“Sex ratio as a measure of conflict-related mortality: The case of Rwanda”

Thesis submitted in partial fulfillment of the requirements for the

Degree of Master of Science in Economics for Development

at the University of Oxford

31 May 2013

By

774047

Word count: 9984

Abstract

Indirect mortality estimation techniques are applied to the measurement of the spatial distribution of violence in Rwanda during the 1990s. A model predicting relative Wartime Excess Mortality Index shows that excess mortality at the commune level will be affected by, inter alia, the percentage of Tutsi in a given commune, the number of extrajudicial reprisal killings by the RPF, and the distance to Kigali. The second model predicts the change in sex ratio at the commune level, excluding population in institutions (e.g. prisons). The two models produce very similar results. The results of the sex ratio model are not robust to the inclusion of the population in prisons and other institutions, probably because 1% of Rwandan men were incarcerated and many were transferred to new communes. The similarity in the results of the WEMI and sex ratio models suggest that they are suitable proxy measures for excess mortality. Sex ratio will be a good proxy for excess mortality if and only if patterns of violence consistently affect men and women in different ways. In the case of Rwanda, the dual effect of killing and incarcerating men makes the sex ratio a good proxy for excess mortality.

INTRODUCTION

Although it is often seen as a deviation from the normal state of affairs, armed conflict is a permanent and important feature of contemporary global landscape. In 2011, the Uppsala Conflict Data Program recorded 37 significant on-going armed conflicts, and their number has ranged every year from 30 to 53 since the fall of the Berlin wall (Themnér and Wallensteen 2012). Given that armed conflict disproportionately affects the developing world, an understanding of this phenomenon is of fundamental importance in the field of development economics. Paul Collier (2004) referred to civil war as "development in reverse", noting both its economic impact and negative outcomes due to forced migration, the deterioration of political rights, and health outcomes. While the social and monetary costs of conflict are considerable, it is also important to consider the human cost and remember that these three are closely related.

It would seem that point has not been forgotten, as most media and government reports about a conflict situation will give an estimate of the death toll. Perhaps this is because the death of a human individual is an easily understood and readily comparable metric of the severity of violence. This measure is by no means perfect, however, as disentangling the channels by which conflict can cause death (e.g. displacement, susceptibility to disease, destruction of infrastructure) can be very complex. A further complexity is that mortality itself has important economic consequences. Most directly, it destroys human capital, and in many of the foundational models of economic growth (Solow 1956, and Kuznets 1966), the growth of the labour force is essential for economic growth. Thus, the counting of the dead should also be considered an economic problem with consequences for the welfare of those who have survived.

This paper considers one of the most infamous episodes of mass killing in modern history: the Rwandan genocide and related armed conflicts. Using census data and geospatial indicators, I attempt to answer the question of how mortality is best measured, and what its measurement can tell us about the nature of the Rwandan conflict. This paper uses data from Rwanda to compare two different methods of relative spatial mortality estimation. The method of "indirect mortality estimation" is applied at the level of the commune and compared to results presented in Marijke Verpoorten's 2012 paper

"Detecting hidden violence: The spatial distribution of excess mortality in Rwanda." The second method used to indicate mortality is the change in the ratio of men to women in the population. This same method is then applied to a sample excluding population in government institutions, notably prisoners, in order to show the sensitivities of this approach.

Measuring death tolls is important, but it is far from easy. One approach often used is to obtain information about incidences of violent death and use those data to estimate the number of violent deaths in a population. One such effort was a study in Iraq following the American invasion (Burnham et al. 2006). The authors used cluster sampling to ask households about violent deaths they had suffered, comparing the estimated violent mortality rate with a crude mortality rate. Criticisms of their methodology abounded, with one critic giving evidence that their survey had breached standard ethical guidelines, used questionable methodology concerning death certificates, and showed large discrepancies with other data sources (Spagat 2010). Another well-known series of mortality surveys are those carried out in the Democratic Republic of the Congo (DRC) by the American NGO the International Rescue Committee (2007). After estimating a crude mortality figure through household cluster sampling, the authors of the study subtracted an average mortality rate for sub-Saharan Africa and then applied these rates to a population estimate for the DRC. The methodology of this study has also been highly criticised, with the 2011 Human Security Report claiming that non-random samples were selected in areas known for high conflict intensity and that the baseline mortality rates used for purposes of calculating excess mortality were too low. Many mortality studies, even the most well-resourced, suffer such criticisms.

Overcoming these recurring difficulties may be the method of "indirect mortality estimation". This method infers rates of mortality from observable demographic ratios such as the proportion of dead children amongst children born to women in a given marriage duration group (Hill and Trussell 1977). Using standard expressions in conjunction with marital fertility schedules and nuptiality schedules, it is possible to estimate population excess mortality based on how certain indicators have changed. The advantage of this approach is that often the estimates can be inferred from existing census data, and does not require purpose-built surveys. Both of the approaches used in this paper to estimate mortality fall under the rubric of “indirect mortality estimation”. In one model, a matrix of indicators is combined to measure mortality, whereas in the second model a single indicator – the change in the sex ratio – is used as a proxy for mortality. Unlike the Iraq and DRC studies cited above, this paper does not try to establish an absolute measure of the number of people killed in Rwanda. The models proposed herein examine the spatial distribution of excess mortality: how different regions of the country were affected in different ways and what this can tell us about different types of violence.

The next section gives a brief overview of the Rwandan crisis in the 1990s. The subsequent section reviews the existing literature concerning the estimation of the death toll during this period in Rwanda’s history and how men and women were affected by this violence in different ways. A section on data and methodology follows. The main econometric results of the paper are then presented. The first regressions try to identify the bivariate relationships between indicators of violence and the change in the sex ratio. The second set of results looks at estimations of excess mortality and then estimations of the change in sex ratio by applying a similar model. A discussion of these results follows, considering the impact of mortality and sex ratio on economic outcomes. The final section concludes.

CONTEXT

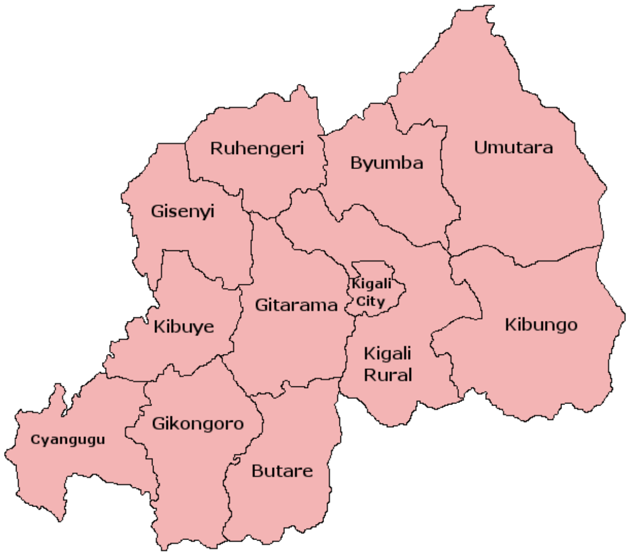
The Rwandan genocide was not an isolated and spontaneous phenomenon, but took place within a longer timeline of competition between two major social groups: the Hutu and the ruling minority, the Tutsi. Belgian colonialists co-opted Rwanda’s existing power structures, further entrenching the power of the Tutsi as a means to exert influence in the colony. In the 1950s, faced with a wave of independence movements and under pressure from the United Nations, Belgium granted some Hutu administrative positions in an effort to create a balance of power (Des Forges 1999). The more populous Hutu took political control and the Tutsi experienced a strong backlash against their previous dominance. Many Tutsi were driven into exile in the decades following independence.

Tutsis in exile in Uganda formed the Rwandan Patriotic Front (RPF) and in October 1990 began launching guerrilla-style attacks inside Rwanda (Prunier 1995). The conflict between Paul Kagame's RPF and government forces escalated. The government investigation and molestation of Tutsi dissidents during this period gave rise to a broader Hutu extremist movement beginning in 1993 (Prunier 1995). This spurred the RPF and the Rwandan government into signing peace accords in Arusha, Tanzania, that detailed plans for a power-sharing deal between the two ethnic groups. However, on 6 April, 1994, a plane carrying the Rwandan (Hutu) President was shot down by unknown assailants, and the peace accords dissolved.

The genocide began in the capital city, Kigali, immediately following the plane crash, and then spread to the eastern part of Rwanda, an area that had been a fertile recruitment ground for the RPF, and its main corridor in launching its insurgency (Newbury 1998). The killing then spread to Rwanda's second largest city, Butare (capital of Butare Province), known for its high concentration of Tutsi. A French military mission known as Opération Turquoise created a safe zone in Provinces of Cyangugu, Kibuye and Gikongoro in the southwest. The RPF continued closing in on the capital and, in July 1994, they succeeded in taking control of Rwanda and establishing a transitional government. Many reprisal killings of Hutu took place and several million people fled into neighbouring DRC (Newbury 1998).

Following the genocide, hundreds of thousands of people were arrested and jailed. At its peak, the prison population in Rwanda reached 130 000 people, and ten years after the genocide it still stood at 85 500, more than 1% of the population (Tertsakian 1998). Roughly 97% of prisoners at this time were male (Schindler and Verpoorten, working paper). Hutu militias based in neighbouring DRC launched attacks in Rwandan territory, notably in the provinces of Gisyeni and Ruhengeri, and this continued through the end of the 1990s.

FIGURE 1: PROVINCES OF RWANDA (PRIOR TO 2006)



LITERATURE REVIEW

The death toll and patterns of violence

The death toll of the Rwandan genocide has been a source of much debate. Commonly accepted figures range from 500 000 victims to 800 000, and some authors have given estimates as high as 1 000 000. Such estimates are complicated by the fact that the genocide was part of a chain of armed and civilian conflict spanning an entire decade, the elements of which are difficult to disentangle. Patricia Justino and Philip Verwimp (2008) list four conflict shocks:(1) the RPF incursions and resulting war from 1990 to 1993, (2) the genocide in 1994, (3) waves of mass migration into and out of Rwanda from 1994 to 1998, and (4) attacks launched by Hutu militias from the Democratic Republic of the Congo from 1997 to 1999. All four shocks are associated with mortality and migration, and taken as a whole resulted in massive demographic shifts inside Africa's most densely populated country.

Although the Tutsi were not the only victims of violence during the genocide, ethnic identity was the strongest determinant in the geo-spatial patterns of killing. According to

Justino and Verwimp (2008) Tutsi were concentrated mostly in the south and west of the country, in the provinces of Butare, Gikongoro, Cyangugu and Kibuye. Although Tutsis bore the brunt of the genocide, a large number of Hutu were killed in reprisal killings afterwards, when the RPF executed thousands of civilians and moved many more into camps (DesForges 1999). This violence was most prevalent in Butare Province, as many Hutu were killed as the RPF swept through the south. In the other western provinces, however, the French military's Opération Turquoise created a safe zone that prevented the RPF advance and, as such, Hutu in these areas were spared (Justino and Verwimp, 2008).

Some have used econometric techniques to create estimates more precise than the prevailing aggregate figures. In her detailed death toll analysis for Gikongoro Province, Marijke Verpoorten (2005) uses the Tutsi population from the 1991 census, to make the counterfactual estimate that there would have been 650 900 Tutsi in the absence of genocide. By subtracting the number of surviving Tutsi, she estimates that 500 900 Tutsi were killed in the genocide. However, these estimates are contingent upon the accuracy of the count of Tutsi in the population census of 1991, and it is likely there is a downward bias in this number. During this era of civil unrest and growing anti-Tutsi sentiment, many Tutsi declared themselves as Hutu in the census. Also during this period the Rwandan government was constrained to allot a certain number of posts to ethnic minorities based on population figures, so it was in their interest to under-report the number of Tutsi. Verpoorten (2005) corrects for this bias in a number of ways, adjusting for different levels and patterns of under-reporting. Assuming 40% under-reporting of Tutsi throughout the country gives a genocide death toll of 763 600 Tutsi (83.1% of the Tutsi population killed).

The relative mortality of men and women

Just as there were identifiable social and geographical trends in the killings in Rwanda, the somewhat distinct waves of violence affected men and women differently. If men and women are killed in different numbers relative to their share in the population, this will result in a change in the sex ratio, defined as the number of men divided by the number of women. For example, in the USSR after the Second World War, the sex ratio in the 20-29 age bracket had declined from .91 to .65 (Brainerd 2007). Purely military conflicts between professional armies will tend to overwhelmingly cause the death of men in greater numbers than women. However, the Rwandan conflict shocks of the 1990s had a much larger effect on civilians than on combatants, so in order to understand the sex ratio one must consider separately the killing of women and men.

Concerning the genocide itself, evidence suggests that slightly more men were killed than women. In her detailed analysis for Gikongoro Province, Marijke Verpoorten (2005) compares local population records to the official nationwide census data. She uses a nonlinear least squares estimation to predict the change in sex ratio based on violent death, natural mortality, emigration, and birth rates for Tutsi men and women. This structural model estimates that Tutsi men in Gikongoro Province had a 21% chance of surviving the genocide on average and women had a 29% chance. Philip Verwimp (2003) uses data from a household-level survey to create a logistic regression model predicting the probability of violent death versus the probability of surviving or dying a natural death. Verwimp reports the marginal effects and the probability of violent death is reduced by 2.1% for women, with the coefficient significant at the 1% level. In a later study, however, the same researcher (Verwimp 2004) finds no significant difference in the death rates of men and women. He uses another logistic regression (binary dependant outcomes) to predict the chance of dying during the genocide, using data from a single commune in Kibuye Province. Verwimp found that older women fared better than men in surviving the genocide, but for the principal age cohorts the difference in the survival rates was not significant.

Although a skewed sex ratio can be a good indicator that men and women were killed in different numbers, analysts must be careful in assuming that any sex ratio deviating from 1 is evidence of a demographic shock. Amartya Sen (1998) notes that men outnumber women in the developing world, notably in Africa and Asia. Globally, mortality tends to be higher for men because men are more likely to die from violent causes, and also because of the historical tendency of males to smoke more than females (Sen 1998). However, in the developing world, social and economic biases against women will lead to an increase in female mortality, skewing the ratio in the other direction. Therefore, although some violent population shocks can be observed in the sex ratio, one must be careful to understand the demographic context before jumping to analytical conclusions.

DATA AND METHODOLOGY

The primary data used in this paper are two official government censuses in Rwanda. The first was completed in 1991, during the civil war but before the genocide, and the second during peacetime in 2002. The secondary data used in this paper were compiled by Marijke Verpoorten. Using GIS software, Verpoorten (2012) generated Local Indicators of Spatial Association (LISA), using distance measures to create variables that may be useful as predictors of different forms of violence. I also use sex ratio numbers compiled from the same census data by Schindler and Verpoorten (working paper). The summary statistics are listed in table 1.

Under the Habyarimana regime, Rwanda was divided into 12 provinces ("prefectures"), 145 communes ("communes"), and 1533 sectors ("secteurs"). All the analysis in this paper is undertaken at the commune level, but some data were only available at the sector level. LISA distance variables were converted by averaging the sector-level measurements in the commune. Whereas this process gives a strong estimate of the distance between the centre of the commune and a fixed point (e.g. Kigali), distance to the nearest major road could in fact be an average of distances to several different points. The dummies Operation_Turquoise and RPF_control_1990 were converted by taking an arithmetic mean of the values at the sector level and then rounding up or down. This is a fairly arbitrary conversion but, as I lacked information about the strategic importance of the individual sectors, this transformation was the only one possible. The dummy Kibeho_within_10km was given a value of 1 for the commune if any one of the sectors in the commune had a value of 1. The RPF_days variable concerning military activity was calculated by taking the median value from the sectors in the commune, so as to represent the number of days that a large part of the commune was occupied.

It is worth noting certain limitations of the data. Firstly, as discussed in the above section, the number of Tutsi are likely to be underreported in the 1991 census leading to downward bias in the Tutsi population share. Furthermore, the post-genocide Tutsi regime outlawed the use of identity, and so questions about ethnic affiliation were not included in the 2002 census. Secondly, population values for urban areas were not available. In order to prevent a strong downward bias in the calculated values for commune-level population density, I was forced to drop from the dataset all urban sectors. Out of 1530 observations, 34 were dropped. As it is completely urbanised, the Province of Kigali Ville (the centre of the capital city region) was excluded from my analysis and this should be taken into consideration when examining my results.

There are two dependent variables we will examine in this paper: the death toll and the change in sex ratio. Change_in_sex_ratio was calculated using a simple first difference in a commune-level panel dataset for 1991 and 2002. The sex ratios for many age subsets were available in the dataset, and I use the broadest one available, incorporating persons from 15 to 60 years of age. Throughout the paper, I will compare results using the full sample Change_in_sex_ratio to Change_in_sex_ratio_i: the sex ratio omitting persons living in government institutions. The massive incarceration rates in Rwanda have meant that in 2002 institutionalised individuals made up 1.97% of the Rwandan population, of which 66% were prisoners (Schindler and Verpoorten, working paper). Given that prisons are concentrated in a small number of communes across Rwanda, and that prisoners are overwhelmingly male, the phenomenon of mass incarceration has skewed the sex ratio all over the country. Removing the institutionalised population corrects for this skewedness to some extent: taking men out of a population may emulate mortality, but with the restricted sample at least does not commit the error of disproportionately "putting them back in" to a few communes with large prisons.

Deathtoll is the other dependent variable I use, and it is derived from the Wartime Excess Mortality Index (WEMI) following Verpoorten (2012). Rather than count violent deaths or calculate a population deficit by estimating counterfactual population growth, Verpoorten (2012) uses the technique of "indirect mortality estimation" discussed in the introduction. She defines several variables that should be strong indicators of mortality and then combines them using Principal Component Analysis (PCA). PCA is a means by which to create a single vector that is as orthogonal as possible to the component vectors, and as such will explain as much as possible the total variation in those vectors. More formally, the first principal component is a vector of constants that maximises the variance when it is multiplied by the vector of constituent variables[1] (Joliffe 2002). This reduction in dimensionality makes the information easier to manipulate and safeguards against the pitfalls of using a single, arbitrary measure. The variables used to create the WEMI are:

1. Mortality of sons: (total number of boys died)/(number of boys born)
2. Mortality of daughters: (total number of girls died)/(number of girls born)
3. Widowhood: the proportion of widows among women at least 30 years old
4. Double orphanhood: the proportion of people under 30 missing both of their parents
5. Disability: the proportion of the population reporting a disability due to genocide or armed conflict

While these measures do indicate the intensity of violence in a given sector, they may also pick up variation between sectors due to other characteristics. In order to correct for the effect of time-invariant unobservables, Verpoorten uses the first difference in these characteristics. PCA produces a single vector that is normalised to 1, such that the commune with the lowest mortality takes a value of 0 and the commune with the highest mortality takes a value of 1. This measure indicates the relative mortality between communes, but is quite abstract and makes regression results difficult to interpret.

Following Verpoorten (2012) I create the Deathtoll variable in order to estimate the death toll in each commune based on its share of the overall mortality in Rwanda for this period. First, extrapolating from the research presented above and other estimates, I assume an overall national death toll of 1 000 000 for the 1991 to 2002 period. Next, I assign to each commune its relative share of the total mortality, using the following formula:

$$\mathrm{Deathtoll_j} = \frac{\mathrm{WEMI_j}}{\sum \mathrm{WEMI_j}} * 1000000$$

[1] The constituent variables must first be mapped onto a [0,1] scale using a linear transformation.

where j is a given commune, WEMI is the Wartime Excess Mortality Index, and Deathtoll is the number of persons killed.

TABLE 1: SUMMARY OF STATISTICS (N=142)

Variable	Description	Mean	St. Dev.
WEMI	Wartime Excess Mortality Index	0.42	0.18
Deathtoll	Number of persons dead (from WEMI)	7042.25	3122.77
Change_in_sex_ratio	Change in sex ratio, 1991 to 2002, persons aged 15 to 60	-0.09	0.14
Change_in_sex_ratio_i	As Change_in_sex_ratio but exlucding those in institutions	-0.14	0.06
RPF_days	Number of days under RPF control in 1994	40.49	42.63
Distance_to_main_road	Distance to national road in 1991 in km	7.84	5.02
Distance_to_Kigali	Distance to the capital city in km	63.33	29.43
Tutsi_%	Percentage of self-declared Tutsi	0.07	0.08
Distance_to_nearest_camp	Distance to the nearest refugee camp in km	40.54	17.98
Kibeho_within_10km	Dummy; 1 if within 10km of the largest IDP camp at Kibeho	0.04	0.18
Extrajudicial_killings	Extrajudicial reprisal killings carried by RPF, in thousands	0.07	0.31
Operation_Turquoise	Dummy; 1 if part of the Opération Turquoise safe zone	0.14	0.35
RPF_control	Dummy; 1 if under RPF at the end of the civil war	0.10	0.30
Population_1991	Commune-level population; 1991 census	49894.77	20063.44
Population_2002	Commune-level population; 2002 census	52678.99	22223.16
Population_density_1991	Population density (inhabitants per km^2); 1991 census	407.88	132.67
Population_density_2002	Population density (inhabitants per km^2); 2002 census	428.23	189.49
Widows_%_1991	Percentage of widows over the age of 30; 1991 census	0.18	0.03
Widows_%_2002	Percentage of widows over the age of 30; 2002 census	0.31	0.05

RESULTS

Bivariate relationships between the sex ratio and mortality

In this first half of the results section I ask whether the change in the sex ratio is a good proxy for mortality. One way to measure the relevance of the proxy is to see to what extent the change in sex ratio can predict other indicators of mortality. There are four indicators of mortality that I will consider:

1. The absolute change in the population in every commune, measured in thousands of persons: (pop2002-pop1991)/1000
2. The percentage change in the population for every commune: pop2002/pop1991

3. The change in the population density level: popdens2002-popdens1991
4. The change in the proportion of widows in the population over the age of 30: widowhood2002-widowhood1991

I use bivariate regressions in order to measure the relationships of these variables with the change in sex ratio. There are two sets of regressions. The first results, reported in table 2, use as an independent variable the first difference of the sex ratio, including the entire population. The second set of results, reported in table 3, uses the same independent variable but excludes the population in prisons and other government institutions. In each table, the first model regresses the change in sex ratio on WEMI. The remaining four regressions are based on a two period fixed effects model, again using the first difference of the sex ratio as the independent variable. By allowing for fixed effects at the commune level, we are removing the impact of time-invariant unobservables. All of the regressions use Huber-White robust standard errors to correct for heteroskedasticity.

TABLE 2: CHANGE IN SEX RATIO AS A DETERMINANT OF MORTALITY INDICATORS

	WEMI	Pop_level_first_dif	Pop_density_first_dif	%_change_pop_level	Widows_%_first_dif
Change_in_sex_ratio	-0.232 (0.172)	32.039 (7.143)***	409.305 (109.562)***	0.720 (0.131)***	-0.014 (0.048)
Constant	0.395 (0.023)***	5.665 (1.038)***	57.150 (14.167)***	1.117 (0.019)***	0.121 (0.007)***
R^2	0.03	0.24	0.33	0.32	0.00
N	142	142	142	142	142

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

TABLE 3: CHANGE IN SEX RATIO (EXLCUING POPULATION IN INSTITUTIONS) AS A DETERMINANT OF MORTALITY INDICATORS

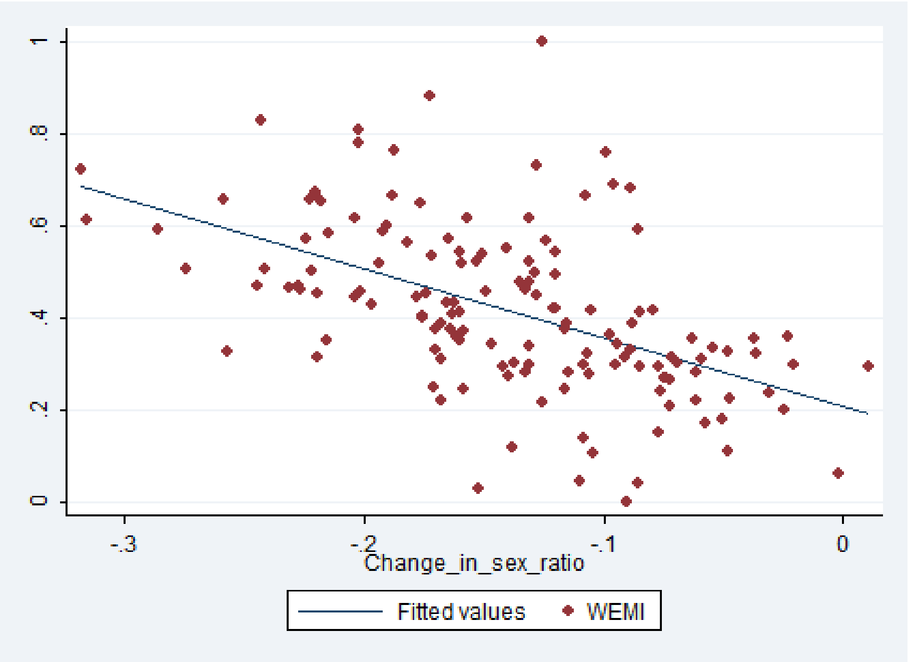
	WEMI	Pop_level_first_dif	Pop_density_first_dif	%_change_pop_level	Widows_%_first_dif
Change_in_sex_ratio_i	-1.506 (0.163)***	39.650 (10.472)***	340.422 (90.903)***	0.811 (0.198)***	-0.346 (0.057)***
Constant	0.206 (0.026)***	8.314 (1.470)***	67.824 (13.604)***	1.166 (0.027)***	0.074 (0.008)***
R^2	0.28	0.08	0.05	0.09	0.17
N	142	142	142	142	142

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

From the results in tables 2 and 3 many bivariate relationships can be observed. Using the entire population to generate the Change_in_sex_ratio, we see that this variable has a strong impact on all of the three population variables. Also we can see that these three simple models explain a fair amount of the variation in the population levels, with their R-squared coefficients falling between 0.24 and 0.33. Excluding the population in institutions to generate Change_in_sex_ratio_i leads to even stronger relationships. A 0.1 drop in the sex ratio (=men/women) is associated with a rise in the WEMI of nearly 1 standard deviation. This relationship is plotted in Figure 2. It is also notable that, by using this independent variable, the impact on the change in the percentage of widows becomes significant.

These results show that the differenced sex ratio including the entire population is a fair predictor of the change in population values, and that the differenced sex ratio excluding those in institutions is a somewhat better predictor of WEMI and its components. In an instrumental variables scenario, these sex ratio variables would satisfy the relevancy condition for instrument, as they do explain a fair amount of the variation in the population or mortality changes.

FIGURE 2: SCATTER PLOT – WEMI AND CHANGE_IN_SEX_RATIO_i



Commune-level determinants of the spatial distribution of excess mortality

Moving to the second half of this section on results, I will consider the regression results in which relative mortality measures are regressed on explanatory variables. The first dependent variable I use is the death toll for each commune, as extrapolated from the relative Wartime Excess Morality Index (WEMI). The regression specifications are the same applied to the WEMI at the sector level by Marijke Verpoorten in the paper "Detecting hidden violence: The spatial distribution of excess mortality in Rwanda" (2012). All of the specifications use Ordinary Least Squares estimation. Breusch-Pagan LM tests were used to check for heteroskedasticity, and in all cases the test rejected at the 5% level of significance the null hypothesis of constant variance of the in the error term of the regression. In order to correct for this heteroskedasticity, Huber-White robust standard errors were used, which is a valid estimator provided that the classical linear model assumptions hold (Wooldridge 2009).[2]

In her sector-level analysis, Marijke Verpoorten links the spatial variables to four major events of the Rwandan conflict cycle. The first event is (1) civil war. Given that the RPF insurgency moved directly towards the capital city along main roads, proximity to Kigali and proximity to a main road are used to indicate the intensity of civil war. The number of days that the RPF was present in a given commune is another measure. The second event is (2) the genocide. Verpoorten uses the percentage of Tutsi in an area as an indicator of genocide, as well as distance to a main road. The third event is (3) the refugee crisis. Verpoorten uses the distance to the nearest refugee camp as an indicator of the impact of this crisis on a given sector. She also uses proximity to the largest IDP camp, Kibeho. The last event is (4) the Hutu militia attacks launched from the DRC. Verpoorten uses dummies for the provinces of Gisenyi and Ruhengeri (bordering the DRC) as indicators of this event, as well as extrajudicial killings by RPF forces. Controls are added for the presence of Opération Turquoise, for control by the RPF at the end of the civil war in the early 1990s, population density, and for fixed effects for all provinces (Butare Province is the reference province). With Deathtoll constructed at the commune level, all of these same indicators of violence will apply, but perhaps in different ways. It is possible that certain characteristics of a commune – its reputation as being under the

[2] The same regressions were run with standard errors clustered at the province level (not reported). The overall results were similar, with the variables RPF_days and Distance_to_Kigali having slightly less significance. Since provincial borders were purely administrative and do not seem to have affected the spread of violence, I have here preferred the Huber-White robust standard errors.

influence of the Tutsi community, or certain actions of the commune administration – would make particular effects more relevant at the commune level.

The results are reported in table 4. These regressions are readily interpretable in terms of the number of persons killed in each commune. The number of extra people dead in the average Gisyeni commune varies from 4113 to 4975 across the models; for Ruhengeri Province is it between 2552 and 3450. On average, an additional 1000 extrajudicial reprisal killings will increase the death toll by between 1426 and 1687. Looking at the logged distance variables, a ten per cent decrease in the distance to Kigali is associated with a commune experiencing between 18 and 29 more fatalities. A ten percentage point higher pre-genocide Tutsi population increased the number of deaths in the commune by at least 1645 and as many as 1799.[3] RPF control of a commune at the end of the civil war decreased its death toll dramatically, by anywhere between 2407 and 3089 depending on the model used. The Kibungo Province in the southeast is associated with an elevated share of mortality, possibly due to RPF reprisal operations against Hutu genocidaires.

It is interesting to note that when compared to the sector-level regression in the paper by Verpoorten (2012), many of the same indicators of violence are significant predictors of mortality in all regression specifications. Aggregating up to a coarser level of measurement should mean that relative differences in the spatial distribution of mortality are diluted. In fact, we do see a drop in the significance levels of other variables when compared to the sector-level regressions, which is to be expected given that there are fewer observations leading to higher standard errors, less variation in the data, and more crude LISA measures being used. Some variables however, remain highly significant predictors of mortality: RPF_Days, Distance_to_Kigali, Tutsi_%, Extrajudicial_killings, and RPF_control. By measuring at the coarser commune level, the impact of these indicators of violence is thus even more pertinent in terms of the spatial distribution of excess mortality. As the results hold at this level, it is conceivable that the concentration of a Tutsi population served to attract violence to the entire commune, and not just sectors where Tutsis were present.

---

[3] A different regression specification (not reported) using quadratic terms suggested a "safety in numbers" effect in which a higher concentration of Tutsi people increased mortality at a diminishing rate. The turning point in which the coefficient on Tutsi_% became negative was outside of the range of the data.

Several robustness checks were carried out using variables at the sector level from the existing dataset and converting them into commune level variables using the arithmetic mean. Given that WEMI is a relative ranking measure, taking an average will only give a crude approximation, but one that is sufficient to check these results. The first check was to include persons who have changed residence between 1991 and 2002. The second was to include distance to the nearest mass grave as a sixth component in the PCA construction of the WEMI. This was to correct for the fact that in areas of mass killings the probability was high that entire families would be eradicated, in which case the mortality inferred from the surviving population would be underreported. The third and fourth checks were to increase and decrease the age range used when computing widowhood and orphanhood. The results are robust in all cases.

Commune-level determinants of the spatial distribution of the change in sex ratio

The same regressions used to estimate Deathtoll are repeated using the change in sex ratio as the dependent variable. The aim is to determine whether the same patterns of violence that generate excess mortality will generate a change in the sex ratio, given the assumption that more men died than women. An independent variable will be deemed to have the same effect if its coefficient has the opposite sign in this second set of regressions: an increase in mortality overall (more men dead or missing) should mean a decrease in the sex ratio (more men dead or missing). Again, Huber-White robust standard errors were used to correct for heteroskedasticity in the error term.

The results are reported in Table 3. In every specification almost none of the regression variables are significant. In the most parsimonious specification, the F test for joint significance of all the variables (testing with 9 variables with 132 degrees of freedom) is not significant at the 5% level. By definition, the R squared increases with every extra variable included in the specification, but the R-squared value is only 0.16 for even the most general model. Here the F test (k=19, DF=122) does reject at the 5% level the null hypothesis that all of the independent variables are jointly insignificant. In this model, RPF_days is significant at the 1% level, showing that on average one more day of RPF activity during their military campaign causes the sex ratio to drop by 0.036 points. Given that the mean value of RPF_days is 40, the average impact on the sex ratio is quite strong.

In a final set of regressions, I again consider the change in sex ratio for persons between the ages of 15 and 60, but excluding persons living in government institutions. The results are shown in table 6. When the institutionalised populations are excluded, the regressions using Deathtoll and Change_in_sex_ratio_i as dependent variables are strikingly similar. In both sets of regressions, the conflict-related variables tend to be good predictors of the independent variable, and the same variables of interest are significant: RPF_days, Distance_to_Kigali, Tutsi_%, Distance_to_nearest_camp, Extrajudicial_killings, and RPF_control. Some variables become more significant in some or all of the specifications when the dependent variable is changed to the sex ratio: RPF_days, Distance_to_nearest_camp, and Extrajudicial_killings. We can postulate why these variables are more strongly represented in the change in sex ratio than in the overall measure of mortality. Extra judicial killings by the RPF were much more likely to affect only men. The Amnesty International report from which these quantitative data were derived mentions the killing of civilians, including men, women and children (Amnesty International 1997). However the report also states that the declared purpose of the RPF[4] was a "cordon and search" operation to seek out militants and resistance fighters and it is very likely that men were killed in a higher proportion. A similar argument can be made as to why the days of military activity by the RPF would be more significant, in that military skirmishes will primarily cause casualties among men, and that under these circumstances civilian men were more likely to be killed indiscriminately as potential combatants.

Robustness checks were carried out using sex ratio variables that had been constructed using different upper and lower age bounds. The general qualitative results were robust, but these data showed some sensitivity to changes. Notably, certain age bounds and certain specifications show significant effects for the province dummies.

---

[4] By this time, the Rwandan Patriotic Front has become the national army of Rwanda and had been renamed the Rwandan Patriotic Army. For simplicity, I omit this distinction throughout.

TABLE 4: SPATIAL DETERMINANTS AND OTHER PREDICTORS OF THE DEATH TOLL IN RWANDA, 1991 TO 2002

	Deathtoll	Deathtoll	Deathtoll	Deathtoll	Deathtoll
RPF_days (log)	412.889	326.437	795.837	775.510	346.281
	(185.254)**	(253.860)	(244.149)***	(235.566)***	(407.461)
Distance_to_main_road (log)	-7.963	13.841	25.525	-61.589	116.273
	(384.327)	(393.476)	(378.321)	(534.357)	(470.200)
Distance_to_Kigali (log)	-2,903.984	-2,885.767	-1,762.192	-1,807.066	-2,009.645
	(646.035)***	(634.781)***	(689.637)**	(676.229)***	(925.059)**
Tutsi_%	17,985.564	17,500.449	17,093.525	17,201.542	16,447.246
	(3,872.345)***	(4,269.913)***	(4,097.126)***	(4,140.745)***	(3,512.755)***
Distance_to_nearest_camp (log)	-1,194.723	-1,250.536	-578.355	-633.751	-291.303
	(492.503)**	(544.791)**	(568.598)	(577.535)	(729.391)
Kibeho_within_10km	-464.350	-546.487	-404.291	-450.574	203.609
	(1,078.303)	(1,103.910)	(1,004.487)	(1,009.277)	(924.120)
Extrajudicial_killings (thousands)	1,686.708	1,636.646	1,514.160	1,492.369	1,426.379
	(636.575)***	(634.758)**	(579.127)***	(581.075)**	(561.821)**
Province_Gisenyi	4,398.566	4,112.969	4,952.436	4,974.556	4,480.216
	(1,091.404)***	(1,212.291)***	(1,150.970)***	(1,145.539)***	(1,332.317)***
Province_Ruhengeri	2,660.307	2,551.990	3,383.498	3,450.167	3,176.135
	(1,067.368)**	(1,063.380)**	(965.199)***	(960.593)***	(1,095.077)***
Operation_Turquoise		-576.252	325.938	291.859	225.842
		(943.400)	(912.582)	(915.029)	(941.485)
RPF_control			-3,089.181	-3,026.269	-2,407.359
			(838.551)***	(865.204)***	(967.123)**
Population_density_1991				-279.689	867.238
				(839.752)	(930.766)
Province_Byumba_and_Umutara					338.302
					(1,024.916)
Province_Cyangugu					-1,001.400
					(1,170.843)
Province_Gikongoro					-1,485.080
					(1,063.640)
Province_Gitarama					-537.376
					(788.365)
Province_Kibungo					2,905.477
					(906.365)***
Province_Kibuye					910.663
					(1,187.587)
Province_Kigali_Rurale					505.020
					(1,066.444)
Constant	19,877.367	20,356.799	12,128.430	14,395.546	7,917.448
	(4,202.053)***	(4,642.607)***	(4,946.229)**	(7,904.555)*	(8,456.332)
R^2	0.46	0.46	0.51	0.51	0.57
N	142	142	142	142	142

* p<0.1; ** p<0.05; *** p<0.01

TABLE 5: SPATIAL DETERMINANTS AND OTHER PREDICTORS OF CHANGE IN SEX RATIO, 1991 TO 2002

	Change_in_sex_ratio	Change_in_sex_ratio	Change_in_sex_ratio	Change_in_sex_ratio	Change_in_sex_ratio
RPF_days (log)	-0.008	-0.009	-0.017	-0.009	-0.036
	(0.010)	(0.012)	(0.017)	(0.018)	(0.013)***
Distance_to_main_road (log)	-0.047	-0.046	-0.047	-0.012	-0.010
	(0.023)**	(0.023)**	(0.023)**	(0.021)	(0.025)
Distance_to_Kigali (log)	0.036	0.036	0.016	0.033	-0.016
	(0.031)	(0.031)	(0.041)	(0.040)	(0.037)
Tutsi_%	-0.222	-0.228	-0.221	-0.264	-0.209
	(0.216)	(0.216)	(0.213)	(0.209)	(0.198)
Distance_to_nearest_camp (log)	0.013	0.012	-0.000	0.022	0.006
	(0.044)	(0.044)	(0.049)	(0.043)	(0.053)
Kibeho_within_10km	-0.005	-0.006	-0.008	0.010	-0.035
	(0.056)	(0.057)	(0.056)	(0.056)	(0.062)
Extrajudicial_killings (thousands)	-0.032	-0.032	-0.030	-0.021	-0.031
	(0.023)	(0.023)	(0.023)	(0.020)	(0.017)*
Province_Gisenyi	-0.047	-0.050	-0.065	-0.074	-0.100
	(0.049)	(0.048)	(0.054)	(0.054)	(0.053)*
Province_Ruhengeri	-0.005	-0.006	-0.021	-0.047	-0.038
	(0.024)	(0.025)	(0.028)	(0.037)	(0.049)
Operation_Turquoise		-0.007	-0.023	-0.010	-0.009
		(0.046)	(0.051)	(0.054)	(0.044)
RPF_control			0.056	0.031	0.067
			(0.047)	(0.048)	(0.031)**
Population_density_1991				0.111	0.148
				(0.067)	(0.103)
Province_Byumba_and_Umutara					0.053
					(0.039)
Province_Cyangugu					-0.064
					(0.084)
Province_Gikongoro					0.048
					(0.066)
Province_Gitarama					-0.006
					(0.052)
Province_Kibungo					0.129
					(0.120)
Province_Kibuye					-0.077
					(0.066)
Province_Kigali_Rurale					0.000
					(0.051)
Constant	-0.140	-0.134	0.015	-0.881	-0.793
	(0.307)	(0.303)	(0.382)	(0.548)	(0.679)
R^2	0.06	0.06	0.07	0.10	0.16
N	142	142	142	142	142

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

TABLE 6: SPATIAL DETERMINANTS AND OTHER PREDICTORS OF CHANGE IN SEX RATIO, 1991 TO 2002 – POPULATION IN INSTITUTIONS INCLUDED

	Change_in_sex_ratio_i	Change_in_sex_ratio_i	Change_in_sex_ratio_i	Change_in_sex_ratio_i	Change_in_sex_ratio_i
RPF_days (log)	-0.008	-0.010	-0.018	-0.017	-0.023
	(0.004)**	(0.005)**	(0.005)***	(0.006)***	(0.008)***
Distance_to_main_road (log)	-0.010	-0.010	-0.010	-0.005	-0.008
	(0.009)	(0.010)	(0.009)	(0.010)	(0.010)
Distance_to_Kigali (log)	0.046	0.046	0.026	0.029	0.026
	(0.016)***	(0.017)***	(0.016)	(0.017)	(0.024)
Tutsi_%	-0.411	-0.419	-0.412	-0.418	-0.325
	(0.094)***	(0.094)***	(0.091)***	(0.092)***	(0.087)***
Distance_to_nearest_camp (log)	0.044	0.043	0.031	0.034	0.035
	(0.012)***	(0.012)***	(0.012)***	(0.013)***	(0.016)**
Kibeho_within_10km	0.042	0.040	0.038	0.040	0.007
	(0.033)	(0.033)	(0.033)	(0.034)	(0.035)
Extrajudicial_killings (thousands)	-0.033	-0.034	-0.032	-0.030	-0.038
	(0.008)***	(0.009)***	(0.009)***	(0.009)***	(0.010)***
Province_Gisenyi	-0.009	-0.014	-0.029	-0.030	-0.020
	(0.017)	(0.019)	(0.019)	(0.019)	(0.025)
Province_Ruhengeri	0.022	0.020	0.005	0.001	0.031
	(0.015)	(0.016)	(0.016)	(0.017)	(0.023)
Operation_Turquoise		-0.010	-0.026	-0.024	-0.035
		(0.016)	(0.017)	(0.018)	(0.016)**
RPF_control			0.056	0.052	0.028
			(0.021)***	(0.022)**	(0.022)
Population_density_1991				0.016	0.006
				(0.020)	(0.022)
Province_Byumba_and_Umutara					0.067
					(0.022)***
Province_Cyangugu					0.007
					(0.030)
Province_Gikongoro					0.020
					(0.028)
Province_Gitarama					-0.008
					(0.021)
Province_Kibungo					0.001
					(0.022)
Province_Kibuye					-0.030
					(0.026)
Province_Kigali_Rurale					0.013
					(0.030)
Constant	-0.411	-0.403	-0.255	-0.386	-0.307
	(0.105)***	(0.106)***	(0.103)**	(0.208)*	(0.234)
R^2	0.39	0.39	0.42	0.43	0.51
N	142	142	142	142	142

* p<0.1; ** p<0.05; *** p<0.01

DISCUSSION

Interpretation of the results

These results provide evidence that indirect mortality estimation based on inferences from demographic data can provide a useful measure of relative mortality. Critics of this approach may question the mechanism by which indirect indicators are translated into the absolute numbers of dead. The data used in this paper have been combined using PCA, but traditionally with this approach "model life tables" are used to map single indicators to absolute mortality figures. Assuming a given shape for the correlation could be unwise when studying novel high-mortality phenomena such as the HIV/AIDS epidemic (Bhat 2004) or an acute and sudden genocide. In this paper I have used two indirect estimation techniques to make findings about the relative spatial distribution of morality: the WEMI (a composite of 5 indirect mortality indicators) and the change in the sex ratio (a single indirect mortality indicator). Tables 2 and 3 show a fairly strong correlation between these two measures.

Further evidence as to the mutual consistency of these approaches is the similarity of the regression results using Deathtoll and using Change_in_sex_ratio_i. I believe that this is due to two separate effects both causing the disappearance of men from the sample. In the first instance, men were killed somewhat disproportionately to women: men to a much larger extent were victims of battle deaths, were targeted by the RPF in killings after the genocide, and there is some evidence that men were killed more often than women during the genocide (see above). In the second instance, almost all of the persons sent to jail during the massive post-genocide wave of incarceration were men. Since the genocide was a nationwide, populist phenomenon, the *genocidaires* tended to be locals. Men accused and jailed would tend to be more numerous in areas where killing was more prevalent. Thus, in communes where killing took place, men were killed in higher numbers than women, and men were incarcerated in higher numbers than women. This dual compound effect may be one of the reasons why the change in sex ratio is so closely related to the Deathtoll.

Considering for a moment the limitations of sex ratio as a proxy for mortality, these results also show that its predictive power hinges upon the way in which it is constructed. In the post-genocide period, the massive wave of incarceration had a substantial impact on the sex ratio, by concentrating a small fraction of the Rwandan male population in certain areas. By comparing Tables 5 and 6, we see that this change in the construction of the variable has a considerable impact the predictive model. This example should serve as a warning to those wishing to use sex ratio as a strict, one-to-one indicator of mortality. Even without any particular bias in the sample, the usefulness of sex ratio as an indirect indicator of mortality will depend upon how strongly the lethal phenomena are disproportionately affecting one gender. If men and women are present in the population in equal numbers and are killed in equal numbers, then the sex ratio will not move, making it useless as an indicator of mortality. A final difficulty to be aware of is that the sex ratio may be shifting for other reasons. For example, in certain contexts leaving a warzone as a refugee may be much more likely for women than for men, or outmigration in search of wage employment may be much more likely among men than among women.

The economic and social impact of changes in sex ratio

While this paper has concentrated on the relationship between mortality, sex ratio and other indirect indicators of morality, it has also elaborated a statistically significant model for predicting the change in sex ratio during a given historical period in Rwanda. Separate from mortality, a change in the ratio between men and women can have a strong social impact in and of itself. The model presented in Table 6 is particularly interesting in that it excludes men in prison, and as such gives a strong indication of the changes in "free society" in Rwanda. The number of women relative to men has grown overall, and should then ask what impact this shift has had on the daily life of these women.

In keeping with the results presented here, Verpoorten and Berlage (2007) observe that over this period in Rwanda, the proportion of female-headed households increased from 18% to 43%. They draw attention to the same dual compound effect mentioned here, noting that roughly 75% of households that lost member due to violence were female-headed, and that 70% of the households with at least one member in prison were female-headed. A related negative welfare outcome was an increase in the dependency ratio: in 1990 there were 1.07 dependents for every active household member, whereas in 2002 this number had risen to 1.28. Concerning this change in household composition, David Newbury (1998) points out that highly patriarchal legal and social systems were slow to adjust, leaving women household heads without clearly defined legal rights. Justino and Verwimp (2008) provide empirical evidence of these difficulties for female-headed households. Although land-poor, income-poor households were able to move out of poverty when an active adult member died, female-headed households were more likely to be poor and less likely to recover from income shocks.

The social changes observed in this paper may also have implications for the marriage market in Rwanda. In his seminal Treatise on the Family, Gary Becker (1981) noted that if the number of men relative to the number of women decreases, the bargaining power of women will be reduced, weakening their position both in the marriage market and within the household unit. Josh Angrist (2002) applied this model to American data, using the fluctuation in immigration as a natural experiment and measured first, second and third generation effects. His results support Becker's hypothesis that a high sex ratio (relatively more men on the marriage market) increases the bargaining power of women, and that in this case men were more likely to invest in earnings potential to make themselves more attractive in the market. Elizabeth Brainerd (2007) studied the effects of the Second World War and the massive shift in the sex ratio in the Soviet Union, which lost nearly 14 per cent of its population, largely due to the death of men. Brainerd found that regions with lower sex ratios (a deficit of men) showed significant second-generation effects concerning health and nutritional status of children – when the bargaining power of women was reduced it translated into worse outcomes for their children. If these types of relationships hold for Rwanda, the model will not only predict a change in sex ratio, but also a decline in the bargaining power of women and a reduction of their social security.

The economic and social impact of mortality

Although death tolls are often an object of study for their own sake, mortality can have a significant effect on economic and social wellbeing. The death of a portion of the labour force is one of the commonly-observed economic features of civil wars (Collier 1999). Verpoorten and Berlage (2007) looked at relative economic mobility in a sample of 188 rural households in the Provinces of Gikongoro and Gitarama. They identify a permanent lowering of human capital in Rwanda because economically active members in families had been killed or permanently handicapped. Furthermore, they show that limited access to food or medical care can have lasting effects on household welfare and productivity.

Yet just how economically devastating is this loss of life, and is there any hope for recovery? Verpoorten and Berlage (2007) found that households experiencing the death or long-term imprisonment of one of their members tended to move downwards in the income distribution. However, families experiencing other conflict-related shocks were not worse off compared to families experiencing no shocks. MacKay and Loveridge (2005) combined various household-level Rwandan government surveys to measure income, agricultural productivity and nutrition. They also found a strong recovery of average incomes among rural households during the postwar period, but observed also a striking increase in inequality. Limited opportunities for off-farm work, and increasing land size pressure has meant that for nearly 70% of the poorest rural inhabitants, income levels have not recovered. Further to this point, Verpoorten and Berlage (2007) cite official Rwandan government statistics as showing that the Gini coefficient has been rising sharply, from 0.29 in 1984/86 to 0.45 in 2000/2001 (Government of Rwanda, 2002).

Clearly the massive wave of mortality measured in this paper had negative consequences for economic outcomes in Rwanda, at both the aggregate and household levels. By extension, it can be expected that the communes predicted to have considerable excess mortality would have negative economic outcomes as well. The above evidence does suggest, however, considerable economic recovery since this period in Rwanda. There are several possible reasons for this. Firstly, the levels of GDP and capital were very low by world standards before the conflict of the 1990s. Rwanda is a largely agricultural economy, and as such there was little physical capital to destroy. Secondly, Rwanda suffers from relative land scarcity, so it is possible that it was already at the limit of its productive capacity and that most of the population could be considered as mere “surplus labour” (Lewis 1954). Finally, there has been a massive influx of foreign aid and direct development assistance programmes. For example, a 2001 report by the Rwandan Ministry of Agriculture, Animal Resources and Forestry, lists 51 national and international non-governmental organizations acting in the agricultural sector alone (Bingen and Mpyisi, 2001).

CONCLUSION

This paper has tried to demonstrate the applicability of indirect mortality estimation techniques to the measurement of the spatial distribution of violence in Rwanda during the 1990s. The first model uses Principal Component Analysis to combine 5 different indirect indicators of mortality into a relative Wartime Excess Mortality Index. Interpreting this index as a death toll and regressing it on spatial indicators and other predictors of violence, several variables are found to significantly affect excess mortality at the commune level: the number of days of RPF presence in 1994, the distance to Kigali, the percentage of Tutsi in a given commune, the number of extrajudicial reprisal killings by the RPF, and whether the RPF controlled the commune at the end of the civil war in 1993. Regional dummies for Gisyeni and Ruhengeri provinces were also significant. These results confirm the findings of the literature: that the genocide was more intense in areas where Tutsi people were concentrated, and that reprisal killings of Hutu also took place and were subject to their own geo-spatial patterns. These results are also consistent with the findings in Verpoorten (2012) at the sector level.

The second model uses the change in sex ratio as the dependent variable, regressing it on the same independent variables. When the change in sex ratio variable includes the whole population, the model has little predictive power. This is probably due to the fact that many male prisoners were concentrated in a small number of communes with large prisons. When the change is sex ratio is truncated to exclude the population in prisons, the regression results are very similar to the model derived from the WEMI, and the same variables are significant. Given that two differently-constructed dependent variables produced similar results, it suggests that they are useful measurements of excess mortality, or are at least measuring it in the same way. A fairly strong bivariate correlation between

WEMI and the differenced sex ratio further supports this contention.

It is easier to measure sex ratio or other demographic characteristics from censuses than to launch purpose-built mortality studies that count violent deaths. Sex ratio will be a good proxy for excess mortality if and only if the patterns of violence consistently affect men and women in different ways. The present example from the Rwanda data works well. This is perhaps because the male population suffered a dual compound effect: men were killed in greater numbers both as part of the military conflict and during the genocide, and men were incarcerated overwhelmingly more than women. Not only do these results help us understand the spatial distribution of excess mortality, but they are indicative of certain socioeconomic outcomes. In other contexts, a lower sex ratio has major direct and indirect welfare outcomes, thus making it an important object of study in its own right. The specific evidence for Rwanda shows that male scarcity leads to a preponderance of female-headed households with lower overall welfare for whom it is more difficult to escape poverty.

WORKS CITED

Amnesty International. 'Rwanda: Civilians trapped in armed conflict - "The dead can no longer be counted."' https://www.amnesty.org/en/library/asset/AFR47/043/1997/en/7976bb52-e843-11dd-bca7-eb90848b856c/afr470431997en.html. Accessed May 17th, 2013.

Angrist, Josh. "How do sex ratios affect marriage and labor markets? Evidence from America's second generation." The Quarterly Journal of Economics 117.3 (2002): 997-1038.

Becker, Gary S. *A Treatise on the Family.* Harvard university press, 2009.

Bhat, PN Mari. "Commentary: On reappraisal of adult mortality." International Journal of Epidemiology 33.4 (2004): 717-718.

Bingen, Jim and Edson Mpyisi. "Non-Governmental Organizations in Agricultural Development: Preliminary Survey Results ." Ministry of Agriculture, Animal Resources and Forestry (Rwanda), 2001.

Brainerd, Elizabeth. "Uncounted Costs of World War II: The Effects of Changing Sex Ratios on Marriage and Fertility of Russian Women." National Council for Eurasian and East European Research, 2007.

Burnham, Gilbert, et al. "Mortality after the 2003 invasion of Iraq: a cross-sectional cluster sample survey." The Lancet 368.9545 (2006): 1421-1428.

Collier, Paul. "On the economic consequences of civil war." Oxford economic papers 51.1 (1999): 168-183.

Collier, Paul. "Development and conflict." Centre for the Study of African Economies (2004).

Des Forges, A. *Leave None to Tell the Story.* Human Rights Watch, 1999.

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

Hill, Kenneth, and James Trussell. "Further developments in indirect mortality estimation." Population Studies 31.2 (1977): 313-334.

Human Security Report Project. *Human Security Report 2009/2010: The Causes of Peace and the Shrinking Costs of War*. New York: Oxford University Press, 2011.

International Rescue Committee. "Mortality in the Democratic Republic of Congo: An ongoing crisis." 2007.

Jolliffe, Ian T. *Principal component analysis.* Springer verlag, 2002.

Justino, Patricia, and Philip Verwimp."Poverty dynamics, violent conflict and convergence in Rwanda." (2008). MICROCON Research Working Paper 4.

Kuznets, Simon, and John Thomas Murphy.Modern economic growth: Rate, structure, and spread. New Haven: Yale University Press, 1966.

Lewis, W. Arthur."Economic development with unlimited supplies of labour." The Manchester school 22.2 (1954): 139-191.

McKay, Andrew and Scott Loveridge. *Exploring the Paradox of Rwandan Agricultural Household Income and Nutritional Outcomes in 1990 and 2000*. No. 11582. Michigan State University, Department of Agriculture, Food, and Resource Economics, 2005.

Newbury, David. "Understanding genocide." African Studies Review (1998): 73-97.

Prunier, Gérard. *The Rwanda crisis: History of a genocide.* Columbia University Press, 1995.

Sen, Amartya. "Mortality as an indicator of economic success and failure." The Economic Journal 108.446 (1998): 1-25.

Solow, Robert M. "A contribution to the theory of economic growth." The quarterly journal of economics 70.1 (1956): 65-94.

Spagat, Michael, et al. "Estimating War Deaths An Arena of Contestation." Journal of Conflict Resolution 53.6 (2009): 934-950.

Spagat, Michael. "Ethical and Data-Integrity Problems in the Second Lancet Survey of Mortality in Iraq." Defence and peace economics 21.1 (2010): 1-41.

Spiegel, Paul B., and Courtland Robinson. "Large-Scale “Expert” Mortality Surveys in Conflicts—Concerns and Recommendations." JAMA: the journal of the American Medical Association 304.5 (2010): 567-568.

Tertsakian, Carina. *Le Château: The lives of prisoners in Rwanda.* Arves, 2008.

Themnér, Lotta, and Peter Wallensteen. "Armed Conflicts, 1946–2011." Journal of Peace Research 49.4 (2012): 565-575.

Verpoorten, Marijke. "The death toll of the Rwandan genocide: a detailed analysis for Gikongoro Province." Population (English edition) 60.4 (2005): 331-367.

Verpoorten, Marijke. "The intensity of the Rwandan genocide: Measures from the gacaca records." Peace Economics, Peace Science and Public Policy 18.1 (2011).

Verpoorten, Marijke. "Detecting hidden violence: The spatial distribution of excess mortality in Rwanda." Political Geography 31.1 (2012): 44-56.

Verpoorten, Marijke, and Lode Berlage. "Economic mobility in rural Rwanda: a study of the effects of war and Genocide at the household level." Journal of African Economies 16.3 (2007): 349-392.

Verwimp, Philip. "Death and survival during the 1994 genocide in Rwanda." Population Studies 58.2 (2004): 233-245.

Verwimp, Philip. "Testing the double-genocide thesis for central and southern Rwanda." Journal of Conflict Resolution 47.4 (2003): 423-442.

Wooldridge, Jeffrey M. Introductory econometrics: a modern approach. South-Western Pub, 2009.