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The price of war: A cross-country analysis on the conflict-growth nexus

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A B S T R A C T

With the growth in conflict around the world, the measurement of the likely economic cost of conflict is an important task in making the case for peacekeeping, peacemaking and post conflict reconstruction to prevent recurrence. Conflict is also a development issue, as most of the conflicts affect the poorest countries and are often civil wars. This paper deals with a number of issues that arise in the literature and presents a comprehensive analysis of the relationship between conflict and economic growth in the present geopolitical environment. Utilizing an extensive cross-country panel dataset and a structural growth model incorporating conflict dynamics, it offers robust estimates of the effects of conflict. It finds that they are higher for low-income countries with direct and spillover effects larger for Asia. It also showed that the spillover effects of conflict do not affect the overall damage on the GDP loss and this result does not change in the post-Cold War period.

1. Introduction

While a large empirical literature on the economic costs of conflict does exist and is large, there is disagreement over the effects. Blattman and Miguel (2010) estimated that since 1960, twenty percent of all countries had experienced at least ten years of civil conflict, and Collier (1999) had estimated that during a war, the growth rate of a country is typically reduced by 2.2% per year. More recently, estimates based on panel data suggest that the damage caused by conflict ranges from 1.5 (Costalli et al., 2017; Petrova et al., 2023) to 4.4% per year (Mueller, 2016). These losses can continue post-war, with Cerra and Saxena (2008) finding output to decline by about 6% after a civil war. In 2008 the United Nations Development Programme (UNDP) Bureau for Crisis Prevention and Recovery suggested that the economic cost of civil war lies somewhere between 1.7 and 3.3 percent of GDP per country per conflict year before 1990 and the average reduction was about 12.3 percent of GDP after 1990, the post-Cold War era (Ohiorhenuan, 2008). The apparent loss of output is, however, staggering, and although countries recover it is not for a good number of years. Gates et al. (2012) and Mueller (2012) revised the estimates of GDP loss which increased to 15%–18% considering duration as well, while Novta and Pugacheva (2021) estimate a larger cost of conflict, with GDP per capita 28 percent lower after ten years after the conflict onset.

In contrast, some contributors have questioned whether there is a cost of conflict at all. Tilly (1992) and Cramer (2006) pointed out the potential benefits of regime change, while Organski and Kugler (1980) suggested the impact of the major European wars was historically

marginal. In a cross country panel analysis, Bove et al. (2016) compare the impact of civil war on GDP using a variety of methods. They eschew a structural model and use synthetic control, case study, and large *N* panel methods to get a range of estimates. While, on average, the impact is found to be negative, they find a large degree of heterogeneity across countries, estimating 27 individual case studies, with a range of estimates between minus 33 percent of GDP and plus 32.

The debate, however, has continued, as the net effect of conflict remains an important question, with arguments for the economic costs of conflict often the main justifications for engagement by the international community, after loss of life. There also remain a number of areas of contention that would benefit from re-examination and continuing to provide up to date findings as data availability increases is an important task for researchers. This is especially so in a period in which conflict seems to be growing rapidly. In addition, the literature has usually split conflict into two categories, war between countries and civil war. This distinction has, however, become less clear. Inter state wars are when there are two or more nation states involved in conflict. Intra state war refers to civil conflicts within a nation state, which will tend to have a lower profile in the international media. This can take several forms of government against insurgent groups, guerillas, militia, and sometimes armies. There may or may not be external involvement, though there usually is. Such conflicts can be devastating and destructive and they have been both prevalent and increasingly persistent over the past sixty years. There is also an overlap with terrorism and criminal networks that may introduce transnational elements into domestic

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disputes. This is now recognized in the *Uppsala Conflict Data Program* (UCDP) database, which distinguishes state-based conflict, non-state conflict, and one-sided violence, and looks at the best estimates of the number of people killed, both civilians and combatants (Pettersson, 2019).

This paper revisits the analysis of the impact of conflict on growth in the present climate, using extensive cross-country panel data and a structural growth model with conflict included. Since most wars are relatively small, with most in the range of 25–999 battle-related deaths per year, the common measure of conflict is now an event with more than 25 battle related deaths (Davies et al., 2022) and is used as a benchmark for the analyses. It considers conflict experience, both state and non state, and confronts the estimation concerns that have been raised in the literature. In addition, internal and external conflict indicators from the Country Risk Guide (ICRG) are used for robustness (Crippa et al., 2024). Finally, the continuous indicator of conflict related battle deaths is also considered, to account for its intensity.¹ However, continuous measures of conflict can suffer from problems of spurious accuracy, as it is not clear how consistently or well the deaths are measured. It is not clear from the data exactly when a conflict becomes disruptive for the economy, and it may differ across regions of the country. Using a variable that recognizes a conflict when 25 or more battle-related deaths are observed is informative about the intensity of the conflict over the years, its duration, and the unobserved behaviour of people during the conflict.

For the empirical analysis, the study first, takes advantage of an extensive dataset to move beyond the general reliance on static forms of the empirical growth models and, second, deals with concerns of endogeneity. Third, it considers the spillover effects of conflict, whose presence cannot be easily determined and fourthly, it uses the estimated coefficients to construct the expected cumulative impact of conflict on GDP per capita as a whole and across groups of economies. The results confirm that there is a robust negative effect of conflict on GDP per capita growth, with a magnitude consistent with those found in other studies. We also show that there are significant spillover effects that need to be accounted for. While less heterogeneity is found than in some other studies, it does still exist, across regions and income levels. Estimates of the macroeconomic costs of conflict are generally large, with GDP per capita of about 35 percent lower and they suggest that spillover costs in the long run are less important.

The next section offers a review of the cost of conflict literature and the approaches taken. Section 3 presents the data and the empirical analysis within the growth model framework, considering several issues. Section 4 then considers the spillover effects and Section 5 considers the economic losses across the globe using the long run cumulative percentage of output losses for countries and regions. Finally, Section 6 provides some conclusions.

2. Measuring the costs of conflict

Very few conflicts are simple, they are often the result of a combination of factors and this fact can have important implications for the achievement of peace and the success of post-conflict reconstruction policies (Dunne, 2013). The costs of conflict are wide-ranging and in the short and medium term, these include the lives lost, the permanent injuries, the refugees, military expenditure, asset losses (i.e. destroyed capital including human), GDP or production losses (i.e. income), trade losses. Long term costs, which are less frequently considered include intergenerational effects, transboundary effects, and environmental effects, and are cumulative in terms of GDP losses.

Battle-related deaths are not the whole story by any means, as in many countries conflict leads to many hidden casualties and the

devastation can mean people die for years after a conflict ends - a legacy cost of the conflict that is often ignored (Smith, 2013). Deaths are only part of the violence engendered by conflict, as the existence of conflict in a country creates the environment in which all forms of violence are possible and the less “headline” forms of violence often remain as a legacy when the conflict is supposedly over (Brauer & Dunne, 2012). Thus, the effect of conflict may exacerbate the economic growth declines associate with violence, generating long-term impacts after the fighting ceases (Gates et al., 2012). This is confirmed by Moyer (2023) who used simulations to evaluate the impact of past conflict on future growth, finding that even without further conflict, the long term effects of past conflict would mean conflict affected states.

Vesco et al. (2025) provide a comprehensive review of the cross-disciplinary studies on the effects of conflict on human development. Their review posits that the macro estimates of the effects of conflict are larger than would be predicted by the micro studies, because of reinforcing impacts across different domains.² This also justifies the search for better macro estimates of the effects of conflict undertaken in this paper.

There are two main approaches used in attempting to measure the economic costs of conflict and put a figure on it. First, attempts to measure the actual cost of conflict, using the accounting and counterfactual methods. In the accounting method, the researcher tries to work out the total value of goods, assets, etc. destroyed in the conflict. A fairly comprehensive schema would set the direct and indirect costs and find values for as many of the headers as possible. This is a very difficult task and can only be attempted for case studies of individual countries and in most cases, there will be many missing values and ‘guesstimates’. The more commonly used counterfactual method makes an effort to compare the path of the economy during the conflict with the likely path it would have taken in the absence of conflict. This comparator could be a simple trend, the average growth for the income bracket of the country, a similar country, or an artificial country (a combination of countries that reflect the characteristics of the one under study). The area between the lines then indicates cumulative GDP losses (Brauer & Dunne, 2012). This is a stylized perspective and there is some debate over what happens during the crisis and how to measure the counterfactual, but it is a useful heuristic device. Novta and Pugacheva (2021) use pre conflict IMF forecasts for the comparator. Other contributors have used the synthetic control method from the Abadie and Gardeazabal (2003) study of the impact of conflict on the Basque region. This approach compares the actual trajectory of a Region/country, with a combination of other regions/countries weighted and aggregated to look like the treated unit. So, the comparator is a synthetic country that represents the treated country (Bove et al., 2016; Costalli et al., 2017).³

A second approach, the economic growth approach, considers that if conflict affects the performance of the economy, it should be through the factors of production or technology, plus the institutions and culture that augment them. However, different theoretical approaches can give different conclusions. In a basic neoclassical growth model, a one-time shock to capital stock may not affect the equilibrium, but poverty trap, endogenous growth, and vintage type models will give persistent effects that can be damaging (Sachs, 2005). Asymmetric destruction could influence the recovery of an economy and certainly in a Barro-type endogenous growth model (Barro, 1990) a disproportionate loss

² Disruptions in production networks play a crucial role in shaping both micro- and macroeconomic impacts of conflict. Amodio and Di Maio (2017) demonstrate that import substitution accounts for a large part of the decline in output value among Palestinian firms in high-conflict districts during the Second Intifada.

³ An alternative panel data approach can be employed to construct a counterfactual, and Bove et al. (2016) propose a method to evaluate the significance of synthetic control effects by comparing panel and synthetic control estimates of the cost of conflict.

¹ See, Barrett (2022), Mueller (2016), Novta and Pugacheva (2021) for a discussion of using battle-related deaths and war-related deaths per capita.

of human capital could lead to slower recovery. There is also an identification problem in that countries in conflict could be different from peaceful countries, so bad performance after the conflict could reflect what the country was like before the conflict rather than the fact that it was damaged by the conflict. As regards physical capital, the evidence suggests the post-war evolution of capital shows a rapid recovery to equilibrium, consistent with the neoclassical prediction. Although some evidence as the study by Miguel and Roland (2011) on U.S. bombing in Vietnam finds that the destruction of infrastructure does not appear to have long-term effects, such predictions may be generally overoptimistic, as economic devastation may also prevent a durable peace, leading to further costs (Dunne, 2013).

In addition, there are also factors that these models do not consider, the destruction of household assets, the flight of capital, and the effect of uncertainty on the cost of capital, which can play an important roles in economic recovery. As mentioned, plenty of people are killed in conflict, and this has an impact on the labour force and human capital, but while there may be mixed evidence on how long the economic effects last, there are negative human capital effects on both non-combatants and combatants.⁴ While fatalities may be relatively low, as a proportion of the population, related deaths, and injuries can increase the impact significantly (Gates et al., 2012; Ghobarah et al., 2003). At the same time institutions and economic networks also suffer damage and these can be important in hampering growth, though there is little work on how they evolve, adapt, and decline in war.⁵ What effects conflicts have can also vary depending on how the war started and why and how it ended, such as in stalemate or victory for one side (Blattman & Miguel, 2010).

While there is little discussion of the possible benefits of conflict and armed violence, they do exist and can be important. Many modern states owe their formation to some form of conflict, and war can sometimes have positive economic effects by removing ineffective leaders or prompting the introduction of structures and governance necessary for modernization.⁶ The basic neoclassical models would forecast that countries will just bounce back quickly from conflict to long-term trend, with some sort of phoenix effect (Organski & Kugler, 1980). But such predictions would be for the long run, and it is unclear how long that could take. Certainly, the destruction of old capital can have benefits and there may even be human capital benefits, while there may be positive effects of spillovers, as immigrants/refugees can boost the labour force in the host country. There may be such benefits, such as it is extremely difficult to measure them or to disentangle them from the negative impacts.

When conflicts occur, it is not just a cost to the countries involved but also to neighbours and other countries in the region. Collier (1999) recognized this, and Murdoch and Sandler (2002a) provided an analysis of spillover effects on neighbouring countries, finding for a sample of 84 countries during the period 1960 to 1990, that civil wars had a significant negative influence on the steady-state level of GDP per capita for both the conflict afflicted country and its neighbours. In two subsequent papers, Murdoch and Sandler (2002b, 2004) varied the periods, country samples, and the definition of contiguity, using the Gleditsch and Ward (2001) minimum distance between nations' datasets. In all

three papers, the long-run effects of conflict were insignificant, which they attribute to Organski and Kugler (1980) 'phoenix effect', while civil wars were found to have a negative and significant short-run growth effect on both the host and neighbouring countries. De Groot (2010) argued that the theoretical model should include multidirectional spillover effects, between contiguous states, as there could be a growth trade-off that benefits secondary neighbours but punishes primary neighbours. Dunne and Tian (2014) developed this work to allow for the issue of whether physical distance measures are adequate in assessing spillover effects, following the Beck et al. (2006) suggestion that political, economic, and even cultural 'distance' needed to be considered.

This large empirical literature and the range of detailed case studies provide valuable contributions to the understanding of the impact of conflict on countries, but do not obviate the value of research using large panel datasets. It is still important to get estimates of average effects, to get some idea of the costs of conflict, and to justify expenditures on conflict prevention and post-conflict reconstruction. Using a structural model arguably provides a more grounded approach and over time data availability improves estimation and specification. Improvements in dealing with issues such as endogeneity allow better estimates to be provided. Convincing estimates of the cost of conflict remain important inputs into policy debate.

3. Empirical analysis

Taking an extended version of a neoclassical exogenous growth model:

$$Y(t) = K(t)^\alpha H(t)^\beta [A(t)L(t)]^{1-\alpha-\beta}, 0 < \alpha + \beta < 1 \quad (1)$$

where α and β are the elasticities of output with respect to physical and human capital respectively. $Y(t)$ denotes output at time t , $K(t)$ is physical capital, $H(t)$ is stock of human capital and $A(t)$ is the technology parameter with output elasticity of $(1 - \alpha - \beta)$. Labour is assumed to grow at an exogenous growth rate of n , technical progress will grow at the exogenous rate of g and both physical and human capital will depreciate at the identical rate δ .

As outlined above, conflict leads to the destruction of resources, the most obvious way is through killing or maiming of the labour force and destruction of goods, capital, and infrastructure, but it will also disrupt social order, suppressing civil liberties (political and social freedom) and so reducing the efficiency of public expenditure. Such effects will damage the rate at which human and physical capital is accumulated; limit investor confidence and hence divert investment away from the country and the region (Collier, 1999; Isham et al., 1995).

While physical investment and education level are known to be correlated with conflict and long-term impacts on the productive capacity of an economy (e.g., Chin et al. 2023, Égert and de la Maisonnette 2023), other covariates also have mediating effects in dynamic growth models. The quality of political institutions, measured by state capacity and democracy can shape the impact of conflict. Disruption induced by war can contribute to weaker fiscal capacity. Examples include the finding by Unfried and Kis-Katos (2023) that loss of income and human capital due to conflict is mostly felt in weak states. In addition, finding mixed results for the effect of civil wars on democratization does not obviate the need to control for such factors. They are potential mediating factors that can have important indirect effects. In addition, the expectation of violence and/or conflict can also lead to the diversion of investments, currency devaluation and reduced trade, further amplifying the macroeconomic costs. Indeed, fluctuations in the exchange rate affecting a country's trade balance, triggering negative feedback mechanisms with long repercussions, particularly for developing economies (Michail, 2021). It is thus important to control for these factors in a dynamic growth model.

⁴ Recent work on macro forecasting by Diakonova et al. (2024) suggests that expectations of violence and resulting disruptions in asset prices are valuable predictors of GDP. However, since full economic recovery occurs only when peace is perceived as stable, the economic disruptions may persist long after the conflict ends.

⁵ A discussion of the impact of war on institutions is carried out by Rohner and Thoenig (2021).

⁶ In an attempt to re-balance the analysis of civil wars, Cramer (2006) points out that conflicts could be important in the process of economic development, referencing the Marxist concept of primitive accumulation. Removing feudal style fetters to capitalist development and allowing the creation of a surplus that can be invested in industrialization.

Table 1
Descriptive statistics.

	Countries	Obs.	Mean	Std Dev	Std Dev (between)	Std Dev (within)
<i>Panel Data - 1960–2021</i>						
GDP per capita (000)	183	8840	10.643	1.740	19.996	6.050
Conflict (%)	183	8840	12.262	32.802	23.061	24.332
Trade (% GDP)	171	7529	75.474	49.164	47.582	21.024
Investment (% GDP)	165	6888	22.399	8.340	5.984	6.280
Tertiary school enrolment (% Gross enrolment)	174	7053	23.109	24.218	20.271	14.246
Polity 2 (–10 to 10)	157	6993	1.864	7.199	5.886	4.264
<i>Panel Data - 1980–2021</i>						
GDP per capita (000)	183	6881	11.735	18.631	19.9966	60.508
Conflict (%)	183	6881	13.966	34.666	23.061	24.33
Trade (% GDP)	171	6016	80.639	49.668	47.582	21.024
Investment (% GDP)	165	5742	22.617	8.272	5.984	6.2802
Tertiary school enrolment (% Gross enrolment)	174	6248	25.059	24.850	20.271	14.246
Polity 2 (–10 to 10)	157	5332	2.703	6.917	5.886	4.264

Notes: Data on real GDP, population, capital stock or investment, education and trade are taken from the World Development Indicators (WDI) of the World Bank. Conflict data is taken from the UCDP/PRIO Armed Conflict Database. Institutional quality measured by Polity 2 is extracted from the Polity IV dataset.

A dynamic specification of the estimated model, following Dunne et al. (2005), is:

$$\Delta \ln y_{i,t} = \gamma \ln y_{i,t-1} + \sum_{j=1}^3 \beta_j \Delta \ln x_{j,i,t} + \sum_{k=1}^3 \alpha_k \ln x_{k,i,t-1} + \theta_1 (\text{conf}_{i,t}) + \mu_i + v_{i,t}$$

(2)

where y is GDP per capita, x_1 is gross fixed capital formation as a share of GDP (proxy for investment or capital stock),⁷ x_2 is the share of tertiary education enrolment on total enrolment, x_3 is the population growth rate plus 0.05 or $(n + g + d)$.

The parameterized first-order dynamic model in Eq. (2) is then estimated, with Δ representing the change in the variable, $(t - 1)$ denoting a lag of one period, the dependent variable in all regressions is $\Delta \ln y$ and represents the change in per capita GDP. The dynamic specification is augmented by including episodes of conflict ($\text{conf}_{i,t}$), in line with Dunne and Tian (2019) study of civil wars, but in this case considering state and non state conflict.

To estimate Eq. (2), an extensive cross-country panel dataset was constructed from various sources covering the period 1960–2021. A comprehensive list of variables used in the analysis, along with their corresponding descriptive statistics, is presented in Table 1. To account for the shorter time span when the instrumental variable (IV) approach is employed, Table 1 reports statistics for both the full 1960–2021 period and the 1980–2021 period used in the IV analysis. Descriptive statistics for the Africa and Asia subsamples, as well as different income groups, are provided in Table A.1. As expected, it appears that low income countries are largely involved in conflict, while upper and middle countries less.

The conflict indicator was sourced from the UCDP/PRIO armed conflict database, where a value of 1 indicates the occurrence of over 25 battle-related deaths within a given year, while 0 denotes its absence. On average, the probability of experiencing a conflict is approximately 12% for the entire sample period (1960–2021) and increases to around

14% when the sample is restricted to start from the 1980s. Considering the probability of conflict by country and year in Fig. 1 for 1980–2021 period, shows the likelihood of conflict to be significantly higher in Asia, Africa, and low-income countries, while remaining relatively stable in the upper- and middle-income country groups. Asia has a higher average probability of conflict over the period (23%), but there is a striking increase in Africa at the end of the 1980s and in the last decade. This suggests that while conflicts are not ubiquitous over years, they remain a significant concern across countries and continents.

Data on real GDP, population, capital stock or investment, trade as a share of GDP and education were extracted from the World Bank's World Development Indicators (WDI). The level of education was measured as the share of tertiary school enrolment on total enrolment. Institutional quality was measured using a widely accepted proxy variable derived from the Polity V dataset. Provided by the Centre for Systemic Peace, it assesses political rights and institutional capacity on a 21-point scale ranging from –10 (high autocracy) to 10 (high democracy).

Columns (1) and (2) of Table 2 provide estimation results for the benchmark growth model, using the fixed effect (FE) estimator. The growth model is generally well-specified. Armed conflict in the host country has a significant negative influence on economic growth, with a coefficient of –0.018, which does not change when control variables (i.e. trade and democracy) are included. This suggests conflict reduces growth on average by just less than 2 percentage points per year, which is very similar to the results of Collier (1999).

One immediate problem that is now recognized in the literature is that the conflict variable may not be exogenous, finding that conflict is affected by GDP growth (Blattman & Miguel, 2010). Thus, some form of instrumental variable estimation needs to be considered. Dunne and Tian (2019), used a method developed by Gyimah-Brempong and Corley (2005), which takes the one-period lead of the predicted probability of conflict as an instrument for conflict. It is likely that it will not deal completely with reverse causality, however, and a more satisfactory approach was developed by Brückner (2011). This entails adjusting for the effect that growth might have on conflict, to produce an instrument that is 'by construction' uncorrelated with the dependent variable, real per capita GDP growth, and is strongly correlated with conflict. A detailed description of the used procedure, along with the first stage regression results, is presented in Appendix B.

Here, the two-step instrumental variable (IV) procedure uses two excluded variables as instruments. In line with Brückner (2011) the country-specific international commodity export price index (ComPI), taken from the IMF database, and, in line with Bergholt and Lujala

⁷ Investment is lagged and treated as a predetermined variable. To verify this, IV estimates were compared using both the original investment variable and a version that removes its autoregressive component. The lagged value was obtained from a fixed-effects regression including the second lag, while the first-difference transformation used a two-way fixed-effects model with the lagged difference. This approach controls for past growth effects on investment. The results confirmed that the potential bias about the endogeneity of investments is negligible. Full results are available upon request.

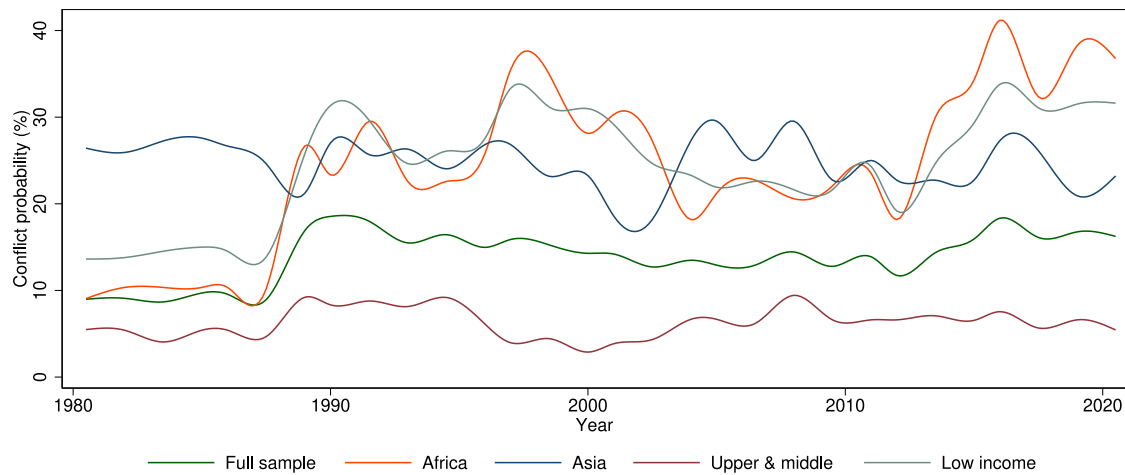


Fig. 1. Probability of conflict by country and time. *Notes:* The graph presents median spline representations of the probability of conflict. The median is weighted by the number of countries in each year.

Table 2
Conflict and growth: benchmark estimates.

Variables	(1) FE $\Delta \ln y$	(2) FE $\Delta \ln y$	(3) IV* $\Delta \ln y$
$\Delta \ln(inv)$	0.044 (0.010) [0.000]	0.046 (0.011) [0.000]	0.040 (0.011) [0.000]
$\Delta \ln(edu)$	0.016 (0.005) [0.003]	0.016 (0.005) [0.001]	0.012 (0.004) [0.005]
$\ln(n + g + \delta)$	-0.005 (0.002) [0.004]	-0.006 (0.002) [0.001]	-0.005 (0.002) [0.051]
$\ln(y_{t-1})$	-0.037 (0.006) [0.000]	-0.040 (0.007) [0.000]	-0.063 (0.009) [0.000]
$\ln(inv_{t-1})$	0.018 (0.005) [0.000]	0.017 (0.005) [0.002]	0.014 (0.006) [0.011]
$\ln(edu_{t-1})$	0.001 (0.002) [0.582]	0.000 (0.002) [0.914]	0.002 (0.002) [0.322]
Conflict	-0.018 (0.003) [0.000]	-0.019 (0.003) [0.000]	-0.020 (0.004) [0.000]
Constant	0.341 (0.063) [0.000]	0.367 (0.072) [0.000]	0.560 (0.088) [0.000]
Linear trend	✓	✓	✓
Country f.e.	✓	✓	✓
Additional controls	×	✓	✓
Weak instrument tests			
Cragg-Donald Wald F - statistic			2161.27
Kleibergen-Paap Wald F - statistic			30.97
Observations	5312	4547	3658
Countries	156	138	125
Countries in conflict	72	70	64

Notes: Dependent variable: $\Delta \ln y$. The OLS estimates with fixed effect (FE) are shown in columns 1 and 2. Instrumental variable (IV) estimates are shown in column 3. The IV procedure uses two excluded variables as instruments, the country-specific international commodity export price index (*ComPI*), which was taken from the IMF database, and the number of natural disasters, which was taken from the Emergency Events Database (EM-DAT). * Extension of the time series of the latter variable constraints the estimation span from 1980 to 2021. A detailed description of the IV procedure and the IV results of the first stage can be found in the [Appendix B](#). Robust standard errors, clustered by year, are given in round brackets. P-values are in square brackets.

(2012), and the number of natural disasters, taken from the Emergency Events Database (EM-DAT), are used⁸ in a second-stage IV regression, which gives the results in Column (3) of [Table 2](#). Given that most countries in conflict are highly dependent on the agricultural sector, these two instruments should capture the economic growth that is affected by external shocks and impacts on the productivity of the agricultural sector. The exclusion restrictions apply since international commodity prices and natural disasters are random and countries in conflict can be considered price takers. The results show a negative coefficient on the conflict variable of -0.020 . So allowing for endogeneity in this way does not alter the result that conflict has a significant negative effect on growth, while using IV specification, the results show a sharp increase in the speed of convergence of GDP per capita ($\gamma = -0.063$).

To investigate heterogeneity, the sample was stratified by continent and income group. [Table 3](#) shows that the coefficients associated with conflict remain consistently significant and negative for the African and Asian subsamples. It is worth noting that the Asian subsample includes the Middle East. For the sake of brevity, considering the IV estimation results, the overall estimate of -0.020 obtained from the full sample closely aligns with the estimate for Africa, but the estimate for Asia is notably higher at -0.038 . There are no significant effects of conflict on high-income countries and on upper and middle-income category, as is commonly found. The effect on low-income countries is significant and in line with the full-sample analysis at -0.023 . This variation across the sub-groups indicates some heterogeneity within the sample. Furthermore, comparing the IV and FE results shows that the endogeneity issue should be particularly relevant when the upper & middle income countries, including the high income countries, are accounted for. Indeed, in this case the FE estimates produce significant results, while IV results are not significant. This should indicate that, a possible source of heterogeneity in the previous estimated results could be due to the bias caused by reverse causality between economic growth and conflict.⁹

⁸ Developed by the Centre for Research on the Epidemiology of Disasters (CRED), EM-DAT is a global dataset that has records on disasters since 1900. To qualify for inclusion in EM-DAT, an event must meet at least one of the following criteria: 10 or more casualties, 100 or more people affected, declaration of a state of emergency, or call for international assistance. The data is used to construct the annual, normalized, time-adjusted population affected over the year (*DIS_aff*). [Appendix B](#) gives more detail.

⁹ Finding that the negative effect of conflict is only evident in low-income countries may simply reflect the lack of observed major conflicts in high-income countries before the war in Ukraine. To assess the robustness of this finding, an additional check was made using only high-intensity conflicts,

Table 3
Conflict and growth: sub-sample estimates.

	Countries	Conflict	Std. errors	P-value
OLS/FE estimates				
(1) Africa	31	−0.022	0.007	0.004
(2) Asia	35	−0.035	0.008	0.000
(3) Upper & middle income	75	−0.027	0.007	0.000
<i>High income</i>	38	−0.009	0.003	0.011
(4) Low income	63	−0.016	0.004	0.000
IV estimates*				
(1) Africa	28	−0.021	0.008	0.006
(2) Asia	28	−0.038	0.010	0.000
(3) Upper & middle income	66	−0.001	0.004	0.803
<i>High income</i>	35	−0.012	0.009	0.172
(4) Low income	59	−0.023	0.005	0.000

Notes: The income samples use the World Bank's income classification. The original classification comprised four categories: high income, upper-middle income, lower-middle income, and low income. The first two were combined to give an upper & middle income group and the next two combined to give a low income group. The IV procedure then uses two excluded variables as instruments, the country-specific international commodity export price index (*ComPI*), taken from the IMF database, and the number of natural disasters, taken from the Emergency Events Database (EM-DAT). * Extension of the time series of the latter variable constraints the estimation span from 1980 to 2021. A detailed description of the IV procedure, along with the first stage IV results are reported in [Appendix B](#). First stage weak instruments are available upon request. Robust standard errors, clustered by year, are reported in round brackets. P-values are in square brackets.

As a robustness test, the Arellano–Bond (AB) method was used. The results are given in [Table 4](#) and give an even larger negative value for the conflict coefficient, −0.061. However, when the IV estimation used previously are introduced to augment the AB procedure, the coefficient is −0.023, which is close to the estimate obtained from the Brückner method (in the third column of [Table 2](#)). This would suggest that the main IV results are not driven by any lagged dependent variable bias or autocorrelation. There are potential biases in dynamic heterogeneous panels, that are unrelated to the autocorrelation bias addressed by the Arellano–Bond (AB) estimator, even in those with a large time dimension. These biases primarily concern the accurate estimation of the GDP convergence rate, which are associated with the lagged value of the dependent variable and may also influence the estimated cost of conflict. To address these concerns, an alternative specification of the model was estimated, in line with the suggestions of [Smith \(2024\)](#). This specification uses the level of GDP per capita as the dependent variable, rather than its first difference, and excludes investment and education as control variables. In both, the OLS and IV estimates (row 2 and 3 of [Table 4](#)) are consistent with the benchmark model, showing no significant differences.

Following [Bove et al. \(2016\)](#) heterogeneity can be considered by using the mean-group estimator (MG) and unobserved common factors and introducing the cross-section averages into the regressions, the Common Correlated Effects Mean Group (CCE-MG) estimator. The CCE-MG estimator has advantages over the MG estimator. Firstly, the CCE-MG estimator considers the presence of unobserved common factors that are correlated with the explanatory variables. This addresses the issue of omitted variable bias, which can lead to biased and inconsistent estimates in the MG estimator. Secondly, the CCE-MG estimator allows for heterogeneity across individuals or entities in the panel by accommodating both time-varying and time-invariant individual-specific effects. Finally, the CCE-MG estimator is robust to

defined as those with more than 1000 battle-related deaths, which is interacted with the log of per capita income. This variable was then used to test whether the effect of conflict was greater for higher income countries. The results showed an insignificant effect of conflict in the upper & middle-income countries. These results are available upon request.

Table 4
Conflict and growth: robustness to different estimation methods.

	Conflict	Std. errors	P-value
Arellano Bond	−0.061	0.008	0.000
Arellano Bond + IV	−0.023	0.005	0.000
Level equation	−0.018	(0.004)	[0.000]
Level equation + IV	−0.022	(0.004)	[0.000]
Mean group	−0.006	0.004	0.081
CCE Mean Group	−0.012	0.004	0.040

Notes: The specification of the Arellano–Bond estimator includes the lagged value of GDP per capita as an endogenous variable. The number of lags to be considered is limited to the first lag. The model estimated using the Common Correlated Effects Mean Group is chosen using the Margaritella & Westerlund information criteria. The IV procedure uses two excluded variables as instruments, the country-specific international commodity export price index (*ComPI*), which was taken from the IMF database, and the number of natural disasters, which was taken from the Emergency Events Database (EM-DAT). * Extension of the time series of the latter variable constraints the estimation span from 1980 to 2021.

A detailed description of the IV procedure and the IV results of the first stage can be found in the [Appendix B](#). First stage weak instruments are available upon request. For the Arellano–Bond method, robust standard errors, clustered by year, are given in round brackets. Robust standard errors are used for the estimates for the middle group of the CCE. P-values are in square brackets.

endogeneity concerns.¹⁰ As usual, using the mean group estimator leads to estimates that are not significant and are smaller negative than the other methods. The MG-CCE method, however, gives estimates that are larger negative than the MSG and in line with the FE and IV estimates. The results also show much less in the way of heterogeneity than [Bove et al. \(2016\)](#), who report a range from high positive to high negative coefficients. Allowing for dynamics and adjusting gives coefficient estimates that are negative for all but three of the countries are positive.

Another concern with the analysis relates to the adequacy of measuring conflict with a dummy (an event with more than 25 battle-related deaths or not) which may obscure the heterogeneous effects of conflict. To check the robustness of the results three alternative conflict indicators were considered and the IV estimates are given in [Table 5](#). First, data on the number of battle-related deaths in each country is used to capture the impact of large-scale conflicts ([Murdoch & Sandler, 2002b](#)). To standardize conflict intensity, the number of battle-related deaths in a country is measured as the standard deviation relative to the number of deaths in that year, compared to global conflict intensity in the same year. Second, the internal conflict indicator from the International Country Risk Guide (ICRG), was used, following [Crippa et al. \(2024\)](#). This indicator reflects political violence and its actual or potential impact on governance, in three sub-dimensions: civil war and coup threats; terrorism and political violence; and civil disorder. Each sub-dimension is scored from 0 to 4, with an overall score near 12 indicating extremely low risk and a score close to 0 indicating extremely high risk of internal conflict. The original indicator is transformed into a 0–1 scale.¹¹ Third, an external conflict indicator was taken from the ICRG dataset. This measure evaluates the risk of interstate conflict.¹² To ensure comparability with the benchmark model results, the corresponding elasticity measures when accounting for the

¹⁰ A study by [Pesaran and Yamagata \(2008\)](#) demonstrated the superior performance of the CCE-MG estimator in capturing unobserved common factors and accommodating heterogeneity in panel data analysis.

¹¹ This indicator has two potential advantages: First, it is designed by the ICRG to assist international investors in identifying suitable investment locations, and second, it is better suited to capture the heterogeneity in the relationship between conflict and growth.

¹² Specifically, the indicator assesses the likelihood of a country being involved in an interstate war; border disputes, territorial claims and tensions with neighbouring countries; risks associated with international sanctions, trade embargoes, diplomatic isolation, and foreign interventions.

Table 5
Conflict and growth: estimates using alternative conflict indicators.

	Countries	Conflict	Std. errors	P-value
Battle related deaths (sd)	125	−0.013	0.003	0.000
Country Risk Guide: Internal conflict (Elasticity %)	72	−0.139 −2.237	0.026 0.489	0.000 0.000
Country Risk Guide: External conflict (Elasticity %)	72	−0.699 −3.146	0.154 0.890	0.000 0.000

Notes: The battle-related deaths variable is computed as the standard deviation relative to the total number of battle related deaths in that year. The internal and external conflict variables, originally ranging from 0 to 12, were rescaled to a 0–1 range. The IV procedure employs two excluded variables as instruments: the country-specific international commodity export price index (*ComPI*), sourced from the IMF database, and the number of natural disasters, obtained from the Emergency Events Database (EM-DAT). Using this variable limits the estimation period to 1980–2021. A detailed description of the IV procedure, along with the first-stage IV results, is provided in [Appendix B](#). Results from weak instrument diagnostics for the first stage are available upon request. Robust standard errors, clustered by year, are reported in parentheses, while p-values are presented in square brackets.

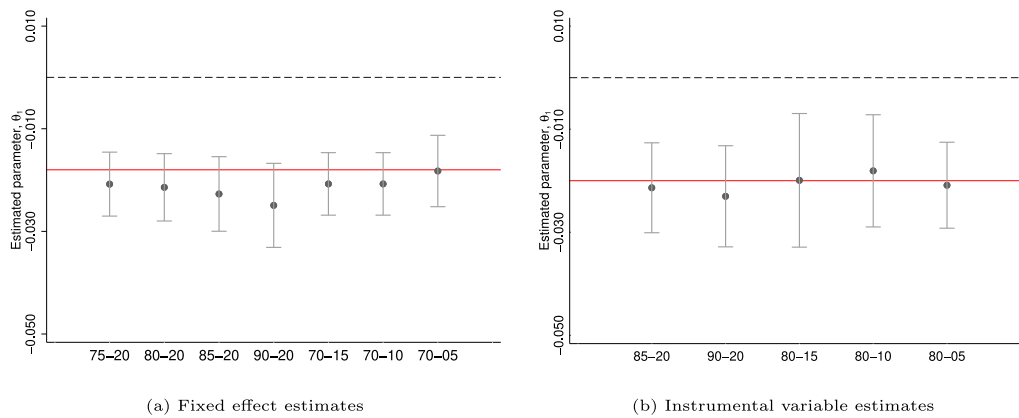


Fig. 2. Conflict estimates for fixed effects and instrumental variable specifications: time stability. *Notes:* The red line indicates the estimated parameters reported in [Table 2](#).

internal and external conflict indicators from the ICRG are reported. Descriptive statistics for these alternative conflict indicators are presented in [Appendix C](#).

The results of these alternative conflict indicators show a significant negative effect of conflict on GDP growth ([Table 5](#)). An increase of one standard deviation in the number of battle-related deaths (i.e., when the number of deaths in a country in a given year exceeds the sample average for that year) reduces economic growth by approximately 1.3%, while a 1% increase in conflict risk reduces growth by 2.2% when considering internal conflict and by 3.1% when considering external conflict. Interestingly, although the elasticity of external conflict is larger in magnitude than that of internal conflict, the difference is not statistically significant. This suggests that distinguishing between internal and external conflict is unnecessary when considering the economic costs of conflict.

One final concern is the stability of these results across different time periods. To address this, [Fig. 2](#) estimates the model for different time periods. The coefficients [2](#) (red lines in the figure) remain within the confidence intervals of the whole period estimates. Notably, the instrumental variable (IV) estimates in the figure closely align with those from the benchmark model. This means there is no evidence that any sub periods are driving our findings.

4. Spillover effects of conflict

To deal with the potential conflict spillover effect of neighbouring countries, the growth model specification can be extended, following [Murdoch and Sandler \(2004\)](#) and [Dunne and Tian \(2019\)](#). First, creating a dummy variable that assigns a value of 1 to countries that share a border with the conflict country and 0 otherwise. Second, creating a variable that computes the shared border length with a neighbouring country relative to the total length of a country's border.

Primary neighbours are then identified as those who share a border and secondary neighbours are identified as countries which do not share a border, but are within a 1000-kilometre radius of the conflict country, using the length of the closest route between the host country and all secondary neighbours. These variables are interacted with the conflict indicators to generate the spillover variables.

The empirical growth model specification of [Eq. \(2\)](#) is further generalized to allow spatial dependence using a Durbin model specification ([Muriuki et al., 2023](#)):

$$\Delta \ln y_{i,t} = \gamma \ln y_{i,t-1} + \sum_{j=1}^3 \beta_j \Delta \ln x_{j,i,t} + \sum_{k=1}^3 \beta_k \ln x_{k,i,t-1} + \theta_1 (\text{conf}_{i,t}) + \theta_2 W + \theta_3 W(\text{conf}_{i,t}) + v_i + \varepsilon_{i,t}. \quad (3)$$

W denotes the contiguity matrix for primary neighbours and then for both primary and secondary neighbours. The term $W(\text{conf}_{i,t})$ represents the interaction between the contiguity matrix and the conflict variable. Additionally, v_i captures the country fixed effects, while $\varepsilon_{i,t}$ represents the error term. A selection procedure compared the extended spatial dependence model, specified in [Eq. \(3\)](#), against restricted alternatives using Likelihood Ratio (LR) tests. The alternatives were first an OLS model, where the parameters θ_2 and θ_3 are constrained to zero; second, a SAR model, where only θ_3 is constrained to zero; and third, a SLX model, where only θ_2 is constrained to zero.¹³

A concern with this extended model is that to estimate it, one should really use a balanced panel. This is not always done because it can significantly reduce the size of the sample and the missing observations will not be random (it is most likely that missing values will be in poor conflict-ridden countries or in small countries), suggesting possible

¹³ Since we implement an IV strategy, the spatial error model is not relevant.

Table 6
Conflict and growth estimates accounting for spatial spillovers, IV estimates.

	Border		Distance		
	Primary neighbour	Primary & secondary neighbour	From border	From borders <1000 km	From capitals
Pattern A)					
(1) Full-sample	−0.022 (0.004) [0.000]	−0.025 (0.005) [0.000]	−0.021 (0.005) [0.000]	−0.021 (0.005) [0.000]	−0.021 (0.005) [0.000]
Countries	98	98	98	98	98
Observations	3822	3822	3822	3822	3822
LR test SDM v.s. OLS	19.652 [0.000]	66.238 [0.000]	65.214 [0.000]	60.460 [0.000]	46.198 [0.000]
LR test SDM v.s. SAR	9.870 [0.001]	5.020 [0.025]	5.456 [0.019]	5.754 [0.016]	1.860 [0.172]
LR test SDM v.s. SLXM	39.799 [0.000]	42.405 [0.000]	56.172 [0.000]	51.558 [0.000]	39.799 [0.000]
Pattern B)					
(2) Africa	−0.024 (0.007) [0.001]	−0.028 (0.008) [0.000]	−0.031 (0.010) [0.001]	−0.031 (0.009) [0.001]	−0.025 (0.010) [0.009]
(3) Asia	−0.045 (0.017) [0.010]	−0.061 (0.025) [0.016]	−0.052 (0.018) [0.005]	−0.053 (0.019) [0.004]	−0.044 (0.019) [0.021]
(4) Upper & middle income	−0.039 (0.024) [0.104]	−0.040 (0.027) [0.138]	−0.039 (0.016) [0.014]	−0.039 (0.015) [0.012]	−0.037 (0.022) [0.083]
<i>High income</i>	−0.012 (0.008) [0.175]	−0.002 (0.005) [0.602]	−0.004 (0.005) [0.469]	−0.004 (0.005) [0.432]	−0.005 (0.003) [0.157]
(5) Low income	−0.017 (0.006) [0.002]	−0.022 (0.007) [0.003]	−0.019 (0.008) [0.022]	−0.019 (0.008) [0.019]	−0.012 (0.008) [0.109]

Notes: Dependent variable: $\Delta \ln y$; robust standard error in brackets. P-values are in square brackets. The IV estimates are based on a balanced panel 1980–2020. The IV procedure uses two excluded variables as instruments, the country-specific international commodity export price index (*ComPI*), which is taken from the IMF database, and the number of natural disasters, which is taken from the Emergency Events Database (EM-DAT). A detailed description of the IV process and the IV results of the first stage can be found in [Appendix B](#). First stage weak instrument results are available upon request.

measurement errors and estimation bias. An alternative approach is to impute the missing values of the selected variables if their numbers are not large. The underlying idea is that small countries and countries in conflict have a higher probability of having missing data. It is worth noting that since the IV estimates restrict the period to 1980–2020, the need for imputation is reduced. Only 0.4% of the observations for GDP per capita are imputed and the proportion of the observations imputed for the variables with more missing years, namely investment and education, is still below 10%.¹⁴

Table 6 presents the conflict coefficient estimates using IV and the Likelihood Ratio (LR) tests for the spatial dependence. The Durbin model for spatial dependence is the preferred specification, over the simple OLS model without the inclusion of any spatial matrix, the spatial autoregressive (SAR) model, and the spatial lag-X (SLX) model. The first column gives results considering only primary neighbours (primary or directly contiguous/sharing a border), the second column considers both primary and secondary neighbours. The effect of conflict in a host country is negative and significant, −0.022 when considering primary neighbours and −0.025 when secondary neighbours are also considered. These results for primary neighbours are in line with [Murdoch and Sandler \(2004\)](#) and [Dunne and Tian \(2019\)](#), but also suggest significant spillovers for secondary neighbours, as in [De Groot \(2010\)](#).

The remaining columns give the results when actual distance measures are used: (i) the distance of countries that share a border from the centre of the country being considered; (ii) the distance from the centre for countries within 1000 km of the border; and (iii) the distance between the capital cities when the border is shared. Using the distance measures to account for spillovers gives similar values to the primary

neighbour effect. This might imply that the indirect effect is increased not so much by geographical distance per se, but by closeness of economic activity.

In the pattern B of Table 6, the extended model specification with the IV estimation procedure is applied to the African and Asian countries separately and to subsamples of countries grouped by income level.¹⁵ The results show some variation, with losses due to conflict in the Asian region particularly large, ranging between 4.5 and 6.1 percentage points.

Again, there is a concern that the dummy variable conflict indicator may not adequately reflect the nature of the conflict. Using alternative conflict indicators, battle related deaths, the country risk guide for internal and external conflict, gave the results in [Appendix D](#). These confirm the robustness of the results, suggesting that spillovers amplify the negative impact of conflict on growth.

5. The long-run effect of conflict

So far the results have shown that conflict destroys physical and human capital, which reduces the current and future growth potential of countries and regions. Conflict can also have identifiable long run effects and the macroeconomic costs are not limited to only those countries experiencing conflict. Neighbouring and non-neighbouring countries can be negatively affected, through trade, refugee flows, and other spillovers, that can continue to have effects over many years

¹⁵ Since the spillover effects are estimated using contiguous matrices, which are assumed exogenous to the principal country in conflict, the point estimates obtained control for these (positive) spatial correlations but cannot be interpreted as causal estimates of the indirect spatial effects.

¹⁴ We use a multiple imputation technique to impute the data ([Rubin, 1976](#)).

Table 7
Long run effect of conflict on growth, IV estimates.

	Full-sample	Sub-samples			
		Africa	Asia	Upper & middle income	Low income
(1) Conflict (θ_1)	−0.020 (0.005) [0.000]	−0.023 (0.008) [0.002]	−0.033 (0.011) [0.002]	−0.006 (0.013) [0.114]	−0.019 (0.005) [0.001]
$\ln(y_{t-1})$ (γ)	−0.056 (0.008) [0.000]	−0.080 (0.014) [0.000]	−0.073 (0.020) [0.001]	−0.061 (0.013) [0.000]	−0.048 (0.008) [0.000]
Long-run effect	0.359 (0.082) [0.000]	0.292 (0.104) [0.005]	0.449 (0.131) [0.007]	0.324 (0.214) [0.131]	0.395 (0.110) [0.003]
Countries	98	25	23	52	46
Observations	3822	830	845	2016	1806

Notes: Dependent variable: $\Delta \ln y$; robust standard error in brackets. P-values are in square brackets. The IV estimates are based on a balanced panel over the period 1980–2020. The IV procedure uses two excluded variables as instruments, the country-specific international commodity export price index (*ComPI*), which is taken from the IMF database, and the number of natural disasters, which is taken from the Emergency Events Database (EM-DAT). A detailed description of the IV process and the IV results of the first stage can be found in [Appendix B](#). First stage weak instruments are available upon request.

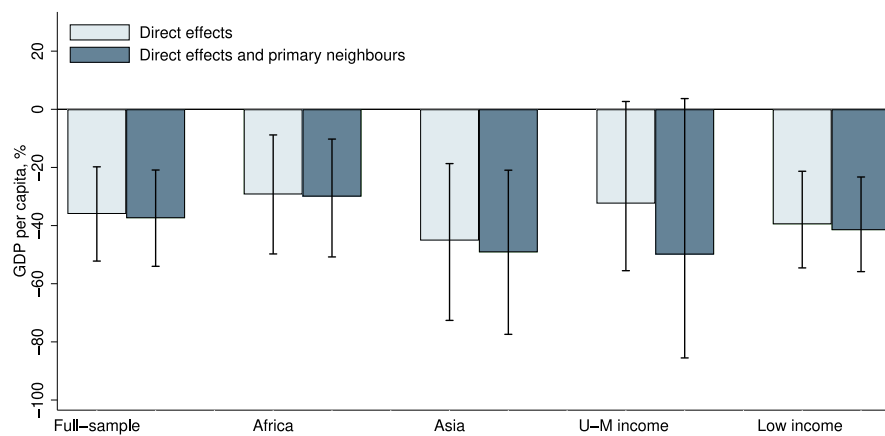


Fig. 3. Long-run estimates direct and indirect effects. Notes: Dependent variable: $GDP_{percapita}$. Confidence intervals are computed using a correlation-adjusted delta method approximation.

following conflict onset. The estimate of the error correction parameter in Eq. (2) allows the computation of the long term magnitude of conflict by the ratio θ_1/γ .¹⁶

Table 3 presents the long run IV estimates for the period 1980–2021, considering both the full sample and the subsamples. The GDP per capita (γ) and the conflict coefficient estimates (θ_1) show the expected signs and magnitude and are significant at the confidence level 5%, except for the upper & middle income sample.

Fig. 3 shows the long-run direct effects of conflict and the combined direct and indirect effects that arise from primary neighbour spillovers. It is estimated that conflict cumulatively reduced economic production in host countries by approximately 35%, with a decline of 29% in Africa and 45% in Asia, and in low-income countries the decline is 39%. In accordance with the short run findings, there is no statistically significant loss of GDP in the long run for the upper & middle income countries. These results are consistent with the estimates by Novta and Pugacheva (2021) who found that ten years after conflict onset, the cumulative reduction in the level of GDP was about 28 percent relative to the pre-conflict year and even larger for a major conflict.¹⁷ The spillover effects only increase the overall negative impact of conflict

marginally, with the confidence intervals containing both estimates. This suggests that the spillover effects primarily influence growth in the short run. The same conclusions can be drawn when all the spillover indicators are used, as presented in [Appendix E](#).

This empirical framework can also be used to investigate whether the long run economic losses generated by conflict have changed since the end of the Cold War. In the post-Cold War period the dominant form of conflict shifted from interstate wars to civil wars, often driven by ethnic and religious differences, with insurgencies and terrorism (Obermeier & Rustad, 2023). The location of major conflict also shifted, from Sub-Saharan Africa in the 1990s to the broader Middle East region, before increasing again in Africa in recent years (see, Fig. 1). Fig. 4 shows the long-run estimates of conflict using the full period (1980–2021) and compares them with those obtained excluding the Cold War (1990–2021) and (2000–2021). Although the long run effects are smaller for the post-Cold War period, the difference between the periods are not statistically significant.

¹⁶ One potential limitation of this approach is the need to use a balanced panel to correctly estimate spillovers. As argued in Section 4, this is not a concern here, as the size of the (balanced) panel can be maintained using a small number of imputed data points.

¹⁷ Given that uncertainty can lead to continued violence and disruption long after the conflict ends, evaluating the effect of conflict over a specific period, as their simulations do, might be expected to provide an underestimate. As

an example, using the notion of half-life to compare economic convergence speed of countries to predict length of time required to converge to the long run equilibrium shed some light. In our case, although the GDP per capita convergence speed estimated by IV approach is very large (−0.063), the amount of time it takes for half convergence to the long run is, however, of 11 years ($t=0.692/0.063$).

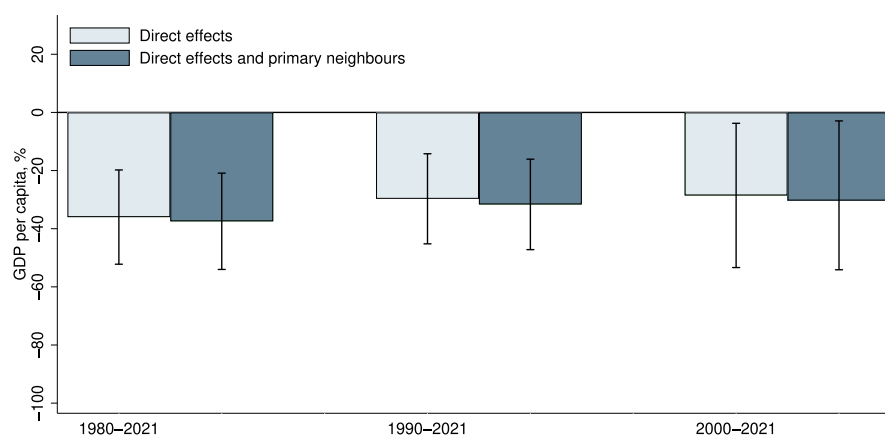


Fig. 4. Long-run estimates direct and indirect effects. Notes: Dependent variable: *GDPpercapita*. Confidence intervals are computed using a correlation-adjusted delta method approximation.

6. Conclusions

Conflicts are a major issue for development, given the prevalence among developing countries and the potentially devastating effects for the countries affected and their neighbours. Few countries that have experienced conflict have attained any of the UN SDGs (Gates et al. 2012). While it seems self-evident that conflicts have economic costs, there is still some debate in the literature, not only over how big the costs are, but also whether there are economic costs at all. Estimates of the costs of conflict are important as inputs to policymaking, to justify peace keeping, peace making and post conflict reconstruction (Dunne, 2013).

There are several unresolved issues in the literature and this paper has considered them and has taken advantage of increased data and improved estimation methods to provide an empirical analysis of the impact of conflict. It has confronted the claim that heterogeneity makes measuring average costs invalid and has also considered the impact of the revised definitions of conflict in the data, which reflects the changing nature of conflicts over time.

An exogenous growth model was estimated and found to be well specified and to show a significant negative impact of conflict, where conflict reduces growth on average by around 1.8 percentage points per year, which is similar to the results of Collier (1999) and Dunne and Tian (2019). A number of issues were then dealt with. To account for the potential endogeneity of the conflict variable and its impact on the results, the growth model was re-estimated using an instrumental variable (IV) method. The findings continued to indicate a significant negative effect of conflict on economic growth. The estimated coefficients were even more substantial, showing a negative impact of –2 percentage points, compared to the fixed-effect (FE) estimates. Additionally, an alternative method for dealing with instrumental variables, the Arellano Bond Generalized Method of Moments (A-B GMM), was employed. The coefficient obtained using this method was even more negative, though when the instrumental variables were incorporated into the A-B GMM estimation, the coefficient aligned with the previous findings at –0.023.

An additional concern raised in the analysis is the presence of heterogeneity within the pooled data, as highlighted. This issue was considered, firstly by stratifying the sample based on World Bank income categories and continents. This showed that the negative effect of conflict is only evident in low-income countries, specifically in Africa and Asia. Second, using the Mean Group Estimator (MGE). This approach gave a smaller negative estimate and reduced the significance of the conflict variable, as expected. Improving on this method by using Common Correlated Effects (CCE) method to account for potential contagion effects, the coefficient estimate became closer to the Fixed Effects (FE) estimates. Upon examining the individual country

estimates, it was observed that the majority displayed negative effects, with only two countries exhibiting significantly positive effects. This implies much less heterogeneity than found by Bove et al. (2016).

A further concern was that the cost to neighbours could be even larger than the effects of the conflict on the war-torn country (Collier, 1999; Dunne, 2013). Updating the analysis of Dunne and Tian (2019) an extended model using distance weights gave a negative effect of conflict on the host economy and negative effects of spillovers on neighbours. Estimating with A-B gave results close to the IV, with only the main variable significant. Using MG and CCE again gave small negative coefficients and, as usual, less significant ones.

To provide a clearer statement of the costs of conflict, the coefficient estimates were used to compute the loss of GDP per capita by country, by region and over time. This illustrated the particularly severe impact on Asia, which has seen the largest costs since the end of the Cold War. Despite the prevalence of conflicts in Africa, it is poor relative to Asia and so the loss is less, though still significant. It was also interesting that while the overall direct effects of conflict lead to an overall reduction in GDP per capita of around 35%, spillovers show only a marginal effect in the long run.

Overall, these are important results, as they make clear the likely cost of conflict in terms of lost output. There is of course considerable heterogeneity, but not as much as found earlier. Having an idea of the average effect remains of value, but finding ways to reflect for heterogeneity is important. Finding spillovers are important adds weight to the argument of Murdoch and Sandler (2004) that post conflict aid is potentially necessary for conflict regions, rather than just the directly affected countries. As they suggested, conflict really is an important public bad, and it would appear increasingly so.

CRediT authorship contribution statement

A. Crippa: Software, Resources, Investigation, Formal analysis, Data curation. **G. d'Agostino:** Software, Resources, Formal analysis, Data curation, Conceptualization. **J.P. Dunne:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **L. Pieroni:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization.

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Declaration of competing interest

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Table A.1
Sub-samples descriptive statistics.

	All countries			Countries in conflict			Countries not in conflict		
	Obs.	Mean	S.d.	N.	Mean	S.d.	N.	Mean	S.d.
<i>Africa</i>									
GDP per capita (000)	1752	22.904	28.252	23	15.965	18.374	13	36.159	37.576
Conflict (%)	1752	20.548	40.417	23	31.304	46.393	13	–	–
Trade (% GDP)	1443	66.806	37.958	23	56.506	28.773	13	91.392	45.272
Investment (% GDP)	1309	21.445	9.648	23	20.578	9.585	13	23.502	9.494
Tertiary school enrolment (% Gross enrolment)	1401	7.042	10.577	23	7.349	11.517	13	6.402	8.268
Polity 2 (–10 to 10)	1479	–1.614	6.047	23	–2.603	5.432	13	0.708	6.746
<i>Asia</i>									
GDP per capita (000)	2031	93.498	148.512	23	28.908	49.496	21	181.269	188.000
Conflict (%)	2031	23.338	42.309	23	40.512	49.112	21	–	–
Trade (% GDP)	1749	82.622	62.925	23	61.985	38.999	21	112.045	77.256
Investment (% GDP)	1608	25.209	9.245	23	23.355	8.003	21	28.005	10.240
Tertiary school enrolment (% Gross enrolment)	1751	21.347	18.995	23	18.018	15.194	21	25.738	22.334
Polity 2 (–10 to 10)	1633	–1.408	7.123	23	–0.900	6.617	21	–2.231	7.808
<i>Upper and middle income</i>									
GDP per capita (000)	5051	175.863	204.225	23	95.048	114.304	84	200.908	218.947
Conflict (%)	5051	5.603	23	23	23.682	42.530	84	–	–
Trade (% GDP)	4295	86.477	56.572	23	65.046	38.692	84	93.604	59.699
Investment (% GDP)	4135	22.958	6.621	23	21.753	6.961	84	23.370	6.449
Tertiary school enrolment (% Gross enrolment)	4062	33.503	25.627	23	30.511	22.407	84	34.499	26.541
Polity 2 (–10 to 10)	3770	4.286	7.100	23	2.784	6.657	84	4.877	7.182
<i>Low income</i>									
GDP per capita (000)	3789	13.891	10.0971	52	13.609	11.701	24	14.598	8.845
Conflict (%)	3789	21.140	40.836	52	29.568	45.643	24	–	–
Trade (% GDP)	3234	60.861	31.672	52	54.446	26.953	24	78.738	36.619
Investment (% GDP)	2753	21.561	10.346	52	21.382	9.770	24	22.109	11.936
Tertiary school enrolment (% Gross enrolment)	2991	8.993	12.053	52	8.804	11.978	24	9.561	12.263
Polity 2 (–10 to 10)	3223	–0.969	6.212	52	–1.610	6.002	24	0.991	6.433

Notes: Data on real GDP, population, capital stock or investment, education and trade are taken from the World Development Indicators (WDI) of the World Bank. Conflict data is taken from the UCDP/PRIO Armed Conflict Database. Institutional quality measured by Polity 2 is extracted from the Polity IV dataset. A country is considered to be in conflict if it has experienced at least one year of conflict during the period.

Appendix A

See Table A.1.

Appendix B. Instrumental variables estimation

Estimates of the effect of conflict on economic growth may be affected by endogeneity issues as, for example, low economic growth in less developed countries may lead to the onset of conflict. To deal with this the two-step IV procedure suggested by Brückner (2011) was used. A “conflict adjusted regressor” is constructed from a first-step IV estimation of a conflict equation, using as instruments the changes in international commodity price shocks and climate-induced natural disasters. Given that the majority of countries in conflict are highly dependent on the agricultural sector, these two instruments should capture the economic growth that is affected by external shocks and impacts on the productivity of the agricultural sector.

International commodity price shocks are measured by the country-specific international commodity export price index, taken from the IMF database, and disaster data comes from the Emergency Events Database (EM-DAT), developed by the Centre for Research on the Epidemiology of Disasters (CRED). Following Bergholt and Lujala (2012), the annual time-adjusted size of the population affected over the year is then calculated as: $\sum_{j=1}^h x_{ijt} = \sum_{j=1}^h \left(\frac{\text{population affected}_{ijt}}{\text{total population}_{it-1}} * \frac{12 - \text{event month}_{ijt}}{12} \right)$, where $\text{population affected}_{ijt}$ is the population affected in the country i by disaster j at year t , total population $_{it-1}$ is the previous year's population size, and $(12 - \text{event month}_{ijt})/12$ is the imposed time weight to correct for the time of the event (an event that happened

in January has potentially a larger effect on the current year's income than an event that happened towards the end of the year).

The exclusion restrictions apply since natural disasters are random and countries in conflict can be considered price takers. Estimating the reverse causality bias in this way allows the construction of an “exogenous” conflict variable for the growth equation. To do this, an exponential conditional mean model with a control function was estimated, as in Wooldridge (2010). This CF estimator assumes the existence of a relationship between the endogenous regressors and the instruments. With multiplicative errors, the first-stage IV conflict equation is determined by economic growth ($\Delta \ln y_{i,t}$) and a unit-mean error ϵ_i as:

$$\text{Conflict}_{i,t} = \exp(\Omega_1 \Delta \ln y_{i,t}) \epsilon_i \quad (\text{B.1})$$

The CF estimator augments the exponential conditional mean model with a parameter ρ that controls for the endogeneity of $\Delta \ln y_{i,t}$. The augmented model is:

$$\text{Conflict}_{i,t} = \exp(\Omega_1 \Delta \ln y_{i,t} + \nu_i' \rho) \epsilon_i. \quad (\text{B.2})$$

Eq. (B.2) shows that when there is reverse causality, $\rho \neq 0$ and $\Omega_1^* \neq 0$ because $(\Omega_1^* = \Omega_1 + \rho)$, the OLS estimate of the effect of conflict on economic growth is biased. This endogeneity bias can be addressed by constructing an adjusted measure of conflict, where the response of conflict to economic growth is partialled out by the IVs. In this case, $\text{Conflict}_{i,t}$ can be reparametrized as:

$$\text{Conflict}_{i,t}^* = \text{Conflict}_{i,t} - \Omega_1^* \Delta \ln y_{i,t}. \quad (\text{B.3})$$

Following Brückner (2011), the generated regression $\text{Conflict}_{i,t}^*$ can be used as an instrument in a second step to estimate Eq. (2), which is

Table B.1
The effect of economic growth on conflict.

Instrument set:	$\Delta \ln y_{i,t}$	$Conflict_{i,t}$				
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	Poisson FE	Poisson FE	IV Poisson <i>ComPI</i> + <i>DIS_{aff}</i>	IV Poisson $\Delta ComPI$ + <i>DIS_{aff}</i>	IV Poisson $\Delta ComPI$
$\Delta \ln y_{i,t}$			−1.462 (0.331) [0.000]	−64.203 (30.530) [0.035]	−42.609 (17.046) [0.012]	−28.769 (10.109) [0.004]
<i>ComPI</i>	0.036 (0.014) [0.013]	−1.268 (0.306) [0.000]				
<i>DIS_{aff}</i>	−0.050 (0.023) [0.032]	3.524 (1.428) [0.014]				
Additional controls	×	×	×	×	✓	×
Number of observations	5685	1466	2273	5685	5685	5930

Notes: Standard errors in parentheses. P-values are in square brackets.

Table C.1
Descriptive Statistics: other conflict indicators.

	Countries	Obs.	Mean	Std Dev	Std Dev (between)	Std Dev (within)
Battle-related deaths (s.d.)	183	8840	0.373	2.910	2.038	2.521
ICRG: Internal conflict	72	3718	0.261	0.201	0.148	0.136
ICRG: External conflict	72	3718	0.185	0.166	0.112	0.124

Table D.1
Conflict and growth accounting for spatial spillovers using other conflict indicators, IV estimates.

	Border		Distance		
	Primary neighbour	Primary & secondary neighbour	From border	From borders <1000 km	From capitals
Battle related deaths (s.d.)	−0.013 (0.003) [0.000]	−0.015 (0.004) [0.000]	−0.020 (0.007) [0.002]	−0.020 (0.006) [0.001]	−0.022 (0.010) [0.028]
Country Risk Guide: Internal conflict	−0.609 (0.094) [0.000]	−0.675 (0.147) [0.000]	−0.959 (0.278) [0.001]	−0.904 (0.261) [0.001]	−1.557 (0.401) [0.000]
(Elasticity %)	−9.328 (3.974) [0.004]	−9.360 (4.193) [0.007]	−5.587 (1.853) [0.003]	−6.310 (1.982) [0.001]	−1.768 (0.322) [0.000]
Country Risk Guide: External conflict	−0.780 (0.127) [0.000]	−0.950 (0.170) [0.000]	−1.373 (0.558) [0.014]	−1.311 (0.519) [0.011]	−1.568 (0.549) [0.004]
(Elasticity %)	−7.882 (3.940) [0.045]	−5.691 (1.814) [0.002]	−3.002 (1.465) [0.041]	−3.325 (1.414) [0.019]	−1.805 (0.288) [0.000]

Notes: Dependent variable: $\Delta \ln y$; robust standard error in brackets. P-values are in square brackets. The number of battle-related deaths are introduced in standard deviation relative terms relative to the total number of deaths in that year. The internal and external conflict variables, originally ranging from 0 to 12, have been rescaled to a 0–100 range. The IV estimates are based on a balanced panel over the period 1980–2020. The IV procedure uses two excluded variables as instruments, the country-specific international commodity export price index (*ComPI*), which is taken from the IMF database, and the number of natural disasters, which is taken from the Emergency Events Database (EM-DAT). A detailed description of the IV process and the IV results of the first stage can be found in [Appendix B](#). First stage weak instruments are available upon request.

equivalent to introducing in Eq. (2) the estimated residuals from Eq. (B.2).

Table B.1 presents the two-stage least squares (TSLS) estimates of the impact of per capita GDP growth on conflict (IV, first step), while in the second stage, the corrected estimations of conflict on growth are listed in Table 2 or 6. In Column (1), the first-stage estimates are linked with the instrumental variables, *ComPI* and *DIS_{aff}* to $\Delta \ln y_{i,t}$, and are presented using the fixed effects (FE) estimator. The two excluded instruments are significant at the conventional 5% level, with a significant increase in per capita GDP growth. The second column of the table shows the results of the reduced-form equation, estimated using the Poisson fixed effects (FE) model. In this case, international prices of exported commodities and natural disasters are shown to have a higher probability of influencing conflict.

Column (3) of Table 7 shows the Poisson FE estimates. It is evident negative results that are only significant at 8 per cent, but this likely reflects the degree of reverse causality bias. The last three columns present the second-stage TSLS estimates. Column (4) presents the instrumental variable (IV) estimate, using *ComPI* and *DIS_{aff}* as excluded instruments. The estimated parameter on growth is now significant at the 5% level. Column (4) and Column (5) introduce additional controls to demonstrate that the results are driven by the instrumental variable mechanisms. In this case, dummy variables account for countries that have received aid to recover from natural disasters, the number of disasters each country experienced in a given year, as well as indexes of ethnic and religious fractionalization. Although the estimated parameter increases in magnitude, the confidence intervals reveal that the parameter estimated in Column (5) is not statistically

Table E.1

Long run effect of conflict on growth accounting for spatial spillovers, IV estimates.

	Border		Distance		
	Primary neighbour	Primary & secondary neighbour	From border	From borders <1000 km	From capitals
(1) Conflict (θ_1)	−0.022 (0.004) [0.000]	−0.025 (0.005) [0.000]	−0.021 (0.005) [0.000]	−0.021 (0.005) [0.000]	−0.021 (0.005) [0.000]
$\ln(y_{t-1})$ (γ)	−0.056 (0.008) [0.000]	−0.054 (0.008) [0.000]	−0.051 (0.008) [0.000]	−0.051 (0.008) [0.000]	−0.051 (0.008) [0.000]
Long-run effect	0.374 (0.084) [0.000]	0.464 (0.104) [0.000]	0.406 (0.091) [0.000]	0.408 (0.092) [0.000]	0.408 (0.092) [0.000]
Countries	98	98	98	98	98
Observations	3822	3822	3822	3822	3822

different from the benchmark model. Finally, Column (6), gives the IV estimates when using a just-identified model, where only *ComPI* is introduced as an excluded instrument. Again, no statistically significant difference is found from the benchmark model estimate in Column (4).

Appendix C

See Table C.1.

Appendix D

See Table D.1.

Appendix E

See Table E.1.

Data availability

Data will be made available on request.

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