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ABSTRACT

The Impact of Armed Conflict on Economic Performance: Evidence from Rwanda[1]

Important gaps remain in the understanding of the economic consequences of civil war. Focusing on the conflict in Rwanda in the early 90s, and using micro data to carry out econometric analysis, this paper finds that households and localities that experienced more intense conflict are lagging behind in terms of consumption six years after the conflict, a finding that is robust to taking into account the endogeneity of violence. Significantly different returns to land and labour are observed between zones that experienced low and high intensity conflict which is consistent with on-going recovery. Distinguishing between civil war and genocide, the findings also provide evidence that these returns, and by implication the process of recovery, depend on the form of violence.

JEL Classification: civil war, economic growth, Rwanda, human capital

Keywords: O0, E2, O5

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1. Introduction

Civil conflict remains important in many developing countries and has become an integral part of the study of economic development. Especially the last decade has seen a boom in studies on conflict.[2] One finding that stands out from this work is the strong negative association between conflict and economic development. However, while conflict may lead to poor economic performance, the reverse relationship seems equally credible, and this complicates the analysis.[3] Moreover, very little is known about the micro-economic mechanisms underlying post-war recovery (or lack thereof). This paper carries out econometric analysis accounting for both these issues. It analyses whether conflict has a sustained effect on economic performance at the micro level years after it has ended while also taking endogeneity into account; it also investigates the underlying processes, focusing on the interaction between conflict and the returns to production factors in the post-war period.

From an economic theoretical perspective there is no consensus about the impact of conflict on economic performance. Neoclassical growth theory predicts that an economy recovers relatively quickly, and converges to its steady state. Alternative models argue that catch up may take a long time, for instance because human capital recovers only slowly (see Barro and Sala-i-Martin 2004), or that countries can be trapped in a low level equilibrium where conflict and poor performance coexist (Sachs 2005). Current evidence, relying on cross-country data, provides support for either of these views, with some work finding evidence for relatively rapid catch up, while other studies indicating that convergence may be slow or countries may be stuck in a bad equilibrium.[4]

One possible explanation for these apparent contradicting findings lies in the nature of the data that is employed. Using cross country data, these studies leave a number of factors that may affect the relationship between conflict and economic performance, unobserved. The speed of economic recovery may, for instance, depend on the type of damage caused by the war, e.g; the destruction of physical capital may have different consequences than human capital destruction. The identity of the parties at war may also play a role, in particular

[2] For an excellent overview see Blattman and Miguel (2010).
[3] See also Djankov and Reynal-Querol (2010) work on poverty and civil war.
[4] In political science the process of catch up is sometimes referred to as 'The Phoenix Factor', as described in Organksi and Kugler (1977), and the focus lies on analysing political and community processes underlying catch up (see for instance Kugler and Arbetman 1989; Flores and Nooruddin 2009). In this paper we abstract from political processes.

whether the conflict was between states, often relying on professional armies, or within a state between fractions of society (some of them non-army forces). While any of these factors may play a role, each of them remains unobserved in cross country data. This makes estimates more sensitive to what part of the data is being analysed, and complicates accounting for endogeneity (since possible instruments may be correlated with the many factors that remain unobserved).

Using micro level data is a promising way forward as (some of the) previously unobserved factors become observable. This is illustrated by the small but emerging literature, discussed in the next section, that analyses the micro-economic consequences of conflict. Like most of these studies, this paper also focuses on one country, but differs from existing work in four ways. First, while existing micro-empirical work focuses on the effects of conflict *between* nations, this paper looks at the effects *within* a country. Second, considering the dramatic events of 1994 in Rwanda, this study investigates the consequences of a destruction of human, rather than physical capital. Third, we consider a much shorter time horizon, assessing economic performance six years after the conflict. Finally, this paper explicitly investigates the underlying post-conflict process.

To study the effect of conflict on economic performance, we investigate whether rural households and communities that have experienced more conflict in 1994, have lower consumption six years after the end of the violence, relative to the other households and communities. We find that they do. This result remains after controlling for a wide range of community characteristics (including displacement) and after taking into account endogeneity, relying on the distance to the Ugandan border and the distance to Nyanza, the former capital of the ancient Tutsi monarchy, as identifying instruments. Investigating the process of economic growth, we assess whether returns to factors of production depend on the experience of past conflict, and find that returns to land are lower in conflict intense areas, which is consistent with a decrease in land pressure, and suggests an on-going process of post-war catch-up. Finally, to investigate the role of human capital destruction, we investigate whether different types of conflict have distinct effects, and, distinguishing between genocide and civil war, find that they do. Areas that experienced genocide have lower returns to land, and higher returns to labour and education compared to other areas, while areas that experienced civil war have relatively lower returns to education. In a robustness check these results are compared with those from a difference-in-difference analysis relying on limited household income data from a pre-war (1990) and post-war (2000) nationwide household survey. The results are very similar.

The remainder of this paper is structured as follows. Section 2 discusses the conceptual framework and provides an overview of the relevant literature, while Section 3 discusses the Rwandan context. After detailing our econometric strategy in Section 4, and discussing the data in Section 5, Section 6 presents the results and Section 7 presents a series of robustness checks. Section 8 concludes.

2. Conflict, economic performance and human capital

Conceptually, our benchmark is a growth model that includes human capital and is of the general form $Y = AK^{\alpha}L^{\beta}H^{\gamma}$.[5] This model predicts that economies converge to their own steady state, with the speed of convergence depending on the distance from the steady state, assuming decreasing returns to individual production factors. A reduction in physical or human capital will result in a more rapid accumulation of physical or human capital after the conflict, and the economy will converge to its steady state, assuming that other parameters in the model do not change. Barro and Sala-i-Martin (2004) predict that the speed of recovery depends on the type of capital that is destroyed, with a slower recovery if human capital, rather than physical capital, is destroyed, because it has a higher adjustment cost. [6] Endogenous growth models, as well as poverty trap models, predict that conflict has a direct effect on an economy's steady state, and as a result otherwise similar economies do not converge (Azariadis and Drazen, 1990, Rodrik 1999, Collier 1999).

Existing empirical evidence, mostly relying on cross country data, does not allow rejecting either of these views. Organski and Kugler (1977), among the first to present evidence on catch up, find that, while economies suffered heavy short term losses from the two world wars, these effects dissipated after 15-20 years, when the economy had returned to pre-war growth trends. Cerra and Saxena (2008) also find that, while output falls steeply immediately after the conflict (6% on average), the economy recovers relatively soon afterwards, with, in their case, half of the fall made up within a few years. Murdoch and Sandler (2004), on the other hand, find that civil war reduces a country's growth by 85% in the first five years, and while there is recovery, growth is still reduced by 31% after 35 years. Rodrik (1999) argues that growth rates have lacked persistence in many countries since the

[5] This is a general form of the model presented in Romer (2006) and can be seen as a generalization of Arrow's (1962) Mankiw, Romer & Weil (1992) or Lucas (1988).

[6] For a detailed discussion see Blattman and Miguel (2010), who also mention vintage capital models, which are less relevant for our case.

1970s because of domestic conflict. Collier (1999) lays out how civil war reduces the desired stock of factors of production, and how the duration of civil war affects post-war performance (with longer conflict durations leading to higher post-war growth). [7]

However, because these papers rely on cross country data, accounting for causality remains a challenge, and the results may be fragile, as argued in the introduction.[8] Cross country analysis also rarely takes into account the nature of conflict, considering the joint effects of war between states, which is associated with large scale destruction of physical capital, and civil conflict, which tends to be more detrimental for human capital, institutions and social order (see Collier, 1999). Finally, the use of cross country data implies an implicit focus on middle and high income countries, since data for poor countries that remain in conflict is typically absent, thus introducing a selection bias.[9]

To address these shortcomings, recent work makes use of micro level data, comparing outcomes between neighbouring areas with different exposure to conflict. Three papers stand out for our purpose. Davis and Weinstein (2002) show that Japanese cities that were bombed had completely recovered in size 20 years after the U.S. bombing in World War II. In a similar vein, Brakman et al. (2004) find that bombing of Germany had a significant but temporary impact on post-war city growth in West Germany, but a sustained impact in East Germany. Miguel and Roland (2011), finally, studying the effect of the destruction of physical capital by the bombing in Vietnam, find that the economy in hit areas had recovered 30 years after the conflict in terms of consumption, infrastructure, poverty, literacy and population density. All three studies look at the effects of *physical* capital destruction, *several decades* after an *international* conflict. This paper differs in four ways: it studies the consequences of the destruction of *human capital* caused by *civil* conflict, much *shorter after* the conflict, and provides insight into the *underlying mechanisms* of post war growth. [10]

Although there is, by our knowledge, little direct evidence on the impact of human capital destruction on economic growth, two existing studies indicate that the effects of a sudden drop in human capital can be profound. Historical research suggests that the black death in

[7] The argument goes that the effect of peace depends on whether the economy has already adapted to the new situation, e.g. by adjusting investment rates when taking increased insecurity and risk into account. If the country has not adapted yet (e.g. during a short war), the economy will continue to have lower growth (adjust its investment rates downward), while if it has adapted (e.g. during a long war), it will have higher growth.

[8] For a discussion of the reverse relationship, see Collier and Hoeffler (1998). Miguel, Satyanath and Sergenti (2004) also estimate the effect of economic factors on the likelihood of civil conflict using a convincing identification strategy.

[9] Chen, Loayza, and Reynal-Querol (2008) address some of these issues comparing before and after outcomes with a control group of countries that are similar except for the conflict.

[10] We use 'human capital' in its broadest sense, referring to the qualities that allow people to perform labour, including 'being alive', but also the level of education completed.

the mid-14th century led to a change in the land labour ratio and resulted in a rise in real wages, leading to the start of the 'Golden Age of the English Labourer' (Farmer 1991).[11] A second example is provided by Young (2005). Investigating the effect of high HIV infection rates on future living standards in South Africa, the author shows that the negative effect on human capital accumulation (especially for orphans) is compensated by a positive effect of slower population growth, which is caused both by lower sexual activity and an increase in the value of woman's time due to the increased scarcity of labour associated with high mortality.

There is ample evidence that conflict can have strong impacts on human capital. With respect to health, Alderman, Hoddinot and Kinsey (2009), analysing data for Zimbabwe, find that greater exposure to civil war has a negative effect on child height. Bundervoet et al. (2009), focusing on Burundi, find that an additional month of war decreased children's height for age z-scores by 0.05 standard errors compared to non-affected children; and Arcand and Wouabe (2009) find that conflict intensity worsened child health during and after the conflict in Angola.[12] There is also micro evidence for the effects of conflict on education. Akresh and de Walque (2008) show that the armed conflict in Rwanda had a negative effect on schooling outcomes, with exposed children completing half a year less. De Walque (2004) discusses how civil conflict in Cambodia had a lasting impact on educational attainment, mostly because of the collapse of the education system, and Shemyanika (2011) presents evidence of the negative impact of conflict on schooling in the case of Tajikistan. Chamarbagwala and Morán (2011) find a strong negative effect of the civil war in Guatemala on the education of Mayan men and women in rural areas, the most disadvantaged groups. In contrast, Arcand and Wouabe (2009), find that conflict increased school enrolment in Angola.

These results, which are also summarized in a literature review by Justino (2007), indicate that conflict can have profound negative effects on human capital, thereby sustaining poverty and slowing down economic recovery.

[11] More recent work concentrates on the increase in nominal wages , as new evidence suggests that rising food prices resulting in high inflation may have neutralised a rise in real wages (see Munro 2004).

[12] For evidence on the effects of conflict on fertility, see de Walque (2004), who observes that fertility and marriage rates in Cambodia were very low under the Khmer Rouge but bounced back after the regime collapsed, and Shemyakina (2011) finds that conflict made young women in Tajikistan marry either earlier or later, and had children earlier.

3. The context of Rwanda

This study focuses on the violence that took place in Rwanda in 1994. In April of that year, when the plane carrying President Habyarimana was shot down, genocide broke out, and the civil war between the RPF and the Rwandan government, which had been halted the year before, restarted and intensified.[13] By the end of June 1994, the RPF had taken control of the country and had put an end to the ethnic cleansing of Tutsis. Relative peace was established, although militias from the old regime (FAR and Interhamwe) continued with insurgencies in the North-West for some time.

Rwanda thus experienced distinct forms of violence, which were concentrated in different geographical areas and had different consequences. The map in Figure 1 illustrates the geographical spread, with civil war taking place in most of the northern and eastern provinces, as well as in the centre, and the genocide concentrated in the South. While the genocide had a high direct death toll, up to 800,000, mostly targeting the active male Tutsi population, and in particular the educated ones[14], the civil war was characterized by indirect deaths caused by a variety of factors, including limited access to food and health care, and took its largest toll among the weakest in the population (Verpoorten, forthcoming). Although there is by our knowledge no full assessment of the physical capital destroyed by civil war and genocide respectively, the former, with its aim to gain ground and sabotage government, is generally associated with more physical capital destruction. Two illustrations are the damage to the Ntaruka power station (by RPF) and Cyangugu tea factory (by FAR), as mentioned by Justino and Verwimp (2006).

There is only a small body of evidence documenting the economic set back caused by the conflict in Rwanda. Lopez and Wodon (2005) using aggregate data over time argue that, without the occurrence of conflict, GDP per capita in 2000 would have been 25% to 30% higher in Rwanda. Verpoorten and Berlage (2007), using panel data to analyse the effects of different types of genocide-related household level shocks between 1990 and 2002, find that these shocks had very little effect on households' income mobility. With respect to physical capital, Verpoorten (2009) finds that household cattle stock had fallen by half during 1994, but bounced back to about 74% of its pre-war level by 2002. Justino and Verwimp (2006)

[13] The Rwanda Patriotic Front (RPF), an army built up by refugees from Rwanda's previous conflicts living in Uganda, invaded Rwanda from the North at the end of 1990 and this led to intermittent hostilities and negotiations with the Rwandan government until a peace agreement was reached in 1993.
[14] See de Walque and Verwimp (2010)

provide descriptive evidence for convergence at the province level (N=10) and hypothesize that this is related to a number of factors including changes in labour-capital ratios, the location of battles, waves of migration and local resurgencies.[15]

A second group of studies, mentioned earlier, have focused on the consequences of conflict for human capital in Rwanda. Akresh, Verwimp and Bundervoet (2011) show how the 1991-1992 conflict resulted in reduced height-for-age z-scores for children living in conflict zones. McKay and Loveridge (2005) show how national nutrition levels - an important input to health - had recovered completely by 2000 to their 1992 levels. Looking at education levels, Akresh and de Walque (2008) find a substantial and significant fall (18%) in education attainment for children exposed to armed conflict. Only the latter study takes endogeneity of conflict into account.

While the first set of studies, looking at the consequences of conflict for economic performance, remain at the aggregate level or consider measures other than (the preferred) household consumption, the studies looking at education and health assess differences within the country, but do not make the explicit link to economic performance. This paper brings these two strands closer together.

This paper focuses on rural areas, or the agricultural sector, which harboured over 90% of the population at the peak of the conflict, and plays a dominant role in Rwanda's economy. This allows us to abstract from the strong differences in the nature of the production process between the rural and urban sector (see our production function approach below). Conceptually the context of rural Rwanda provides an additional dimension of interest. Having one of the highest population densities in Sub-Sahara Africa, and harbouring surplus labour, it provides a setting that allows studying what happens if population density is reduced substantially in a short period.[16]

4. Econometric strategy

To investigate the effect of conflict on economic performance, and assess the role of human capital destruction, this paper tests three hypotheses. It first tests whether households and

[15] Justino and Verwimp (2006) present rank correlations at the province level between pre-conflict (1990) income, 1990-2000 growth, and changes in labour-capital ratios, and uses province level event data to interpret observed patterns.

[16] This is further of interest because the recurrent violence in Rwanda's history has been explained in terms of the relative small amount of land available for households in rural areas (André and Platteau, 1998).

communities that have experienced conflict in 1994 have lower consumption six years after the conflict ended, compared to the other households and communities. Second, it examines the process of post-war economic growth, by comparing the returns to factors of production between heavily affected areas and less affected areas. In a robustness check we also investigate whether the results remain when taking migration into account. Finally, we test whether areas that have experienced distinct types of conflict, namely genocide and civil war, which are associated with human and physical capital destruction respectively, have different levels of economic performance and yield different returns to factors of production

4.1. Conflict and economic performance

To study the effect of conflict on economic performance the following equation is estimated:

$$y_i = \beta_0 + \beta_1 C_i + AX_i + BP_i + \varepsilon_{1i} \quad \text{with} \quad H_0: \beta_1 = 0 \tag{1}$$

Where *y* is the log of household consumption, *C* is a conflict index, as discussed in detail in Section 5, *X* are control variables (also discussed in Section 5) and *P* province fixed effects.

Since conflict intensity is related to economic factors, including land scarcity and income inequality among farmers in the case of genocide, as documented among others by André and Platteau (1998), Equation (1) may suffer from endogeneity. To address this, the following instrumental variable estimation is carried out:

$$y_i = \beta_0' + \beta_1' \hat{C}_i + A'X_i + B'P_i + \varepsilon_{1i}' \quad \text{with} \quad H_0: \beta_1' = 0 \tag{2}$$

$$C_i = \gamma_0 + \Gamma_1 Z_i + \Gamma_2 X_i + \Gamma_3 P_i + \varepsilon_{2i}' \tag{3}$$

Two instrumental variables (Zi) are used to proxy exogenous geographical variation in conflict intensity namely the distance to Uganda (DUi) and Nyanza (DNi). Because the RPF infiltrated from Uganda and moved only gradually towards Kigali engaging in heavy battles with the Rwandan army before eventually taking over the capital[17], distance to Uganda is appropriate as an identifying instrument. The exogenous character of the border stems from colonial history, as the border between Uganda and Rwanda was fixed in 1910 at an Anglo-German-Belgian Convention in Brussels, which provided that the boundary between British and German territories should follow the parallel of one degree south latitude across Lake Victoria and should continue westward to its intersection with the 30th meridian of longitude east of Greenwich (Bureau of Intelligence and Research, 1965). [18]

[17] The battle front then moved to other areas of the country, safeguarding the remaining Tutsi from being killed and engaging in reprisal killings on Hutu who allegedly participated in the genocide. (Davenport and Stam, 2009).

[18] Other work uses a similar identifying instruments for conflict, including Miguel and Roland (2011) who use the historic border between North and South Vietnam; and Akresh and de Walque (2008) in their study on

Distance to Nyanza, the original capital of the Tutsi monarchy that ruled most of Rwanda territory between the 15th and 19th century, serves as the second identifying instrument for conflict intensity. Its economic and political importance faded during colonization and was over by independence in 1962.[19] Today nothing is left of Nyanza's past glory. Its population density and economic development is indistinguishable from surrounding areas, but the proportion of Tutsi in the communities close to Nyanza was, for historical reasons, still higher prior to the genocide. However, note that even in the communities close to Nyanza, Tutsi remained a minority group and did not outnumber Hutu.

The distance to the border with Uganda and the distance to Nyanza qualify as appropriate instruments provided that they do not have a direct effect on economic performance, other than through the conflict. Therefore, in the estimated model, these instruments are used conditional on control variables like population density and distances to the road and the capital (although results remain when dropping these controls). As described in more detail in Sections 6 and 7, the usual overidentification tests as well as a Conley tests support the validity of these instruments.

4.2. Investigating the process of economic growth: conflict and factors of production

Theory argues that if conflict affects economic performance, it must be because it affects either the factors of production, or their prices, or the technology or institutions augmenting these factors.[20] To study the role of production factors in the presence of conflict we estimate a standard production function that includes the conflict variable, while taking its endogeneity into account:

$$y_i = \alpha_0 + \alpha_1 k_i + \alpha_2 l_i^u + \alpha_3 l_i^s + \alpha_4 \hat{C}_i + A'' X_i + B'' P_i + \varepsilon_{1i}'' \quad (4)$$

$$C_i = \gamma_0' + \gamma_1' DU_i + \gamma_2' DN_i + + \gamma_3' k_i + \gamma_4' l_i^u + \gamma_5' l_i^s + \Gamma_6 X_i + \Gamma_7 P_i + \varepsilon_{2i}'' \quad (5)$$

where k reflects land owned, l^u stands for unskilled and l^s for skilled labour. The coefficient α_4 reflects by how much output is lower in areas that have experienced more intensive conflict, after controlling for factors of production, for instance because of structural reasons, like technology or institutions, or due to market frictions. We test $H_0: \alpha_4 = 0$, which would

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schooling in Rwanda also use the distance to Uganda, but at the level of the eleven provinces. Here we make use of more detailed spatial data, containing the distance of each of the 139 rural communes to Uganda.

[19] Nyanza is located in the North-western corner of Butare, a Southern province in Rwanda, , more specifically at the cross-section of the provinces Butare, Gitarama and Gikongoro, as shown on the map in Figure 1. Its power was further weakened by a reorganization of Rwanda's administrative division shortly after independence, when the southern and western outskirts of Nyanza were attached to eastern Gikongoro, a highland area inhabited largely by Hutu, with the aim of further weakening Tutsi influence around the former royal capital (Desforges, 1999).

[20] See also Blattman and Miguel (2010) for a discussion on this.

be rejected in a poverty trap model, as well as in a neoclassical model if the economy converges to a new (lower) steady state.

To assess whether returns to production factors are different in areas that have experienced conflict, the conflict variable is interacted with each of the production factors To account for the possible endogeneity of conflict, we need to instrument for conflict as well as for its interactions with the three production factors. In order to do so, we follow the three-step procedure described in Wooldridge (2002, p.236). In the first step, we predict conflict intensity by regressing C_i on the set of included instruments as well as the set of excluded instruments (DU_i and DN_i). Next, predicted conflict intensity is interacted with the production factors, yielding a set of three interaction terms which are then used as additional instruments in a conventional 2SLS procedure. Formally, we estimate the following set of equations:

$$y_i = \alpha_0' + \alpha_1' k_i + \alpha_2' l_i^u + \alpha_3' l_i^s + \alpha_4' \hat{\hat{C}}_\iota + \alpha_5' \widehat{(k_\iota \times C_\iota)} + \alpha_6' \widehat{(l_i^u \times C_\iota)} + \alpha_7' \widehat{(l_i^s \times C_\iota)} + A''' X_i + B''' P_i + \varepsilon_{1i}''' \quad (6)$$

$$C_i = \gamma_0'' + \gamma_1'' DU_i + \gamma_2'' DN_i + \gamma_3'' k_i + \gamma_4'' l_i^u + \gamma_5'' l_i^s + \gamma_6'' \left(k_i \times \widehat{C}_\iota\right) + \gamma''_7 \left(l_i^u \times \widehat{C}_\iota\right) + \gamma_8'' \left(l_i^s \times \widehat{C}_\iota\right) + \Gamma_9 X_i + \Gamma_{10} P_i + \varepsilon_{2i}'' \quad (7)$$

$$(k_i \times C_i) = \gamma_0''' + \gamma_1''' DU_i + \gamma_2''' DN_i + \gamma_3''' k_i + \gamma_4''' l_i^u + \gamma_5''' l_i^s + \gamma_6''' \left(k_i \times \widehat{C}_\iota\right) + \gamma_7''' \left(l_i^u \times \widehat{C}_\iota\right) + \gamma_8''' \left(l_i^s \times \widehat{C}_\iota\right) + \Gamma_9' X_i + \Gamma_{10}' P_i + \varepsilon_{2i}''' \quad (8)$$

$$(l_i^u \times C_i) = \gamma_0'''' + \gamma_1'''' DU_i + \gamma_2'''' DN_i + \gamma_3'''' k_i + \gamma_4'''' l_i^u + \gamma_5'''' l_i^s + \gamma_6'''' \left(k_i \times \widehat{C}_\iota\right) + \gamma_7'''' \left(l_i^u \times \widehat{C}_\iota\right) + \gamma_8''' \left(l_i^s \times \widehat{C}_\iota\right) + \Gamma_9'' X_i + \Gamma_{10}'' P_i + \varepsilon_{2i}'''' \quad (9)$$

$$(l_i^s \times C_i) = \gamma_0''''' + \gamma_1''''' DU_i + \gamma_2''''' DN_i + \gamma_3''''' k_i + \gamma_4''''' l_i^u + \gamma_5''''' l_i^s + \gamma_6''''' \left(k_i \times \widehat{C}_\iota\right) + \gamma_7''''' \left(l_i^u \times \widehat{C}_\iota\right) + \gamma_8''''' \left(l_i^s \times \widehat{C}_\iota\right) + \Gamma_9''' X_i + \Gamma_{10}''' P_i + \varepsilon_{2i}''''' \quad (10)$$

Where $\widehat{C}_\iota$ is obtained from equation (5). If there is rapid catch up, returns to production factors are expected to be the same across areas with low and high violence intensity, or $H_0: \alpha_5' = \alpha_6' = \alpha_7' = 0$.

Ceteris paribus one would expect the mass killings that characterized the conflict in Rwanda to increase returns to labour. However, if surplus labour was substantial, these returns may remain low, even after the mass killing. Conversely, while returns to land are likely to be high in Rwanda's setting of extreme land scarcity, they may be lower in conflict intensive areas, where the complementary factor of labour is scarcer. Turning to skilled labour, given the general low levels of education, one expects returns to skilled labour to be positive and large, and - because the genocide targeted the more educated, as shown by de

Walque and Verwimp (2010) - one expects, ceteris paribus, these returns to be higher in areas that experienced genocide more intensively.

4.3. Taking migration into account

Migration, including both war-induced displacement and resettlement, may affect economic performance and catch up. Therefore, we investigate whether the results are robust to controlling for migration.[21] Since the process of migration may be simultaneous to that of economic development, we account for its endogeneity.

Because by far most migration in post-war Rwanda was related to war-induced displacement and resettlement, we use the same instruments as before. The estimation is similar as above, with an additional first stage regression for migration (of which the predicted variable is then added to the second stage regression). If migration has an effect on its own, one expects its coefficient to be significantly different from zero. More importantly for our purpose, we assess whether the earlier results on our coefficients of interest remain.

4.4. Does the type of conflict play a role?

We consider two types of conflict that took place in Rwanda in 1994, namely genocide and civil war, associated with human and physical capital destruction respectively. Exploiting the rich and detailed information at the local level, two conflict indices are developed (see Section 5) and the above equations are re-estimated using these specific indices.

Because the genocide targeted individuals, and specifically able and active men, we expect the difference in returns to labour between areas that were affected by the genocide and those that were not, to be larger than the difference between areas that experienced civil war and those that did not. Given that the genocide also targeted the relatively educated, we also expect the difference in returns to skilled labour between genocide affected and non-affected areas to be higher than the difference between civil war affected and non-affected areas.

[21] Areas where surplus labour has been reduced may now yield relatively higher returns to labour and therefore attract migrant labour and resettlers. This may also affect the returns to land, bring new technologies and affect existing institutions. While the role of migration is interesting in itself, it is also complicated, and requires a separate in-depth analysis. Here we limit ourselves to investigating whether our results are robust to controlling for migration.

5. Data and measurement

We combine three types of data: the 1999-2000 national household survey (EICV/IHLCS[22]) , conflict data derived from two consecutive population censuses and the records of the gacaca (a transitional justice system for genocide suspects), and geographical data to define the instruments This combined data set has variables at the household, sector and commune level.[23] Consumption and household production factors are at the household level, while the conflict index and instrumental variables are at the commune level, and most control variables are at the sector level. To show the robustness of the results, we run the regressions both at the household and sector level. The first stage regressions are always at the commune level. We discuss the key variables in turn.

Economic performance, which is measured at the household level, is proxied by household consumption, and obtained from the IHLCS 1999-2000. Figure 2 plots a kernel density for the logarithm of household expenditures and Table 1 reports the corresponding descriptive statistics, showing that average annual (rural) household consumption is 271,776 FRW or 693 USD (PPP) or, in per capita terms, 158 USD (PPP) per capita.[24] The average amount of land owned is 0.37 ha, while the average number of active household members (those aged between 15 and 65), which is our proxy for unskilled labour, is 2.09. Mean years of schooling of the household head, our proxy for skilled labour, is 2.68.[25]

The conflict measures are from Verpoorten (2011), who develops three indices reflecting the intensity of the conflict in general, genocide and civil war respectively. They are calculated at the commune level from the 2002 population census data (N=8.1 million), a 10% sample of the 1991 population census data (N=742,918 individuals) and the records of the Gacaca, the transitional justice system for judging genocide suspects. Here we limit ourselves to a brief description of the measures; more details can be found in Appendix.

General conflict intensity is measured by the Wartime Excess Mortality Index (WEMI), which measures commune level excess mortality in the period 1991-2002 and is the weighted sum of the first differences of five excess mortality proxies derived from the 1991

[22] Enquête Intégrée sur les Conditions de Vie des ménages / Integrated Household Living Conditions Survey
[23] The sector corresponds to the smallest codified Rwandan administrative unit. At the time of the genocide, Rwanda was divided in 10 prefectures, 145 communes (of which 6 entirely urban) and 1565 sectors. The first administrative reform (1996) replaced the 10 prefectures by 12 provinces, adding Kigali City and Umutara. The second administrative reform (2002) replaced the 145 communes by 30 districts and the 12 provinces by 5 regions. On average a sector counts 5,000 inhabitants, while a commune counts 50,000 inhabitants.
[24] using a 2000 exchange rate of 393 RWF/$
[25] All results are very similar if we use per capita consumption, if we use land cultivated instead of land owned, or of we use other measures of education (see robustness checks).

and 2002 population census, in particular, the mortality of sons, the mortality of daughters, widowhood, orphanhood, and disability due to war or genocide.[26] In line with previous work on the construction of conflict indices, the weights equal the vector of (positive) loadings of the first Principal Component (PC) (e.g. Hibbs, 1973; Venieris and Gupta, 1983; Gonzales and Lopez, 2007). These loadings and the summary statistics for the five 1991-2002 excess mortality proxies are listed in Table A1 in appendix.

To proxy for the intensity of genocide, the above set of five general excess mortality measures is augmented with an extra six genocide proxies, namely the number of genocide suspects (using three different categories) and the number of genocide victims who survived but lost close relatives in the genocide (widowed, orphaned and disabled genocide victims); all taken proportional to the population. When subjected to PCA, the loadings on the first Principal Component are positive across the eleven variables and highest on the genocide proxies, indicating that the first component can be interpreted as reflecting genocide specific excess mortality. The loadings on the second PC are positive on the general excess mortality proxies, but negative on the genocide proxies, allowing us to interpret Principal Component 2 as reflecting the intensity of civil war rather than genocide.[27] For ease of interpretation, each of the indices are rescaled to fall in the [0,1] interval. The standard deviation of the indices, reported in Table 1, indicates that there is substantial variation in exposure to violence across communes; this is confirmed by their kernel density plots in Figure 3a-3c. To visualize the geographical spread, Figure 4 presents a map for each of the three indices, with a darker shade reflecting a higher mortality index. These maps confirm that Genocide Excess Mortality (GEMI) is concentrated in the South, while Civil war Excess Mortality (CEMI) is concentrated in the centre, East and Northwest, as summarized in Figure 1.

To reduce sample heterogeneity (and increase the power of our instruments), the regression controls for a number of pre-conflict commune and sector characteristics, including sector level precipitation and altitude to control for differences in climate and

[26] Developing these indices follows a long standing demographic tradition to infer excess mortality from characteristics of the surviving population, a method referred to as Indirect Mortality Estimation (Hill & Trussel, 1977; Timaeus, 1986). Because obtaining absolute numbers of excess mortality is extremely demanding in terms of data requirements (as well as assumptions) the present method focuses on capturing relative excess mortality and its spatial distribution.

[27] More accurately, Principal Component 2 captures the intensity of other-than-genocide related excess mortality. The denomination 'civil war' is a simplification made for ease of exposure, but captures the key dimension in this context, as is clear from the discussion in Section 3.

geography (which determine agricultural conditions, like soil type).[28] The model also includes 1991 sector level population density and 1978-1991 commune level population growth, which both proxy for differences in land productivity.[29] It further includes the 1991 sector level distance to a main road and distance to Kigali, which proxy for market integration and proximity to the economic centre; and because civil war tended to be more intense in sectors closer to the main road and closer to Kigali. However, the control variables are not crucial as the results remain similar when excluding these control variables. Summary statistics for these variables are listed in the appendix Table A2.

6. Results

6.1. Do war-affected areas perform worse six years after the conflict ended?

Table 2 reports the results from estimating Equation 1 first at the sector level (columns 1-3) and then at the household level (Columns 4-9). In each case, OLS estimates are reported first, followed by the IV and first stage estimates. The results are very robust. According to OLS, sectors that experienced maximum violence in 1994 (having a value of one for the conflict index) had 36% lower consumption levels in 2000 than sectors that experienced no conflict in 1994 (zero value of the index). The IV approach yields a substantially larger negative estimate and finds that consumption in areas that experienced maximum conflict is 88% lower than in zero conflict areas. The substantially higher IV estimates indicate that richer areas suffered more intensive violence, biasing the OLS estimate upwards. Applying Equation 1 to the household data yields very similar results, namely -0.35 for the OLS estimate and -0.92 for the IV estimate, as reported in Columns 4 to 5 in Table 2.

The reported coefficients reflect what happens when moving from minimum to maximum conflict intensity, and therefore tend to be large. When expressing the effect in

[28] Annual long-term average precipitation and altitude are calculated for all administrative sectors based on information of a subsample of sectors (taken from the Direction des Statistiques Agricoles) and a distance-based spatial weighting procedure run in GeoDa (Anselin, 1995).

[29] Population density is a classic proxy for land productivity in Rwanda because the most fertile areas are the most densely populated ones. This can, however, be ambiguous because, by 1970, population density had become so high in these areas that even marginal lands were being cultivated and land conflict became very frequent, putting a strain on land productivity (André and Platteau, 1998). As a consequence of the lack of land in the fertile Western highlands, migrants were encouraged to settle in areas with lower soil fertility, especially in the East of the country. In a disaggregated spatial analysis of demographic trends in Rwanda during the period 1978-1991, Olson (1994) convincingly demonstrates that areas with infertile soils experienced the highest population growth. Hence, to further distinguish differences in soil fertility among the high populated ones, we use population growth between 1978 and 1991 using the census data for these years.

standard deviations, the respective coefficients are considerably smaller, namely -0.07 (rather than 0.36) for OLS and -0.17 (rather than -0.88) for IV at the sector level and 0.07 (rather than 0.35) and 0.19 (rather than 0.92) for the OLS and IV estimates at the household level.

The first stage regression reported in Table 2 Column 3 demonstrates the importance of both instruments, which show up highly significant and have the expected signs. Distance to Nyanza has a negative sign, reflecting high conflict and genocide intensity near Nyanza. Distance to Uganda has a positive sign, indicating high conflict intensity further away from the border with Uganda, and reflecting the 1994 civil war in the centre and the east, with the battle intensifying as the RPF proceeded. [30] The F-statistics are all well above 10, confirming the instruments' strength. A Sargan-Hansen test of overidentification also performs well as the joint null hypothesis that the instruments are uncorrelated with the error term cannot be rejected, supporting the validity of our instruments. Since the Wooldridge procedure to instrument for interaction terms yields biased standard errors, we report bootstrapped standard errors for the second stage.[31]

To estimate equations 4 and 5 the model is then extended to include land owned, as well as skilled and unskilled labour in the household. The results, reported in Columns 7 to 9 in Table 2, confirm earlier results and show that conflict has a large significant negative effect, both in OLS and IV estimation, with the latter again larger in magnitude. This indicates that even after controlling for household endowments, those living in areas that experienced more intensive violence perform worse six years after the conflict ended. The estimates also confirm that the returns to land, unskilled and skilled labor are all positive and significant.

Although the approach followed in this paper is not well suited to make a country wide assessment, it is still interesting to carry out a simulation to approximate the nationwide effect of conflict. Assuming everything else remains the same, which may be a conservative assumption, we obtain an idea of the nationwide effect by multiplying the point estimate with the conflict index, taking into account the entire distribution of conflict intensity. Using the IV (OLS) estimate, we find that consumption in rural areas would have been 35% (14%) higher if there would not have been excess mortality. This estimate closely matches the findings of Lopez and Wodon (2005), who extrapolate a national trend in GDP (including urban areas) and conclude that GDP/capita would have been 25% to 30% higher in Rwanda if there would not have been conflict.

[30] See also Davenport and Stam (2009) on the sequencing of genocide and the advancement of the RPF.
[31] The standard errors only change marginally and the results remain qualitatively the same.

6.2. Are returns to factors of production different for areas that have experienced conflict ?

One possible reason why conflict areas have lower consumption is that recovery takes time, and six years is too short. If this is the case, we should see mechanisms for catch up at play. The results of estimating Equation 6, presented in Table 3, indicate that while the return to land is positive in general, it is basically zero in areas with maximum past conflict. This is consistent with land becoming less scarce due to excess mortality. Alternative explanations, like a lack of complementary inputs due to market disruption, are also possible. The returns to unskilled labor are slightly higher in areas with high intensity of violence, but not significantly so. This seems at least partially the consequence of unobserved heterogeneity in the form of violence, as we will see later. Returns to skilled labor are slightly lower in conflict areas (but not significantly), contrary to our expectations (since the genocide targeted the most educated). This may suggest that activities where returns to education are highest, like off farm work, may still be largely absent in past conflict areas, for instance because of a lack of infrastructure, or that the educated have been replaced by equally educated immigrants.

6.3. Controlling for migration

So far migration has not been taken into account. In the aftermath of genocide, a substantial number of people have been displaced both internally and externally .[32] However, by 2000 more than 97% of the refugees who moved abroad had returned to Rwanda (UNHCR, 2000). These returnees, as well as the internally displaced, did not necessarily resettle in their communities of origin. The relevant dimension of migration to focus on in this analysis is therefore resettlement in a Rwandan community different from one's pre-genocide residence. Results from the 2002 population census show that this is limited in scale, with 8.3% of the population residing in a different community from where they resided before the start of the conflict in 1991 (Government of Rwanda, 2002). Nevertheless, this may influence our estimation results as migration may affect labour supply and economic performance.

To check the robustness of the results, we add the proportion of immigrants in a sector (calculated from the entire 2002 population census) to our model, as set out in Section 4.3,

[32] Estimates vary, with a maximum of up to two million internally and externally displaced. Most of the externally displaced resettled in Rwandan in the course of 1997-1998. Rwandans who lived in exile prior to the genocide also returned to their country of origin after the genocide (Prunier, 1998).

and take endogeneity of immigration into account using the same identifying instruments. Table 4 reports the results of the household level estimation. In both OLS (Column 1) and IV (Column 2) the estimated coefficient of conflict is very close to the original estimates reported in Table 2 (Column 4 & 5). The results in columns (3) - (6) confirm that the coefficients of the household production factors and of the interaction terms between conflict measures and household production factors also remain virtually unchanged after controlling for immigration.

In the first stage regressions for immigration (not reported), distance to Nyanza has a high predictive power, while distance to Uganda does not show up significantly. This is consistent with immigration being concentrated in communities that are affected by the genocide.

6.4. Does the type of conflict matter?

Table 5 reports OLS and IV estimates for the different types of conflict, replacing the general conflict index (WEMI) with the genocide (GEMI) and civil war (CEMI) indices respectively.[33] Comparing the effects of genocide (Columns 1 to 3 of Table 5) with those of civil war (Columns 4 to 6) shows that the relative gap in economic performance between areas that have experienced violence and those that have not, tends to be similar for genocide and civil war.[34] In the first stage regression of the genocide index, distance to Nyanza has a stronger negative effect than in the general conflict index, confirming that this instrument mainly captures violence against Tutsi.

To assess whether the underlying growth process depends on the type of conflict, we include the interaction effects of the production factors with the genocide and civil war indices respectively. Interestingly, the results in Table 6 show that, once controlling for endogeneity, the drop in returns to land is much stronger for genocide related violence than for civil war related violence, a consequence of the fact that the genocide targeted adult males. For the same reason, returns to unskilled labor are high and significant in genocide affected areas, while they are not significant in civil war affected areas. This suggests that the

[33] Note that because the respective indices limit themselves to different types of violence the coefficient here reflect the effect of a one unit change in the genocide (civil war) index. The GEMI (CEMI) effect thus reflects how genocide (civil war) affected areas perform *relative to non-genocide (civil war) affected areas*. Because the two violence specific indices are orthogonal by construction, their coefficients can become larger than those of the compact index.

[34] To address the concern that the civil war effect reflects the effects of post 1994 (counter) insurgencies, we carry out a robustness test by excluding the two provinces where these insurgencies were concentrated namely Gisenyi and Ruhengeri, and find that the results remain very similar (not reported).

reduction in labor supply brought about by the genocide was substantial enough to increase returns to labor, a scenario that resembles the labor market effects of the Black Death in mid-14th century United Kingdom and of the HIV epidemic in South Africa mentioned earlier.

The type of conflict also seems to matter for the returns to skilled labor, and this sheds light on the earlier general result. Returns to skilled labor are higher in genocide affected areas, but only just significant. In contrast, they are significantly lower in civil war related areas. This disparity is likely related to the different type of damage but may also stem from the distinct profile of victims associated with each form of violence. Because civil conflict is more likely to destroy factors that augment skilled labor, like, for instance infrastructure (see a.o. Collier 1999), the returns to skilled labor are lower in civil war affected areas. On the other hand, since the genocide targeted the better educated, returns to education in genocide affected areas are higher. These results remain the same when we include migration (not reported).

7. Robustness checks

An empirical tudy of conflict faces many constraints. We carry out a number of robustness checks to address weaknesses imposed by the data.

We first verify whether the estimated equations are well specified. The main issue is whether unobserved heterogeneity is important, as some production factors are omitted from the model. To address this, the model is enriched with the number of livestock, the number of dependents (who may provide additional labour), and whether the household is female headed (having less access to physical labour).[35] The results remain the same. Also, while the analysis has focused on rural areas to address potential heterogeneity in the process of production, the results are very similar when urban areas are included.

Second, we test whether the results remain when using alternative measures of conflict. A possible weakness of the indices used is that they suffer from a potential survival bias, since they are based on population census data from the surviving population, and may thus underestimate conflict intensity when entire households are killed. To address this, three alternative indices are constructed which also include the distance to a mass grave, as the

[35] Livestock ownership is measured by the log of Tropical Livestock Units owned. The number of dependent household members is measured as the log of members aged younger than 15 or older than 65. Using an alternative method to control for heterogeneity of household size, i.e. using per capita household consumption as a dependent variable, also yields similar results.

probability that entire families were executed is strongly associated with the proximity to such a site (Verpoorten, forthcoming). [36]

Third, we assess whether an alternative strategy to identify causality gives similar results, first by considering alternative instruments, and second by pooling with other data in order to carry out difference-in-difference estimation. While it is accepted that conflict may be endogenous to economic performance, it is also recognized that finding good instruments often remains a challenge. In what is becoming an accepted approach in the conflict literature[37], this paper uses distance measures as instrumental variables. A potential concern may be that these distances are correlated with the level of economic activity itself. To avoid this, the instruments were made conditional on relevant factors like the distance to the main road, distance to the capital, and land productivity, which are all included as control variables. However, to further address the concern we carry out a number of inspections. Conley et. al (2011) provide a novel way to assess to what extent the exclusion restriction can be relaxed without invalidating the IV results.[38] Applying their method we find that the direct effect of the respective instruments on economic performance is allowed to be large, namely +0.28 and -0.11 (for the logarithms of distance to Nyanza and distance to Uganda respectively), before the IV result disappear, providing strong arguments in favour of our instruments. In a further check the regressions are rerun with an additional control for 1991 baseline wealth as right hand side variables, proxying for the initial level of economic activity, but the results remain the same.[39] In another check the sectors close to the Ugandan border, which may drive the results because they may have higher economic performance due to cross border trade, are removed from the analysis.[40] Again the results remain the same. Together with the Hansen-Sargan test results, this provides strong arguments in favour of the validity of our instruments.

Finally, as an alternative to the instrumental variable estimation, difference-in-difference estimation is carried out. If the negative effect of conflict observed above stems

[36] The distance to a mass grave is calculated at the commune level using information from the Yale Genocide Studies on the location of 71 mass graves (see http://www.yale.edu/gsp)..
[37] See for instance Miguel and Roland (forthcoming) and Akresh and de Walque (2008).
[38] Simulations are available upon request. The method exists of regressing the difference between the dependent variable and the iv on the predicted endogenous variable obtained from the first stage [Y-mZ=a+b(pX)], and then increase the weight of the iv (m) until the coefficient on the predicted endogenous variable (b) reaches zero to conclude that the direct effect of the iv needs to be as large as m in order to yield a significant effect while the actual effect is zero.
[39] We use the commune average of assets owned and the commune average of the years of schooling of the active population (15-65). These variables are calculated from the 1991 population census. The asset variable is constructed as the simple sum of indicator variables for ownership of high value assets.
[40] We use 20 km as the break off point but the results are similar when using alternative distances.

from unobserved factors associated with high propensity of conflict, dif-in-dif should produce different results. To do this we pool our 2000 EICV data with the 1990 MINAGRI/MSU agricultural survey, a nationally representative survey that took place before the war. This data has a number of shortcomings that prohibit using it for the main analysis. A first constraint is the limited number of observations, namely 84 rural sectors (compared to 405 for the IHLCS data) -with very low numbers in some provinces, and a very small overlap across the two surveys.[41] A second shortcoming is that the data only contains information on income, and not on consumption which tends to be smoother and is a better measure for permanent income or welfare. This is especially important in the context of rural Rwanda where farmer's income is strongly related to rainfall, with substantial micro fluctuations and incidences of local famines (see FEWS NET, 2000; Verpoorten, 2009)[42]. A final major shortcoming of the 1990 survey is the sample selection bias, stemming from the fact that the survey only includes land owning households, excluding the poorest who do not own land.

Because of these limitations, the 1990 data can at best be used to carry out a robustness check. The following dif-in-dif estimation is carried out at the household level:

$$y_i = \beta_0'' + \beta_1'' C_i + \beta_2 T_{2000i} + \beta_3 (C_i \times T_{2000i}) + A''' X_i + B''' P_i + D(P_i \times T_{2000i}) + \varepsilon_{1i}''' \quad (11)$$

where C_i is the conflict index like before, and T_{2000i} is a dummy variable taking the value of one if the household (or sector) is observed in the post-war 2000 data and zero otherwise, we test $H_0 : \beta_3 = 0$. The estimates, presented in Table 7, confirm our earlier results as the interaction between the conflict index and T_{2000} has a large and negative coefficient (Column 1 of Table 7), which is of the same order of magnitude as the earlier IV estimates in Table 2, and becomes extremely similar when controlling for factors of production (Column 2 of Table 7). This provides further support for our earlier IV results.

[41] Only 25 sectors are present in both surveys. The data also has no panel dimension at the household level.
[42] This is particularly relevant for the years under study, since two of the provinces with the highest genocide intensity (Gikongoro and parts of Butare) were also hit by a famine just before the 1990 survey. Including time-varying province or locality dummies does not address in a satisfactory way because the climate changes that lead to these local famines are at a more local (micro) level).

8. Conclusion

This paper studies the effect of mass killings and human capital destruction on economic performance in Rwanda, using micro-econometric analysis. Joining a small body of work that studies the impact of conflict on economic performance within a single country (Davis and Weinstein, 2002; Brakman et al., 2004; Miguel and Roland, forthcoming), the analysis differs in four ways from existing work, as it studies the consequences of the destruction of human rather than physical capital, brought about by civil rather than interstate conflict, and considers the economy short after the conflict, namely 6 years, as opposed to 15-25 years, and allows us to examine the ongoing recovery process.

Combining rich household data with unique data on violence in Rwanda, the paper finds that households and localities that experienced more intensive conflict lag behind in terms of consumption, relative to those that experienced less intensive conflict. This finding is robust to taking into account the endogeneity of violence, using geographical variables as identifying instruments. It is also robust to controlling for migration.

The lower economic performance of areas that have experienced more conflict contrasts with findings from other studies. The most obvious reason for this difference is that this paper looks at economic performance much shorter after the end of conflict, when the economy may be in a phase of post-conflict transition. Indeed, when comparing the returns to factors of production between low and high conflict intensity areas using a production function approach, the paper finds significantly different returns to land and labour. While the return to land is positive in general, it is almost reduced to zero in past conflict areas, which is consistent with land becoming less scarce in these areas due to excess mortality.

Another potential reason why conflict areas (still) have lower levels of consumption is that it takes an economy longer to recover from human capital destruction than from physical capital destruction, as suggested by Barro and Sala-i-Martin (2003). Distinguishing between genocide, which reflects a brutal destruction of human capital, and civil war, which destroyed less human capital and is associated with higher losses of physical capital, we find distinct effects. Returns to land are lower, and returns to unskilled labor higher for genocide affected areas, more so than for civil war affected areas. This is a direct consequence of the decrease in labor force, as the genocide targeted adult males in particular. In contrast, the returns to skilled labor are lower in civil war affected areas, but not in areas that experienced genocide, which is consistent with civil war bringing more damage to factors that augment skilled

labor, although it may also stem from the genocide having targeted the highly educated. Summarized, these findings provide supportive evidence that recovery depends on the form of violence.

While considering a shorter period after the conflict is one of the strengths of the data, it also puts limits to the inference that can be drawn. In particular, although we can exclude that a new steady state has been reached, we do not know whether the ongoing process of recovery will end in the pre-war steady state, as suggested by neoclassical growth models, or in a new, lower steady state, as implied by poverty trap models. Hence, one direction for future research is a detailed analysis of the time path of recovery. Another research avenue that may proof particularly useful involves assessing the role of factors that have remained unobserved so far, like infrastructure, institutions and technology. Future work on other countries will also shed light on how specific the story of Rwanda is, and what we can learn for other settings.

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Figure 1: Overview of the Geographical Distribution of the Conflict

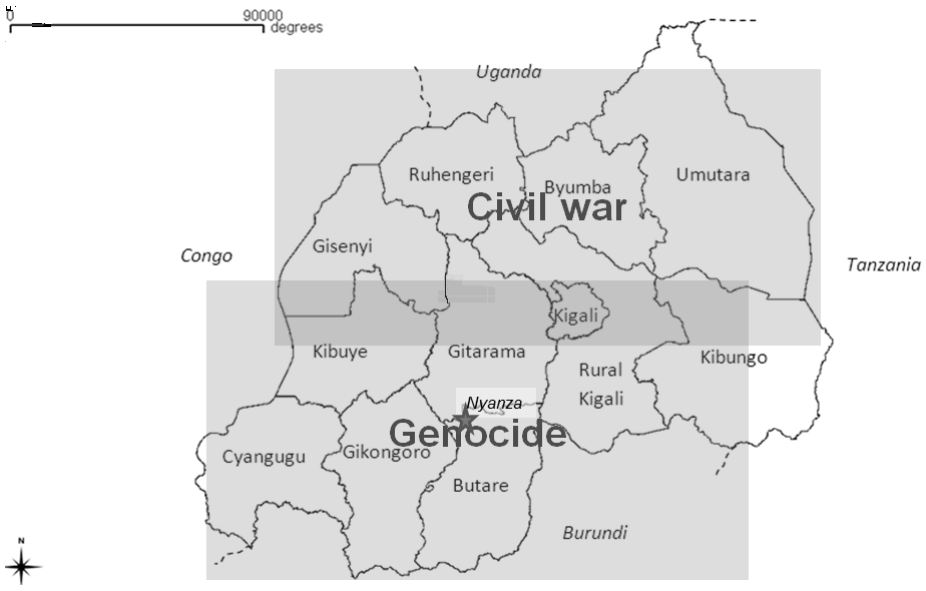


Figure 2: kernel density of log household consumption (2000) with food and total poverty line

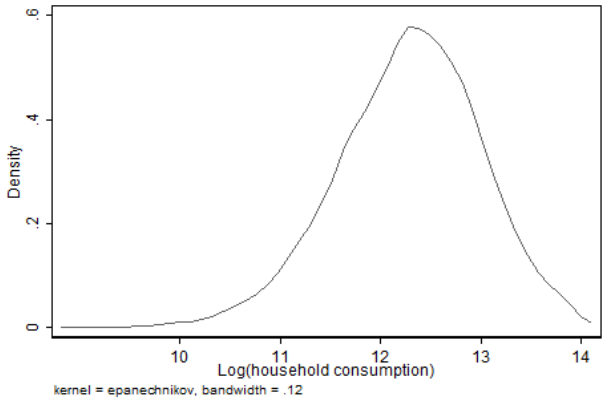


Figure 3: kernel density of the excess mortality indices

(a) War Excess Mortality Index (WEMI)

(b) Genocide Excess Mortality Index (GEMI) and Civil War Excess Mortality Index (CEMI)

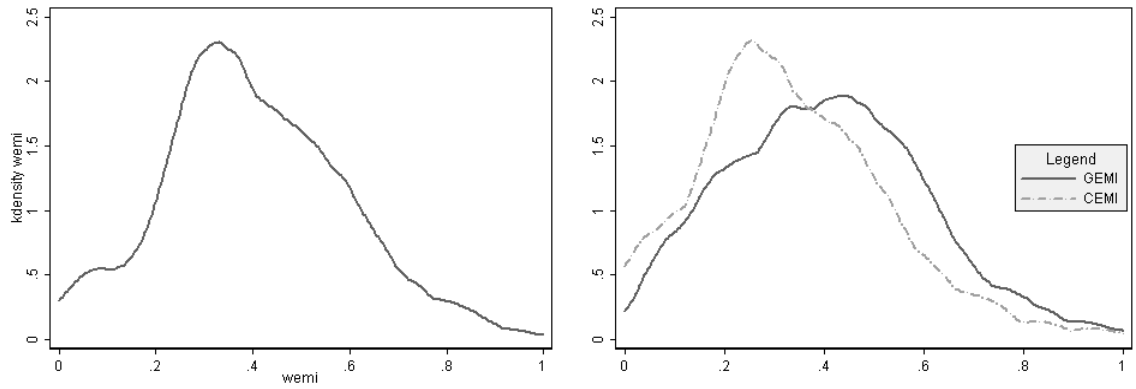
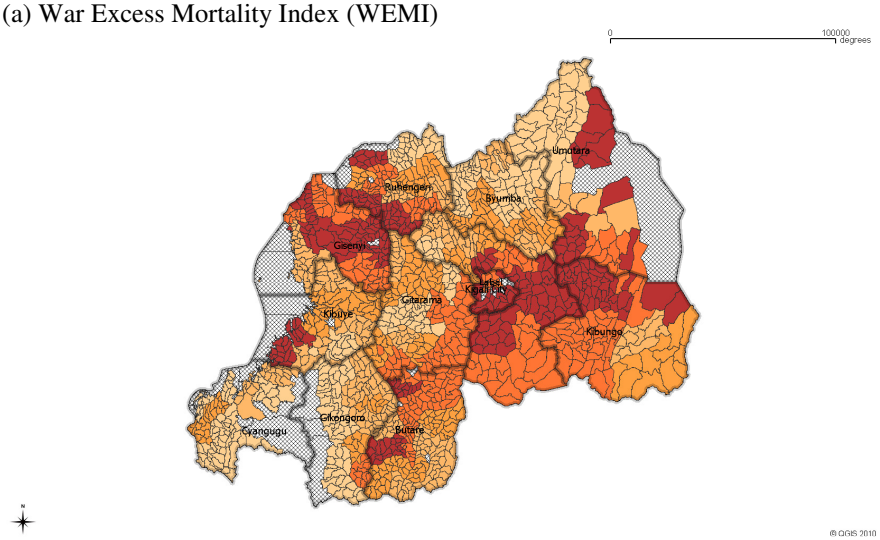
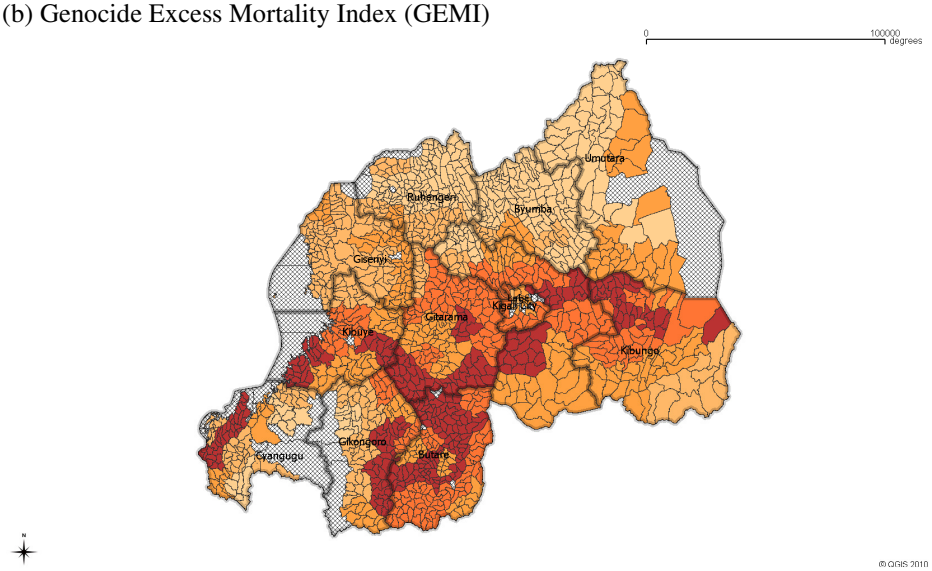


Figure 4: Geographical Distribution of the conflict indices, expressed in (darkest reflects top quintile)

(a) War Excess Mortality Index (WEMI)



(b) Genocide Excess Mortality Index (GEMI)



(c) Civil War Excess Mortality Index (CEMI)

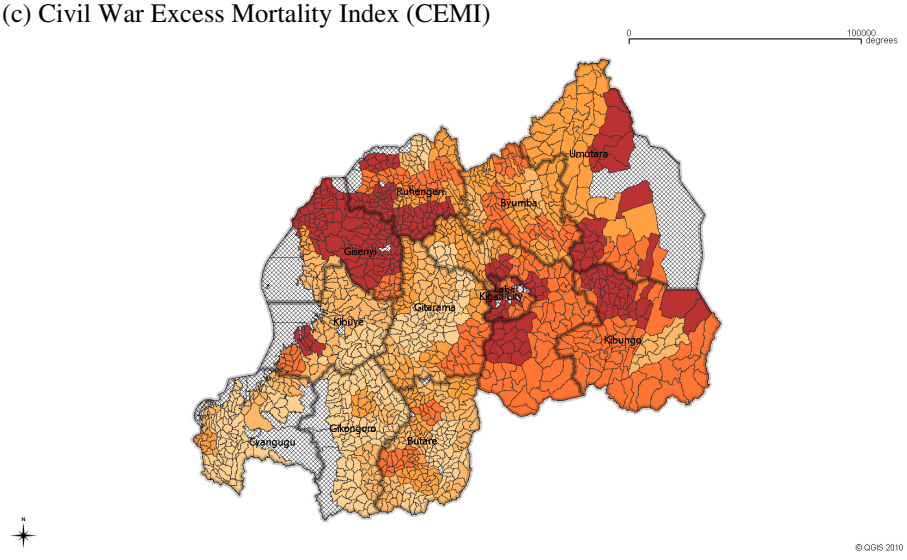


Table 1: Descriptive statistics

a. Household level variables (N=4,828)		Mean	St. Dev
Household consumption in 2000	Household consumption expenditures (RWF)	271,776	190,437
Per adult equivalent consumption in 2000	Household consumption expenditures per adult equivalent (RWF)	61,802	44,561
Land owned	Land owned by household	0.37	0.54
Active	Household members aged 15-65	2.09	1.05
Schooling head	Years of schooling household head	2.68	3.20
b. Commune level variables (N=139)			
WEMI	Wartime Excess Mortalty Index. First principal component (PC) of 5 excess mortality proxies taken from 1991-2002 population census. Rescaled to the interval [0,1]	0.40	0.19
GEMI	Genocide Excess Mortality Index. First PC of the 5 excess mortality proxies and 6 genocide proxies taken from gacaca records. Rescaled to the interval [0,1]	0.37	0.19
CEMI	Civil war Excess Mortality Index. The second PC of the 5 excess mortality proxies and the 6 genocide proxies. Rescaled to the interval [0,1]	0.36	0.19
Distance to Nyanza	Distance to Nyanza, the former capital of the Tutsi monarchy that ruled between the 14th and 19th century (km)	65	29
Distance to Uganda	Distance to the Uganda border, from where the RPF invaded Rwanda in October 1990 (km)	73	42

Notes: The household level data are taken from the (EICV/IHLCS). The conflict data is obtained from Verpoorten (2011). The geographic data is obtained from calculations in GeoDa (GIS software; Anselin, 1995).

Table 2: General conflict and economic performance

Dependent variable:	Sector level estimates			Household level estimates					
	Log(consumption)		WEMI	Log(consumption)		WEMI	Log(consumption)		WEMI
	OLS	IVE 2nd stage	IVE 1st stage	OLS	IVE 2nd stage	IVE 1st stage	OLS	IVE 2nd stage	IVE 1st stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
WEMI	-0.362***	-0.883***		-0.350***	-0.921***		-0.284***	-0.853***	
	(0.115)	(0.192)		(0.112)	(0.217)		(0.097)	(0.172)	
Log(land)							0.383***	0.368***	-0.008
							(0.038)	(0.039)	(0.010)
Log(active)							0.740***	0.726***	-0.009
							(0.028)	(0.028)	(0.006)
Log(schooling)							0.163***	0.167***	0.002
							(0.011)	(0.011)	(0.003)
Log(distance to Nyanza)			-0.057***			-0.056***			-0.055***
			(0.017)			(0.017)			(0.017)
Log(distance to Uganda)			0.096***			0.097***			0.097***
			(0.018)			(0.017)			(0.017)
X_j	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
P_j	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nr. of clusters				400	400	400	400	400	400
Obs.	400	400	400	4,828	4,828	4,828	4,828	4,828	4,828
R^2	0.232	0.246	0.546	0.051	0.056	0.549	0.279	0.284	0.549
First stage F-test			22.67			25.04			24.67
p-value			(0.000)			(0.000)			(0.000)
Hansen J statistic		0.012			0.009			0.012	
Chi-sq(1) P-val		(0.912)			(0.926)			(0.913)	

Notes: *** p<0.01, ** p<0.05, * p<0.1. The robust standard errors are adjusted for clustering within sectors and are reported between brackets; the IV 2nd stage st. errors are bootstrapped. X includes sector-level covariates (rainfall, altitude, 1991 population density, distance to Kigali City, distance to main road) and commune-level covariates (1978-1991 population growth, 1991 asset ownership and 1991 educational attainment); P are province fixed effects.

Table 3: General conflict, economic performance and returns to production factors

Dependent variable:	Log(consumption)		WEMI	Log(land)* WEMI	Log(active)* WEMI	Log(schooling) * WEMI
	OLS	IVE 2nd stage	IVE 1st stage	IVE 1st stage	IVE 1st stage	IVE 1st stage
	(1)	(2)	(3)	(4)	(5)	(6)
WEMI	-0.241	-0.834***				
	(0.200)	(0.215)				
Log(land)	0.633***	0.566***	-0.037*	0.099***	-0.040*	-0.030
	(0.084)	(0.094)	(0.022)	(0.018)	(0.024)	(0.027)
Log(land)*WEMI	-0.670***	-0.533**				
	(0.193)	(0.240)				
Log(active)	0.658***	0.693***	0.021*	0.001	0.156***	0.014
	(0.066)	(0.082)	(0.012)	(0.004)	(0.018)	(0.013)
Log(active)*WEMI	0.203	0.082				
	(0.153)	(0.197)				
Log(schooling)	0.202***	0.217***	0.000	0.000	-0.004	0.125***
	(0.025)	(0.032)	(0.006)	(0.002)	(0.007)	(0.017)
Log(schooling)*WEMI	-0.095*	-0.122				
	(0.055)	(0.081)				
Log(distance to Nyanza)			-0.060***	0.010**	-0.006	-0.005
			(0.017)	(0.005)	(0.018)	(0.017)
Log(distance to Uganda)			0.105***	-0.001	0.004	0.002
			(0.018)	(0.004)	(0.018)	(0.019)
Log(land)*pWEMI			0.068	0.657***	0.088*	0.082
			(0.048)	(0.036)	(0.053)	(0.059)
Log(active)*pWEMI			-0.069**	-0.006	0.536***	-0.046
			(0.027)	(0.009)	(0.041)	(0.030)
Log(schooling)*pWEMI			0.005	0.001	0.008	0.610***
			(0.012)	(0.004)	(0.014)	(0.037)
X_j	Yes	Yes	Yes	Yes	Yes	Yes
P_j	Yes	Yes	Yes	Yes	Yes	Yes
Nr. of clusters	400	400	400	400	400	400
Obs.	4.828	4.828	4.828	4.828	4.828	4.828
R^2	0.282	0.286	0.550	0.891	0.670	0.852
First stage F-test			12,92	74,09	45,72	61,18
p-value			(0.000)	(0.000)	(0.000)	(0.000)
Hansen J statistic		0,046				
Chi-sq(1) P-val		(0.831)				

Notes: *** p<0.01, ** p<0.05, * p<0.1. The robust standard errors are adjusted for clustering within sectors and are reported between brackets; the IV 2nd stage st. errors are bootstrapped. For the meaning of X and P, see Table 2. For the IV estimates, we follow Wooldridge (2000, p.236-7) and first obtain predictions for WEMI using equation(5); then, WEMI's predicted value is interacted with the household production factors and these interaction terms are used as additional instruments. (pwemi stands for predicted WEMI).

Table 4: General conflict and economic performance, when controlling for migration

Dependent variable:	Log(consumption)		Log(consumption)		Log(consumption)	
	OLS	IVE 2nd	OLS	IVE 2nd	OLS	IVE 2nd
	(1)	(2)	(3)	(4)	(5)	(6)
WEMI	-0.400***	-0.935***	-0.314***	-0.839***	-0.263	-0.808***
	(0.119)	(0.279)	(0.102)	(0.200)	(0.201)	(0.301)
Immigration	0.608	0.067	0.366	-0.070	0.396	-0.137
	(0.382)	(0.704)	(0.345)	(0.463)	(0.343)	(0.646)
Log(land)			0.381***	0.369***	0.635***	0.570***
			(0.038)	(0.037)	(0.084)	(0.101)
Log(land)*WEMI					-0.680***	-0.538*
					(0.194)	(0.286)
Log(active)			0.740***	0.727***	0.661***	0.690***
			(0.028)	(0.029)	(0.066)	(0.090)
Log(active)*WEMI					0.196	0.090
					(0.153)	(0.206)
Log(schooling)			0.163***	0.168***	0.202***	0.217***
			(0.011)	(0.012)	(0.025)	(0.034)
Log(schooling)*WEMI					-0.095*	-0.121*
					(0.055)	(0.072)
X_j	Yes	Yes	Yes	Yes	Yes	Yes
P_j	Yes	Yes	Yes	Yes	Yes	Yes
Nr. of clusters	400	400	400	400	400	400
Obs.	4,828	4,828	4,828	4,828	4,828	4,828
R^2	0.052	0.056	0.280	0.284	0.283	0.286

Notes: *** p<0.01, ** p<0.05, * p<0.1. The robust standard errors are adjusted for clustering within sectors and are reported between brackets; the IV 2nd stage st. errors are bootstrapped. For the meaning of X and P, see Table 2. For the IV estimates in column (6) , we follow Wooldridge (2000, p.236-7, cf. also notes in Table 3). The first stage results are not reported.

Table 5: Genocide, civil war and economic performance

Dependent variable	Log(consumption)		GEMI	Log(consumption)		CEMI
	OLS	IVE 2nd stage	IVE 1st stage	OLS	IVE 2nd stage	IVE 1st stage
	(1)	(2)	(3)	(4)	(5)	(6)
GEMI	-0.183*	-1.197***				
	(0.098)	(0.231)				
CEMI				-0.317***	-1.231***	
				(0.111)	(0.349)	
Log(land)	0.383***	0.361***	-0.014	0.385***	0.375***	-0.002
	(0.038)	(0.041)	(0.010)	(0.038)	(0.036)	(0.008)
Log(active)	0.743***	0.739***	-0.000	0.740***	0.718***	-0.010*
	(0.028)	(0.028)	(0.005)	(0.028)	(0.030)	(0.005)
Log(schooling)	0.163***	0.168***	0.002	0.163***	0.167***	0.001
	(0.011)	(0.012)	(0.002)	(0.011)	(0.011)	(0.002)
Log(distance to Nyanza)			-0.090***			-0.010
			(0.022)			(0.016)
Log(distance to Uganda)			0.078***			0.069***
			(0.012)			(0.016)
X_j	Yes	Yes	Yes	Yes	Yes	Yes
P_j	Yes	Yes	Yes	Yes	Yes	Yes
Nr. of clusters	400	400	400	400	400	400
Obs.	4,828	4,828	4,828	4,828	4,828	4,828
R^2	0.278	0.283	0.550	0.279	0.283	0.646
First stage F-test			43,41			10,53
p-value			(0.000)			(0.000)
Hansen J statistic		0,673			1,100	
Chi-sq(1) P-val		(0.412)			(0.294)	

Notes: *** p<0.01, ** p<0.05, * p<0.1. The robust standard errors are adjusted for clustering within sectors and are reported between brackets; the IV 2nd stage st. errors are bootstrapped. For the meaning of X and P, see Table 2.

Table 6: Genocide, civil war and economic performance – returns to factors of production

Dependent variable: log(consumption)				
	OLS	IVE 2nd stage	OLS	IVE 2nd stage
	(1)	(2)	(3)	(4)
GEMI	-0.537***	-1.731***		
	(0.197)	(0.281)		
CEMI			-0.085	-1.073***
			(0.205)	(0.266)
Log(land)	0.605***	0.732***	0.575***	0.428***
	(0.087)	(0.111)	(0.077)	(0.070)
Log(land)*GEMI	-0.600***	-1.002***		
	(0.213)	(0.271)		
Log(land)*CEMI			-0.579***	-0.169
			(0.201)	(0.255)
Log(active)	0.583***	0.489***	0.731***	0.801***
	(0.064)	(0.088)	(0.057)	(0.061)
Log(active)*GEMI	0.419***	0.659***		
	(0.146)	(0.169)		
Log(active)*CEMI			0.026	-0.239
			(0.148)	(0.224)
Log(schooling)	0.152***	0.121***	0.207***	0.232***
	(0.023)	(0.027)	(0.023)	(0.025)
Log(schooling)*GEMI	0.033	0.131*		
	(0.055)	(0.071)		
Log(schooling)*CEMI			-0.120**	-0.178**
			(0.056)	(0.080)
X_j	Yes	Yes	Yes	Yes
P_j	Yes	Yes	Yes	Yes
Nr. of clusters	400	400	400	400
Obs.	4,828	4,828	4,828	4,828
R^2	0.280	0.287	0.281	0.285

Notes: *** p<0.01, ** p<0.05, * p<0.1. The robust standard errors are adjusted for clustering within sectors and are reported between brackets; the IV 2nd stage st. errors are bootstrapped. For the meaning of X and P, see Table 2. For the IV estimates , we follow Wooldridge (2000, p.236-7, cf. also notes in Table 3). The first stage results are not reported.

Table 7: Difference-in-difference estimation of the effect of conflict on income

Dependent variable	Household level estimates log(income)	
	OLS	OLS
	(1)	(2)
WEMI	0.389	0.335
	(0.431)	(0.358)
y2000	0.746***	0.897***
	(0.245)	(0.206)
WEMI*y2000	-0.992**	-0.851**
	(0.495)	(0.416)
Log(land)		0.555***
		(0.0627)
Log(active)		0.814***
		(0.0512)
Log(schooling)		0.228***
		(0.0233)
Xj	yes	yes
Pj	yes	yes
Pj*y2000	yes	yes
Nr. of clusters	447	447
Obs.	5,545	5,545
R^2	0.027	0.127

Notes: *** p<0.01, ** p<0.05, * p<0.1. The robust standard errors are adjusted for clustering within sectors and are reported between brackets. For the meaning of X and P, see Table 2.

Appendix: Construction of the conflict indices

Here we provide a summary of the construction of the conflict intensity measures for general conflict (WEMI), genocide related conflict (GEMI) and civil war related conflict (CEMI). These measures are taken from Verpoorten (2011) which also provides a complete and detailed description, and a discussion of external validity and robustness of the indicators.

General conflict excess mortality (WEMI) is the first principal component of the five 1991-2002 excess mortality proxies listed in Table A1: Δ mortality of sons, Δ mortality of daughters, Δ widowhood, Δ orphanhood and disability due to war or genocide. These excess mortality proxies are calculated using 1991 and 2002 population census data. For the latter, we have access to the complete database, including information on approximately 8,000,000 individuals (Government of Rwanda, 2002). For the 1991 baseline census, we have access to a 10% random draw of the database, including information on approximately 700,000 individuals (source: IPUMS international, Minnesota Population centre). The excess mortality proxies are calculated at the level of 145 administrative communes in Rwanda. A commune has an average size of 173 squared km and counted on average 48,605 inhabitants in 1991.

It is noteworthy that we find strong evidence for high wartime excess mortality: compared to 1991, the 2002 mortality proxies of sons and daughters are respectively nine and seven percentage points higher, the proportion of widows among women aged 30 or more increased with 12 percentage points (from 0.18 to 0.30) and the proportion of double orphans among individuals aged 30 or less increased with three percentage points (from 0.02 to 0.05).

In order to distinguish between excess mortality stemming from genocide (GEMI) and from other forms of violence (CEMI), we augment the set of five general excess mortality proxies with six excess mortality proxies that are specific to genocide (Table A1). The six genocide proxies are derived from the Gacaca data which includes the number of genocide suspects in a sector classified in three categories (suspect categories 1, 2 and 3) as well as three categories of people who survived the genocide but were affected by it (widows, orphans, disabled), proportional to the 1994 population.

In order to determine GEMI and CEMI, the five general excess mortality proxies and the six genocide proxies are jointly subjected to PCA to obtain up to 11 PCs. The loadings on the first two PCs are given in the last two columns of Table A1. Combined, they account for 75% of the joint variance of the set of proxies. Moreover, they both have a rather straightforward interpretation (see section 5).

Table A1: Conflict measures

Variable	Description	Mean	St. Dev.	Factor loadings resulting from Principal Component Analysis (PCA)		
Excess mortality proxies				**WEMI**	**GEMI**	**CEMI**
Δ Mortality of sons	2002-1991 Total number of boys died/number of boys born	0.085	0.031	0.48	0.23	0.40
Δ Mortality of daughters	2002-1991 Total number of girls died/number of girls born	0.069	0.030	0.43	0.19	0.38
Δ Widowhood	2002-1991 Widows (% women >=30)	0.123	0.054	0.46	0.12	0.46
Δ Double orphanhood	2002-1991 Double orphans (% children and youngsters <30)	0.030	0.017	0.48	0.16	0.46
Disability	Disabled due to war or genocide (% population)	0.003	0.002	0.38	0.23	0.31
Genocide proxies (% 1994 population)						
Category 1 suspects	Genocide suspects accused of planning, organizing or supervising the genocide, and committing sexual torture	0.012	0.009		0.39	-0.15
Category 2 suspects	Genocide suspects accused of killings or other serious physical assaults	0.068	0.044		0.39	-0.19
Category 3 suspects	Genocide suspects accused of looting or other offences against property	0.049	0.035		0.31	-0.25
Widowed genocide survivors	Survivors are mainly Tutsi who were living in Rwanda at the time of the genocide, but can also include Hutu widows (or widowers) who were married to Tutsi	0.005	0.004		0.39	-0.18
Orphaned genocide survivors		0.012	0.010		0.39	-0.15
Disabled genocide survivors		0.002	0.002		0.33	-0.08

Notes: the excess mortality proxies are calculated at the level of 145 administrative communes using data from the 1991 and 2002 population census; the genocide proxies are calculated from the gacaca records and the 1994 population (projected forward from the 1991 population census), also at the level of the 145 administrative communes.

Table A2: Additional sector and commune level controls

		Mean	St. Dev
Altitude	Sector level altitude in m	1807	285
Rainfall	Sector level long term average annual rainfall in mm	1140	313
1991 population density	Sector level population density taken from the 1991 population census (pop/km²)	403	174
1978-1991 population growth	Commune level population growth between 1978-1991	0.03	0.01
Distance to main road	Sector level distance to main road (= national road) in 1991 (km)	9	6
Distance to Kigali City	Sector level distance to the Kigali City (km)	66	29
Proportion immigrants	Immigrants who moved to the sector after 1991 as a proportion of the 2002 population	0.08	0.09

Notes: The geographic data is obtained from calculations in GeoDa (GIS software; Anselin, 1995). Annual long-term average precipitation and altitude are calculated for all administrative sectors based on information of a subsample of sectors (taken from the Direction des Statistiques Agricoles) and a distance-based spatial weighting procedure run in GeoDa (Anselin, 1995). The population data is taken from the 1978 and 1991 population census. The share of immigrants is caluclated based on the entire 2002 population census.