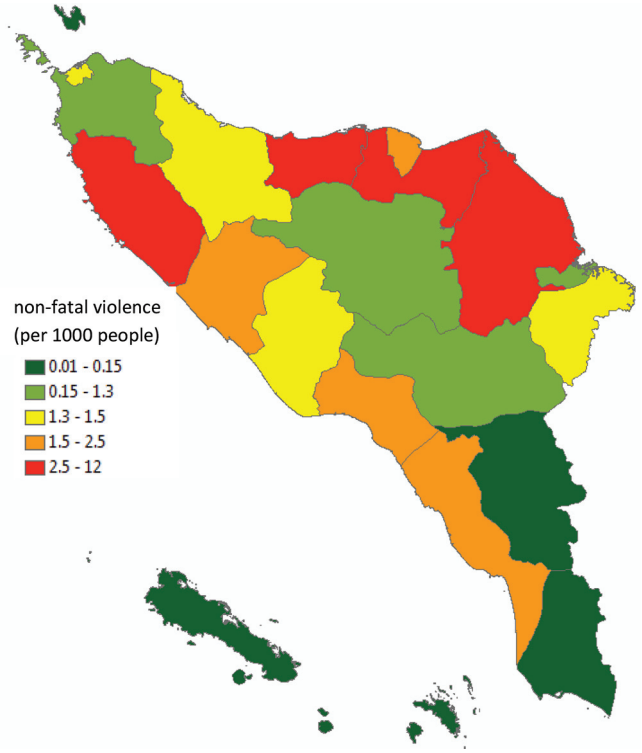


Map 2. GDP dynamics in Aceh's districts experiencing above- vs. below-median violence.
Note: GDP measures are normalized to the year 2004.

are, however, robust to including the recorded growth rates in Subulussalam over this period (results not shown).

We employ the technique of differences-in-differences regression for causal identification. This is an ideal technique for a case like ours in which it is contested whether the end of conflict can plausibly be regarded as being exogenous owing to the 2004 Boxing Day tsunami such that the treatment (the end of armed conflict) could be regarded as providing a quasi-natural experiment. As Angrist and Pischke (2015: 178) explain: 'The differences-in-differences (DD) method recognizes that in the absence of random assignment, treatment and control groups are likely to differ for many reasons. Sometimes, however, treatment and control outcomes move in parallel in the absence of treatment. When they do, the divergence of a post-treatment path from the trend established by a comparison group may signal a treatment effect'. In our case, the identifying assumption is therefore that more violent districts grew in parallel with less violent districts before the cessation of conflict, an assumption that can be tested and for which we provide supporting evidence.

There are three main periods in our dataset, namely the conflict period 1999–2004, the transition year 2005 and the post-conflict period 2006–2012. However, we further disaggregate the post-conflict period into two subperiods, estimating separate treatment effects, namely the period in which international aid of a total of US$7.7 billion was disbursed (2006–2008) and the period thereafter – aid was officially completed in early 2009



Map 3. Human capital destruction vs. physical capital destruction. (A) Fatalities per capita; (B) non-fatal violence per capita.
Note: Buildings damaged includes buildings destroyed. All measures refer to the cumulative count from 1999 to 2004.

(Henderson and Lee, 2015; Masyrafah and McKeon, 2008). We therefore estimate the following equation with district- and year-specific fixed effects and standard errors adjusted for panel-specific serial correlation within units and for contemporaneous spatial autocorrelation across units up to a distance of 100 km (Conley, 1999, 2008; Hsiang, 2010):[5]

$$\Delta Y_{i,t} = \alpha + \beta_1 \sum_{t=2003}^{2004} [(P_i * T_t)] + \beta_2 \sum_{t=2005}^{2005} [(P_i * T_t)] + \beta_3 \sum_{t=2006}^{2008} [(P_i * T_t)] + \beta_4 \sum_{t=2009}^{2012} [(P_i * T_t)] + \gamma_i + d_t + \varepsilon_{it} \quad (1)$$

Note that because our dependent variable is the economic growth rate, we lose the year 1999 since the first year for which we have information on economic growth (as opposed to GDP) is 2000. The omitted reference category in equation (1) is therefore the period 2000–2002. P_i measures conflict intensity (fatal or non-fatal violence per capita) and T_t is equal to 1 in year t and 0 otherwise. The district fixed effects γ_i are necessary for differences-in-differences estimation, while the year-specific fixed effects d_t capture any time-varying shocks over the period 2000–2012 that affect all districts within Aceh equally.

In estimating equation (1), β_1, which estimates whether more violent districts grew statistically significantly differently from less violent districts during 2003–2004, should not be statistically significant if the parallel historic paths assumption between districts that were exposed to relatively high violence and districts exposed to relatively low violence is correct.[6] Violation of this condition would throw differences-in-differences into doubt as a causal identification strategy. The coefficient β_2 estimates whether districts with higher conflict intensity experienced higher or lower growth in the transition to peace year 2005. The coefficient β_3 captures the economic legacy effect of civil conflict during the post-conflict but aid-fuelled reconstruction period of 2006–2008. With aid flows drying up in 2008, the coefficient β_4 tests whether the economic legacy effect of civil conflict is affected by this change in macroeconomic context.

Results

Before we show results from the differences-in-differences analysis, we start with some descriptive statistics that provide a tentative picture of association without being based on a causal identification strategy. If the argument is correct that districts that saw relatively little violence during the conflict can function as credible counterfactuals in the post-conflict period for districts that saw relatively more violence during the conflict, then it must be true that, across districts, there is no relationship between the extent of violence and GDP growth *during* the conflict period. Figure 3 provides a scatter plot diagram of the two variables where we use fatalities per capita as our measure of conflict intensity. The correlation coefficient between wartime violence and contemporaneous levels of GDP is practically zero at −0.01 and statistically insignificant.

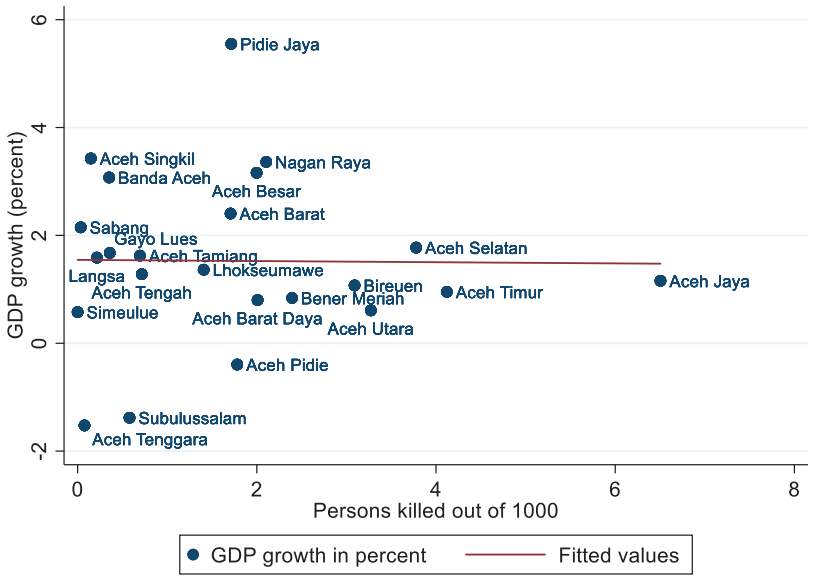


Figure 3. Non-fatal violence from separatist conflict in Aceh over time.
Note: The graph depicts the sum of all persons injured, raped or kidnapped in all districts of Aceh.

The fact that the relatively peaceful districts grew on average by about the same rate as the relatively violent districts during the conflict period is likely to result from economic spill-overs from the relatively violent onto the relatively peaceful districts during the conflict. Murdoch and Sandler (2004) find such spill-over effects for economic growth from one country affected by civil war to another; the same can be expected and is likely to be stronger within a country and particularly so for a region that is small in geographic size as Aceh. The sheer threat of violence may be enough to dissuade economic activity. Both foreign and domestic investment, for example, could have been lower in relatively peaceful areas as many potential investors may have lumped all of the districts together, not discerning the geospatial nuances of investment risk.

Remaining with purely descriptive statistics, Figure 4 provides a scatter plot diagram of conflict intensity during 1999–2004 vs. peacetime (2006–2012) economic growth rates. There is now a statistically significant negative correlation line with the correlation coefficient at -0.63, suggesting negative economic legacy effects: relatively violent districts grew more slowly than relatively peaceful districts in the post-conflict period. Of note, every district in Aceh grew faster during peacetime than it did during wartime. These descriptive statistics therefore provide evidence as follows: on the one hand, peace is clearly good for the Acehnese economy, benefiting all districts within Aceh; on the other hand, there seem to be negative economic legacy effects of armed conflict in that districts that were relatively less affected by the conflict violence receive a higher peace dividend in the form of stronger economic growth than districts that experienced relatively more violence during the conflict.

As the last piece of illustrative evidence before moving to the formal differences-in-differences analysis, Figure 5 displays the mean GDP growth dynamics of districts that experienced below-median violence as measured by deaths per capita (blue line) vs. districts above median violence (red line). The figure is consistent with the parallel historical paths assumption up until 2004 on which the differences-in-differences analysis is built. Divergence starts from 2005 onwards with districts with below-median violence during the conflict outperforming districts with above-median violence.

Descriptive statistical analysis is no substitute for causal identification, however, and we now move to the differences-in-differences analysis. Table 1 reports the results from estimating equation (1), once for fatal violence per capita and once for non-lethal violence per capita as our measures of conflict intensity. We find that the results are similar for both measures of conflict intensity. In both cases we find a statistically insignificant coefficient close to zero for the 2002–2004 period, which supports the identifying assumption of parallel historical paths between relatively more violent and relatively more peaceful districts. The transition to peace in 2005 sees the first growth disadvantage of more violent districts. Crucially, the growth disadvantage of previously relatively more violent districts continues during the 2006–2008 period. From 2009 onwards, it appears that the economic legacy effects have been overcome and the districts that experienced relatively more violence no longer grow statistically significantly more slowly than the districts that experienced relatively less violence during the conflict. In substantive terms, a 1 standard deviation increase in violence during the conflict is estimated to result in a growth disadvantage of about 2.7 percentage points in 2005 and about 1.3 percentage points per annum during the period 2006–2008 if violence is measured as fatalities per capita and, respectively, 2.8 percentage points and 0.7 percentage points per annum for non-fatal violence per capita.

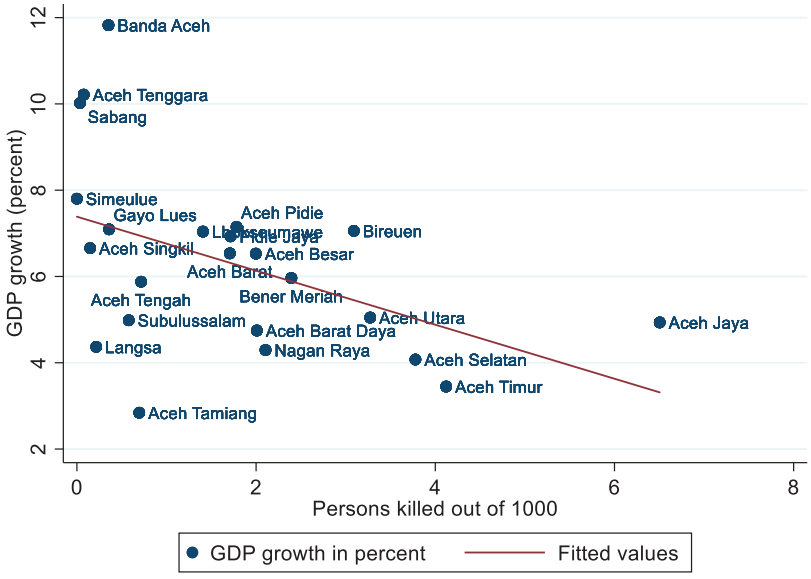


Figure 4. Fatal violence per capita in Aceh from 1999 to 2004.
Source: NVMS dataset.

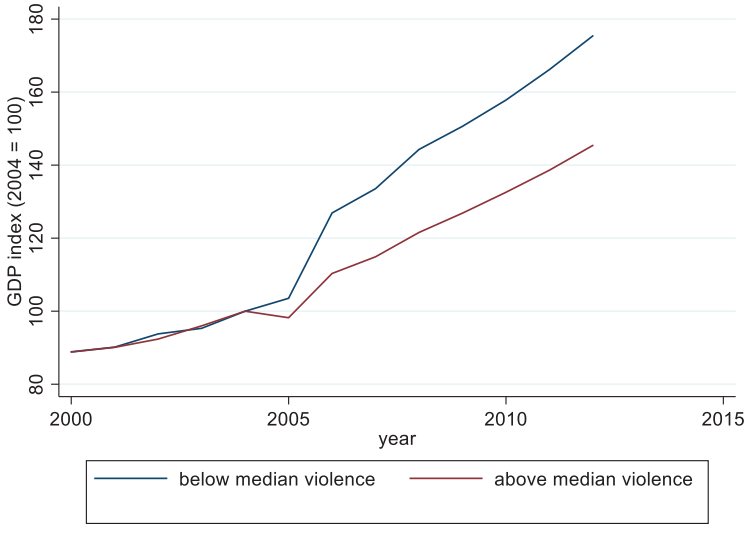


Figure 5. Non-fatal violence per capita in Aceh from 1999 to 2004.
Source: NVMS dataset.

Is it possible to attribute the economic legacy effects to destruction of physical capital vs. destruction of human capital during the conflict? Unfortunately, the available data do not allow us to disentangle one from the other. The main reason for this is that physical capital

Table 1. The effect of conflict intensity on district-level GDP growth.

Measure of conflict intensity	Fatalities per capita	Non-fatal violence per capita
Conflict intensity (2003–2004)	0.00155	0.000237
	(0.00267)	(0.00112)
Conflict intensity (2005)	−0.0412**	−0.0324***
	(0.0172)	(0.00780)
Conflict intensity (2006–2008)	−0.0120**	−0.00466**
	(0.00602)	(0.00207)
Conflict intensity (2009–2012)	−0.000657	−0.000417
	(0.00196)	(0.000629)
Observations	295	295
R^2	0.697	0.721

Note: Dependent variable is annual GDP growth rate. Each column reports results from separate ordinary least squares (OLS) regressions with district and year fixed effects included. Standard errors adjusted for panel-specific serial correction, heteroscedasticity and contemporaneous spatial correlation in parentheses. Asterisks mark statistical significance at the * 10, ** 5 and *** 1% levels.

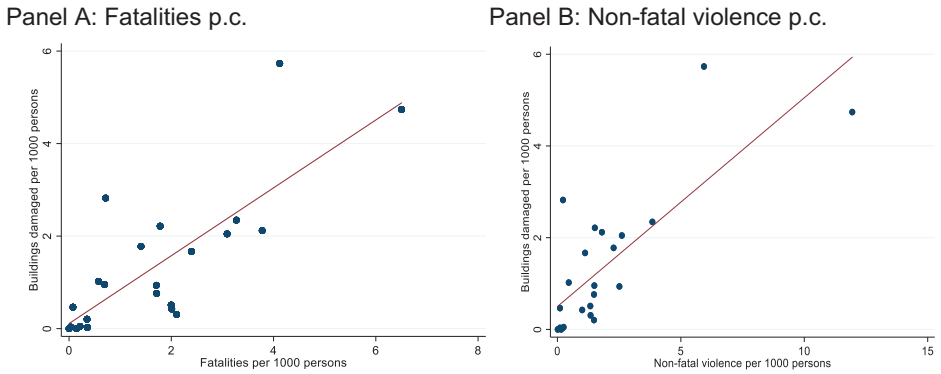


Figure 6. Wartime growth (2000–2004) vs. wartime conflict casualties per capita (1999–2004) in Acehnese districts.
Note: GDP growth rate in percent refers to the average annual growth rate. The equation for the fitted linear regression line is $y = 1.55 - 0.01x$, with an insignificant coefficient ($p = 0.939$) and an R^2 of 0.0001.

and human capital destruction were closely related in the civil war, as Figure 6 shows, which plots the number of buildings damaged or destroyed per capita (as a proxy for physical capital destruction) against number of fatalities per capita and non-fatal violence per capita (as our two proxies for human capital destruction). As can be seen, there is a very strong positive correlation.

What can we say about the reasons or causal mechanisms for the economic legacy effects found in Table 1? In Heger and Neumayer (2019) we explore the tsunami's effect on structural economic change and, using synthetic control as the inferential technique, we show that Aceh as a whole expanded its tertiary sector much faster post-tsunami than a counterfactual synthetically created Aceh would have done. Building on this finding, the results reported in Table 2 explore whether these are also causal mechanisms why districts more exposed to violence during the conflict grew more slowly during 2005–2008. We have no district-level data

Table 2. The effect of conflict intensity on district-level growth in tertiary sector and construction sector.

Dependent variable	Tertiary sector growth		Construction sector growth	
Measure of conflict intensity	Fatalities per capita	Non-fatal violence per capita	Fatalities per capita	Non-fatal violence per capita
Conflict intensity (2003–2004)	0.0123	0.00540	0.00400	0.000962
	(0.0128)	(0.00544)	(0.00537)	(0.00238)
Conflict intensity (2005)	−0.0280*	−0.0225**	−0.0267	−0.0257**
	(0.0165)	(0.00894)	(0.0206)	(0.0108)
Conflict intensity (2006–2008)	−0.0247	−0.0110*	−0.00262	−0.00249
	(0.0158)	(0.00602)	(0.00665)	(0.00336)
Conflict intensity (2009–2012)	0.000492	0.000312	−0.00354	−0.00223*
	(0.00259)	(0.00106)	(0.00315)	(0.00127)
Observations	295	295	295	295
R^2	0.586	0.582	0.380	0.392

Note: Dependent variable is annual tertiary sector growth rate and construction sector growth rate, respectively. Each column reports results from separate OLS regressions with year and district fixed effects included. Standard errors adjusted for panel-specific serial correction, heteroscedasticity and contemporaneous spatial correlation in parentheses. Asterisks mark statistical significance at the * 10, ** 5 and *** 1% levels.

on capital formation but use growth in the construction sector as a (crude) proxy for capital formation. We find some statistically significant evidence that violence experience matters for tertiary sector and construction sector expansion, particularly if non-fatal violence per capita is our measure of conflict intensity.

Robustness tests and potential threats to inferential validity

In this section, we subject our findings to robustness tests (Neumayer and Plümper, 2017) and we discuss the potential confounding effects of the impact of the tsunami, the distribution of aid and the displacement of people as potential threats to inferential validity. Firstly, one may wonder whether our decision to group years into certain, albeit well-defined, periods hides significant variation within these periods. The results reported in Table 3 therefore present separate effects for every single year rather than aggregated into periods. The results suggest that statistically significant economic growth disadvantages occur during the years 2005–2007, but not from 2008 onwards.

Secondly, it is not entirely clear whether the GDP growth rate or the growth rate in GDP per capita should be the main outcome of interest. We agree with Hodler (2019), who argues in favour of GDP on the basis that, firstly, GDP per capita measures can fail to account for economic losses from fatalities and, secondly, population data are typically heavily smoothed over time. Clearly, views differ on which of the two should be the main outcome of interest but in any case the results reported in Table 4 show that we arrive at qualitatively the same result if we employ growth in GDP per capita rather than growth in GDP as the dependent variable.

Table 3. Robustness test: yearly effect estimates.

Measure of conflict intensity	Fatalities per capita	Non-fatal violence per capita
Conflict intensity (2001)	−0.00124	−0.000740
	(0.00249)	(0.000668)
Conflict intensity (2002)	−0.00196	−0.000689
	(0.00285)	(0.000785)
Conflict intensity (2003)	0.00210	0.000181
	(0.00459)	(0.00224)
Conflict intensity (2004)	−0.00122	−0.000685
	(0.00266)	(0.000728)
Conflict intensity (2005)	−0.0423**	−0.0329***
	(0.0173)	(0.00785)
Conflict intensity (2006)	−0.0329**	−0.0129**
	(0.0139)	(0.00621)
Conflict intensity (2007)	−0.00256	−0.00130*
	(0.00280)	(0.000684)
Conflict intensity (2008)	−0.00405	−0.00133
	(0.00389)	(0.00180)
Conflict intensity (2009)	−0.00218	−0.00102
	(0.00343)	(0.00113)
Conflict intensity (2010)	−0.00167	−0.000797
	(0.00310)	(0.000984)
Conflict intensity (2011)	−0.00118	−0.000666
	(0.00264)	(0.000856)
Conflict intensity (2012)	−0.00185	−0.00109
	(0.00260)	(0.000823)
Observations	295	295
R^2	0.717	0.729

Note: Dependent variable is annual GDP growth rate. Each column reports results from separate OLS regressions with district and year fixed effects included. Standard errors adjusted for panel-specific serial correction, heteroscedasticity and contemporaneous spatial correlation in parentheses. Asterisks mark statistical significance at the * 10, ** 5 and *** 1% levels.

Table 4. Robustness test: district-level GDP per capita growth.

Measure of conflict intensity	Fatalities per capita	Non-fatal violence per capita
Conflict intensity (2003–2004)	−0.000475	−0.00177
	(0.00266)	(0.00148)
Conflict intensity (2005)	−0.0208***	−0.0155***
	(0.00617)	(0.00361)
Conflict intensity (2006–2008)	−0.0161***	−0.00831***
	(0.00586)	(0.00179)
Conflict intensity (2009–2012)	−0.00154	−0.00114
	(0.00361)	(0.00236)
Observations	295	295
R^2	0.572	0.569

Note: Dependent variable is annual GDP per capita growth rate. Each column reports results from separate OLS regressions with district and year fixed effects included. Standard errors adjusted for panel-specific serial correction, heteroscedasticity and contemporaneous spatial correlation in parentheses. Asterisks mark statistical significance at the * 10, ** 5 and *** 1% levels.

Table 5. Robustness test: including oil and gas revenues in GDP measures.

Measure of conflict intensity	Fatalities per capita	Non-fatal violence per capita
Conflict intensity (2003–2004)	−0.00851	−0.00564
	(0.0152)	(0.00992)
Conflict intensity (2005)	−0.0349	−0.0237
	(0.0261)	(0.0231)
Conflict intensity (2006–2008)	−0.0262*	−0.0153*
	(0.0141)	(0.00792)
Conflict intensity (2009–2012)	−0.00721	−0.00446
	(0.00907)	(0.00556)
Observations	295	295
R^2	0.269	0.268

Note: Dependent variable is annual GDP per capita growth rate. Each column reports results from separate OLS regressions with district and year fixed effects included. Standard errors adjusted for panel-specific serial correction, heteroscedasticity and contemporaneous spatial correlation in parentheses. Asterisks mark statistical significance at the * 10, ** 5 and *** 1% levels.

In the next robustness test, for which results are reported in Table 5 we include the oil and gas sector in the GDP measures on which growth rates are based. Results are robust except for the growth disadvantage in 2005, with the coefficient of this variable becoming smaller in size as well as statistically insignificant.

The conflict hotspots were rural areas, rather than cities. GAM rebels located preferentially in rural districts as it was easier to hide in the rural jungle than in the cities, among other tactical reasons. Part of the reason why the more conflict-affected districts grew more slowly could therefore have something to do with the fact that their counterfactuals contain city districts that have a different growth potential than rural districts (Kabupatens). The identifying assumption of our differences-in-differences design is that more violent districts grew in parallel with less violent districts during the conflict period. We have presented supportive evidence for this identifying assumption but critics might argue that this is sheer coincidence. In a robustness test for assessing whether the negative economic legacy effects still hold if we exclude city districts that may have a structurally different growth trajectory and potential, we exclude the five city districts (Kotas) of Banda Aceh, Langsa, Lhokseumawe, Sabang and Subulussalam and repeat the differences-in-differences analysis without them – see Table 6.

The negative economic legacy effects are almost identical for 2005 but become slightly weaker in the 2006–2008 period if the city districts are excluded from the analysis and statistically insignificant if we use fatalities per capita as the measure of conflict intensity.

In Table 7 we explore whether the conflict experience in neighbouring or adjacent districts has spillover effects onto the post-conflict growth performance. In formal terms, this requires the inclusion of a spatial-x variable, where the spatial-x variable measures how exposed adjacent (contiguous) districts have been on average during the armed conflict. We include such a variable in the robustness test reported in Table 7. We do not find statistically significant effects for the spatial-x variables (coefficients not shown), whilst the results for exposure to violence in the district under observation are hardly affected.

Turning to potential threats to inferential validity, the effect from the tsunami and reconstruction efforts in its wake, which differentially affected districts in Aceh, may potentially confound the economic legacy effects of civil war. In Heger and Neumayer (2019), we

Table 6. Robustness test: rural districts only.

Measure of conflict intensity	Fatalities per capita	Non-fatal violence per capita
Conflict intensity (2003–2004)	0.00208	0.000342
	(0.00315)	(0.00127)
Conflict intensity (2005)	−0.0449**	−0.0331***
	(0.0194)	(0.00737)
Conflict intensity (2006–2008)	−0.00883	−0.00386*
	(0.00623)	(0.00208)
Conflict intensity (2009–2012)	−0.000605	−0.000325
	(0.00184)	(0.000494)
Observations	234	234
R^2	0.690	0.728

Note: Dependent variable is annual GDP per capita growth rate. Each column reports results from separate OLS regressions with district and year fixed effects included. Standard errors adjusted for panel-specific serial correction, heteroscedasticity and contemporaneous spatial correlation in parentheses. Asterisks mark statistical significance at the * 10, ** 5 and *** 1% levels.

Table 7. Robustness test: controlling for conflict intensity in adjacent districts.

Measure of conflict intensity	Fatalities per capita	Non-fatal violence per capita
Conflict intensity (2003–2004)	0.00137	0.000135
	(0.00264)	(0.000944)
Conflict intensity (2005)	−0.0412**	−0.0324***
	(0.0172)	(0.00771)
Conflict intensity (2006–2008)	−0.0118**	−0.00443**
	(0.00578)	(0.00182)
Conflict intensity (2009–2012)	−0.000648	−0.000405
	(0.00199)	(0.000635)
Observations	295	295
R^2	0.697	0.724

Note: Dependent variable is annual GDP growth rate. Each column reports results from separate OLS regressions with district and year fixed effects included. Spatial-*x* variables measuring average conflict intensity in adjacent districts included (coefficients not shown). Standard errors adjusted for panel-specific serial correction, heteroscedasticity and contemporaneous spatial correlation in parentheses. Asterisks mark statistical significance at the * 10, ** 5 and *** 1% levels.

demonstrate that flooded districts grew faster from 2006 to 2008, that is, after the natural disaster, than non-flooded districts. Map 4 shows where the tsunami made landfall in the Aceh province.

In a further robustness test we formally control for the impact of the tsunami to make sure that the destructive effects followed by massive aid-fuelled reconstruction efforts do not conflate our findings on the economic legacy of armed conflict. To do so, we add time-invariant tsunami treatment variables D_i to the estimation equation, with D_i measuring how many people are estimated to have been killed by the tsunami as a proportion of each district's population with data taken from Doocy et al. (2007). We also control for the total sum of aid per capita disbursed from 2005 onwards to districts, where A_i measures aid disbursements per capita. The estimation equation therefore becomes:

Map 4. Inundation areas of the 2004 Indian Ocean tsunami in the Aceh province.
Note: Flooded areas according to the German Aerospace maps and the Dartmouth Flood Observatory estimations. The Aceh province has 23 districts, of which 10 were flooded and 13 were not. The above map does not show the two island districts of Simeulue and Aceh Singkil that were also flooded.

$$\begin{aligned}\Delta Y_{i,t} = {} & \alpha + \beta_1 \sum_{t=2003}^{2004} [(P_i * T_t)] + \beta_2 \sum_{t=2005}^{2005} [(P_i * T_t)] + \beta_3 \sum_{t=2006}^{2008} [(P_i * T_t)] \\ & + \beta_4 \sum_{t=2009}^{2012} [(P_i * T_t)] + \lambda_1 \sum_{t=2003}^{2004} [(D_i * T_t)] + \lambda_2 \sum_{t=2005}^{2005} [(D_i * T_t)] \\ & + \lambda_3 \sum_{t=2006}^{2008} [(D_i * T_t)] + \lambda_4 \sum_{t=2009}^{2012} [(D_i * T_t)] + \mu_1 \sum_{t=2003}^{2004} [(A_i * T_t)] \\ & + \mu_2 \sum_{t=2005}^{2005} [(A_i * T_t)] + \mu_3 \sum_{t=2006}^{2008} [(A_i * T_t)] + \mu_4 \sum_{t=2009}^{2012} [(A_i * T_t)] + d_t + \gamma_i + \varepsilon_{it}\end{aligned} \tag{2}$$

The results reported in Table 8 demonstrate that our results are hardly affected by including these two potential confounders. The results are practically identical to the ones reported in Table 1. In non-reported further tests, we interacted the conflict with the tsunami

Table 8. Robustness test: controlling for tsunami deaths per capita and aid disbursements per capita.

Measure of conflict intensity	Fatalities per capita	Non-fatal violence per capita
Conflict intensity (2003–2004)	−0.000162	−0.00202
	(0.00323)	(0.00228)
Conflict intensity (2005)	−0.0197***	−0.0154***
	(0.00529)	(0.00454)
Conflict intensity (2006–2008)	−0.0181**	−0.0135**
	(0.00749)	(0.00538)
Conflict intensity (2009–2012)	−0.000864	−0.000858
	(0.00228)	(0.00196)
Observations	295	295
R^2	0.768	0.765

Note: Dependent variable is annual GDP growth rate. Each column reports results from separate OLS regressions with district and year fixed effect included. Estimations include the tsunami deaths per capita and aid disbursement per capita variables from equation (2) as control variables (coefficients not shown). Standard errors adjusted for panel-specific serial correction, heteroscedasticity and contemporaneous spatial correlation in parentheses. Asterisks mark statistical significance at the * 10, ** 5 and *** 1% levels.

variables. We find a statistically significant negative interaction effect in 2005 only. This suggests that some of the growth disadvantage in 2005 of districts that experienced greater conflict intensity might be down to them having experienced greater economic damage by the tsunami in that year than less violent districts. However, the economic growth disadvantage of more violent districts is not impacted by their tsunami experience over the period 2006–2008. Similarly, we interacted the conflict with the aid disbursements variables, following a finding by De Juan et al. (2020) on the conditioning effect of reconstruction aid on post-conflict economic development in the wake of an earthquake in Nepal, but found no evidence for statistically significant interaction effects.

Another potential threat to inferential validity stems from internal population displacement during the civil war. Movements of people out of the units of analysis, the districts within Aceh, may violate the stable unit treatment value assumption. There are two types of displacement that may pose a challenge. Firstly, internally displaced persons (IDPs) may move from one district to another within Aceh; secondly, IDPs may move out of Aceh altogether and flee to another Indonesian province, such as North Sumatra.

It is estimated that the conflict led to between 500,000 and 600,000 IDPs from 1999 to 2004 (IDMC, 2006, 2010). There were two main waves of displacement (Czaika and Kis-Katos, 2009). The first wave took place from 1999 to 2000 when most people only temporarily fled from the violence in their village, escaping to, inter alia, community centres and mosques within the province, mostly even still within the districts, and they returned within one or two weeks to their villages. This first wave therefore does not violate the stable unit treatment value assumption.

The second wave of displacement, when the fighting intensified from 2001 onwards, is potentially more problematic. The increasing violence resulted in a swell in numbers of IDPs, reaching almost 180,000 by September 2002, and eventually amounting to more than half a million. Many of these displaced people had to stay away from their villages for months and in some cases for as long as 2 years. The great majority of them returned before the end of the civil war (Ramly, 2005), but about one-quarter of IDPs have stayed at the destination

where they fled to, particularly if they fled to another province outside Aceh. According to one estimate as many as almost 150,000 IDPs who fled to neighbouring provinces during the separatist conflict were still outside of Aceh by 2010 (IDMC, 2010). The majority of these IDPs who have still not returned are ethic Javanese (Hedman, 2005). They fled, occasionally even with military escort, predominantly to Medan in Northern Sumatra (Buiza and Risser, 2003). The ethnic Acehnese who moved outside of the province were often met with considerable amounts of hostility and risk of arrest and detention, and therefore many returned to Aceh before the end of the civil war. However, the non-return of the ethnic Javanese people to districts within Aceh that saw intense violent conflict during the war probably leads to an overestimation of the negative economic legacy effects if estimated in growth in GDP since fewer economically productive people are present after the civil war than before people fled. Yet the fact that we find very similar economic legacy effects in growth in GDP per capita suggests that the legacy effects cannot simply be due to population loss.

Conclusion

In this study, we have exploited data on subnational violence and economic growth in Aceh to analyse the economic legacy effects from civil war. Our analysis over the period 2000–2012 showed that, for each and every district in the sample, average economic growth rates were higher after the end of conflict in 2005 than during the war years, which indicates a general peace dividend in the form of catch-up growth, consistent with macro-economic theory and with much of the existing empirical evidence at the national or cross-national level.

Importantly, however, at the same time we find specific negative economic legacy effects of armed conflict since the districts exposed relatively more to violent conflict during the war experience statistically significantly lower economic growth during the years 2005–2008 than their counterfactual counterparts, namely districts that were exposed relatively less to violence during the conflict. In contrast, relatively more violent and relatively more peaceful districts grew at similar rates that are not statistically distinguishable during the conflict period. This suggests that even though relatively peaceful districts were less directly affected by violence during the war, they were indirectly held back economically by a state of perpetual civil war throughout the province of Aceh. Once the conflict is over, however, the heterogeneous exposure to conflict intensity results in a negative economic legacy effect for the hot spots of conflict violence. Somewhat ironically, therefore, in relative rather than absolute terms, being exposed to more intense violence during the conflict in Aceh proved economically damaging after the end of rather than during the civil war for these hot spots of violence. Preliminary evidence that deserves a much more detailed exploration in future research suggests that more peaceful districts managed to expand their tertiary sector faster and increase their per capita capital formation by more than more violent districts managed to.

This finding of relative negative economic legacy effects corroborates similar findings by Collier and Duponchel (2013) for Sierra Leone and Serneels and Verpoorten (2015) for Rwanda. Since social science should, at its best, provide cumulative knowledge, this is encouraging as it provides evidence on the external validity of these findings. Owing to their research design, which is limited by the availability of data over time, neither of these two studies can estimate when the negative legacy effects disappear. In our own study, the negative effects are relatively short-lived: at the latest from 2009 onwards, i.e. 4 years after the full cessation of conflict, we no longer find a statistically significant growth disadvantage of

districts that were more heavily exposed to violence during the conflict. Future research, which like our analysis must employ subnational economic and violence data, can provide further insight into the external validity of our central finding of negative economic legacy effects in the aftermath of armed conflict that, in the case of Aceh at least, last for about 4 years.

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Notes

1. The data can be accessed at: http://microdata.worldbank.org/index.php/catalog/2626 (accessed 15 November 2020).
2. If we were to employ the UCDP data in our estimations, then we find similar results except the negative co-efficient for the 2006–2008 period becomes marginally statistically insignificant.
3. Official statistics point to about 30,000 people killed during the violent conflict between GAM rebels and government soldiers from 1976 to 2005 (MSR, 2009). The NVMS records start in 1999 and account for about 8500 deaths.
4. For a more in-depth documentation of the dataset, see http://data.worldbank.org/data-catalog/indonesia-database-for-policy-and-economic-research (accessed 15 November 2020).
5. The choice of 100 km as cut-off point is somewhat arbitrary. We can set the cut-off limit much lower or much higher without any major impact on the results.
6. The choice of 2 years for the pre-treatment period of 2003–2004 is somewhat arbitrary. Results are robust to choosing a longer period of 2002–2004, in which case the omitted reference category becomes 2000–2001 instead of 2000–2002.

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