The impact of armed conflict on economic performance Evidence from Rwanda

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Abstract

Important gaps remain in our understanding of the economic consequences of civil war. The most promising way forward to address these gaps is to carry out micro-economic analysis, as underlined by Blattman and Miguel (2010) in their recent JEL review. This paper studies the effect of mass killings and human capital destruction on economic performance in Rwanda. Combining rich household data with unique local data on violence in Rwanda, we investigate the effect of conflict on economic performance at the household and community level six years after the conflict. We find that households and localities that experienced more intensive conflict are lagging behind in terms of per capita consumption. This finding is robust to taking into account the endogeneity of violence. Comparing returns to factors of production between zones that experienced low and high intensive conflict, we find significantly different returns to land and labor, shedding light on the differences in catch up. Distinguishing between civil war and genocide, the results indicate that the returns to production factors depend on the form of violence and the type of capital destroyed, and that catch up is slower in the case of human capital destruction.

Key words: civil conflict, economic growth, Rwanda
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1. Introduction

Civil conflict remains important in many developing countries. It has therefore also become an important part of the study of economic development, both from a theoretical and empirical perspective. The last decade has seen a boom in studies on conflict and economic performance. A finding that stands out for its robustness in existing analysis is the strong negative association between conflict and economic development. While this relationship is now well documented, identifying the direction of causality often remains a challenge. While conflict may lead to poor economic performance, the reverse relationship seems equally credible, and this raises challenges for the analysis. This paper focuses on the former and analyses whether conflict has a sustained effect on economic performance years after the conflict ended, focusing on Rwanda.

From a theoretical perspective there is no consensus about the impact of conflict on economic performance. Neoclassical growth theory predicts that an economy recovers relatively quickly from conflict and converges rapidly to its new steady state. Alternative models argue that economic catch up may take a long time, for instance because human capital recovers only slowly (see Barro and Sala-i-Martin 2003). Still other models argue that countries may be trapped in a low level equilibrium where conflict and poor economic performance coexist (Sachs).

Existing empirical evidence, relying on country analysis, provides support to any of these views. While some work finds evidence for relatively quick catch up (e.g. Organski and Kugler), other work indicates that catch up may be slow or countries may be stuck in a situation of poor economic performance (Collier, Rodrik, Murdoch and Sadler). Cerra and Saxena (2008) 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, which may reconcile the apparently contradictory evidence, and suggests that while countries may appear to be stuck in the short run, there is catch up when considering a longer period of time. This also suggests that the length of the considered time period is important when testing theoretical predictions.

Another explanation for the apparently contradicting findings lies in the nature of the data used so far. Cross country data, still the dominant source of data for this type of analysis, leaves 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, namely whether the conflict resulted mostly in the destruction of physical or human capital; whether it mostly destroyed private or public goods, and in the case of the latter, whether it destroyed physical or social infrastructure, like trust or local institutions. The identity of the parties at war may also play a role: was the conflict *between* states relying on (more or less) professional armies, or was it *within* a state between fractions of society? While any of these factors may be important, each of them remains unobserved in cross country data. This unobserved heterogeneity may also make empirical results more sensitive to what part of the data is being analysed and to the estimation method used. The country level estimation may also make the identification of causality a bigger challenge.

Hence, while the analysis of cross country data has produced rich insights, it does not allow to understand the underlying process of catch up - or its absence. The most promising way forward therefore lies in the use of more detailed micro level data. Blattman and Miguel (2010) in their recent review article in the Journal of Economic Literature recognize this, and point to the need for more micro-economic data collection and analysis.

A small body of work is emerging that analyses the economic consequences of conflict focusing on one country and using micro data. Davis and Weinstein (2002) show that Japanese cities had completely recovered 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 only temporary impact on post-war city growth in West Germany, but a sustained impact in East Germany. Miguel and Roland (2008), finally, studying the effect of the destruction of physical capital by the bombing in Vietnam, and find that the economy has recovered thirty years after the conflict.

This paper takes a similar approach and studies the impact of conflict on economic performance in one country, Rwanda, combining nationally representative household

data with unique local information on the conflict, as well as geographical information that provides valid and relevant instruments for conflict intensity, and helps identify causality.

There are three ways in which this paper differs from previous work. While the latter mostly looks at the effects of conflict between nations, this paper focuses on the effects of civil conflict. Given the dramatic events of the 1994 conflict in Rwanda, we also focus on the consequences of a destruction of human capital, rather than physical capital. Third, we consider a shorter time horizon compared to other work, and assess economic performance six years after the conflict, which may help us understand the process of recovery itself. From a development economics perspective 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 labor, the dramatic events of the 1994 genocide, provide a setting that allows us to study what happens if population density and surplus labor are reduced substantially.¹

During the nineties, Rwanda experienced civil conflict, characterised by civil war, genocide and (counter-) insurgencies, resulting in large excess mortality. While the dramatic human cost has received attention, little is known about the economic costs. This paper studies whether rural households and communities that have experienced more conflict, still have lower consumption six years after the end of the violence, and finds that they do. Because the conflict in Rwanda coincided with displacement and migration, we also test the robustness of this finding when taking migration into account. Investigating the underlying process of catch up, the analysis indicates that returns to land are lower and returns to unskilled labor higher in conflict intense areas, while returns to skilled labor do not differ. This is consistent with a decrease in land pressure.

The remainder of this paper is structured as follows. Section 2 discusses the conceptual framework and provides an overview of the relevant literature, while

¹ It is worth mentioning that 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).

Section 3 explains the econometric strategy. Section 4 discusses the Rwanda context and data, and Section 5 presents the results. Section 6 concludes.

2. Conflict, economic performance and human capital

The literature on conflict and economic performance is young but expanding at a fast rate (recent reviews include Blattman & Miguel and Justino, 2010). Our benchmark is a neoclassical growth model that includes human capital (cf. Lucas, 1988; Mankiw, Romer & Weil, 1992), which predict that economies converge to their own steady state, with the speed of convergence depending on the distance from the steady state. A reduction in physical or human capital will then 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. Alternative approaches predict that conflict affects an economy's steady state, and as a result otherwise similar economies do not converge. In poverty trap models (cf. Azariadis and Drazen, 1990) an economy may get stuck in a low level equilibrium where conflict and low economic performance coexist (Rodrik 1999, Collier 1999).² Endogenous growth models also allow for a change in the steady state. Barro and Sala-i-Martin (2003) predict that the speed of recovery may depend 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.^{3 4}

Existing empirical evidence, mostly relying on cross country data, provides support for either prediction. Organski and Kugler (1977) were among the first to present evidence for rapid catch up. They find that, while economies suffered heavy short time losses from the two world wars, their economic effects dissipated after 15-20

² If conflict negatively affects economic performance, and if poorly performing countries are more prone to conflict, economies may be trapped in a self-sustaining cycle of conflict and poor economic performance

³ Focusing on the ratio between capital and labor and its deviation from its steady state, they argue that a disproportionate loss of human capital will result in slower economic growth and recovery than the destruction of physical capital when adjustment costs for human capital accumulation are greater than for physical capital accumulation, which seems plausible empirically.

⁴ For a more detailed discussion see Blattman and Miguel (2010), who also mention vintage capital models, which are less relevant for our case, which focuses on the destruction of human capital.

years, when the economy returned to pre-war growth trends. Cerra and Saxena (2008) also provide evidence for catch up relatively soon after the conflict ended.

Murdoch and Sandler (2004), on the other hand, find that a civil war reduces a country's growth by 85% in the short run (5 year) but, while there is some recovery, still reduces growth by 31% in the long run (35 year). Collier (1999) presents evidence that countries that have been longer in civil conflict grow faster, which is consistent with having a lower post conflict equilibrium. Rodrik (1999) also argues that domestic conflict are key to understanding why growth rates have lacked persistence in many countries since the 1970s.⁵

What these papers have in common is that they use country level data. As mentioned in the introduction, because many factors remain unobservable in the data, the analysis may be sensitive to whether or how this unobserved heterogeneity is treated. Identifying causality in a credible way is often also more challenging in this context.⁶ Moreover, cross country data implicitly focuses on middle and high income countries, since data for poor countries that remain in conflict is typically absent, and this may introduce a selection bias (see Blattman and Miguel 2010 for more on this). Cross-country data also often focuses on war between states, which is typically characterized by large scale destruction of physical capital accompanied by a large death toll. Civil conflict may be less detrimental than international conflict in terms of physical capital, because it uses lower technology, but tends to be more detrimental for institutions and social order, as argued by Collier (1999).

More recent work attempts to gain further insights into the effect of conflict and economic performance by using micro level data. As mentioned above, three papers stand out in this respect. Using micro level data, Davis and Weinstein (2002) show complete recovery of Japanese cities (in terms of size) 53 years after the U.S. bombing in World War II, when accounting for initial conditions. Similarly, Brakman et al. (2004) find that bombing had a significant but temporary impact on

⁵ At a subnational level, Abadie and Gardeazabal (2003) find that the violence in the Basque region has reduced economic growth relative to neighbouring regions.

⁶ 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.

post war city growth in West-Germany. More recently, Miguel and Roland (forthcoming) studied the impact of US bombing on Vietnam's economy 30 years later, and find no robust negative impact on consumption levels, infrastructure, poverty, literacy or population density in 2002. These three studies all look at the effects of international war 25 to 35 years after the conflict, and the effect of the resulting physical capital destruction on the economy. This paper differs in three ways. It studies the consequences of the destruction human capital caused by civil conflict, shorter after the conflict, namely 6 years.

Although there is, by our knowledge, no direct evidence of the impact of human capital destruction on economic growth, existing work indicates that conflict has a strong impact on human capital at the micro level. 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 Verwimp and Akresh (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 nonaffected children. Arcand and Wouabe (2009), looking at Angola, find that conflict intensity worsens child health and decreases fertility during and after the conflict. Shemyakina (2006) finds that conflict made young women in Tajikistan marry either earlier or later, and had children earlier. De Walque (2004) finds that fertility and marriage rates were very low under the Khmer Rouge but bounced back after the regime collapsed.

There is also micro evidence for effects of conflict on education. Akresh and de Walque (2008) show that the genocide in Rwanda had a negative effect on schooling outcomes, with exposed children completing half a year less and less likely to complete fourth grade. De Walque (2004) finds that the civil conflict in Cambodia had a lasting impact on the educational attainment of the population, mostly because the education system collapsed during the period. Arcand and Wouabe (2009), however, find that conflict increased school enrolment in Angola.

Summarized, these findings suggest that reconstruction of human capital may take considerable time. Justino (2007), underlines this and argues that conflict may lead to poverty through its effects on health, education and livelihoods. In what follows we investigate the direct effect of human capital destruction on economic performance.

3. Econometric strategy

We research four questions. First, we investigate whether conflict intensity affects the level of economic activity six years later, taking its endogeneity into account. Second, does the process of economic growth, in particular the returns to factors of production, differ depending on the experience of past conflict? Third, does migration play a role and do our results remain when we take into account migration (and its endogeneity)? Finally do distinct types of conflict, namely genocide and civil war, which took place during the same period but with different intensities in different places, have distinct effects on economic performance?

3.1. Economic performance and conflict

To study the effect of conflict on economic performance we estimate the following equation:

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

Where y is the log of consumption per capita, C is a fine spatial conflict index discussed in section 4, X is a vector with control variables to reduce heterogeneity, as discussed in Section 4.5, and P are province fixed effects. We estimate equation (1) both at the household and the community (or sector) level.⁷

Equation (1) may, however, suffer from endogeneity since the intensity of genocide was related to economic determinants, including land scarcity, income divergence between peasants, a rising rural elite who engaged in off-farm wage work and the resulting increase in rural income inequality, as documented among others by André and Platteau (1998) and Verwimp (2006). To take endogeneity into account we proceed with estimating the following equations:

⁷ A sector is the smallest codified administrative unit in Rwanda counting on average approximately 5000 individuals.

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

$$C_j = \gamma_0 + \Gamma_1 Z_j + \Gamma_2 \bar{X}_j + \Gamma_3 P_j + \varepsilon_{2j} \quad (3)$$

Where $\hat{C}_{ij}$ is the predicted value obtained from equation 3, and Z_i are instrumental variables. We use two instrumental variables that reflect exogenous geographical variation in conflict intensity, namely the distance to Uganda (DU_i) and Nyanza (DN_i). Below (subsection 4.4.) we explain that these instruments are relevant and valid.

3.2. Investigating the driving forces of catch up: conflict and factors of production

If conflict affects economic performance, it must be because it affects a factor of production, the technology, the institutions and culture that augments these factors, or the prices, as argued by Blattman and Miguel (2010). To study the role of production factors in the presence of conflict we first estimate a standard production function:

$$y_i = \alpha_0 + \alpha_1 k_i + \alpha_2 l_i^u + \alpha_3 l_i^s + A X_{2i} + B P_{ij} + \varepsilon_i \quad (4)$$

where k_i reflects land owned, l_i^u stands for unskilled and l_i^s for skilled labor; X contains control variables.⁸ To test whether conflict still has an effect when controlling for factors of production we then estimate the following production function that includes the conflict variable on its own, and takes into account its endogeneity:

$$y_i = \alpha_0' + \alpha_1' k_i + \alpha_2' l_i^u + \alpha_3' l_i^s + \alpha_4' \hat{C}_{ij} + A' X_{2i} + B' P_{ij} + \varepsilon_{2ij} \quad (5)$$

$$C_j = \gamma_0 + \gamma_1 DU_j + \gamma_2 DN_j + \gamma_3 \bar{k}_j + \gamma_4 \bar{l}_j^u + \gamma_5 \bar{l}_j^s + \Gamma_6 \bar{X}_{2j} + \Gamma_7 P_j + \varepsilon_{3j} \quad (6)$$

⁸ We focus on the key factors of production. Including additional factors like cattle, or additional proxies for the quality of factors, like age of the household, female headed household, yields the same results.

we test $H_0 : \alpha_4' = 0$

In a final step, to assess whether returns are different in post conflict areas, we interact conflict with each of the production factors, and estimate:

$$y_i = \alpha_0'' + \alpha_1'' k_i + \alpha_2'' l_i^u + \alpha_3'' l_i^s + \alpha_4'' \hat{C}_{ij} + \alpha_5'' (k_i \times \hat{C}_{ij}) + \alpha_6'' (l_i^u \times \hat{C}_{ij}) + \alpha_7'' (l_i^s \times \hat{C}_{ij}) + A'' X_{2i} + \beta_3'' P_{ij} + \varepsilon_{2ij}' \quad (7)$$

$$C_j = \gamma_0 + \gamma_1 DU_j + \gamma_2 DN_j + \gamma_3 \bar{k}_j + \gamma_4 \bar{l}_j^u + \gamma_5 \bar{l}_j^s + \Gamma_6 \bar{X}_{2j} + \Gamma_7 P_j + \varepsilon_{3j} \quad (8)$$

If there is rapid catch up, we expect returns to the production factors to be the same across areas with low and high violence intensity, or $H_0 : \alpha_5'' = \alpha_6'' = \alpha_7'' = 0$

Similar to the argument made for the destruction of physical capital, *ceteris paribus* we expect the mass killings that characterized the conflict in Rwanda to increase returns to labor. However, because there is surplus labor, the returns to unskilled labor may have been negative in the first place, and the reduction of surplus labor resulting from the mass killings, does not necessarily reach the level at which returns to unskilled labor become positive. While we expect returns to unskilled labor to increase, they may thus remain negative. The presence of surplus labor also has implications for the returns to land. While returns to land are likely to be positive, because there is not enough land available, they may drop in more conflict intensive areas, where the complementary factor of labor becomes more scarce. Turning to skilled labor, given the general low levels of education, we expect returns to skilled labor to be positive and large, and - because the genocide targeted the more educated, as shown by de Walque and Verwimp (2009) - we expect these returns to be higher in areas with high genocide intensity.

3.3. The role of migration for economic performance and catch up

Migration may play a role in the process of catch up. Areas where surplus labor has been reduced may now yield relatively higher returns to labor and therefore attract migrant labor. This may also affect the returns to land. We investigate whether immigration plays a role by including it in the production function, estimating:

$$y_i = \alpha_0''' + \alpha_1'''k_i + \alpha_2'''l_i^u + \alpha_3'''l_i^s + \alpha_4'''C_{ij} + \alpha_5'''(k_i \times \hat{C}_{ij}) + \alpha_6'''(l_i^u \times \hat{C}_{ij}) + \alpha_7'''(l_i^s \times \hat{C}_{ij}) \\ + \alpha_8'''m_i + A'''X_{2i} + \beta'''P_{ij} + \varepsilon_{3ij}'$$

Because the process of migration may be simultaneous to that of economic development, we also take into account its endogeneity, using the same instruments, and estimate:

$$y_i = \alpha_0''' + \alpha_1'''k_i + \alpha_2'''l_i^u + \alpha_3'''l_i^s + \alpha_4'''C_{ij} + \alpha_5'''(k_i \times \hat{C}_{ij}) + \alpha_6'''(l_i^u \times \hat{C}_{ij}) + \alpha_7'''(l_i^s \times \hat{C}_{ij}) \\ + \alpha_8'''m_i + A'''X_{2i} + B'''P_{ij} + \varepsilon_{3ij}' \quad (9)$$

$$C_{ij} = \gamma_0 + \gamma_1 DU_{ij} + \gamma_2 DN_{ij} + \gamma_3 k_i + \gamma_4 l_i^u + \gamma_5 l_i^s + \Gamma_6 X_{2i} + \Gamma_7 P_{ij} + \varepsilon_{3ij} \quad (10)$$

$$m_i = \delta_0 + \delta_1 DU_j + \delta_2 DN_j + \delta_3 k_i + \delta_4 l_i^u + \delta_5 l_i^s + \Delta_6 X_{2i} + \Delta_7 P_j + \varepsilon_{4ij} \quad (11)$$

If migration plays a role, its coefficient should be positive, which can be tested as $H_0 : \alpha_8 = 0$. More importantly for our purpose, to see whether the results remain when we include migration, we test $H_0 : \alpha_1''' = \alpha_1''; \alpha_2''' = \alpha_2''; \alpha_3''' = \alpha_3''$.

3.4. Does the type of conflict play a role?

The conflict in Rwanda has been characterized by a coincidence of genocide and civil war, as discussed in more detail in the next section. Exploiting the rich and detailed information available at the local level allows to distinguish between these two types of conflict and their consequences.

Constructing two alternative indices of conflict: one that emphasises the genocide, and one that emphasizes the civil war, we re-estimate the above equations replacing the general wartime excess mortality index (WEMI) first by the genocide excess mortality index (GEMI), and then by the civil war excess mortality index (CEMI). Section 4 discusses the construction of these indices in detail.

Because genocide targeted individuals, and specifically able and active men, we expect returns to labor higher in genocide affected areas compared to civil war areas. Given that the genocide also targeted the relatively educated (de Walque and Verwimp, 2009), we also expect higher returns to skilled labor in genocide affected areas, compared to areas affected by civil war.

4. Context, measurement and data

4.1. The context of Rwanda

This study focuses on the most recent conflict in Rwanda, which started in 1990 with the invasion of the Rwanda Patriotic Front, an army built up by refugees from Rwanda's previous conflicts in Uganda. Initially, fighting was concentrated in the North, at the border with Uganda, and a peace agreement was reached in the course of 1993. Then, in April 1994, when the plane carrying President Habyarimana was shot down, genocide broke out, and the civil war between the RPF and the Rwandan government restarted at the same time. By the end of June 1994, the RPF had put an end to the violence against Tutsi and had taken control of the country. Relative peace was established, although in the northwest militias from the old regime (FAR and Interhamwe) raised insurgencies, which stopped by the end of 1998.

Rwanda thus experienced different forms of violence, which were concentrated in different geographical areas, and resulted in different types of damage and death toll. The map in Figure 1 illustrates the geographical spread. While genocide took place in the relatively short period of three months in 1994, civil war and counter-insurgency were more spread in time. And, while genocide especially had a high direct death toll, up to 800,000, and was concentrated among the active (male) population (Prunier, 1998, Verpoorten, 2005), the other forms of violence were characterized by a large number of indirect deaths because of lower access to food and health care, and took its largest toll among the weakest in the population (de Walque and Verwimp, 2009; Verpoorten, 2010a).

While the human cost of the Rwanda conflict, especially genocide has received considerable attention, there is now a small body of evidence documenting the

economic set back caused by the conflict in Rwanda, and the country's subsequent recovery. Lopez and Wodon (2005) using aggregate data over time argue that, without the occurrence of conflict, GDP per capita would have been 25% to 30% higher in Rwanda in 2000. Verpoorten and Berlage (2007), using panel data to analyse the effects of different types of household shocks between 1990 and 2002, find that the conflict had very little effect on household level income mobility. In a similar vein, Verpoorten (2009) finds that investment in cattle, which serves the purpose of smoothening consumption, had fallen by half during 1994 but had bounced back to pre-war levels by 2002. Justino and Verwimp (2006) examine the impact of different forms of conflict in Rwanda at the provincial level (N=10) and present evidence for 1990-2000 income convergence across provinces, a result they explain by referring to changing capital labour ratio's brought about by different forms of violence. This paper takes the analysis several steps further by measuring conflict at the commune level (N=145), controlling for the endogeneity of conflict intensity, and presenting evidence of the nature of the differential returns to production factors.

A number of studies that were mentioned earlier have focused on the consequences of the conflict in Rwanda for human capital. Looking at education levels, Akresh and de Walque (2009) find a substantial and significant fall of 18% in education attainment for children exposed to armed conflict. Akresh, Verwimp, Bundervoet (2009) show how the 1991-1992 civil war resulted in reduced height-for-age z-scores for children living in conflict zones, while McKay and Loveridge (2004) show how national nutrition levels, lowered by the conflict, recovered completely by 2000 to their 1992 levels.

While the first set of studies looks at the consequences of conflict for economic performance, their analysis remains largely at the aggregate level. At the same time, the studies looking at education and health, assess differences within the country, but do not link this explicitly to economic performance. This paper aims at bringing these two strands closer together. Combining micro data on household consumption and factors of production with community data on violence and excess mortality, the analysis in this paper sheds light on the differences in conflict and economic performance *between* communities in Rwanda.

To do this, we combine different sources of data. The main data set is a standard national household survey (EICV, or the English acronym IHLCS) which contains information on household and community characteristics. The conflict data is obtained from Verpoorten (2010c), which estimates conflict intensity indices from combining different data sets, as discussed in more detail below. Finally, the geographic data, which allows us to define the instrumenting variables is obtained from calculations in GeoDa (GIS software; Anselin, 2005) and is also described in Verpoorten (2010c).

To clarify combining these different data sets, we need to explain the different units of observations. We distinguish three levels of observation: the community, the commune, and household level. While most information is available at the household level, some of the control variables, like rainfall, are available at the community level only, while the conflict index and instrumental variables are calculated at the commune level. As a result, we run the key regressions both at the household and community level, in order to show the robustness of the results, and the first stage regressions at the commune level.⁹

Throughout the analysis the paper focuses on rural areas (or the agricultural sector). The importance of rural areas is underlined by the fact that anno 1994, at the peak of the conflict, over 95% of the population lived in rural areas. An additional argument to exclude urban areas is that, given the substantial aid flows to Rwanda after the genocide and the high proportion flowing to the capital, - through elite capture or geographically concentrated spending by donors and expat communities, Kigali may actually have benefited from the conflict on balance, which would make all other communities look worse in relative terms, i.e. we would potentially be underestimating recovery

4.2. Household consumption, production and characteristics

⁹ In Rwanda, the communities are called 'sector'. At the time of the genocide, Rwanda was divided in 10 prefectures, 145 communes, 1565 sectors and more than 9000 cells. 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.

Economic performance is measured at the household level, and is proxied by per capita household consumption. This data is obtained from the EICV 1999-2000, a standard national household survey. We focus on the 4,959 rural households with complete information. Figure 2 plots a kernel density for the logarithm of consumption and includes the food and total poverty lines. Sixty five percent of the rural population fall below the poverty line of 163 USD per year and 42 percent has consumption level below the food poverty line (of 114 USD per year). Table 1 reports the corresponding descriptive statistics, showing that average annual rural per capita household consumption is 164 USD (PPP) or 64,731 FRW, which corresponds to the average of 10.84 for the log of household expenditures reported in Table 1.¹⁰ The average amount of land owned is 0.38 ha¹¹, while the average number of active household members (those aged between 15 and 65), which is our proxy for unskilled labor, is 2.11. Mean years of schooling of the household head, our proxy for skilled labor, is 2.75.¹²

4.3. Measuring conflict intensity

The conflict indices are calculated at the commune level from the 1991 and 2002 population census data and the records of the gacaca, the transitional justice system for judging genocide suspects. We construct three indices: (i) the Wartime Excess Mortality Index (WEMI) which is the first principal component of five 1991-2002 excess mortality proxies derived from the 1991 & 2002 population census; (ii) the Genocide Excess Mortality Index (GEMI) which is the first principal component of the five excess mortality proxies and six genocide indicators taken from the gacaca tribunals¹³; and (iii) the Civil war Excess Mortality Index (CEMI) which is the second principal component of the 5 excess mortality proxies and six genocide indicators taken from the gacaca tribunals.¹⁴ For ease of interpretation of the results,

¹⁰ using the 2000 exchange rate of 393 RWF/\$

¹¹ The results remain the same whether we use land owned or cultivated.

¹² We perform robustness checks with other measures of education at household level, but find similar results. The current measure is attractive as it is transparent and because education levels tend to be relatively persistent across generations (see for instance Black and Devereux 2010).

¹³ Gacaca courts are the Rwandan transitional justice system to deal with crimes related to the genocide.

¹⁴ More precise, the CEMI captures other-than-genocide-related excess mortality, including direct and indirect deaths from both civil war as well as death toll resulting from insurgency and displacement.

we rescale the indices to fall in the interval $[0,1]$. A description of the indices can be found in Table 1 Table A1 and Appendix A provides a more detailed description of the indices; a more elaborate discussion, including a discussion of external validity and robustness can be found in Verpoorten (2010c).

The standard deviation of the Wartime Excess Mortality Index (WEMI), reported in Table 1, indicates that there is substantial variation in exposure to violence across communes; this is confirmed by the kernel density, which is plotted in Figure 3a and also suggests a bimodal distribution. Table 1 also reports the mean and standard deviation for the Genocide Excess Mortality Index (GEMI) and the Civil war Excess Mortality Index (CEMI), while Figure 3b plots their respective densities, and confirms that there is substantial variation in each of these measures.

To better visualize this variation, Figure 4 presents geographical maps for each of the three indices, with a darker colour in each case reflecting a higher mortality index (using quintiles). While Genocide Excess Mortality (GEMI) is concentrated in the South of the country, Civil War Excess Mortality (CEMI) is concentrated in centre and East. Taken together these maps reflect what is summarized in Figure 1.

4.4. Instrumental variables

A good instrument is correlated with the variables instrumented for, for reasons that can be verified and explained, but is uncorrelated with the unexplained part of the error term in the main regression.

We use the distance to Uganda as a first identifying instrument. In 1990, the civil war broke out at the border with Uganda and, at the peak of the civil war and genocide in 1994 the RPF infiltrated from Uganda to move to the East of Rwanda and then to the South (Davenport and Stam, 2009). 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, following a 1890 compromise agreement between the United Kingdom and Germany relative to their respective

The denomination ‘civil war’ is thus a simplification made for ease of exposure, but captures the key dimension.

spheres of influence west of Lake Victoria. The agreement 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). Previous work on Rwanda has also used the distance to Uganda, measured at the level of 11 provinces, as identifying instrument for civil war (see for instance Akresh and de Walque, 2009).¹⁵ Note that we use more detailed spatial data, i.e. the distance of each of the 145 communes to Uganda. The use of this finer instrument should considerably add to its strength.

A second identifying instrument for conflict intensity is the distance to Nyanza, located in the North-western corner of Butare, a Southern province in Rwanda, as shown on the map in Figure 1. Located at the cross-section of the provinces Butare, Gitarama and Gikongoro, Nyanza was the capital of the Tutsi monarchy, which controlled most of the present-day Rwandan territory from as early as the 14th century. Its economic and political importance faded during colonization and abruptly ended with the 1959 revolution and subsequent 1962 independence. The government reorganized Rwanda's administrative division shortly after independence. The southern and western outskirts of the Nyanza region were attached to what is now the eastern part of Gikongoro, a highland area inhabited largely by Hutu. The aim was to weaken Tutsi influence around the former royal capital Nyanza (Desforges, 1999). Today nothing is left of Nyanza's former glory, but the proportion of Tutsi in the communities close to Nyanza still counted more Tutsi prior to the genocide (Verpoorten 2005).¹⁶ The distance to Nyanza is also calculated for each of the 145 administrative communes.

One of the robustness checks verifies whether the results remain when we control for migration. The latter may, however, also be endogenous. Because we are mostly interested in resettlement, as discussed in more detail below, we can use the same instruments to address this endogeneity.

¹⁵ This is in the same spirit as Miguel and Roland (2006)

¹⁶ In robustness checks we used two alternative instruments, namely distance to northern border and 1991 commune level proportion of Tutsi, which also work well.

4.5. Control variables

To reduce heterogeneity in the estimation sample, we control for a number of pre-conflict community and commune characteristics. To control for variations in climate and geography, which determine agricultural conditions like soil type, we include community level variables for precipitation (annual long-term average precipitation) and altitude, as well as commune level population density in 1991 and 1978-1991 commune level population growth, which both proxy for differences in land productivity.¹⁷

We further include the 1991 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 communities close to the main road and Kigali (see Verpoorten (2010a)). While these variables reduce heterogeneity in our data, they are not crucial as the results remain qualitatively the same when excluding these control variables. Table 1 reports the summary statistics for these variables.

5. Results

5.1. Are war-affected areas still lagging behind six years after the conflict ended?

Table 2 reports the results from estimating Equation 1 using the community level data, with first OLS estimates, then IV estimates, and then the first stage of the IV estimation in columns 1 to 3 respectively. According to the OLS estimate, communities with maximum violence (which corresponds to a value of one for the

¹⁷ Population density is a classic proxy for land productivity. It is a good proxy because the most fertile areas in Rwanda are the most densely populated. It can also be ambiguous because, by the 1970s, population density had become so high in these areas that even the marginal lands were being cultivated and land conflicts 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 proxy differences in soil fertility we use population growth between 1978 and 1991 using the census data for these years.

index), had 23% lower consumption levels in 2002 than communities that experienced no conflict in 1994 (which corresponds to zero value of the index). The IV approach yields a substantially higher estimate and finds that consumption in the latter is 54% lower, indicating that there is positive feedback from standards of living to violence, with richer areas having suffered more intensive violence, which represses the OLS estimate.

Although the approach followed in this paper is not well suited to making 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 get some idea of the nationwide effect by multiplying the point estimate with the average value of the conflict index. Using the IV estimate, we find that consumption per capita would have been 22% higher if there would not have been excess mortality.¹⁸

When applying Equation 1 to the household level data we find similar results. As reported in Columns 4 to 6 in Table 2 the OLS estimate is -0.29 and the IV estimate of -0.59.

Both in the commune level and the household level estimates, the first stage regressions, reported in Columns 3 and 6 respectively, show the importance of our instruments which both show up highly significant. Distance to Nyanza has the expected negative sign, reflecting high genocide intensity near Nyanza. Distance to Uganda has a positive sign, indicating high excess mortality further away from Uganda, which suggests that our measure of 1991-2002 excess mortality is picking up the impact of the 1994 civil war in the centre and the east. In addition, as argued by Akresh and de Walque (2009), the higher excess mortality further away from Uganda may be because the RPF, who put a halt to the ethnic cleansing, infiltrated from the

¹⁸. Our simulation does not take into account that overall GDP may actually have increased, for instance due to post-conflict aid flows. Lopez and Wodon (2005), for instance extrapolate a national trend in GDP and conclude that GDP/capita would have been 25% to 30% higher in Rwanda if there would not have been any conflict. They estimate that each year of civil war brings about a negative GDP per capita growth of -2.2% growth, implying that 4 years of war would lead to a drop in GDP of close to 9%. If our assumption is conservative, the cost of conflict in per capita consumption terms would be substantially higher than argued by Lopez and Wodon (2005).

Northern border with Uganda and reached the South only after large scale massacred had taken place.¹⁹

A Kleibergen-Paap test for underidentification and a Anderson-Rubin & Stock-Wright test for weak identification are both rejected, indicating that our instruments are relevant. A Sargan-Hansen test of overidentification also performs well: the joint null hypothesis that the instruments are uncorrelated with the error term cannot be rejected, supporting the validity of our instruments.²⁰ Note that, because we estimate the IV models with 2SLS, which yields consistent parameter estimates but biased standard errors, we correct the standard errors using the procedure proposed by Baltagi (2002). The standard errors only change marginally and the results remain qualitatively the same.

We then extend our model and include land owned, as well as skilled and unskilled labor in the household, and estimate equation 4-6. The results, reported in Columns 7 to 9 in Table 2, confirm the earlier results and show that conflict has a large significant negative effect, both in the OLS and IV estimation, with the latter again larger in magnitude than the former. This indicates that even after controlling for household endowments, those living in areas that experienced more intensive violence still lag behind six years after the end of the conflict. The estimates also indicate that while the returns to land are positive, the returns to unskilled labor are negative, which is consistent with there being substantial surplus labor. The returns to skilled labor, on the other hand, are positive.

5.2. Is there evidence for mechanisms driving catch-up?

A straightforward reason why areas that have experienced conflict have not yet caught up, would be that that recovery takes time and six years is too short. If this is the case, we should nevertheless see mechanisms for catch up at work. To assess this, we estimate Equation 5 and interact conflict with each of the production factors. The results, presented in Table 3, indicate that while the return to land is positive in

¹⁹ See also Davenport and Stam (2009) on the sequencing of genocide and the advancement of the RPF.
²⁰

general, it is reduced to zero in past conflict areas. This is consistent with land becoming less scarce in these areas due to excess mortality. The returns to unskilled labor are negative, and are not distinct in areas with high intensity of violence, which suggests that even after conflict there is persistent surplus labor. Returns to skilled labor are positive in general, and are the same in conflict areas, contrary to our expectations. This may suggest either that educated have been replaced by equally educated immigrants, or that there are no returns to education in the conflict areas, for instance because activities where returns to education are highest, like off farm work, may still be largely absent in those areas.

5.3. Does migration play a role?

So far we have not taken migration into account. In the aftermath of genocide, a substantial number of people were displaced and resettled ²¹. Estimates vary, with a maximum of up to two million internally and externally displaced. Most of the externally displaced resettled in Rwanda in the course of 1997-1998. In addition, an estimated 200,000 Rwandans (old case load refugees) who lived in exile prior to the genocide also returned to their country of origin after the genocide (Prunier, 1998). By 1998, the vast majority of refugees had been resettled (UNHCR, 2000). Migration in our analysis thus refers to resettlement in a Rwandan community different from one's pre-genocide residence. Across communities, on average 8.3% of the population in 2002 were immigrants who had not resided in that community before the start of the conflict in 1991 (Government of Rwanda, 2002c).

Migration may affect the scarcity of labor supply and the economic performance of a community. To check whether our results are influenced by immigration, we add the proportion of immigrants in a community, as set out in Equation 9 -11. To control for endogeneity of immigration, we use the same identifying instruments. Table 4 reports the results when including immigration, with Column 1 reporting the OLS estimates and Column 2 the IV estimates. The results also confirm that even after controlling

²¹ Estimates vary, with a maximum of up to two million internally and externally displaced. Most of the externally displaced resettled in Rwanda in the course of 1997-1998. In addition, an estimated 200,000 Rwandans (old case load refugees) who lived in exile prior to the genocide also returned to their country of origin after the genocide (Prunier, 1998).

for immigration, the coefficients of the interaction terms between conflict measures and household production factors remain largely the same.

The first stage regression for migration indicates that the instruments have high predictive power. The estimated coefficients on the two instruments have the same sign as in the case of predicting conflict intensity, confirming the idea that migrants resettled in communities that experienced excess mortality.

5.4. Does the type of conflict matter?

Table 5 reports the OLS and IV household results when considering the different types of conflict. For ease of interpretation we reproduce the results from the general Wartime Excess Mortality Index (WEMI), replacing the latter by the genocide specific index GEMI and the civil war specific index CEMI.

When comparing the effects of genocide, reported in Columns 1 to 3 of Table 5, with those of civil war, reported in Columns 4 to 6, the results show that the relative gap is larger for genocide than for civil war affected areas. This results suggest that communities that have experienced more intensive civil war may be more behind those that have experienced less civil war, than the communities that have experienced more intensive genocide are behind those that have received less intensive genocide. As a robustness test, we inspect whether (counter-)insurgencies, which continued until 1998, may affect the CEMI results, by removing the two provinces that were affected by these insurgencies, Gisenyi and Ruhengeri, from the sample. We find that the results remain very similar, confirming that the lack of catch up in areas affected by civil war is not caused by the insurgencies..

To assess whether there are differences in the underlying process of catch up, we also study 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 stronger for GEMI than for CEMI, most likely because the genocide particularly targeted adult males. Presumably for the same reason, returns to unskilled labor are higher for genocide than for civil war affected areas. It is noteworthy that Farmer (1991) describes a similar effect on returns to labor

upon the black death in 14th century Europe. In a similar spirit, Young (2005), studying the effects of AIDS on the South-African economy, finds suggestive evidence that the resulting scarcity of labor contributes to a positive effect on welfare²².

A final check is whether these results remain the same when we include migration, and we find they do (results not reported).

6. Conclusion

There has been much progress in the economic analysis of conflict, but our understanding of the economic consequences of civil war and conflict remain limited, among others because the further use of country level data limits the additional insights we can gain. One way forward is to focus on micro level data in order to identify causality more convincingly, something that remains a challenge with cross-country data. Blattman and Miguel (2010), in their recent JEL review underline the need for micro economic analysis in order to increase our understanding of the economic consequences of civil war and conflict. Taking this concern to heart, this paper studies the effect of mass killings and human capital destruction on economic performance in Rwanda.

In this we join a small group of work that studies the impact of conflict on economic performance for one country, focusing mostly on physical capital destruction (Davis and Weinstein, 2002; Brakman et al., 2004; Miguel and Roland, 2008). This work differs in three ways, as it studies (i) the consequences of the destruction human rather than physical, (ii) the event of internal war rather than interstate war, (iii) a shorter period after the conflict, namely 6 years.

Combining rich household data with unique data on violence in Rwanda, we investigate the effect of conflict on economic performance at the household and community level and find that households and localities that were exposed to high conflict intensity are lagging behind in terms of per capita consumption. This finding

²² According to Young the underlying reasons for this positive welfare effect are related to an increase in the value of women's time, which helps reducing fertility.

is robust to taking into account the endogeneity of violence, using geographical variables as identifying instruments. Because the Rwandan conflict also triggered displacement and resettlement, we also investigate whether the results are robust when taking migration into account, and find that they are.

The lack of full catch up, six years after the conflict contrasts with findings from other studies that look at catch up after conflict in Germany, Japan and Vietnam. One possible reason for this difference is that we consider a much shorter period after the end of conflict. While other studies consider a 15 to 30 years period, our study looks at the economy six years after the end of conflict. The economy may therefore still be in a phase of post-conflict transition. Indeed, when we compare the returns to factors of production between low and high conflict intensity areas using a production function approach, we find significantly different returns to land and labor, and these results are robust to controlling for migration. While the return to land is positive in general, it is reduced to zero in past conflict areas, which is consistent with land becoming less scarce in these areas due to excess mortality. The returns to unskilled labor are negative, and are not distinct in areas with high intensity of violence, which may suggest that even after conflict there is persistent surplus labor. Returns to skilled labor are positive in general, and are the same in conflict areas, contrary to our expectations. Taken together, these results suggest that the economy is still in transition, and this has important implications for policy.

Another potential reason why conflict areas have still not caught up 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). To explore this further we distinguish between genocide and civil war, and compare the effects of the two. While the first is associated mostly with human capital destruction, the second is also associated with the destruction of physical capital. The results indicate that the relative gap is slightly larger for civil war than for genocide affected areas. Hence, from this analysis, we do not find evidence that catch up is slower in the case of human capital destruction.

Studying the interaction effects of the production factors with the type of conflict, we find that the drop in returns to land is stronger for areas that have experienced

more intensive genocide relative to those that have experienced less intensive genocide, compared to the drop in returns to land between areas that have experienced more intensive civil war relative to those that have experienced less intensive civil war. The most likely reason is that the genocide particularly targeted adult males. Likewise the rise in returns to unskilled labor is higher for genocide than for civil war, due to the high direct death toll associated with the former. These findings suggest that the process of catch up depends to some extent on the kind of violence and the type of destruction that the community experienced. This has important policy implications as it suggests that communities require different policy responses depending on the type of violence they experienced. From a conceptual perspective, this also underlines the need for more micro economic analysis, that allows us to better understand the distinct effects of different forms of conflict.

Of course our analysis has important limitations. It does, for instance not take into account the role of important unobserved factors like technology and local institutions, and how they are affected by conflict. Emerging evidence shows that conflict may affect collective action and reintegration.²³ It also remains to be seen what the external validity of these results are. Perhaps the story of Rwanda is very specific and does not teach us very much regarding other conflicts. Nevertheless the findings are suggestive, and encourage further empirical analysis. They may also give hope, and indicate that communities do bounce back whatever hell they have seen.

²³ See for instance Bellows and Miguel 2008, Humphreys and Weinstein 2010

References

- Elbadawi and Sambinis (2000), How Much War Will we see?: Explaining the Prevalence of Civil War. *Journal of Conflict Resolution*. 46(3): 307-334.
- Akresh, Richard and Damien de Walque, 2009, "Armed Conflict and Schooling: Evidence from the 1994 Rwandan Genocide, HiCN Working Papers, 47.
- Alesina, A., and R. Perotti (1996): "Income distribution, political instability, and investment, *European Economic Review*", 40(6), 1203-1228.
- André C. and J.P. Platteau. 1998. "Land Relations Under Unbearable Stress: Rwanda Caught in the Malthusian Trap". *Journal of Economic Behavior and Organization*: 34(1): 1-47.
- Anselin, L. (1995): "Local indicators of spatial association". *Geographical Analysis*, 27: 93-115.
- Azariadis and Drazen, 1990
- Barro, R. J. (1991): "Economic growth in a cross-section of countries". *Quarterly Journal of Economics*, 106, 407-444.
- Barro and Sala-i-Martin 2003;
- Boserup E., 1965, The conditions of agricultural growth. The economics of agrarian change under population pressure. London. George Allen and Unwin Ltd.
- Brakman, S. and Garretsen, H. and Schramm, M., "The Strategic Bombing of Cities in Germany in World War II and its Impact on City Growth", *Journal of Economic Geography*, 2004, 4: 1-18.
- Bundervoet Tom, Philip Verwimp, Richard Akresh, *Journal of Human Resources*
- Bureau of Intelligence and Research, 1965, "Zaire, Congo (Leopoldville)] – Rwanda Boundary", *International Boundary study* No. 52, The Geographer, Office of the Geographer.
- Cerra and Saxena (2008)
- Collier. P. and A. Hoeffler (1998), "On economic causes of civil war", *Oxford Economic Papers*, 50, 563-573.
- Collier P. 1999. On the economic consequences of civil war. *Oxford Economic Papers* 51: 168-183.
- Collier, 2006 "Post-Conflict Economic Recovery"
- Davenport, C., and A. Stam (2009): "Rwandan Political Violence in Space and Time". Discussion paper, mimeo.
- Davis and Weinstein (2002), Bones, Bombs, and Break Points: The Geography of Economic Activity. *American Economic Review*. 92 (5): 1269 – 1289.

de Walque D., and P. Verwimp, 2009, The demographic and socio-economic distribution of excess mortality during the 1994 genocide in Rwanda, The World Bank, Policy Research Working Paper Series, 4850.

Des Forges, A. 1999. *Leave None to Tell the Story: Genocide in Rwanda*. New York: Human Rights Watch.

Easterly, W. and R., Levine (1998), "Africa's Growth Tragedy: Policies and Ethnic Divisions", *The Quarterly Journal of Economics*, 112(4): 1203-50.

Farmer, D. L. "Prices and Wages, 1350—1500." In *The Agrarian History of England and Wales*, Vol. III, edited E. Miller, 431—94. Cambridge: Cambridge University Press, 1991.

González, M. A., and R. A. Lopez (2007): "Political Violence and Farm Household Efficiency in Colombia", *Economic Development and Cultural Change*, 55(2), 367 .392.

Government of Rwanda. 2002a. *Poverty Reduction Strategy Paper*. Kigali, Ministry of Finance and Economic Planning.

Government of Rwanda. 2002b. *Integrated Household Living Conditions Survey (2000-2001)*. Kigali: Ministry of Finance and Economic Planning.

Government of Rwanda, 2002c, *Recensement Général de la Population et de l'Habitat Rwanda: 16-30 Août 2002*, Kigali, Service National de Recensement.

Gilchrist and Williams, 2004

Hibbs, D. (1973): "Mass Political Violence: A Cross-national Causal Analysis". John Wiley & Sons.

Jolliffe, I. (2002): *Principal Component Analysis*, no. XXIX in *Springer Series in Statistics*. Springer, NY, 2nd edn.

Justino, P., and P. Verwimp (2006): *Poverty Dynamics, Violent Conflict and Convergence in Rwanda*, HiCN Working Papers 16, Households in Conflict Network.

Justino, P. (2010). "War and Poverty". *Households in Conflict Network*, HiCN Working Paper 81.

Lopez, H., Wodon, Q. 2005. "The Economic Impact of Armed Conflict in Rwanda". *Journal of African Economies*, 14(4): 586-602.

McKay, A., and Loveridge, S., 2005, "Exploring the Paradox of Rwandan Agricultural Household Income and Nutritional Outcomes in 1990 and 2002", *Staff Paper 2005-6*, MSU, Michigan.

Miguel, E., Satyanath, S. and E. Sergenti (2004), "Economic Shocks and Civil Conflict: An Instrumental Variables Approach", *Journal of Political Economy*, 112(4): 725-753.

Miguel, E. and G., Roland, 2006, "The Long Run Impact of Bombing Vietnam", *National Bureau of Economic Research, Working Paper*, 11954.

Olson J.M. 1994, "Demographic Responses to Resource Constraints in Rwanda, Rwanda Society-Environment Project", Working Paper 7, Department of Geography and the Centre of Advanced Study of International Development, MSU

Organski and Kugler (1977)

Prunier, G. 1995, *The Rwanda Crisis. History of a Genocide*, Columbia University Press, 424 pp.

Sachs, Jeffrey D. *The End of Poverty: Economic Possibilities for Our Time*, The Penguin Press: New York, 2005

Sachs, Jeffrey D., John W. McArthur, Guido Schmidt-Traub, Margaret Kruk, Chandrika Bahadur, Michael Faye, and Gordon McCord, *Ending Africa's Poverty Trap*, Paper presented at Brookings Panel on Economic Activity, 2003.

UNHCR (2000): "The State of The World's Refugees 2000: Fifty Years of Humanitarian Action - Chapter 10: The Rwandan genocide and its aftermath", Discussion paper.

Verpoorten, M., 2005, "The death toll of the Rwandan genocide: a detailed analysis for Kigongo Province", *Population*, 60(4): 331-368

Verpoorten, M., Berlage, L., 2007, "Economic Mobility in Rural Rwanda: A Study of the Long Term Effects of War and Genocide at the Household Level", *Journal of African Economies*, 1-44.

Verpoorten, M., 2009, "Cattle Sales in War and Peacetime: a Study of Household Coping in Rwanda, 1991-2001", *Journal of Development Economics*, 88(1): 67-86.

Verpoorten, M. (2010a), "Detecting Hidden Violence: The Spatial Distribution of Excess Mortality in Rwanda", LICOS Discussion Paper 254.

Verpoorten, M. (2010b), "The Intensity of the Rwandan Genocide: Fine Measures from the Gacaca Records", LICOS discussion paper nr. 256.

Verpoorten, M. (2010c), "A way forward in measuring conflict intensity: an illustration for Rwanda", mimeo.

Figures and Tables

Figure 1. Geographical Spread of Conflict

Figure 2: kernel density of 2000 household per capita consumption (logged) with food- and total poverty line

Notes: food poverty and total poverty line were calculated respectively at 45.000 RFW and 64.000 RFW in 2000 (\$114 and \$163)

Figure 3: kernel density of the excess mortality indices

3a. WEMI

3b. GEMI and CEMI

Figure 4: Map of respectively WEMI, GEMI and CEMI quintiles

4a. WEMI

4b. GEMI

4c. CEMI

Notes: top quintile in darkest shade

Table 1: descriptive statistics

a. Household level variables		Mean	St. Dev	Min	Max
Log(per adult equivalent consumption in 2000/01)	Natural logarithm of household consumption expenditures per adult equivalent	64,731	52,647	2,552	735,863
Log(Land owned)	Natural logarithm of land owned by household	0.38	0.55	0.00	6
Log(active)	Natural logarithm of household members aged 15-65	2.11	1.06	0.00	8
Log(schooling head)	Years of schooling household head	2.75	3.29	0.00	18
b. Violence intensity (at commune level)					
WEMI	Wartime Excess Mortality Index. First principal component of 5 excess mortality proxies taken from 1991-2002 population census and distance to mass grave. Rescaled to the interval [0,1]	0.41	0.19	0.00	1.00
GEMI	Genocide Excess Mortality Index and Civil war Excess Mortality Index. Respectively the first and second principal component of 5 excess mortality proxies taken from 1991-2002 population census, 6 genocide proxies taken from gacaca records and distance to mass grave. Rescaled to the interval [0,1]	0.40	0.20	0.00	1.00
CEMI		0.34	0.19	0.00	1.00
c. Other commune level variables					
1978-1991 population growth	Commune level population growth between 1978-1991	0.03	0.01	0.00	0.08
Distance to Nyanza	Sector level distance to Nyanza, the former capital of the Tutsi monarchy that ruled between the 14th and 19th century (km)	65.44	28.82	2.62	130.15
Distance to Uganda	Sector level distance to the Uganda border, from where the RPF invaded Rwanda in October 1990 (km)	72.32	42.03	0.32	153.32
d. Sector level variables					
Altitude	Sector level altitude in m	1805	285	1400	2500
Rainfall	Sector level long term average annual rainfall in mm	1138	312	600	1950
1991 population density	Sector level population density taken from the 1991 population census (pop/km ²)	5.92	0.44	3.67	7.26
Distance to main road	Sector level distance to main road (= national road) in 1991 (km)	8.57	6.04	1.16	34.52
Distance to Kigali City	Sector level distance to the Kigali City (km)	65.8	29.4	7.9	149.7
Proportion immigrants	Immigrants who moved to the sector after 1991 as a proportion of the 2002 population	0.08	0.10	0.00	0.63

Table 2: Impact of WEMI on economic performance, community level estimates, OLS and IVE

Dependent variable:	Community level estimates			Household level estimates					
	Log(consumption per capita)		WEMI	Log(consumption per capita)		WEMI	Log(consumption per capita)		WEMI
	IVE 2nd stage		IVE 1st stage	IVE 2nd stage		IVE 1st stage	IVE 2nd stage		IVE 1st stage
	OLS (1)	(2)	(3)	OLS (4)	(5)	(6)	OLS (7)	(8)	(9)
WEMI	-0.23** [0.110]	-0.54*** [0.207]		-0.29*** [0.071]	-0.59*** [0.118]		-0.30*** [0.069]	-0.68*** [0.140]	
Log(land)							0.30*** [0.035]	0.29*** [0.035]	0.02 [0.141]
Log(active labor)							-0.14*** [0.028]	-0.15*** [0.028]	-0.25 [0.184]
Log(schooling)							0.18*** [0.010]	0.19*** [0.011]	0.08 [0.063]
Log(distance to Nyanza)			-0.06*** [0.027]			-0.07** [0.027]			-0.06** [0.028]
Log(distance to Uganda)			0.10*** [0.037]			0.10*** [0.037]			0.10*** [0.037]
X _j	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
P _j	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	407	407	141	4958	4958	141	4958	4958	141

Table 3: Impact of WEMI on economic performance and returns to production factors, OLS and IVE

Dependent variable:	Log(consumption per capita)		WEMI
	OLS	IVE 2nd stage	IVE 1st
	(1)	(2)	(3)
WEMI	-0.27 [0.178]	-0.57*** [0.168]	
Log(land)	0.55*** [0.080]	0.56*** [0.085]	0.02 [0.141]
Log(land)*WEMI	-0.69*** [0.184]	-0.57*** [0.168]	
Log(active)	-0.20*** [0.067]	-0.19*** [0.070]	-0.25** [0.184]
Log(active)*WEMI	0.16 [0.153]	0.09 [0.121]	
Log(schooling)	0.19*** [0.025]	0.22*** [0.028]	0.08 [0.063]
Log(schooling)*WEMI	-0.03 [0.056]	-0.06 [0.048]	
Log(distance to Nyanza)			-0.06*** [0.028]
Log(distance to Uganda)			0.10*** [0.037]
X _j	Yes	Yes	Yes
P _j	Yes	Yes	Yes
Obs.	4958	4958	141

Table 4: Impact of WEMI on economic performance and returns to production factors, OLS and IVE, controlling for immigration

Dependent variable:	Log(consumption per capita)		Log(consumption per capita)		Log(consumption per capita)		Immigration	Immigration
	OLS	IVE 2nd	OLS	IVE 2nd	OLS	IVE 2nd	IVE 1st stage	IVE 1st stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WEMI	-0.34*** [0.075]	-0.69*** [0.145]	-0.34*** [0.071]	-0.71*** [0.109]	-0.30* [0.179]	-0.62*** [0.175]		
Immigration	0.60** [0.252]	0.43 [0.325]	0.46*** [0.173]	1.11*** [0.235]	0.50*** [0.171]	1.06*** [0.234]		
Log(land)			0.29*** [0.035]	0.29*** [0.036]	0.56*** [0.080]	0.53*** [0.089]		0.00 [0.075]
Log(land)*WEMI					-0.73*** [0.185]	-0.50*** [0.156]		
Log(active)			-0.14*** [0.028]	-0.16*** [0.029]	-0.20*** [0.067]	-0.21*** [0.073]		0.09 [0.089]
Log(active)*WEMI					0.15 [0.153]	0.10 [0.125]		
Log(schooling)			0.18*** [0.010]	0.19*** [0.011]	0.19*** [0.025]	0.22*** [0.029]		0.01 [0.034]
Log(schooling)*WEMI					-0.03 [0.056]	-0.06 [0.050]		
Log(distance to Nyanza)							-0.03*** [0.010]	-0.02 [0.013]
Log(distance to Uganda)							0.00 [0.008]	0.00 [0.011]
X _j	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
P _j	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	4958	4958	4958	4958	4958	4959	141	141

Table 5: Impact of GEMI and CEMI on economic performance, OLS and IVE

Dependent variable	Log(consumption per capita)		GEMI	Log(consumption per capita)		CEMI
	OLS (1)	IVE 2nd stage (2)	IVE 1st stage (3)	OLS (4)	IVE 2nd stage (5)	IVE 1st stage (6)
GEMI	-0.23*** [0.067]	-0.82*** [0.161]				
CEMI				-0.32*** [0.080]	-0.88*** [0.133]	
Log(land)	0.30*** [0.035]	0.28*** [0.036]	-0.14 [0.141]	0.30*** [0.035]	0.30*** [0.036]	0.07 [0.117]
Log(active)	-0.14*** [0.028]	-0.14*** [0.029]	-0.03 [0.162]	-0.14*** [0.028]	-0.15*** [0.029]	-0.27 [0.166]
Log(schooling)	0.18*** [0.010]	0.18*** [0.011]	0.03 [0.054]	0.18*** [0.010]	0.19*** [0.011]	0.08 [0.057]
Log(distance to Nyanza)			-0.09** [0.040]			-0.02 [0.026]
Log(distance to Uganda)			0.09*** [0.025]			0.07** [0.034]
X _j	Yes	Yes	Yes	Yes	Yes	Yes
P _j	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	4958	4958	141	4958	4958	141

Table 6: Impact of GEMI and CEMI on economic performance and returns to production factors, OLS and IVE

Dependent variable: log(consumption per capita)				
	OLS (1)	IVE 2nd stage (2)	OLS (3)	IVE 2nd stage (4)
GEMI	-0.41** [0.181]	-1.17*** [0.256]		
CEMI			-0.17 [0.176]	-0.70*** [0.164]
Log(land)	0.51*** [0.086]	0.59*** [0.136]	0.47*** [0.067]	0.44*** [0.065]
Log(land)*GEMI	-0.52*** [0.185]	-0.52*** [0.215]		
Log(land)*CEMI			-0.56*** [0.186]	-0.33** [0.129]
Log(active)	-0.28*** [0.069]	-0.41*** [0.108]	-0.13** [0.054]	-0.12** [0.052]
Log(active)*GEMI	0.34** [0.150]	0.46*** [0.174]		
Log(active)*CEMI			-0.01 [0.145]	-0.08 [0.095]
Log(schooling)	0.21*** [0.025]	0.21*** [0.037]	0.18*** [0.021]	0.20*** [0.021]
Log(schooling)*GEMI	-0.07 [0.054]	-0.05 [0.061]		
Log(schooling)*CEMI			0.00 [0.054]	-0.03 [0.037]
X _j	Yes	Yes	Yes	Yes
P _j	Yes	Yes	Yes	Yes
Obs.	4958	4958	4958	4958

Note: the IV first stage results are identical to those of column (6) and (9) in Table 5.

Appendix

A.1. Construction of the Indices

Below we provide a summary of the construction of the conflict measures WEMI, GEMI and CEMI. A complete description, discussion of external validity and robustness can be found in Verpoorten (2010c).

WEMI is the first principal component of the six 1991-2002 excess mortality proxies listed in Table A1. The first five excess mortality proxies (Δ mortality of sons, Δ mortality of daughters, Δ widowhood, Δ orphanhood and disability due to war or genocide) are calculated from the 1991 and the 2002 population census. For the latter, we have access to the entire database, including information on approximately 8,000,000 individuals (source: Rwandan Government). 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 website). The excess mortality proxies are calculated at the level of 145 administrative communes in Rwanda. A commune is a rather small administrative unit, with an average size of 173 squared km and counting 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 eight and seven percentage points higher, the proportion of widows increased with 12 percentage points and the proportion of double orphans more than doubled (from 0.02 to 0.05).

In order to distinguish between excess mortality stemming from genocide (GEMI) and from other forms of violence (including civil war and (counter-)insurgency (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 genocide survivors (widows, orphans, disabled), proportional to the 1994 population. A detailed discussion of the suspect categories and how the gacaca data can inform about genocide intensity is provided in Verpoorten (2010b).

In order to determine GEMI and CEMI, the five general excess mortality proxies, and the six genocide proxies are 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. The loadings for the first PC are positive across all variables and highest for the genocide proxies. The loadings for the second PC are negative for the genocide proxies and positive for the general excess mortality proxies. Given that the first PC has dominant loadings on the genocide proxies, it can be interpreted as an indicator of genocide-specific excess mortality (GEMI). The loadings on the second PC imply that, after genocide related violence has been accounted for, the main source of variation is between sectors with large excess mortality proxies relative to the genocide proxies. Therefore, the second principal component can be interpreted as excess mortality stemming from other types of violence, such as civil war, reprisal killings and (counter)insurgency (CEMI).

A detailed discussion of the interpretation of these PCs as well as several robustness checks are presented in Verpoorten (2010c). The robustness checks include controls for survival bias and for population displacement. Verpoorten (2010c) also provides a summary of other studies that use PCA for the construction of conflict indices. A detailed comprehensive exposition of the method of PCA is given by Jolliffe (2002) and Duntzman (2001).

Table A1: Conflict intensity measures

Variable	Description	Mean	St. Dev.	Factor loadings resulting from Principal Component Analysis (PCA)		
				WEMI	GEMI	CEMI
Excess mortality proxies						
Δ Mortality of sons	2002-1991 Total number of boys died/number of boys born	0.08	0.03	0.48	0.23	0.40
Δ Mortality of daughters	2002-1991 Total number of girls died/number of girls born	0.07	0.03	0.43	0.19	0.38
Δ Widowhood	2002-1991 Widows (% women >=30)	0.12	0.05	0.46	0.12	0.46
Δ Double orphanhood	2002-1991 Double orphans (% children and youngsters <30)	0.03	0.02	0.48	0.16	0.46
Disability	Disabled due to war or genocide (% population)	0.00	0.00	0.38	0.22	0.31
Genocide proxies						
Category 1 suspects	Genocide suspects accused of planning, organizing or supervising the genocide, and committing sexual torture	0.01	0.01		0.39	-0.15
Category 2 suspects	Genocide suspects accused of killings or other serious physical assaults	0.06	0.04		0.38	-0.19
Category 3 suspects	Genocide suspects accused of looting or other offences against property	0.04	0.03		0.30	-0.24
Widowed genocide survivors	Widow or widower genocide survivors	0.00	0.00		0.38	-0.18
Orphaned genocide survivors	Orphaned genocide survivors	0.01	0.01		0.38	-0.15
Disabled genocide survivors	Disabled genocide survivors	0.00	0.00		0.38	-0.08